Beauty and success

To those that have, shall be given

The ugly are one of the few groups against whom it is still legal to discriminate. Unfortunately for them, there are good reasons why beauty and success go hand in hand

IMAGINE you have two candidates for a job. They are both of the same sex—and that sex is the one your own proclivities incline you to find attractive. Their CVs are equally good, and they both give good interview. You cannot help noticing, though, that one is pug-ugly and the other is handsome. Are you swayed by their appearance?

Perhaps not. But lesser, less-moral mortals might be. If appearance did not count, why would people dress up for such interviews—even if the job they are hoping to get is dressed down? And job interviews are turning points in life. If beauty sways interviewers, the beautiful will, by and large, have more successful careers than the ugly—even in careers for which beauty is not a necessary qualification.

If you were swayed by someone's looks, however, would that be wrong? In a society that eschews prejudice, favouring the beautiful seems about as shallow as you can get. But it was not always thus. In the past, people often equated beauty with virtue and ugliness with vice.

Even now, the expression “as ugly as sin” has not quite passed from the language. There is, of course, the equally famous expression “beauty is in the eye of the beholder”, to counter it. But the subtext of that old saw, that beauty is arbitrary, is wrong. Most beholders agree what is beautiful—and modern biology suggests there is a good reason for that agreement. Biology also suggests that beauty may, indeed, be a good rule of thumb for assessing someone of either sex. Not an infallible one, and certainly no substitute for an in-depth investigation. But, nevertheless, an instinctive one, and one that is bound to redound to the advantage of the physically well endowed.

Fearful symmetry

The godfather of scientific study of beauty is Randy Thornhill, of the University of New Mexico. It was Dr Thornhill who, a little over a decade ago, took an observation he originally made about insects and dared to apply it to people.

The insects in question were scorpion flies, and the observation was that those flies whose wings were most symmetrical were the ones that did best in the mating stakes. Dr Thornhill thought this preference for symmetry might turn out to be universal in the animal kingdom (and it does indeed seem to be). In particular, he showed it is true of people. He started with faces, manipulating pictures to make them more and less symmetrical, and having volunteers of the opposite sex rank them for attractiveness. But he has gone on to show that all aspects of bodily symmetry contribute, down to the lengths of corresponding fingers, and that the assessment applies to those of the same sex, as well.

The reason seems to be that perfect symmetry is hard for a developing embryo to maintain. The embryo that can maintain it obviously has good genes (and also a certain amount of luck). It is, therefore, more than just coincidence that the words “health and beauty” trip so easily off the tongue as a single phrase.

Other aspects of beauty, too, are indicators of health. Skin and hair condition, in particular, are sensitive to illness, malnutrition and so on (or, perhaps it would be better to say that people's perceptions are exquisitely tuned to detect perfection and flaws in such things). And more recent work has demonstrated another association. Contrary to the old jokes about dumb blondes, beautiful people seem to be cleverer, too.

One of the most detailed studies on the link between beauty and intelligence was done by Mark Prokosch, Ronald Yeo and Geoffrey Miller, who also work at the University of New Mexico. These three researchers correlated people's bodily symmetry with their performance on intelligence tests. Such tests come in many varieties, of course, and have a controversial background. But most workers in the field agree that there is a quality, normally referred to as “general intelligence”, or “g”, that such tests can measure objectively along with specific abilities in such areas as spatial awareness and language. Dr Miller and his colleagues found that the more a test was designed to measure g, the more the results were correlated with bodily symmetry—particularly in the bottom half of the beauty-ugliness spectrum.

Faces, too, seem to carry information on intelligence. A few years ago, two of the world's face experts, Leslie Zebrowitz, of Brandeis University in Massachusetts, and Gillian Rhodes, of the University of Western Australia, got together to review the literature and conduct some fresh experiments. They found nine past studies (seven of them conducted before the second world war, an indication of how old interest in this subject is), and subjected them to what is known as a meta-analysis.

