

SAVED BY CHAOTICS: FROM ELECTIVE AFFINITIES TO FRACTAL ATTRACTION

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“Life is chaos, and that’s a very exciting thing.”
Seven Life Lessons...

Abstract: In man’s endless pursuit of knowledge, science may be seen as having moved from perceiving the world as ordered, linear, reductionist, predictable and/or controllable (Newton) to viewing it as irregular, uncertain, unpredictable/uncontrollable (modern and post-modern chaoticists). On the other hand, the humanists have seen science as destructive of beauty (Romanticism—“unweaving the rainbow”) or as unexpectedly helpful. Three literary pieces have been chosen to illustrate this second perspective: Goethe’s Elective Affinities, presenting a chemical-literary experiment based upon previous scientific claims regarding deterministic dependence of “reactive characters” upon the attraction between elements and compounds; then Goethe’s novel reworked in Banville’s “The Newton Letter”—an experimental exploration of the relationships between author/researcher and his inner/outer environments; third, Tom Stoppard gathering together in his Arcadia all sorts of scientists and writers to discuss a multiplicity of science topics including thermodynamics, fractals, chaoticists...

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This might prove to be a somewhat misleading title, as it has been chosen mostly for the superficial suggestiveness in the combination of two distinctively appropriate titles given to short books published almost two hundred years apart, in 1809 and 1991. In one of our working titles we were playing with something like “the unbridgeable gulf of mutual understanding” between science and the humanities—literature more specifically (too much of a carefully looked for paradox); and, while searching among modern writers with more than a detached interest in science (Zola, Buchner, Wells, Doblin, Huxley, Brecht, Durrenmatt, Calvino, Crichton...), we encountered no difficulty in identifying Goethe as our starting point; especially since, first, he was deeply involved in the science of his day, with contributions in the fields of botany, comparative anatomy, meteorology (like Lorenz, infra), geology...(in fact, he wished to go down in history as a scientist); and, second, since, while believing that the laws of science (chemistry) provide support for such social-moral institutions as marriage (“the marriage of true minds” in Will’s 116 included?), monogamy, divorce, conflict, free will, passion, attraction/affinity..., he was not far from Newton (passim), the earlier founder of modern science, also intent on synthesising all human knowledge (his pioneering work in mathematics, physics, and cosmology intertwined with his later study of magic, alchemy, history, and theology).

The science both these great men viewed in the wider context of other non-scientific human endeavors was itself involved in a post-Renaissance-Enlightenment “paradigm shift” that we are prepared to present here only in the least detailed outline;

from seeing the world as linear and smooth (18th and 19th centuries), as a result of definite cause-and-effect predictable and controllable phenomena (gravity, electricity, chemical reactions...), the scientist-observer at the beginning of the 20th century and later (Pierre Fatou, Gaston Julia, Benoit Mandelbrot...) becomes interested in nature's complexities and irregularities, its branching, non-linear and uneven forms (trees, clouds, rivers, coastlines, landscapes...), its unpredictable, uncertain and uncontrollable phenomena (organs, human brain states, weather, ecosystems, social and economic systems, the stock market...).

In parallel, the (romantic) writer's response to the classical reductionist and mechanistic tendencies of science, aiming to impose man's (the scientist's) ability to predict and control one system or another was expressed in the long-lived and almost commonplace notion that the scientific spirit destroys beauty: "Our meddling intellect/Misshapes the beauteous forms of things--/We murder to dissect..." (Wordsworth, "The Tables Turned," 1815); and thus destroy the world—"The world was void.../Seasonless, herbless, treeless, manless, lifeless;/ A lump of death—a chaos of dark clay..." (Byron, "Darkness," 1816); plus a later American: "Science!.../ Who alterest all things with thy peering eyes!/ ...prey'st upon the poet's heart./ Vulture! Whose wings are dull realities!..." (Poe, "To Science," 1829); and closest to our purposes here, Keats' "Lamia" (1819)—science strips the world of its veil of mystery—and painter Haydon's reminiscence: "During an immortal dinner on 28th December 1817... Keats lightheartedly said Newton 'has destroyed the poetry of the rainbow, by reducing it to the prismatic colours.' He then proposed a toast to 'Newton's health and confusion of mathematics' to the amusement of all..." (Penrose, p.231); whence evolutionary biologist Richard Dawkins' 1998 *Unweaving the Rainbow*, showing that seeing science and the arts as being at odds is a grave misperception, as "A Keats and a Newton, listening to each other, might hear the galaxies sing."

