Intelligence and genetics

The nature of nurture

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Breastfeeding may or may not make children more intelligent. It all depends on their genes

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FEW scientific fields are as fraught with risk as that of research into human intelligence. The two questions that arise over and over again are “is it a result of nature or nurture?” and “to the extent it is nature, does race make a difference?”

Making stupid comments about the second question can be a career-killing move, as James Watson, a co-discoverer of the structure of DNA, recently found. He suggested that he was “inherently gloomy about the prospect of Africa” because “all our social policies are based on the fact that their intelligence is the same as ours [presumably he meant white people]—whereas all the testing says not really”. Such remarks are not merely offensive, they are scientifically weird. If the term race has any useful scientific meaning, then Africa, the continent where modern humanity began, is the most racially diverse place on the planet. The resulting hoo-ha caused Dr

Watson to be eased out of the chancellorship of Cold Spring Harbor Laboratory, near New York, where he had worked for almost 40 years. Fortunately, the study of links between intelligence and genetics has some wiser practitioners than Dr Watson. One of them, Terrie Moffitt, of King's College, London, has just supervised a project investigating the first perennial question — the relative importance of nature and nurture. The result, published this week in the Proceedings of the National Academy of Sciences, neatly illustrates how complex the subject really is. It also shows how the hoary old thesis and antithesis of genetics and upbringing combine in a most intriguing synthesis.

Suck it and see

Dr Moffitt's team (the actual work was led by her colleague, Avshalom Caspi) looked at the effect on intelligence of breastfeeding, but in a genetic context. Several studies in the past have shown that breastfed children are more intelligent, by about six IQ points, than those given baby formulas — an open-and-shut case, it might appear, of nurture trumping nature.

Dr Caspi and Dr Moffitt, however, were not so sure. They suspected the involvement of a gene called FADS2. This regulates the metabolism of a group of molecules called long-chain polyunsaturated fatty acids. These are important for the growth of nerve cells and are abundant in human milk but generally absent from formulas. FADS2 comes in two varieties, known as C and G, and the researchers wondered if these two varieties interacted differently with breast milk.

To find out, they drew on data from two groups of people, one in New Zealand and one in Britain. Each of these groups is an annual cohort (in other words, their members were all born in the same twelve-month period) established for just this sort of long-term medical investigation. Data have been collected on the members of each for years (the New Zealanders were born between April 1972 and March 1973; the Brits in 1994 and 1995). Indeed, Dr Moffitt has already used the New Zealand group to show how a violent family upbringing and different versions of another neurologically important gene interact to produce more and less violent people.

What Dr Caspi and Dr Moffitt found was that the increase in intelligence associated with breastfeeding only happened to people who had inherited at least one copy of the C version of FADS2. (Most genes are present as two copies, one inherited from the mother and one from the father.) The effect did not depend on the social classes or IQs of the parents, nor on the birthweight of the child in question (low birthweight has been linked to lower IQ). And the difference in IQ was preserved into adulthood.

Only about 10% of the population is double-G, but what is curious about this result is that the G version of the gene has survived at all. If intelligence is valuable, the C version might be expected to have become universal. Indeed, this is the nub of the nurturists' argument. Natural selection should have pushed intelligence genes as far as they will go, so all variation should be environmental. That it is not suggests there is some unknown countervailing advantage – at least in reproductive terms – to being less than averagely bright.

It is a nice irony, given the traditional association of the naturist position with eugenic arguments, that if variation in intelligence really is caused by underlying genetic variation, then the dull are as evolutionarily fit as the clever. But that is the logical conclusion.

Cosmic rays

They came from outer space

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A 40-year-old mystery is solved

SMALLER than an atom, they arrive with the energy of a tennis ball served by a champion. When they hit the atmosphere they create showers of daughter particles that zap mountaineers and people in aeroplanes. And no one knows where they come from — nor how, in apparent defiance of the laws of physics, they get to this planet in the first place.

Actually, that last sentence is no longer true. The super-particles in question are a particular type of high-energy cosmic ray and fittingly, given their extreme properties, their origin has now been worked out by a team of 444 researchers from 17 countries, using the biggest piece of scientific apparatus on Earth — the Pierre Auger observatory, which occupies 3,000 square kilometres of western Argentina.

