Good economics

Biodiversity turns out to be nature's strategy to optimise, says s ananthanarayanan

THE living together of many species has been seen as nature's safety net for the survival of them all. Bradley J Cardinale, at the University of Michigan, confirms in a paper in *Nature* that biodiversity is also the way for the different species to make the most of the environment.

Charles Darwin is known for the theory of evolution of the species through the mechanism of *natural selection*. Members of a species, through random, chance variations in genetic make-up, sometimes find themselves better suited to survive. This helps them corner resources and mates so that their number increases and soon the whole population is made up of individuals with the better suited evolutionary feature. The bulk of genetic variations, which confer no survival advantage, continue only for a few generations in the line of the chance individuals, and variations that lead to disadvantages to survival are quickly "selected out".

The principle of natural selection thus explained the specialisation of a species, or a narrowing of diversity. But how the great variety of species and sub-species that is observed in nature, which apparently arises from the same ancestors, is not as easily understood. Darwin, in fact, had examined equally this question thus, "… the tendency in organic beings descended from the same stock to diverge in character as they become modified…" And he developed a complete explanation, the *principle of divergence*, or the appearance of differences in populations that were originally similar, by the action of the slightly different direction of natural selection in various parts of a species' range.

Some such chance variations within the newly evolving strain survive and fix their individual traits by fitting into peculiar "niches" in the environment, ensuring, ironically, a better use of resources by being different rather than the selection to fit best into the surroundings by being alike! As Darwin put it in the celebrated *Origin of the Species*, "… the more diversified the descendants from any one species become in structure, constitution and habits, by so much will they be better enabled to seize on many and widely diversified places in the polity of nature, and so be enabled to increase in numbers".

That this was going on in hundreds of species the world over was actually deduced by Darwin by applying formal statistical methods to analyse vast data that he collected and his earlier writings contain detailed discussions. But in the *Origin of the Species*, the specific question of *diversity of species* has lost focus and has not been discussed except in mention as a result of the same tendency of natural selection.

Uses of biodiversity

With the complexity of life itself, the chemical processes that arise in nature are incredibly diverse. Hidden in the great variety are plant forms that create some complex molecules of medicinal or industrial value and which cannot be synthesised by man using available methods. While the growing field of nanotechnology is trying to harness natural processes to carry out syntheses and atomic manipulations that are otherwise beyond reach, nature has, over millennia, developed a range of these, as represented by biodiversity in the plant and animal kingdom.

An important role that natural organisms play is the fixation of nitrogen from the air and its transition into organic matter. This is the way the nitrogen-rich nutrients of soil, which are depleted by vegetation, are restored, by drawing the nitrogen out of the atmosphere. But in recent times, with the pressures to increase farm production to feed growing populations, man-made nitrogen fixation has overtaken nature and fields and waterways are engulfed with nitrogenous fertilisers. Eventually, this will land up in fresh water sources and coastal environments, with an adverse impact on health and productivity.

Fortunately, the rise in such nitrogen poisoning has been kept in check by biological organisms in water sources, in the form of algae that maintain clean water by extracting and storing nitrogen. It is in this context that Bradley J Cardinale of Michigan took up the question of diversity in the species of algae and their efficiency in mopping up nitrogen.

A stream rich in different kinds of algae ~ such as the one shown above ~ can better filter out harmful nutrient pollutants like nitrates from fertiliser runoff. Bradley J Cardinale (left) of the University of Michigan has determined how algal biodiversity protects against such pollution.

Cardinale's work

It is a consequence of Darwin's *Principle of Divergence* that a fall in the number of species in an ecosystem would affect the way the system works. According to the principle, adaptation to different "niches" in the environment leads to evolution of communities of complementary species, an ecological "division of labour" — an analogy of economic division of labour that the legendary Adam Smith had noted – to increase overall resource capture and productivity.

Reduction in species, naturally, would leave ecological niches underused and bring down the rate of exploitation as well as upset the balance of the rate of depletion and restoration of different resources.

Research over the past two decades has shown that the principle is quite true, especially of ecosystems with more species being more adept at removing nutrients from soil and water. The sequel, naturally, is that conserving biodiversity is a useful tool for managing nutrient contamination in water bodies. But the suggestion has not been universally accepted, largely because the specific mechanisms by which species diversity influences nutrient uptake have not been identified. Cardinale's work, where he observes controlled communities of algae in different conditions, is further, and formal, evidence of what diversity loss does to the functioning of ecosystems.

Cardinale isolated eight of the most widespread species of diatoms and algae that inhabit streams in North America. Specially set up, recirculating stream channels were then populated with the species, in first equal and then varying densites of one, two, four and six of eight species. Next, the niches presented by the environment were manipulated by mimicking two forms of typical heterogeneity by arranging the stream bed to allow for varying flow velocities and, hence, varying algal growth surfaces to create environmental opportunities for species to coexist.