To avoid any such misperception, the scientist's/man's more appropriate participation is certainly needed in his understanding of the dynamics, relationships, and interconnectedness in and of complex systems, together with a better comprehension of their unpredictability and uncontrollability, their multiple variables and non-linear dynamics, their uncertainties and ambiguities (supra); with the Cartesian universe left behind, modern man is invited to accept that nature's and life's complex systems can be both deterministic and unpredictable and that the new paradigm breaks across the lines that separate scientific and humanistic disciplines, moving from any narrow or large specialization of sciences to universality and globalizing perspectives, where different disciplines are drawn to solving similar or identical problems, encompassing both the classical order and the postmodern disorder; unsurprisingly, this is the paradigm of orderly disorder—the "new paradigm of chaotics." (Hayles)

So, before looking at our three writings combining such complex dynamics of science and literature, we may attempt to briefly introduce chaotics and some of its major components, maybe a few chaoticians and the relevant implications. The newcomer to the field may be surprised to find that the "science called chaos" (its first

international conference in the summer of 1977) has little to do with the Greeks' primeval, unfathomable emptiness, the underworld, or Hesiod's abyss of Tartarus, or the void state preceding creation; and, in fact, one should not postpone mentioning that it is less of a new science and more of a progression of thinking, a way of understanding phenomena, a collection of tools or a new style of scientific reasoning; as such, one keeps coming across a statement that seems to have become some kind of motto: "where chaos begins, classical science stops."

Still, as an immature, not well-developed science (with Edward Lorenz, Stephen Smale, Robert May, James Yorke—originator of the name—, Joseph Ford, Benoit Mandelbrot... among the early chaoticians), it is the study of nonlinear dynamics—"freed at last from the shackles of order and predictability, systems liberated to randomly explore their every dynamical possibility..."(Ford); and these "systems" gradually appear to describe man's whole world, from Ice Age cave painting to colliding galaxies, from leaves, trees, branches and clouds to craggy coastlines, snow crystals and ferns, from weather to plots of heart rhythms, traffic jams, biological populations (Stoppard, *infra*), social and economic patterns, stock market prices, water wheels, flips of a coin... All these and others are studied as examples of systems existing and functioning behind apparently random data, but paradoxically governed by deterministic laws—which renders their complexity predictable; so the basic metaphor is that of "deterministic chaos" in the process of humans interacting with nature and technology: "chaos theory teaches us that we are always a part of the problem," (Biggs and Peat, p.160)—as much as Newton himself was in 1693, or Banville's narrator in 1993.

It has become common practice to say that this "chaos" was discovered by Harvard/MIT mathematician-meteorologist Edward Lorenz (1917-2008) in 1961; while trying to develop a mathematical model of the atmosphere, Lorenz imagined (n.b.—the observer's role) a rectangular slice of air cooled from above and heated from below and thus with warm air rising and cool air sinking, resulting in the development of convection cells in rolls of air transferring heat from bottom to top (second law of thermodynamics). At this point, the scientist has three variables for his system: the convective flow, the horizontal temperature distribution, and the vertical temperature distribution, all of which he feeds into his computer program to calculate how they would change over time (such smaller scale rolling convections would also appear in cups of coffee or bowls of rice and jam—for Stoppard's use once again) and fit into his equations; after getting the trajectory for the first run, he types in the "same" numbers for a second run, only, probably to conserve paper in his old, early computer, his instruction is to round the solutions before printing them—something like 0.506.127 becoming 0.506; this seeming (the tiny error introduced by the dropping of three digits) identity resulted, however, in an entirely different wondrous curve, with two overlapping spirals resembling butterfly wings on the screen, looping around forever in a strange kind of order—a picture of chaos; no wonder the scientist thought he could use the metaphor of the "butterfly effect" for this "strange attractor"; and thus the first

principle of chaotics—however small changes in the initial conditions lead to drastic changes in the results (“sensitive dependence on initial conditions”).

