Colour coding in evolution

s ananthanarayan reports on how genetic bases for siblings to ensure they are not treated alike has fallen to research

SPECIES sometimes go to great lengths to look like one another so as to deceive predators, which caused Duke University graduate student Robin Hopkins to work on a contrary feature — instances of the same plant species making arrangement to look different so that butterflies think they are not the same plant and they breed separately. Hopkins has only just finished defending her doctoral thesis and her paper, written with Duke University professor Mark Rausher, has appeared in the journal *Nature*.

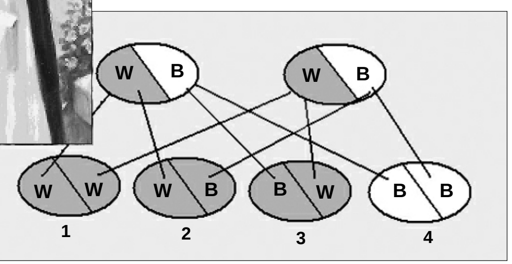
When some individuals of a species happen to resemble similar looking species, which is distasteful to or feared by predators, these "imposter" individuals borrow protection and enjoy a survival advantage. The genetic feature that causes this resemblance is then selected and stabilises. This form of mimicry, which is called Batesian mimicry after its discoverer, Henry Walter Bates, is seen in several butterflies and reptiles and is the most common form. Another form is Müllerian mimicry, where species that have their own individual means of protection still converge, although partly, for mutual benefit. Yet another form is where a harmful species disguises itself as a harmless one, both to avoid conflict as well as to sneak up on unsuspecting prey.

These are all instances of different species trying to look alike, the converse of Robin Hopkins' work, which is on individuals of the same species trying to look different from their brothers and sisters so that they can breed and, hence, evolve along a different direction, to grow as a different species.

Speciation

Growth of new species from a parent species is nature's method of adapting to changing environment and distributing the demands on the environment, so that the species could be sustained. Every act of reproduction usually creates some genetic chance peculiarity. But in the large majority of instances, the distinction is of no consequence and it gets lost in interbreeding. Occasionally, the difference is of material advantage to survival or procreation and then the difference would persist and continue, through natural selection. Such growth of new species adds to biodiversity and ensures the dynamic balance that maintains vast networks of species even as natural conditions vary and change.

Gregor Mendel



When W is dominant, it will dominate in the first three offspring. The recessive, B, will appear only in the fourth case, where both genes are the recessive one.

Robin Hopkins

But there are conditions to be satisfied if a new species is actually to arise. A case where only the individuals with the new feature survive is really not the addition of a new species. But if both kinds continue, there would need to be some separation so that both kinds do not interbreed and the genetic streams diverge. For instance, one kind may forage on a different nutrient or may be physically separated. Sometimes, the parts of a species that are divided by a barrier, like a mountain range or a stretch of water, go on to evolve into separate species because of the physical "gene isolation".

There has been ample work on the genetic bases of such speciation, which arises from a physical restraint of gene flow. But hardly any work has been done on the mechanism, called *reinforcement*, of natural selection directly preventing crossbreeding of the two strains of the species in the same habitat. As the two strains have arisen for some survival benefit, lack of reinforcement would lead to the distinction being lost or the creation of unviable hybrids, both of which are a cost to the community.

In animals and insects, the mutant stream may display small but perceptible differences in odour, colours or behaviour, which could regulate mating and gene exchange. But this mechanism cannot work in the case of plants, which reproduce through pollination by external agencies.

The ornamental phlox

The *Annual Phlox*, a decorative flowering plant native to Texas but now cultivated in many places, exists as two streams, *phlox drummondii* and *phlox cuspidate*. When grown separately, both varieties thrive with flowers of a light periwinkle blue. But if grown together, and there is cross-breeding, the offspring have flowers of intermediate colour, but in nearly in all the cases the plants are sterile. The generation that arises from cross-breeding is, thus, a dead end!

Phlox drummondii, when grown with *cuspidate*, then adopts an ingenious device to avoid pollination, and gene transfer, across species – it develops flowers that are red in colour! As individual butterflies that visit these flowers appear to have a preference for either blue or red flowers, cross-pollination actually occurs only between similar coloured flowers and the strains stay separate. As hybrids are usually sterile, there is powerful natural selection to maintain the colour difference in *p. drummondii* when it breeds along with *p. cuspidate*.

This remarkable mechanism of "colour-coded pollination" has been known for some time, but the genetic basis for the difference in colours of flowers was not understood. In the course of collecting data in her work, Hopkins noticed that the intermediate colours of hybrid flowers were distributed according to a clear pattern that corresponded to the ratios discovered some 150 years ago by Gregor Mendel in his experiments with pea plants.

