# THE PIG THAT FLEW

The lion, it's often said, is king of the jungle. Being king, is what lions do best. But like many clichés, it's more fiction than fact. The lion population of the Ngorongoro Crater in Tanzania was devastated in 1962 by a plague of biting flies following six months of continuous rain. That year at least, the flies ruled the jungle. Or was it the rain?

To embody the power of a lion, flight of a falcon, eyesight of an owl, jaws of a crocodile, spines of a hedgehog, venom of a cobra, reflexes of a mongoose, echo senses of a bat, cunning of a fox, thought processes of a human …, now that would be an animal to fear, a creature to rule the planet. What could compete? Why doesn't such a monster exist?

There again, the theory of evolution predicts that, if a pig, gifted by chance with the slightest modicum of flight, proves a slightly more successful pig than one without, then in time pigs would develop flight. Well, time there has been. Many species have evolved an ability to fly, to their distinct advantage. So why don't pigs fly?

Where it is a matter of basic engineering, the answer to such questions seems straightforward. Powerful animals are more massive, but massive animals are less agile. The power and ferocity of the lion is no match against the agility of the humble fly. In a niche where this becomes decisive, the king of the jungle is doomed.

On the other hand, strong materials tend to be dense, but dense materials prove prohibitive for flight. The albatross may be

master of the ocean’s storms, but its muscle to wingspan ratio means the creature is becalmed on windless days. The hedgehog’s spines are a match for any predator, but the creature is unable to preen itself and is plagued with fleas from the day it is born. Poisonous animals and plants have fewer predators but pay a higher metabolic overhead to sustain their synthesis of toxins and antitoxins.

In the natural world, it would seem, what makes a species better at one thing, *necessarily* makes it worse at something else. We see at work a cost to benefit reckoning of every characteristic a species might possess to better equip itself for life. The ruthless struggle for survival permits no margin of overspend – if wings cost more than they benefit a pig in its niche, then pigs do not evolve wings. A meticulous balance of accounts is

maintained for which ultimately, each generation must pay with their lives - their only legacy, with luck, being a slightly better adapted offspring. This is Darwin's natural selection, but it can also be viewed as a consequence of the *Conservation of Net Benefit*. Being better at one thing necessarily makes you worse at something else. Of course, if the something else is less significant in your current niche, the net effect is an improved adaptation.

The physical sciences are perhaps more familiar with this sort of constraint. It's a fact of life in physics that increasing something in one area necessarily decreases something in another. Such constraints have come to be known as conservation laws. An increase here, a decrease there, but overall some total quantity of the system remains conserved.

Conservation laws of linear momentum, angular momentum, mass, energy, charge, spin, isotopic spin and parity are known and play a fundamental role throughout physics. In fact, every known law of science is thought to relate ultimately to one conservation law or another.

Conservation laws constitute some of the most carefully tested theories of science. One recent experiment has shown that angular momentum is conserved to within one part in $10^{23}$. Mathematically, conservation laws arise from an underlying symmetry in the equations of motion, which in turn reflects the symmetry of space, time and certain other more abstract quantities. For example, the homogeneity of space results in the conservation of linear momentum, the

isotropy of space in the conservation of angular momentum.

The question arises, are there conservation laws of life, overlaying those of physics? If we were able to formulate the population dynamics for an entire ecology of species, would an underlying symmetry permit the formulation of a conservation law? Of course, the equations for a realistic system would be hideously complex, with no hope of mathematical solution, but it might be possible to discern a symmetry to the equations, and from there deduce a useful conservation law. The conservation of net benefit might be such an instance.

Within a niche, the theory of simple competition predicts that if two species are indistinguishable in all but one competing characteristic, the inevitable outcome is

the displacement of the weaker species, weaker here meaning less well adapted to that particular niche. However, niche conditions are never static, inevitably drifting in time and space, so the winner-loser roles may easily reverse in a neighbouring niche. It is the closeness of fit to a niche that determines a species' survival, not the competition per se.

With simpler life forms, it's a case of them and the environment. Everything external, including predators, is simply the environment. With more sophisticated life forms, individual threats and opportunities within the environment can be distinguished and met by individual responses. Implications of the conservation of net benefit are then more subtle and intriguing, for now an additional and entirely new consideration arises, utterly distinct in character from those

based on the underlying biochemistry and engineering. Game Theory.