In addition to spatial heterogeneity in flow was temporal variation – by dividing the growth areas in the stream into 18 habitat patches and disturbing the patches by removal with a brush, randomly, once a week. This action created a mosaic of patches of algae of different ages, with diversity from five to 50 days during the course of the experiment. The trade-offs between the ability of species to colonise the available space versus their ability to compete with other species led to different species dominating at different stages of growth and periodic disturbances.

The results of the study were uniformly that the rate of nitrogen uptake was directly proportionate to the degree of species diversity. The most diverse polyculture sequestered nitrogen 4.5 times faster than a lone species. Diversity did not affect the rate of nitrogen uptake by unit weight of the biomass, as this depends on chlorophyl. But it did affect the total algal biomass itself – thanks to different species maximising growth possibilities.

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Healing touch

tapan kumar maitra explains the practical importance of immunity reactions

SERA are injected in definite doses intramuscularly, subcutaneously — sometimes intravenously — with strict observation of all the rules of asepsis. A preliminary desensitisation, according to Bezredka's method, is necessary.

Sera are employed for treatment and for prophylaxis of tetanus, gas gangrene and botulism. The earlier the serum is injected, the more marked is its therapeutic and prophylactic action. The length of protective action of sera (passive immunity) is eight to 14 days.

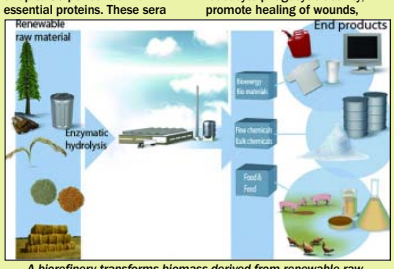
At present many institutes of vaccines and sera in Russia produce purified therapeutic and prophylactic stuff. They are treated by precipitating globulins with ammonium sulphate and fractionation, by the method of ultracentrifugation, electrophoresis and enzymatic hydrolysis that allow the removal of up to 80 per cent of non-essential proteins. These sera have the best therapeutic and prophylactic properties, contain the least amount of unrequired proteins, and have a less distinct toxic and allergic action.

Sera thus produced are subdivided into anti-toxic and anti-microbial sera. Anti-toxic sera include anti-diphtheritic, anti-tetanic sera and those effective against botulism, anaerobic infections and snake bite.

Anti-microbial sera are used against anthrax, encephalitis and influenza in the form of globulins and gamma globulins.

The latter are used for prophylactic purposes against measles, poliomyelitis, whooping cough, virus hepatitis and smallpox. Gamma globulin is used together with vaccine against rabies. They are completely harmless preparations and do not contain the virus of Hepatitis B or causative agents of other diseases.

Specific gamma globulins with a directed effect have been recently produced. These are obtained from donors immunised against the given infection. Such globulins contain a higher titre of anti-bodies. The Cytotoxic anti-reticular serum, as suggested by A Bogomolets, is now used with a favourable therapeutic effect to stimulate the functions of organs; intensify immunogenesis and leucocyte phagocytic activity; promote healing of wounds, ulcers and fractures; increase resistance to malignant growth; and promote restoration of the leucocyte count in leucopenia caused by irradiation. It is also used in cases with diminished reactivity and resistance due to inhibited activity of the connective tissue system.



A biorefinery transforms biomass derived from renewable raw materials into a wide range of commodities by means of advanced biotechnological processes like enzymatic hydrolysis.

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The day the earth stood still

Exactly 50 years ago, Yuri Gagarin became the first man in space. His journey to the heavens, says rupert cornwell**, was a pinnacle of human achievement, the defining triumph of the Soviet Union**

NOT everyone is Yuri Alekseyevich Gagarin, the most perfect specimen imaginable of *Homo Sovieticus* who, on a summer's day 50 years ago, found himself at Buckingham Palace, feted as the most famous man in the world. Seen from this age of al-Qaeda and the Internet, the lumbering confrontation known as the Cold War is almost as distant as antiquity. Remember all those spy scandals, so quaint in the telling now? Did the West believe the Russians were on a supremacy spree, that the East-West conflict might bring about nuclear obliteration? Indeed, it was so. And that is one reason why even today Yuri Gagarin is so remarkable a figure.

By contemporary standards, what he achieved on 12 April 1961 is small beer. His spacecraft, Vostok I (or East I) made just a single orbit of earth lasting 108 minutes, 200 miles up. The vehicle was so basic that it has been likened to a tin can placed on top of a bomb. As was their wont, the Soviets gave some false information about the flight, which was only announced after its completion. Vostok I, they said, had landed safely with Gagarin aboard. In fact, he ejected from the module and made the last 23,000 feet of his journey back to earth by parachute.

