Engenetics
The science of species

The four maxims of ecology

Galileo Galilei, 1564–1642, played a major role in the founding of modern science. His discoveries were legion. Amongst them was his conception of an idealized ball rolling along with a constant velocity. This impossible-in-practice but easy-to-imagine situation laid the foundation for dynamics. It led, through the work of Sir Isaac Newton in particular, to the creation of one of the most precise, extensive, and technically sophisticated fields of science. The Dutch mathematician and physicist Christiaan Huygens, 1629–1695, not only wrote science fiction, but in his Traité de la lumière, he produced the wave theory of light. Since he was the first to use a mathematical formula to explain a physical principle, he is generally regarded as the first mathematical physicist. With his work and ideas, Huygens provided a solid foundation for the entire theory of waves, now one of the lynchpins of contemporary science. In 1801, the English mathematician and physicist Thomas Young, 1773–1829, conducted a seminal experiment. He passed light through slits to produce patterns of dark and light, thus comprehensively vindicating the constructive and destructive interference patterns predicted by Huygens' wave theory. This put Newton's corpuscular theory of light on the back burner, because the diffraction behaviour of light could not, at that time, be explained by looking on light as something made from particles. Wave-particle duality—the idea that something could be both a particle and a wave—would have to wait for the discoveries of quantum physics. The experiment with *Brassica rapa*, or field mustard (sometimes also called 'fast plant'), described on the engenetics web site [http://www.engenetics.net] was designed expressly to test this same hypothesis: can biological entities also be described as waves and/or particles? The data gathered, along with the analysis of it provided, indeed points to the existence, amongst and between varied biological populations, of the same patterns of **constructive and destructive interference** first proposed by Huygens. <u>This establishes that biological entities and their populations can—and</u>

do—exist as waves. The analysis of that same data also indicates that biological populations interact both with each other and with the environment in ways that characterize dynamical objects in motion. This establishes that biological entities and their populations can—and do—also exist as particles. (See further the discussion of the **three constraints or principles** to which all biological entities are subject).

The French physicist Nicolas Léonard Sadi Carnot, 1796–1832, tried hard to understand what made James Watt's famous steam engine work. Although it had become the workhorse that powered the Industrial Revolution, nobody had at that time provided a suitable explanation for how the steam engine worked. More technically, Carnot wondered if there was an upper limit to the power of heat. His ruminations laid the foundation for the laws of thermodynamics which underpin all contemporary science. His ideas in particular led to the powerful modern concept of entropy.

As demonstrated on the engenetics web site [http://www.engenetics.net], Carnot's question about a possible upper bound to the power of heat is conceptually identical to Darwin's very similar question about the existence of an upper bound to the reproductive potential of species. Both phenomena ultimately concede, to the surrounding environment, the ability to provide the necessary limitation. The experiment with *Brassica rapa* described on the engenetics web site [http://www.engenetics.net], has been conducted specifically to provide the theoretical basis that demonstrates the conceptual identity of these two seemingly different questions: (a) the question of an upper bound to the power of heat, and (b) the question of an upper bound to a reproducing population. It also provides the necessary numerical evidence to show this identity via the hard data demanded by the scientific method. The experiment is easily reproducible. It can soon be replicated in any laboratory, and using any species. *B. rapa* was selected simply because it is both fast-growing, and well-documented and extensively studied in the field. The necessary data, along with the details of the experimental design, can be found on the engenetics web site [http://www.engenetics.net]. The experiment establishes, however, that biological entities and their populations can—and do—furthermore exist as thermodynamic systems. (See further the discussion of the three constraints or principles to which all biological entities are subject).

James Clerk Maxwell, 1831–1879, is widely considered to be one of the three greatest physicists ever to have lived (the other two being Sir Isaac Newton and Albert Einstein). Maxwell found solutions to many unresolved problems of his day, including, most importantly, those in wave theory and electrodynamics. His four famous Maxwell field equations are the foundation for all energy studies; allow cell phones to work; and form the backbone to the copious technological advances of our era.

Niels Henrik David Bohr, 1885–1962, was a Danish physicist whose discoveries played a central role in establishing the quantum theory. Working from his laboratory he established what is still called the 'Copenhagen School' or 'Copenhagen interpretation' concerning the wave-particle duality of fundamental particles. Bohr successfully explained an outstanding anomaly in the behaviour of light by merging Planck's very new theory that heat existed in 'quanta', or little bundles of energy, with Einstein's photon theory. Einstein had recently explained yet another anomaly about light by suggesting that light existed as Planck's quanta. Although Bohr's conception of the atom did more than probably anything else to establish Planck's theory of the quantum, his supervisor and sponsor, Ernest Rutherford, 1st Baron Rutherford of Nelson, 1871–1937 (known as 'the father of nuclear physics', the first man to split the atom, and the discoverer of the positively charged nucleus at its centre) rejected his initial paper. Bohr travelled to Manchester; spoke directly to Rutherford; and persuaded Rutherford that in spite of one or two theoretical difficulties, his paper should nevertheless be published. Despite those remaining problems, the central tenets of the Bohr approach still had merit. Thanks to Bohr's vision of the atom, the fundamental particles of which all matter is composed are now known to exist as both particles and waves. As demonstrated on the engenetics web site [http://www.engenetics.net], and in particular in the experiment conducted with *Brassica rapa*, wave-particle duality also holds for biological populations. All biological populations can be understood in the various ways described above, and as provided by Galileo, Newton, Carnot and Bohr. Biological populations are simultaneously particles in the manner discussed and presented by Galileo and Newton; they are waves in the manner discussed and presented by Huygens and Maxwell; and they are additionally thermodynamic systems in the manner discussed by Carnot, Boltzmann, Clausius, Gibbs and the other great thermodynamicists. That realization is validated by the experimental data gathered and exhibited on the engenetics web site [http://www.engenetics.net], and is at the core of engenetics.