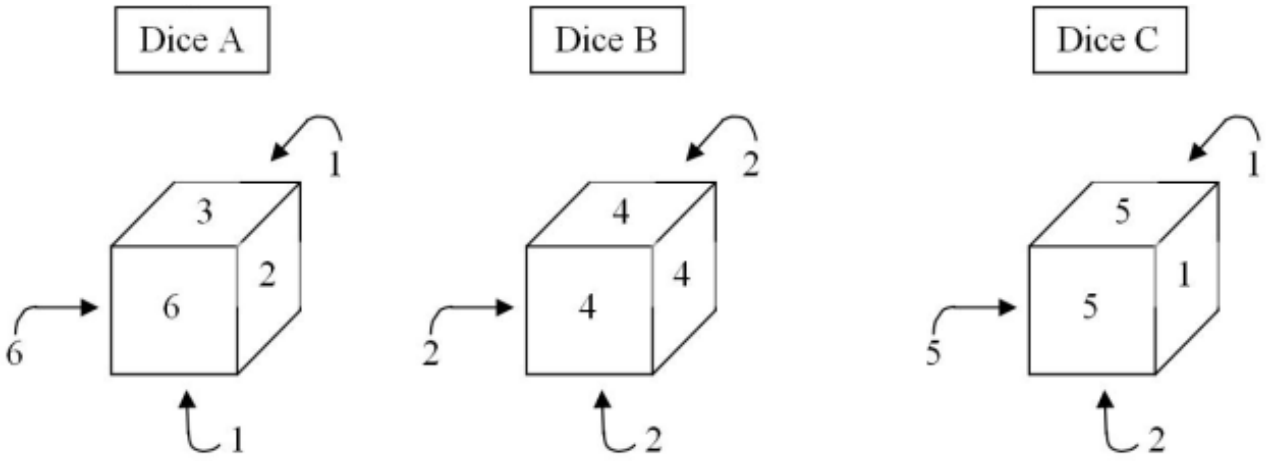
| | Scissors | Paper | Stone |
|---|---|---|---|
| Scissors | | Scissors | Stone |
| Paper | Scissors | | Paper |
| Stone | Stone | Paper | |

Young children enjoy playing the Scissors-Paper-Stone game. Two players simultaneously present hand shapes symbolising scissors, paper or stone. Scissors cut paper, paper wraps stone, but stone blunts scissors, as summarised by the pay-off matrix. Such games, where one player’s gain equates quantitatively to

the other's loss, are known as zero-sum games in game theory.

In this particular game, provided their choices are random, players win as often as each other in the long run. On realising this of course, the game becomes no more interesting than flipping a coin. For all its simplicity though, the game exhibits one of the more unintuitive aspects of game theory, namely, there is no *best* choice, each is better than one and worse than the other. The following game with three dice is similar but more statistical, and potentially more profitable. A, B, C are fair dice but

The following game with three dice is similar but more statistical, and potentially more profitable. A, B, C are fair dice but with non-standard labelling. A pair straightforward to check that, in the long




run, A loses to B, B loses to C, but C loses to A. Once again there is no *best* choice. Which dice does best depends on its opponent, that is, the environment in which it finds itself. In fact, there is no *best* distribution (for a given total score). For any given any distribution, one can always find another that beats it on average.

| | A | B | C |
|---|---|---|---|
| A | | B | A |
| B | B | | C |
| C | A | C | |

Evidence of game theory at work in the animal and plant kingdoms abounds in

nature. Many animal species resort to games of bluff and bluster in hierarchical disputes, rather than risk significant injury or death. Hunter and hunted have each evolved tactics and counter-tactics to maximise their chance of survival. Whether or not such games are played consciously is irrelevant. The ruthless struggle for survival simply ensures those with the better game plan survive longer than those without.

But other, more subtle games, are also observed. On the rocky bluffs of the Californian coastline lives a species of lizard, *Uta stansburiana*. Over time, three distinguishable subspecies have evolved, each with their own distinctive colouring and mating strategies, but all capable of interbreeding. Let's call them A, B, C after the character of the male's mating habits – Attached, Bully and Crafty.

| | A | B | C |
|---|---|---|---|
| A | | B | A |
| B | B | | C |
| C | A | C | |

Mr Attached mates with a single female and guards her diligently from the attentions of all other males. But with just one female, Mr Attached loses out to Mr Bully in the mating game, who aggressively defends an entire territory of females. But Mr Bully loses out to Mr Crafty, who, with neither territory nor females to patrol, is free to sneak in when Mr Bully is otherwise occupied. Mr Crafty however, loses out to the ever vigilant Mr Attached. Each strategy is superior to one and inferior to another. There is no best strategy and each male population persists as a stable sub-niche over many generations.

In nature, zero-sum games could well be called zero-slack games, someone's gain

equates exactly to someone else's loss. They characterise established environments in which all slack has long since been taken up, all the available niches filled. Zero-sum games are inevitable in highly competitive environments and result in rate-limiting constraints on the population growth of each species. If there ever was, in nature, there's no such thing as a free lunch now.