The first people to set eyes on him were not trained recovery specialists, but a peasant woman and her granddaughter, working in the fields near the Volga river, 450 miles southeast of Moscow. The pair were terrified by this apparition from the heavens – not unreasonably, given that U-2 pilot Francis Gary Powers had been shot down over the Soviet Union less than 12 months before. Only when the intruder in a spacesuit assured them he was one of their own, not a dark messenger of US imperialism, were they reassured.

But in that tin can (or, more exactly, a spherical module with a diameter of 2.3 metres) Gagarin had done what no man had done before. He had become the first human to enter space and for a while he redrew the very contours of the Cold War, as well. If there was ever a time when the Soviet Union seemed a somewhat less-than-evil empire, it was during the months around Gagarin's flight. The Khrushchev thaw, that in some respects prefigured Mikhail Gorbachov's perestroika, was in full swing. Yes, a charismatic young President had just taken office in Washington, but just four days after Gagarin's feat, John Fitzgerald Kennedy launched the disastrous Bay of Pigs operation against Cuba, proving that aggression and bullying were not Moscow's exclusive preserve.

And then there was Gagarin himself. If anyone could sell the virtues of Communism to a sceptical world, he could. His was the last and greatest of a series of Soviet space triumphs, starting with the launch of the first satellite, Sputnik, in 1957. Two years later, Soviet spacecraft had made the first hard landing on the moon and took the first photos of its hitherto unknown dark side. But with Gagarin, a stunning technological breakthrough had a human face. Russia now had its own Magellan, the Wright brother or Lindbergh. But he travelled where even these pioneers had not: beyond the confines of the planet. And by common consent, it couldn't have happened to a nicer guy. "A delightful fellow," was the verdict of Harold MacMillan, after meeting Gagarin the day before the luncheon at Buckingham Palace.

From the moment the pilot entered the Soviet space programme in early 1960, it is clear that those most directly involved with his career felt the same. He was quick, shrewd and intelligent and never frightened of responsibility. Polite but firm, he had a rare knack of pleasing his superiors without alienating his peers. He also had a sense of humour. As the field of candidates was whittled down, from the 20 initially selected to six, then two, and finally to the one chosen for the flight, everyone seemed to accept that it would be Gagarin.

Yuri Gagarin in his space helmet in 1961.

On reason, it must be said, was because he was short. We imagine our heroes tall and strapping. At only five feet and two inches tall, Gagarin was almost exactly the height of chairman Nikita Khrushchev (as may be seen from film of the two bear-hugging when they met at Moscow airport). Perhaps most importantly, Gagarin was brave. He handled pressure with an ease approaching grace. Later, he himself would recount how the doctors who monitored him were "amazed by my coolness and calmness, the stability of my psyche and the strength of my nerves".

In those days it took a brave man indeed to contemplate going into space. The training was brutal, prospective cosmonauts were subjected to centrifuges, extreme heat and isolation. No one knew how a human would react to weightlessness: would he be paralysed? Would he go mad. For that reason, Gagarin himself did next to nothing during the flight, which was entirely automatic and controlled from the ground: the scientists simply had no idea whether a pilot could function at all.

Only just before blast-off was he given the three-digit code (it was 1-2-5) to unlock the craft's controls in case of emergency. Gagarin being Gagarin, though, he had already wheedled the number out of one of his instructors. The whole thing was incredibly dangerous. Many missions had failed. Less than six months before Gagarin's flight, a giant R-16 rocket exploded at the test site of Tyura Tam on the Khazakh steppe. Some 120 people died, including Marshal Mitrofan Nedelin, then head of Soviet Rocket Forces – who, like Gagarin, is buried in the Kremlin Wall, the final resting place of the greatest Soviet heroes. The odds were 50/50 at best that Gagarin's flight would be successful.

But he was completely unfazed. On the night before the flight, Gagarin slept like a baby. When he was woken at 5.30 am his pulse rate was reportedly a relaxed 64. As he prepared to board the ship, he saw his mentor, Sergei Korolev, the engineer-designer; the true father of the Soviet space programme, who had clearly had a terrible night. "Don't worry, Sergei Pavlovich," he told the chief designer, "everything will be fine." Korolev loved Gagarin like a son, but was astounded nonetheless: the man who was risking his life was acting as comforter of others as well. "Poyekhali," the cosmonaut said, "let's go."