Ordinary cosmic rays are puny things. Indeed, they are not really “cosmic” at all. They originate from various events (supernovae and so on) within the Milky Way galaxy that is home to the Earth. A few, however, are real whoppers—the products of events far more powerful than occur in the Milky Way. These are the tennis-ball equivalents and their existence is a puzzle.

Two puzzles, in fact. The first is: what created them? The second is: how did they get to Earth at such speed?

One hypothesis about their creation is that they are the result of stars being sucked into giant black holes. A second is that they come from colliding galaxies. A third is that they are caused by the collapse of massive but invisible relics from the beginning of the universe. All those events would be powerful enough, but all tend to happen a long way away. And that is where the second puzzle comes in.

In 1966 Kenneth Greisen, Vadim Kuzmin and Georgiy Zatsepin showed that high-energy charged particles (cosmic rays are mostly atomic nuclei, and thus positively charged) should be slowed by collisions with the photons of the cosmic microwave background (radiation left over from the Big Bang that permeates all space). This would bring them below a well-defined speed limit. Yet that limit is regularly exceeded. So, either the laws of physics are wrongly understood, or the super-rays are coming from close by, even if not from the Milky Way itself.

To find answers to these questions, the team trawled through the data that have accumulated since the Pierre Auger observatory began operating three years ago. The observatory, which is named after the physicist who discovered the showers caused by cosmic rays, has 1,600 detectors on the ground to record the arrival of such cascades and 24 telescopes pointing at the sky to locate the flashes of light produced by the collisions that create them.

So far, it has recorded a million or so showers. Around 80 of these were caused by cosmic rays more energetic than theory allows. The collaborators whittled these down to the 27 biggest events, so that there would be no ambiguity. They then decided to test the first, and easiest, hypothesis: that energetic cosmic rays are caused by hungry black holes. They did this by taking a peek at an astronomers' catalogue of 318 active galaxies located within 300m light years of Earth.

An active galaxy is a star system with a humongous black hole at its centre. Such black holes regularly chomp up stars, and that produces a lot of radiation. Only the 318 in question, however, are close enough to the Milky Way for the predicted galactic speed limit not to have been imposed (300m light years may sound a long way, but it is a short hop on the cosmic scale).

As the team report in this week's Science, all 27 of the cosmic rays they looked at did, indeed, come from the direction of galaxies in the catalogue. Both mysteries thus seem to have been solved. High-energy cosmic rays are caused by black holes consuming stars. And the laws of physics do not have to be torn up after all.

Extrasolar planets

The famous five

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Five planets orbiting a distant star form a real alien solar system

FINDING planets has become commonplace. A new one is unearthed, so to speak, every couple of weeks. But only occasionally is more than one found orbiting any particular star. That is probably not because most solar systems contain only one planet, but rather because it is hard to spot several at once. The signal from the largest tends to overwhelm the others. Which is why the announcement on November 6th by Geoff Marcy of the University of California, Berkeley, and his colleagues that they have identified a system with at least five planets is especially pleasing. At last astronomers have something that they can realistically compare with the eight-planet system that includes the Earth.

The star at the centre of the system in question is 55 Cancri A, a yellow dwarf similar to the sun that lies 40 light years away. Dr Marcy has been looking for wobbles in its position that betray the presence of planets as they tug at it.

Since stars are considerably more massive than planets, such wobbles are small and hard to see directly. Instead, Dr Marcy and others like him look for changes that the wobbles cause in the wavelength of the light from the star. These changes (the result of the Doppler effect—familiar when a siren changes pitch as a fire engine passes by) are much easier to detect than the wobbles themselves, and researchers can thus plot them out as a curve.

So far, so good. But when more than one planet is tugging at a star, deciphering the meaning of the wobble is complicated. To do so, astronomers resort to Fourier analysis, a mathematical technique that allows them to break a complex curve into a set of simple ones called sine waves. In a solar system, each planet has its own sine wave. Big planets close to a star have big effects and orbit quickly. They thus have sine waves with large amplitudes and short wavelengths, both of which make them easy to see. However, smaller planets and those farther from the star take longer to notice. Small planets' waves have small amplitudes, so you can pick the signal from the noise only after several orbits. Distant planets have long orbits and therefore long wavelengths, and you cannot do the analysis properly until you have seen at least one orbit.