All our lives contain ongoing demonstrations of this principle, less scientifically and more conveniently described as the Butterfly Effect; the flapping of a butterfly’s wings in Brazil may set off a tornado in Texas (with the variant “...in China..., in America...”); weather long-range predictions will thus remain a fantasy because of the inevitable inaccuracy and incompleteness of the initial observations (observer and observing as part of the problem). The other four principles have already been hinted at: unpredictability, the transitions between order and disorder, turbulence (fluids cannot be unmixed—see once more Thomasina’s problem in Stoppard, *infra*), and feedback (Mandelbrot’s stock value rises and falls, leading to rising and falling prices as stock is being bought and sold, leading back to stock value rising and falling chaotically); or predicting how animal populations might change over time given a certain set of starting conditions (Valentine and his grouse population, *infra*).

The states of any such systems—*attractors*—belong to a rather restricted set, including point attractors (a single steady state, like the bottom of a sled slope), periodic attractors (cyclical, closed loops), tori attractors (combinations of cycles), and strange attractors (chaotic dynamics—see Lorenz, Smale, Ruelle...); strange attractors and their chaotic, complex, non-linear dynamics (*supra*) also required the study of fractality (fractal geometry), the work of Benoit Mandelbrot and the concept of self-similarity; fractals are “objects”/shapes/space-time structures—snowflakes, tree bark, broccoli buds, coastlines, mountains, rivers, clouds, organs, crystals, sea shells, hurricanes...-- whose irregularity is constant over different scales, so one finds it hard to know where the interior stops and the exterior begins (they exist between dimensions as it were); and they also occur in complex non-linear systems, where each successive state depends on the previous state; and thus, since a smaller section of the fractal resembles the entirety (the Koch curve/snow-flake/star/island) and the researcher finds the same statistical properties at different scales (scale invariance due to self-similarity or self-affinity—Goethe, *infra*), fractal analysis is possible mostly by designing and computer generating fractal images by using iterated systems (see Stoppard, *infra*) and drawing up fractal equations; there is a whole Fractal Attraction (LC) software package describing and illustrating (two versions—standard and enhanced) this process (and procedure); this may be used in all areas of science (from diagnostic imaging, electroencephalography and cancer research to electrical engineering, generation of new music, seismology...), justifying the placing of chaotics as the third scientific revolution of the 20th century, after relativity and quantum physics.

With Newton, Einstein, Heisenberg, Lorenz, Mandelbrot... studying and developing such linear/non-linear, predictable/unpredictable, deterministic/chaotic, controllable/uncontrollable systems, we can iterate (*sic!*) our return to literature and see how writers could cope with and digest the “hard” stuff. As our first choice (*supra*), scientist-writer J. Wolfgang von Goethe (1749-1832) titles his third novel *Die Wahlverwandtschaften* (1809)—“*Elective Affinities*,” a scientific term previously used to

describe the tendency of chemical elements to be naturally drawn to and combine with certain other elements or substances in preference to others; also translated as “Kindred by Choice,” (2009); in fact, this is chemistry—“the science of the properties, composition, and structure of substances (defined as elements and compounds), the transformations they undergo, and the energy that is released or absorbed /thermodynamics, *infra*) during these processes.” (Encyclopaedia Britannica); but chemistry also means a strong mutual attraction, attachment or sympathy, and one wonders if Goethe may not have been the inventor of this connotation in his novella, where he researches the possibility of seeing human interactions (attraction, magnetism, passion..., even working relations, compatibilities in ideologies, politics..., see Max Weber, *infra*) as governed by the scientific laws of chemical affinity or, more generally, the lives of the human species as regulated no differently from the lives of chemical species (a particular type of Newtonian determinism?).