If *best* proves a slippery notion in game theory, *perfect* can prove an outright weakness, both in game theory and the real world. Perfect knowledge and decision making cause chaotic instability on the world's financial markets, everybody choosing to buy the same stock at the same time, only to be followed by everybody trying to sell the same stock at the same time, precipitating the disastrous boom and bust of stock market

crashes. Perfect resonance with niche conditions similarly causes the familiar boom and bust in population explosions associated with insect plagues and bacterial epidemics.

As with truth, it seems perfection in nature, is rarely pure and never simple. Take the human heart. With a product specification calling for a billion pump cycles before failure, one might be forgiven for supposing a perfectly regular periodic pumping cycle would be the preferred choice. Nature thinks otherwise. The human heartbeat is amazingly chaotic and disordered in healthy individuals. It seems too perfectly a regimented pumping cycle induces the cardiac equivalent of metal fatigue in turbine engines and repetitive strain injury in keyboard workers. The most successful species have evolved electrical control

systems which force the heart to beat chaotically, spreading the long term strain over the entire organ. The metronomic beep-beep-beep of hospital soap operas is alas, yet another fiction. Ironically, the diseased heart beats far more regularly before it fails.

The natural world is one thing, but when it comes to the human species we like to think there must be more to our success than a brutal struggle for survival and some selfish tactics from game theory. After all, we live together in large complex societies, we conform to common laws, morals and a sense of justice. We share valuable resources and skills. We care for each other. Surely, as a species, we are a little above the rest of Nature, red in tooth and claw.

The bible tells the story of a rich man who, embarking on a long journey, entrusts three servants with some money. Two of the servants double their money while the master is away, but the third, fearful of the risk, buries it for safe keeping. On his return, the master scorns this servant, confiscates the money and turns him out of the house, to the gnashing of teeth. The other two are rewarded with praise and more money.

We might be a little cautious here of reading too much into this story, written as it was, long ago, in a far off culture and perhaps never intended for the global economy thousands of years later (although the BBC's *The Apprentice* would have us believe some things never change). But without considerable interpretation, simplistic moralising does not work in modern society. Today's

entrepreneur borrows heavily from many small savers in the hope of making substantially more money than must be repaid. But an entire world of entrepreneurs is no more viable than an entire world of savers, a dynamic balance between the two being the only viable long term solution. The frightened servant who buried his money is no less useful a member of society than anyone else, behaving in fact, as the wisest and strongest nations of the world, who bury vast gold reserves in secure vaults. In times of crisis, cash is king and promises evaporate with the morning mist.

Whatever its philosophical status, the theory of evolution is accepted without question in the one human arena to which we all pay homage – money. Everybody knows what SWOT means at school, but in the beginners guide to staying alive in

business it stands for strengths, weaknesses, opportunities and threats. Objectively assess your current strengths and weaknesses and be aware of imminent opportunities and threats, so that when the time comes you have a plan of action and can adapt. Niche market, natural selection, opportunistic, synergistic coexistence, predator-prey, hostile acquisition, survival of the fittest, adapt and survive, your problem is my opportunity, tipping point, break-even point, cost-benefit ratio, pay-off matrix ... It's not called Darwinism in business studies but perhaps it should be.

Striving to do better is another very human trait and one that's served us well in the past. In a highly interdependent society, *better* inevitably comes to mean relative to others – best of the best, the Olympic ideal, *Citius, altius, fortius*, etc.

Unfortunately, in zero-sum games, better at one thing necessitates being worse at something else. A higher score on one side of the dice means a lower score on another. A strength here means a weakness there. As human beings, we have immense difficulty accepting negative terms in the equation of life. The human ego is a delicate flower and while we may be ready to acknowledge such constraints in the natural world, we reject the possibility they might necessarily apply to ourselves. We each believe if we're smart enough and arrange things just right, we can take the upside without the downside.

Fortunately, humans are considerably more objective when it comes to perceiving weakness in other human beings, especially the fictional variety. Perhaps for this reason we turn to

literature for such awkward lessons in life. Here, the cup runs over with proverbial accounts of the tall dark handsome stranger who has it all, only to discover, too late, a fatal flaw. Every hero and anti-hero of literature has their weakness. Achilles, of course, but Superman was cursed with Kryptonite, Poirot was vain, Sherlock Holmes was addicted to opium, women baffled Smiley while his arch enemy Karla was an uncompromising fanatic. Even the all-powerful and ruthless Gollum had one weakness for which he paid the ultimate price. What seems a substantial benefit in one niche can prove a deadly cost in another.

Ancient compilations such as *Aesop's Fables* and the *Bible* overflow with entertaining instances of the conservation of net benefit. A key to their educational value exploits our ability to perceive

weakness readily in others, but having once recognised it perhaps, to re-examine ourselves more closely. More recent psychological studies such as *Games People Play* and the computer simulations of John Maynard Smith have tried to explain the enormous degree of game theoretic tactics at work in human interactions.