When Maxwell eventually presented his electromagnetic theory, he did so both verbally and in mathematical symbols. The words he chose for his first field equation were "magnetic field cannot diverge from any source" (see inter alia Leon N. Cooper, *Physics: Structure and Meaning (New Edition)*, Brown University, 1992, University Press of New England, pp. 228–237). The mathematical symbolism behind that statement is div **B** = 0. By this, and by his words, Maxwell was expressing the discovery that the "field lines" of magnets—the lines of force that surround them—loop continuously around and upon each other. Magnetic field lines do not 'ray out' in straight lines from selected or random points. They instead emerge from the magnet into the environment; loop around; and then return to a different point on their magnet and source. And as they loop, they exert their given effects on their surroundings.

When the Dutch scientist Jan Baptist van Helmont, 1580–1644, was alive, contemporary biologists erroneously believed that life was spontaneously generated, often from inorganic matter. Van Helmont kindly provided the following as a recipe for generating mice:

> If a dirty undergarment is squeezed into the mouth of a vessel containing wheat, within a few days (say 21), a ferment drained from the garments and transferred by the smell of the grain, encrusts the wheat itself with its own skin and turns it into mice. … And, what is more remarkable, the mice from corn and undergarments are neither weanlings or sucklings nor premature but they jump out fully formed. Translated from the German original by Hanson, Earl D., *Understanding Evolution*; Oxford, 1981, Oxford University Press, pp 319.

The German physiologist Theodor Schwann, 1810–1882, was the first to introduce the term 'cell theory' into biology. He observed yeast spores being formed and correctly concluded that the fermentation process was being undertaken by living organisms. He then also noticed that an egg is a single living cell which gradually develops—by growth and division—into a complete living organism. From this he concluded that all living organisms were constructed of cells, an idea he explained in his *Microscopic Researches Into Accordance in the Structure and Growth of Animals and Plants*, 1839, and elsewhere. The first person to appreciate the importance of Schwann's cell concept was the German statesman, anthropologist and pathologist Rudolf Virchow, 1821–1902. His Cellular Pathology as Based Upon Physiological and Pathological Histology, 1858, applied Schwann's cell theory to a detailed study of the body's pathological processes. He concluded that complex living organisms are communities of cells, with a cell then being the smallest possible unit that can characterize a living thing.

Rudolf Virchow also provided biology with the very important dictum *omnis cellula e cellula* or "all cells come from other cells". That is to say, no biological entity emerges, randomly, from some non-biological point, such as was suggested above by van Helmont. Virchow instead insisted that all biological entities are linked to others through established populations. Biological populations loop continuously through time from progenitors to progeny. They thus overlap each other much as magnetic field lines do. Biological populations overlap in offspring. Virchow contended that all currently existing biological entities have emerged as offspring from breeding adults contained in some biological population existing prior to them … with all future entities then similarly emerging from pre-existing adult and breeding entities. In this way, therefore, all biological populations begin and end on other biological populations. A biological cycle therefore begins on a given point within a population; loops energetically through the environment; and terminates upon a similar but different point within the same population. Given this perspective, then Maxwell's div **B** = 0 gives a ready and easy voice to Virchow's dictum of "all cells come from other cells". As demonstrated on the engenetics web site [http://www.engenetics.net], the given Maxwell equation combines logically with the **constraint or principle of constant propagation** to give engenetics its **first maxim of ecology**. The maxim also declares the existence in biology of a 'destructive interference'—as is characteristic of all waves—that exists jointly, and severally, between the members of a population and their environment:

MAXIM 1: <u>Darwin's theory of competition</u> (A) Any entity that can lift a weight will be prevented from so doing; and/or (B) can be put to use for the same purpose. (C) No entity can lift a weight indefinitely.

Maxwell rendered his second field equation as "electric field diverges from electric charge". In symbols it becomes div $\mathbf{D} = \rho$. By it he meant that the density, or intensity, of the charge found in any given region is a function of the quantity of the charges that that region contains.