As the research required laboratory conditions and select circumstances, Goethe’s chemical retort is a rural estate with gardens and castle, in the vicinity of Weimar naturally, where the human elements are brought together so that scientist and watcher/reader could observe the resulting reactions; a literary-chemical experiment, therefore, involving Eduard and Charlotte, an aristocratic couple (second marriage for both, the first unions were forced—no innate affinities, and thus “unlawful”—chemically) who decide to play games and invite Eduard’s childhood friend, the Captain, and Charlotte’s niece, Otilie (in fact, the orphaned daughter of a close friend)—two new elements destined to modify the reaction-s as the Captain and Eduard begin work on a scientific project, not before one evening all four participate in a group reading aloud (Part I, Ch. 4) about elective affinities. Next, the Captain, well-versed in science, explains for the others the subtle exchanges between the scientific and human realms, while Eduard comes up with a formula where the four elements-characters are represented by capital letters: $AB + CD \rightarrow AD + BC$ (Charlotte and Eduard + Otilie and Captain Charlotte and Captain + Eduard and Otilie). But this is science, therefore reductive and mechanistic, so the reaction is not validated, the experiment is a failure; Otilie starves herself to death, Eduard also dies of some mysterious illness, and the two are buried side by side; the Captain leaves, Charlotte is pregnant with Edward’s or the Captain’s child (Otto—to be accidentally drowned in the meantime by Otilie).

What we thus have is a short novel whose plot consists in managing and improving this country estate—its forestry, building work, garden design, church restoration--, and whose language is often refreshed by extracts from Otilie’s aphoristic diary entries, also “more firmly based” on the Hauptman’s “trigonometrical measurements” as well as his “affinity map” and chemical formula (explained by Eduard): “You, Charlotte, represent the A, and I represent your B; for in fact I do depend altogether on you and follow you as A is followed by B. The C is quite obviously the Captain, who for the moment is drawing me away from you. Now it is only fair that, if you are not to vanish into the limitless air, you must be provided with a D, and this D is

unquestionably the charming little lady Ottilie, whose approaching presence you may no longer resist." (I, 4)

Goethe acknowledged in a letter that his title was borrowed from Swedish chemist and mineralogist Tornbern Olof Bergman (1735-1784), author of a 1775 "chemical genealogy" titled *De attractionibus electivis*—chemical affinity tables, translated into German in 1782, and one can compare with the above: "Suppose A combined with c to saturation (this union I shall call Ac) and should upon addition of b tend to unite with it to the exclusion of c; A is then said to attract b more strongly than c, or to have a stronger elective attraction for it; lastly, let the union of A on the addition of a be broken, let b be rejected and a chosen in its place; it will follow that a exceeds b in attraction power, and we shall have a series a, b, c in respect to efficacy."(p.XX)

With his wide range of interests, the great writer might have also known/remembered that, before chemistry came along, affinities used to be at the basis of all magic and also concerned the later alchemists; that Newton himself (with whom he also occasionally disagreed) had studied the attraction of bodies, magnetism, electricity and how certain metals would replace one another when dissolved in nitric acid; that in his 1718 Table showing different relationships observed between different chemical substances, Etienne-Francois de Geoffroy had also indicated the clear preference of various substances to bind with others; and that dozens of other "tables of affinity" were circulated during the Enlightenment (well before Mendeleev's Periodic Table, 1869); and that, often writing ahead of his time, he himself could have anticipated things like the electro-chemical theory, chemical thermodynamics or even how quantum mechanics could fit in here; or that the very rise of capitalism could be described in terms of a number of social, cultural and historical elective affinities (which Max Weber was to do in his book on "protestant work ethic..." for instance); or that exactly two centuries later (Mendez, Gervas & Leon, 2014/2016), on the basis of fuzzy logic, a "storytelling system was to be developed in which arithmetic operators are used to modify the degree of affinity between characters," with the affinity values changeable in the interactions of a story, from foe/no affinity, to indifferent/slight affinity, friend/medium affinity and/or mate/high affinity.