Hopkins carried out greenhouse experiments by interbreeding the two varieties of phlox and found that the hybrids formed with flowers of four specific intermediate colours – dark blue, light blue, dark red and light red – exactly in the ratio of 9:3:3:1.

This is the established ratio when a feature is controlled by a pair of genes, with one being dominant and the other recessive. The dominant gene then appears in three out of four cases, while the recessive one appears in one case. Thus in cross-breeding, genes in the offspring would be distributed as: *3x3=9, 3x1=3, 1x3=3 and 1x1=1*.

With this clue of what to look for, standard genetic methods could lead to the exact genes that were responsible – the change to red is caused by two genes, one recessive and the other dominant, which knock out the plant's production of one blue pigment but allow the two red pigments to continue. The result is an important advance in the mechanism of evolution and maintenance of biodiversity.

"It was two in the morning when I figured this out," Hopkins said. "I almost woke up my adviser."

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What kills also creates

The idea of a single meteor strike causing mass extinction has taken a long time to find acceptance, but now, says ted nield, we should see the bigger picture

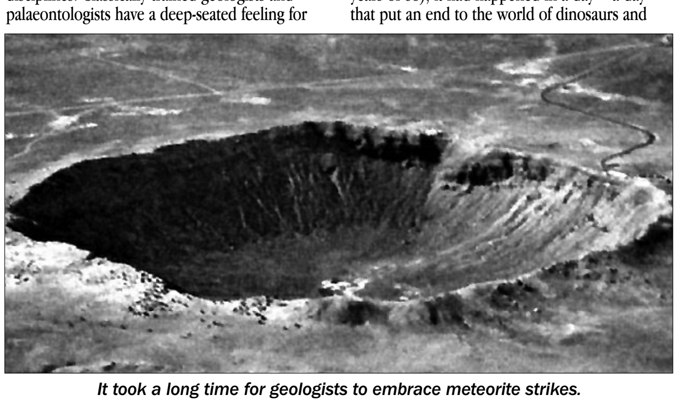
LIFE on earth has suffered five mass extinctions, each leaving an indelible mark, since the emergence of complex life just over half a billion years ago. They were all what geologists call "sudden" Something must have caused them – but what? Did each have a single cause? Did they have different causes? Did each have many causes? Could any single factor be enough to extinguish 90 per cent of all living things? These questions are important, because asking the wrong one – or failing to examine one's implicit preconceptions – is a frequent trap for the unwary scientist, especially when that scientist is operating beyond his/her original discipline, and even the unwary bystander.

When meteorites fall from the sky, witnesses are drawn, like readers scanning the news, to search for meaning. What does this event mean for me? The answer depends, for the most part, upon context – life experiences, intellectual baggage, expectations. Alsatian peasants, seeing a meteorite fall in 1492 near the town of Ensisheim, saw disaster. The Emperor Maximilian, passing nearby, foresaw victory. Oddly, both were right – Maximilian defeated the French, but the peasants of the Rhineland had to endure wave upon wave of war for decades. And academics? They didn't believe any of it. Until the last years of the 18th century, learned men deferred to Aristotle and Newton – neither of whom allowed any grit into the celestial clockwork.

This was an easy line to hold because, until 1794 (when a meteorite finally exploded in full view of Siena's professors and educated Grand Tourists) the only witnesses had been peasants. For example, in 1768, a meteorite shower not far from Le Mans in France was investigated by a group of aristocratic savants (including Antoine Lavoisier, father of modern chemistry). They dismissed eyewitness accounts and ascribed the fallen stones to lightning. Thirty-five years later, in 1803, a similar fall only 100 km away, in a radically changed political context, had a very different outcome. Post-revolutionary France had formed an Institut National out of its royal predecessor and sent in one Jean-Baptiste Biot.

Witnesses' observations treated with respect, enabling Biot to finally break free of centuries of prejudice and bring the idea of "stones from the sky" closer to the scientific mainstream. Same event, different context, different outcome. Similarly, the effect of a major meteorite strike upon life on earth is also likely to depend heavily on circumstances – upon everything else that was going on at the time.

It took a long time for geologists to embrace meteorite strikes. In its quest to understand the earth, geology draws in experts from many disciplines. Classically trained geologists and palaeontologists have a deep-seated feeling for their subject's historical nature and, like all historians, tend to mistrust pat explanations. But scientists from non-historical disciplines, physics in particular, tend to apply subtly different criteria for judging whether a scientific story sounds more or less likely to be true. In the mid-1970s, earth science was galvanised by the plate-tectonic revolution but was otherwise still in thrall to a Victorian assumption that nothing "sudden" could possibly achieve anything lasting in earth history. Mass extinctions were, therefore, a little embarrassing – and tended to be rationalised away.



It took a long time for geologists to embrace meteorite strikes.