By the above first maxim of ecology, the biological entities within a population are subject to loss, which is a decrease in the size of the system—and the exemplar of **destructive interference**. By the **principle or constraint of constant size**, and by the **fourth law of biology**, the lost entities must be replaced so that the population can oscillate around its mean. If this is not so then it will inevitably become extinct. This is therefore a **constructive interference**. The precise values, measures, and interactivity and interoperability of these phenomena is further discussed on the engenetics web site [http://www.engenetics.net]. The reproduction implied and defined by the fourth law of biology tends to increase the size of the system by producing progeny. Since each breeding entity and population has an upper bound to the numbers it can produce, the scale of the increase through reproduction depends upon the number of adults found. James Maxwell's second field equation, his div $\mathbf{D} = \rho$, thus becomes engenetics' second maxim of ecology. The maxim is handmaid to the above first maxim of ecology for it declares the existence of the converse constructive interference between the members of a population, jointly and severally, and their environment:

MAXIM 2: The number of progeny produced depends upon the number of progenitors maintained.

James Maxwell's third declaration, in establishing his electromagnetic theory, was "circulating fields are produced by moving magnetic fields". It was based on an earlier discovery by Michael Faraday. Maxwell represented his epoch-making discovery with his third field equation, curl $\mathbf{E} = -\partial\mathbf{B}/\partial t$. This states that when magnetic field lines oscillate, they can transport an electric field at a rate determined by the strength of that magnetic field.

When we turn to look at biological populations, then reproduction involves the removal of mass and energy from the environment by a group of progenitors. That energy is then circulated back into the population as the progeny that those self-same progenitors then leave behind them. As demonstrated in the experiment with *Brassica rapa* described on the engenetics web site [http://www.engenetics.net], the progenitors use a specified quantity of energy. This represents an energy density, for reproductive purposes, over the population. It is also a constructive interference, and as is again characteristic of waves. The rate at which the progenitors can circulate the mass and energy they remove from the environment back to the progeny they create depends firmly upon the rate at which they can extract that energy from the environment. Maxwell's curl $\mathbf{E} = -\partial\mathbf{B} / \partial t$, thus becomes engenetics' third maxim of ecology—which also formally declares and validates, and in suitable and unarguable mathematical form, Charles Darwin's theory of evolution.

MAXIM 3: [Darwin's theory of competition] The rate at which progeny is produced depends upon the rate at which competition occurs.

James Maxwell verbally rendered his fourth axiom for electromagnetics as "circulating magnetic fields are produced by changing electric fields and by electric currents", and in mathematical symbols as curl $\mathbf{H} = \partial\mathbf{D} / \partial t + \mathbf{j}$. And this was his great discovery. With it he declared that when magnetic fields oscillate, electrical-magnetic effects are created and propagated through the environment at the speed of light. Suitably treated substances can therefore emit electromagnetic waves which can march off into space, as waves, conveniently taking their information along with them.

Maxwell's ideas for an electromagnetic field lead naturally, simply, and directly to the concept of biological activity—or, more formally in engenetics, **bioactivity**. This is formally defined and explained in the experiment with *Brassica rapa* described on the engenetics web site [http://www.engenetics.net]. The analysis there provided demonstrates that there are three, and only three, components to bioactivity. As is again demonstrated on the engenetics web site [http://www.engenetics.net], each of these three aspects of bioactivity is capable of independent measurement and validation.

1. The first aspect of bioactivity is the result of attempts, by the given biological entities, to increase mass. It therefore evidences itself in growth. This mass increase occurs as the entities cleave to themselves ever-increasing quantities of chemical components. They do this by steadily increasing, through the acquired components, the number of chemical bonds that they then have at their disposal. This is their stored chemical potential. That chemical potential can be rigorously measured, and can be given a specified value..
2. The second aspect of bioactivity is formally titled compensatory development. It represents the energy taken on and given off by biological entities as their numbers increase and decrease over the course of a biological cycle. Compensatory development is formally measured for *Brassica rapa*, with its discrete value being given in the data available on the engenetics web site [http://www.engenetics.net].
3. The third aspect of bioactivity is titled essential development. It is formally defined, and a value given, on the engenetics web site [http://www.engenetics.net]. Essential development is an aspect of the bioactivity of all possible—and all conceivable—creatures or entities seeking to be biological. It is present even in those ideal entities that can only be conceived of, and can have no possible existence in reality. As again shown on the engenetics web site [http://www.engenetics.net], essential development provides the very definition of what it means for a given population to be taken as a biological system.

With an understanding of bioactivity now in place, James Maxwell's fourth field equation can be given form as the fourth maxim of ecology:

MAXIM 4: The bioactivity of a biological population is subject to increase from an initial value for one or more of three reasons: (a) increases in mass; (b) decreases in competition. All other increases are due to (c) the essential development of the entity or species.

When these four maxims of ecology are combined with the **three principles or constraints** and the **four laws of biology**, they complete the set of irreducible axioms that establish—and bring a necessary rigour to—the biological sciences, and as is discussed and demonstrated on the engenetics web site [http://www.engenetics.net]. They in particular help to demonstrate the impossibility, even in abstract form, of those theories proposed to explain biological entities but that are centred on the premise of the everlasting and unchanging fixity of species The argument explicating this is available on the engenetics web site [http://www.engenetics.net].