We don’t hear our own voice or see our movements, yet only other people are perceived as having grating accents, quirky mannerisms and dubious preconceptions. Blinded by our own radiant ego, we nonetheless are ready to acknowledge the conservation of net benefit as a limiting constraint for everyone else. Nobody expects the best boxer to be a famous gynaecologist, the best chess player to be a champion weight lifter, the best manager to be the

finest craftsman, or vice-versa. We don't expect the best administrator to make the most tenacious researcher, or the best entrepreneur to survive the mind-numbing drudgery of life on the production line, which also is a life skill, indispensable to modern society.

We readily accept the beguiling salesperson makes a hopeless high court judge, the wily politician an unreliable ally, the prima donna a lousy team player. Great list makers are generally poor closers, great speakers poor implementers, great filers poor innovators. The more methodical, generally the less inventive. As a society we grudgingly accept today's yob can be tomorrow's hero, today's nerd, tomorrow's Nobel Prize for medicine.

Erdős and Poincaré were prolific mathematicians, but Erdős was incapable of organising his own Corn Flakes while Poincaré was so inept at drawing as to be turned down for university. Churchill was an inspirational war-time leader but suffered chronic depression and alcohol abuse. Fleming was an untidy and sloppy researcher, but had the curiosity to recognise and pursue a freak mistake. Turing was a brilliant mathematician and code breaker but socially fragile and naïve, eventually taking his own life. Van Gogh was master of vibrant and joyous colour but helpless in his spiral of depression and suicide. The gift of genius in one direction can exact a dreadful cost in another.

The conservation of net benefit also works in reverse. Why is it, after hundreds of thousands of generations, a large

proportion of the human race suffers from poor eyesight? Surely defective eyesight is an unequivocal disadvantage, even in today's technological age. The conservation of net benefit predicts this defect can only persist if the cost of poor eyesight comes with a concomitant benefit. Better insight perhaps?

Of course, the skilful juxtaposition of strengths and weaknesses of individuals within a group is the bread and butter of team managers, officers of armed forces, captains of industry and political leaders, but similar calculations are at work even in personal relationships. What contribution can someone who is merely a clone of oneself, with identical strengths and weaknesses, bring to a union?

As a society, we tend to accept the need for physical diversity much more readily

than mental diversity, but here some interesting parallels in computer technology are instructive. Computer memories come in three main types. There is the fast, expensive, short-term, foreground type of memory known as chip memory. Then there is the slow, cheap, long-term, background disk based memory. And then there's firmware, the memory used when, having piloted a task in foreground memory, we need to store the perfected program long-term and allow it to run more or less unsupervised in the background, such as learning to walk, drive a car, or fly a plane.

Analogous specialisms are observed in human society. Some people are good at recalling the vast amounts of vocabulary required to speak fluently many different languages, others in weaving ideas and observations together to form theories, as

in the sciences. Yet others excel at perfecting a sequence of computational tasks requiring rapid mental and physical coordination, as in music and sport. Just as computers are optimised for different tasks by combining different proportions of the basic types of memory, so it seems reasonable that people with different proportions of each type of natural memory will exhibit varying aptitudes for different mental tasks. A ten second attention span is useless for tasks requiring ten hours to assimilate. A ten hour attention span is pointless for tasks requiring a ten second turnaround.

Ultimately, it takes all sorts. To remain stable and flourish, human society demands a diversity of talents but also a tolerance to such diversity. The actual degree of tolerance at any particular epoch appears to be a sensitive and

critical function of the time. Generally, we observe a slow gradual increase in tolerance over the centuries, but sometimes, unpredictably, a catastrophic decrease. Diversity may benefit society as a whole, but it seems too much diversity too quickly, can lead to instability.

By living together in large communities of genetically distinct individuals, human

beings have stumbled across a game theoretic fast-track to species success, enabling communities to evolve thousands of times faster than their human constituents - a genetic feat equivalent to a pig that flies. While this has proved highly successful for human societies to date, its individuals retain virtually the same genetic makeup as their predecessors thousands of generations earlier, with the same instincts and phobias to match. The march to ever greater social diversity levies an ever greater demand for tolerance, a tolerance which is not of our genetic nature but must be nurtured afresh with each generation.

The long term outcome of this unique experiment in the animal world, a game begun by nature with a freak roll of the genetic dice, is far from obvious. The present day *zero tolerance* evangelised by

some political and religious authorities, whether it be the continued indifference to the plight of the less fortunate or intolerance to cultural diversity, represents a serious threat to the long term survival of humanity.

For the first time in the history of life on this planet, a species has evolved with some insight and responsibility for its own kind, for other species and the environment. The natural world knows only one game, blind chance, brutal but effective. Nature will march on dispassionately if we fail as a species, just another interesting experiment which didn’t quite work out. Einstein died believing God does not play dice with the physical workings of the universe, but it seems Mother Nature has a certain flair for the game.