Fortunately, Dr Marcy has been looking for a long time. Every month for the past 18 years, he has tuned in to the signal coming from 55 Cancri A. Gradually, the separate sine waves have become visible. The dominant signal, corresponding to a planet with about the same mass as Jupiter but which orbits 55 Cancri A more closely than Mercury orbits the sun, was detected in 1996. Two further sine waves emerged in 2002, corresponding to one planet that has the mass of Saturn and is also orbiting more closely than Mercury, and another with four times the mass of Jupiter that is located in what would be Jupiter's orbit. A fourth object, which has more than ten times the mass of Earth and is the nearest to the star yet found, was noticed by another team in 2004.

The fifth, just announced, is of special interest because it orbits 55 Cancri A at a distance which suggests that, if water is present (and Dr Marcy thinks it probably is), it will be in its liquid form. Sadly, the planet probably does not have the sort of surface on which life could have evolved. Dr Marcy suspects that his new discovery, which has about 45 times the mass of the Earth, is composed of a rocky core surrounded by a thick envelope of hydrogen and helium gas. Details of the discovery will be published in a forthcoming issue of the Astrophysical Journal.

Finding five planets in a solar system other than the Earth's represents a record, and is all the more impressive because many astronomers thought it would not be possible to disentangle so many signals. Whether a sixth is lurking around 55 Cancri A, only time (and Fourier) will tell.

Palaeontology

A hop, a skip and a jump

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Birds first flew by taking off from the ground, not gliding between trees

WHEN Archaeopteryx, a feathered skeleton that was seemingly half dinosaur and half bird, turned up in 1862—three years after the publication of "The Origin of Species"—the origin of birds became a subject of raging debate among palaeontologists. Suggestions that they were the direct descendants of theropod dinosaurs (a group of bipedal meat-eaters that include Allosaurus, Velociraptor and Tyrannosaurus) caused quite a flap. Today, most researchers agree that birds are, indeed, a branch of the Dinosauria. How they made the transition from the land to the sky, though, has yet to be agreed. But a paper in this week's Current Biology, by Christopher Glen and Michael Bennett of the University of Queensland, makes a strong case that they did it by jumping.

Considering the diversity of life on Earth, flight is surprisingly rare. It has evolved only four times: among the insects about 300m years ago, the pterosaurs (230m), the birds (150m) and the bats (50m). That suggests it is a hard trick to pull off. For birds, there is general agreement that feathers came before flight. Fossils from north-eastern China show animals that had feathers but clearly could not have flown, as well as ones that look like proper birds. The best guesses are that feathers evolved either for insulation (as fur did in mammals) or for display, and that natural selection took advantage by turning them into a means of transport.

There are two broad schools of thought about what happened next. One argues that birds' immediate ancestors lived in trees. Members of this school think that powered flight developed as a natural extension of gliding (such controlled falling is used as a way of travelling from tree to tree by several arboreal species today). Gliding itself developed because of the lift provided by feathered forearms.

The alternative is that flight evolved on the ground. Some researchers who belong to this school of thought suggest that the power provided by flapping protowings may have given their owners an edge in the pursuit of prey. Others hypothesise that feathery forearms helped animals steer and stabilise themselves.

Unfortunately, behaviour does not fossilise, so it looked as though the question might never be answered. But Dr Glen, a palaeobiologist, and Dr Bennett, a biomechanic, think they have worked out how to do so. Their crucial observation is that in modern birds the curvature of the third toe (which carries a lot of weight during walking and climbing) varies with species' lifestyles. Birds that spend lots of time climbing around on the trunks of trees have dramatically curved third toes. Those that hop around on branches have mildly curved ones. Those that forage mainly on the ground have the least curved of all.

The two researchers compared these observations with their findings for the bird-like dinosaurs and dinosaur-like birds of China. They noticed that the toes of both feathered dinosaurs and of the earliest flying birds were similar to those of modern birds that spend most of their time on the ground. Flight, in other words, came before birds took to the trees. They are not fallen angels, but risen reptiles.