In the meantime, however, Goethe completes the tragic ending of his own *Elective Affinities* after rearranging the characters/substances and couples/molecules in a chaotic pattern (supra) that seems to underline the unavoidable limitations of scientific knowledge, obviously destined to be part of an elective affinity with literature, interacting in creative tension, each guiding and modifying the other (see Xavier Duran); thoughts with which he would reach deep into the 20th century, where at least two remarkable writers were electively expecting (sic!).

After Dr Copernicus (1976) and Kepler (1981), Nobel Prize nominee John Banville (b. 1945) completes his "Revolutions Trilogy" with a modern reworking of *Die Wahlverwandtschaften* in his 1982 *The Newton Letter* (his other Goethe reworking, *Mefisto* came in 1986—with the devil whispering in the mathematician-hero's ear that "under the chaos of things a hidden order endures..."). Written as a highly self-

conscious, self-reflexive and experimental narrative, Banville's novella is itself a letter from his nameless narrator-biographer-historian to a woman named Clio (muse of history?), sometime in the 1970s; his current project that he was unable to finish for the past seven years was a "Life of Newton" (1642-1727), in which he could not overcome a few years in the 1690s, soon after the scientist had met the Father of Liberalism, philosopher John Locke (1632-1704)—author of a 1688 review of Newton's *Principia*...; they became friends, shared interests in chemistry, theology and natural philosophy (and some heretical views), were members of the Royal Society (with Newton as president later) and started exchanging letters ("the supreme mind in the history of exact sciences" was the author of 1,140 letters—*infra*).

So, what happened to Newton in his early fifties (Banville's narrator is also fifty-one; two midlife crises?)? His letter to Locke of November 14, 1690 was "An Historical Account of Two Notable Corruptions of Scripture"—one of several about disputed Bible passages; then there occurs some sort of mysterious mental breakdown (after a fire that destroyed many of his papers), and there is a disturbing anomalous obscure (fictional?) letter in which he threatens to quit his inquiries and scholarly pursuits (in fact he abandons the absolutes of time, space, and motion and "leaves the universe ambiguous and open to relativity"), and also accuses the philosopher of being immoral, a Hobbes-ist and having tried to "embroil him with woemen/sic/" (Newton had no such "affinities"), with the subscription "I am your most humble and unfortunate servant, Is. Newton"; next he was attracted (sic) to chemical mechanics, alchemy, mysticism and the study of biblical chronology.

To research and elucidate this crisis of belief, "ailment" and fundamental breaking point in Newton's life and career, Banville's historian-narrator rents a lodge in a rural retreat in the South-East of Ireland—a place called Fern House ("fern"—a typical fractal pattern) in County Wexford, Banville's birthplace—from the Lawless-es /sic/, a Quirky English family, who all (two women, a man and a child) live in the old main house; finding himself suffering his own neurotic failure of nerve, the highly unreliable narrator abandons his Newton book as he realizes the danger of making large inferences from small clues and thus pursue, like the scientist himself, an inadequate system of interpretation (Lorenz's butterfly effect?); one obsession (Newton in 1693) is replaced by another obsession (the Lawless family history, which he doesn't understand and misconstrues in all his observations and judgments: abstracted and withdrawn Charlotte, her niece Otilie—a graceless big blonde in her mid-twenties, her clumsy, inarticulate, often drunk husband Edward and a son—i.e. all of Goethe's characters regrouped under the post-Einstein scientific metaphor of relativity as a condition of all perception and knowledge).

With Newton and Locke out of his way/mind, the narrator has an affair with Otilie while in love with Charlotte (spiritual adultery and embroiling with women revisited), befriends dying Edward and leaves Charlotte and Otilie ("Charlottilie" in one place) on their own to manage the estate; the limits of human knowledge (historical, literary-imaginative, scientific), more obvious in chaotics (Lorenz was also an "Edward")

than in classical affinities theories, leave Banville with language alone to obsess with (“the ocean in which we human fish must swim, even as we try to escape it...”) and the writer’s dilemma while writing about writing; an autobiographical story that begins with “Words fail me” and ends with “I am lost,” and with Goethe as “a part of the past, immutable, crystalline and perfect...”/sic!/.