The leading British opponent of such "gradualism", Professor Derek Victor Ager (1926-95) realised a 24-hour hurricane could leave more trace of itself in sediments than intervening ages without name. The rock record was, he held, a scandal-sheet, recording the earth's rare, exciting moments, and largely ignoring its more frequent longueurs. This was the "neocatastrophist" revolution.

By the time the '70s were out, suddenness had been rehabilitated – with a vengeance. While looking for something else entirely, geologist Walter Alvarez and his Nobel prize-winning physicist father Luis Alvarez, discovered (and in 1980, with Frank Asaro and Helen Michel, published) a paper about a thin layer separating the Cretaceous and Tertiary periods rich in the rare element, iridium; a horizon that also marked one of the "big five" mass extinctions when dinosaurs and much else of the Mesozoic world order vanished for ever. Because iridium could only have come from space (earth's crust being heavily depleted in it), there must have been a massive impact. The extinction, it seemed, had not been merely "geologically" sudden (a million years or so); it had happened in a day – a day that put an end to the world of dinosaurs and ammonites and gave birth to the world of mammals, with (eventually) us in it.

Those who have been brought up to think like physicists (as most scientists who study impacts are) found it easy to accept that they had at last cracked the problem of "what killed off the dinosaurs". But many geologists were, and remain, wary. Partly, they felt aggrieved that physicists had apparently shot their fox; but that wasn't all, and only explains their initial reaction. Physicists like the idea because it is simple and parsimonious, whereas many geologists mistrust it for precisely the same reason. As historians, they feel in their bones that there is no imperative for the simplest explanation to also be right one, and the nagging conviction remains – despite the rehabilitation of the rare event – that major changes in earth history simply cannot have single causes.

So what do we know about the impact at the end of the Cretaceous? We know that it happened. There is even a candidate crater called Chicxulub, which lies offshore the Yucatan Peninsula of Mexico. Doubt persists about its precise age, but despite decades of research, when we have found hundreds more craters on earth, only one has been linked to a mass extinction event, and only one of the "big five" mass extinctions can be linked to any extraterrestrial causes. None of the others coincides with impact evidence, including the biggest one of all, the end-Permian extinction 250 million years ago.

However, we do know that the end-Cretaceous earth was choking to death from the effects of unimaginably intense volcanic eruptions in India – effusions that were orders of magnitude bigger than anything humanity has experienced (or will ever experience, if we're lucky). Unlike impacts, convincingly linked to only one mass extinction, every mass extinction event can be correlated with a Large Igneous Province (a region of the earth's surface where a series of large eruptions over a geologically short time period) somewhere on the globe. So could it be that the meteorite that hit earth at the end of the Cretaceous only produced its marked effect because of timing – because the impact or impacts were reinforcing other inimical factors? As new evidence comes in, this is beginning to look increasingly likely.

New discoveries are now even linking meteorites to one of life's greatest-ever diversifications. Some 470 million years ago, when the world was thinly colonised by simple marine organisms, the planet suddenly found itself bombarded by countless meteorites over a period perhaps exceeding 10 million years, following a major collision in the Asteroid Belt. Geologists are finding fossil meteorite material in sediments of this age everywhere. Most intriguingly, these amazing discoveries (first made in Sweden, now being extrapolated worldwide by Professor Birger Schmitz of Lund University) may help explain a baffling burst of evolutionary diversification – the biggest to affect life after the so-called "Cambrian explosion", when complex animals first appeared. This is known as the "Great Ordovician Biodiversity Event and it has puzzled palaeontologists since it was uncovered by computer analysis of species data in the early 1980s.

The theory goes that by sterilising large areas, bombardments helped break the stranglehold of endemic species, allowing new opportunistic organisms to invade, increasing biodiversity by an ecological phenomenon known as the Intermediate Disturbance Effect. Such biodiversity increases would feed through, in time, to faster evolutionary diversification.

So when we read of a meteorite fall today, we should reflect that what may have been bad for T-Rex 65 million years ago was good for birds and aardvarks and us; and had it not been for a collision between asteroids that showered the mid-Ordovician earth, T-Rex himself might never have had his big chance.

Indeed, as with all incoming news, the meaning you derive from it rather depends on where you're standing.

The Independent, London

Varieties of vaccines

Major anti-epidemic measures are prophylaxis and therapy of infectious diseases, writes tapan kumar maitra

IN the general complex of anti-epidemic measures great significance is given to specific prophylaxis and therapy of infectious diseases. Vaccine (L. vacca cow) received its name from the anti-smallpox preparation made from the virus of cowpox. Vaccines are preparations consisting of attenuated or dead causative agents or products of their life activity, while the method of inoculation is known as vaccination or immunisation.