In the event, it all went smoothly. The spacecraft entered orbit and the booster rocket separated as scheduled. "There was a good view of the earth, which had a very distinct and pretty blue halo," Gagarin noted laconically in his official report on the flight three days later. Nor was weightlessness a great problem – "To some extent unusual, but I soon adapted myself," he wrote. Throughout, he was in communication with Flight Control by radio phone. As soon as he landed safely, Khrushchev was informed. The Soviet leader was exultant. He couldn't resist using the flight as proof of Marxist atheism. "Gagarin flew into space but didn't see any God there." Most of all, it was proof for Khrushchev that his country had arrived; definitive refutation of the "arrogant theoreticians" who sneered at "once-illiterate, barbaric Russia". And that, in varying degrees, was how the world felt.

America, in particular, was shocked at how, after Sputnik, its superpower rival had once again left it second best. One Congressman even demanded the USA go on a war footing – if the Russian enemy could do that, what else could he do?

Three weeks later, on 5 May 1961, Alan Shepard became the first American in space. But there was no hiding the fact that the first Mercury mission was a shadow of Gagarin's feat; a suborbital flight that merely followed a ballistic missile's trajectory, travelling 300 miles and lasting 15 minutes. Only 10 months later did John Glenn orbit earth. By then a chastened Kennedy had vowed to put a man on the moon by the end of the decade – and, even more important, put America back on top.

For the time being, though, it was the Soviet Union's hour and in Gagarin they had an unmatchable advertisement for the system. He was no semi-senile *apparatchik* or sinister *agent provocateur*. Gagarin was young, vigorous and handsome; a peasant's son who had made good; a genuine working class hero who was virtually impossible to dislike. Just as he charmed Macmillan, he charmed everyone else he met as he visited other countries, most notably Britain, where he made a trip to Manchester that is fondly remembered to this day. For obvious reasons he was not invited to America. Never again would the Soviet Union's global reputation stand as high. Gagarin's successful flight and the Bay of Pigs debacle had made Khrushchev over-confident. The June 1961 summit with Kennedy in Vienna convinced him he had the untried young President's measure. Two months later the Berlin Wall went up and the following year Khrushchev disastrously over-reached himself, provoking the Cuban missile crisis, in which Kennedy called his bluff and which set in motion the internal revolt that would lead to the Kremlin leader's downfall.

The Soviet Union had reverted to type. Hopes of deeper reform faded and in October 1964 Khrushchev was toppled in a palace coup, ushering in what Gorbachov would later call a "time of stagnation". By then Gagarin was a deputy to the Supreme Soviet, confined mainly to safe desk work – he was a hero the country could not afford to lose. Eventually, though, he was permitted to fly again as a fighter pilot and was killed during a training flight on 27 March 1968, when his MiG-15 crashed in circumstances to this day never fully explained. Once again the authorities threw a veil of secrecy over the event. Almost certainly the crash was an accident caused by bad weather, a mistake by an air traffic controller or evasive action to avoid another aircraft.

But in the absence of fact, the rumours flew. Gagarin was drunk, some said. Others speculated he had become a critic of the regime, which had got rid of him. Five months after his death, the Soviet Union invaded Czechoslovakia to suppress the Prague Spring – and banished any remaining illusion, kindled largely by Gagarin, that Communism could reinvigorate itself from within.

The miracle of humans in space that he pioneered has lost its sparkle, as well. Space travel has become mundane and repetitive; only when disaster strikes does it make headlines. True, the International Space Station still goes about its business, in partial fulfilment of the vision Gagarin spoke of at the Metro Vickers factory in Manchester 50 years ago, "when a Soviet spaceship landing on the moon will disembark a party of scientists, who will join British and American scientists working in observatories in the spirit of peaceful cooperation".

But forget the moon. Between 1969 and 1972, 12 Americans walked on its surface, as President Kennedy's challenge was met. When – indeed, if – another human will do so is anyone's guess. Last year, for budgetary reasons, President Barack Obama killed off his predecessor's plan for a permanent, manned base on the moon, to serve as launch pad for human missions to Mars and beyond. On 28 June 2011 there will be the very last launch of the US shuttle, leaving Russia's single-use Soyuz craft as the only means of getting to the ISS. The ideological rivalry of the Cold War has given way to financial calculation. Why go on with the costly and aged shuttle programme, US government bean-counters argue, when Soyuz can take the National Aeronautics and Space Administration's astronauts to the station, at only $ 63million per ride?

But even the Russian manned space programme is marking time. These days unmanned robotic missions are visiting the planets of the solar system and their pictures are breathtaking, the scientific boons they confer doubtless considerable. But the drama of the Gagarin era is gone. Alas, peaceful cooperation is less stimulating than pioneering competition, when a pilot lieutenant from behind the Iron Curtain caught the imagination of the entire world. Such is human nature.

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