And also part of another affinity with Tom Stoppard (b. 1937 in Czechoslovakia), author, among many others (“Rosencrantz and Guildenstern Are Dead,” “Travesties,” “Life of Galileo,” “Enigma,” ...) of *Arcadia* (1993), one more modern-day remake of *Wahlverwandtschaften*, where chemical affinity is updated with discussions of chaos theory (Stoppard’s initial inspiration was James Gleick’s 1987 bestseller *Chaos: Making a New Science*), thermodynamics, mathematics in general—computer algorithms, fractals, population dynamics...--landscape design, botany, epistemology, history, philosophy, English Literature (romanticism and classicism)...; in fact, this too wide array of subjects in about one hundred pages has come to be most frequently criticized by commentators.

The Greek/Roman/Romantic/Goethean... pastoral ideal—“Arcadia”—is the English estate of Sidley Park in Derbyshire, whose geometry and design—carefully ordered, linear, symmetrical..., or wild, untamed, irregular, Gothic—is an important preoccupation and theme over two overlapping time periods: 1809 (publication of Goethe’s *Elective Affinities*) through 1812 and “the present”; the two acts and seven scenes of the play are all set in one room, from beginning to end, and the same props throughout: a table and chairs, books, coffee mugs, quills and pens, portfolios, laptops, and an ancient living tortoise Plautus; scenes 1, 3 and 6 are set in the past, 2, 4 and 5 in the present, and 7 in both temporal frames.

The characters include the house’s current residents and the people who lived there before, all imagined on the Goethean model of “reactive entities”; Lord Coverly and Lady Croom are the aristocratic owners; Thomasina is their precocious teenage (13-17) daughter, modeled on Ada Lovelace (Byron’s sister, who herself foresaw the binary computer), and two hundred years ahead of her time (intuits chaos theory, entropy and the second law, fractal geometry and attractors—equations for a bluebell, a rose, a leaf, a fern, a snowflake curve--, iterated algorithms...); Thomasina’s tutor, Septimus Hodge, 22, a friend of Lord Byron, who instructs her into the Newtonian vision of the universe; two modern scholars, classicist and writer Hannah Jarvis (studying Sidley Park secrets) and literature professor and critic Bernard Nightingale (romanticism, life of Byron—who had stayed at Sidley); heir to Sidley Park Valentine, post-grad student in mathematical biology and a modern day chaotician (trying to explain the rise and fall of the grouse population on the estate); Lady Croom’s gardener Richard Noakes, “the emperor of irregularity”; poetaster and botanist Ezra Chater and wife Charity; the fleeting presence of Lord Byron and a few others.

The gist of the play is in how present-day /sic/ characters look at past characters through their visions, texts (poems included), records, workbooks, primers, game books, drawings, computations, letters, equations... and how the multiplicity of

scientific-philosophical topics are discussed and reflected in their interactions—all the way up to their final mix-up in Act II, Sc. 7, summed up as “there is an underlying order to seemingly random events” (chaotic thesis); in the final party’s “chaos” time periods and relationships collapse, variations in social norms and assumptions increase, characters disperse or die (Thomasina at 17), but connections and order can still be discerned; so, “there is order in chaos—an unpredictable order, but determined order nonetheless, and not merely random behavior;” (Fleming, 193-4) and it is only through the constant dialectic and tension between chaos and order, reason and emotion, knowing and unknowing, (science and literature together) that existence gets meaning and purpose; so we are back at Scene 1, where Thomasina was trying to understand why jam mixed in rice pudding can never be unstirred and “if you stirred backwards, the /entropic/ pudding does not notice /it observes the second law/ and continues to turn pink just as before;” while amateur chaoticians have known even since before Newton (William Camden, 1605) that “the proof of the pudding is in...” the stirring.

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