Modern vaccinal preparations are subdivided into four groups: a) vaccines from live causative agents with a decreased (attenuated vaccines) virulence; b) vaccines from dead cultures of pathogenic micro-organisms (bacteria, rickettsiae and viruses); c) vaccines from the products of chemical cleavage of some bacteria (chemical vaccines); and d) anatoxins received from exotoxins by treating them with formalin at a temperature of 38-40°Celcius.

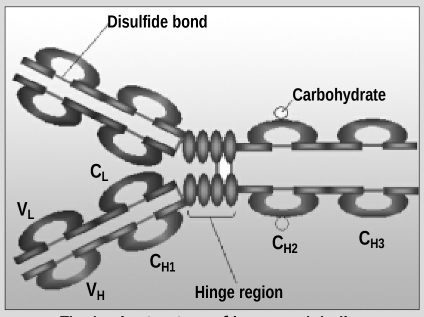
Live vaccines include vaccines against smallpox, anthrax, rabies, tuberculosis, plague, brucellosis, tularaemia, yellow fever, influenza, typhus fever, poliomyelitis, parotitis, measles, etc.

To increase the storage time without loss of immunogenic properties many preparations at present are produced in a dried state. Drying is carried out in a vacuum at a low temperature.

Vaccines prepared from microbes which have been killed by heat or by treatment with alcohol, formalin or merthiolate include the enteric fever, paratyphoid, cholera, whooping cough, poliomyelitis and leptospirosis vaccines. Special strains with sufficiently high immunogenic properties are chosen for the preparation of these vaccines.

Chemical vaccines are preparations composed not of whole bacterial cells, but of chemical complexes obtained by treating culture suspensions according to special methods.

A polyvaccine against typhoid fever and tetanus is now manufactured and used. It consists of O- and Vi-antigens of the typhoid fever bacteria and purified concentrated tetanus anatoxin. The bacterial antigens and the tetanus anatoxin are adsorbed on aluminium hydroxide.



The basic structure of immunoglobulins.

Anatoxins are prepared from exotoxins of the corresponding causative agents. Diphtheria and tetanus anatoxins have a wide application. In recent years an anatoxin has been obtained against gas gangrene. Anatoxins are produced in a purified state, freed from impurities and adsorbed into aluminium hydroxide or aluminium phosphate. They cause the production of antitoxins and consequently reproduce antitoxic immunity.

The possibility is not excluded of using anatoxins as prophylactic preparations for immunising children against cholera and staphylococcal infections. Besides these preparations, associated vaccines are used for specific prophylaxis of infectious diseases — whooping cough diphtheria-tetanus vaccine, diphtheria-tetanus associated anatoxin and whooping cough-diphtheria.

Methods of preparing other associated vaccines are being devised which will provide for the production of anti-bacterial, anti-toxic and anti-virus immunity.

Vaccines are introduced into the body epicutaneously, subcutaneously, intracutaneously, by mouth and into the mucous membranes of the nose and pharynx; after a definite period (from several days to several weeks) the vaccines produce active immunity. Very strict requirements are placed upon vaccines. They must be harmless and highly immunogenic — capable of producing stable immunity of a long duration.

Vaccines are prepared at special biological plants, at production institutes of vaccines and sera or at laboratories of research institutes of epidemiology and microbiology and hygiene. Vaccination is carried out with due account for the epidemic situation and medical contraindications. These include acute fevers, recent recovery from an infectious disease, chronic infections (tuberculosis, malaria), valvular diseases of the heart, severe lesions of the internal organs, the second half of pregnancy, the first period of nursing a baby at the breast, allergic conditions — bronchial asthma, hypersensitivity to any foodstuff, etc.

Vaccines are stored in a dark and dry place at a constant temperature (+ 2 to + 10 degree Celsius). The terms of their fitness are indicated on labels and the method of their administration in special instructions enclosed in the boxes with the flasks or ampoules.

The effectiveness of vaccination depends on the nature and quality of the vaccine, the proper method of its administration, the application of exact doses and exact intervals between the injections and the condition of the person being vaccinated. Vaccination prophylaxis ensures stable immunity against smallpox, tularaemia, yellow fever, poliomyelitis and diphtheria.

The current scientific level of immunology allows it to be accepted as established that the most active immunogenic substances are small components of bacterial cells and viruses responsible for the production of immunoglobulins, while most of the vaccine substrates cause side effects.

The best immunological effect is produced by injection of complexes localised in the membrane structures possessing antigenic information. Among such complexes are the capsular antigen of the plague microbe, the antigens from the cell membranes of the causative agents of tularaemia, tuberculosis, whooping cough, the antigens of the capsular substance and cell walls of bacteria of the intestinal group, in particular the Vi-antigen of Salmonella typhi, S. paratyphi and others.

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