The studies in question had all used more or less the same methodology, namely photograph people and ask them to do IQ tests, then show the photographs to other people and ask the second lot to rank the intelligence of the first lot. The results suggested that people get such judgments right—by no means all the time, but often enough to be significant. The two researchers and their colleagues then carried out their own experiment, with the added twist of dividing their subjects up by age.

Bright blondes

The results of that were rather surprising. They found that the faces of children and adults of middling years did seem to give away intelligence, while those of teenagers and the elderly did not. That is surprising because face-reading of this sort must surely be important in mate selection, and the teenage years are the time when such selection is likely to be at its most intense—though, conversely, they are also the time when evolution will be working hardest to cover up any deficiencies, and the hormone-driven changes taking place during puberty might provide the material needed to do that.

Nevertheless, the accumulating evidence suggests that physical characteristics do give clues about intelligence, that such clues are picked up by other people, and that these clues are also associated with beauty. And other work also suggests that this really does matter.

One of the leading students of beauty and success is Daniel Hamermesh of the University of Texas. Dr Hamermesh is an economist rather than a biologist, and thus brings a somewhat different perspective to the field. He has collected evidence from more than one continent that beauty really is associated with success—at least, with financial success. He has also shown that, if all else is equal, it might be a perfectly legitimate business strategy to hire the more beautiful candidate.

Just over a decade ago Dr Hamermesh presided over a series of surveys in the United States and Canada which showed that when all other things are taken into account, ugly people earn less than average incomes, while beautiful people earn more than the average. The ugliness “penalty” for men was -9% while the beauty premium was +5%. For women, perhaps surprisingly considering popular prejudices about the sexes, the effect was less: the ugliness penalty was -6% while the beauty premium was +4%.

Since then, he has gone on to measure these effects in other places. In China, ugliness is penalised more in women, but beauty is more rewarded. The figures for men in Shanghai are −25% and +3%; for women they are −31% and +10%. In Britain, ugly men do worse than ugly women (-18% as against -11%) but the beauty premium is the same for both (and only +1%).

The difference also applies within professions. Dr Hamermesh looked at the careers of members of a particular (though discreetly anonymous) American law school. He found that those rated attractive on the basis of their graduation photographs went on to earn higher salaries than their less well-favoured colleagues. Moreover, lawyers in private practice tended to be better looking than those working in government departments.

Even more unfairly, Dr Hamermesh found evidence that beautiful people may bring more revenue to their employers than the less-favoured do. His study of Dutch advertising firms showed that those with the most beautiful executives had the largest size-adjusted revenues—a difference that exceeded the salary differentials of the firms in question. Finally, to add insult to injury, he found that even in his own cerebral and, one might have thought, beauty-blind profession, attractive candidates were more successful in elections for office in the American Economic Association.

That last distinction also applies to elections to public office, as was neatly demonstrated by Niclas Berggren, of the Ratio Institute in Stockholm, and his colleagues. Dr Berggren's team looked at almost 2,000 candidates in Finnish elections. They asked foreigners (mainly Americans and Swedes) to examine the candidates' campaign photographs and rank them for beauty. They then compared those rankings with the actual election results. They were able to eliminate the effects of party preference because Finland has a system of proportional representation that pits candidates of the same party against one another. Lo and behold, the more beautiful candidates, as ranked by people who knew nothing of Finland's internal politics, tended to have been the more successful—though in this case, unlike Dr Hamermesh's economic results, the effect was larger for women than for men.

If looks could kill

What these results suggest is a two-fold process, sadly reminiscent of the biblical quotation to which the title of this article refers. There is a feedback loop between biology and the social environment that gives to those who have, and takes from those who have not.

That happens because beauty is a real marker for other, underlying characteristics such as health, good genes and intelligence. It is what biologists call an unfakeable signal, like the deep roar of a big, rutting stag that smaller adolescents are physically incapable of producing. It therefore makes biological sense for people to prefer beautiful friends and lovers, since the first will make good allies, and the second, good mates.

That brings the beautiful opportunities denied to the ugly, which allows them to learn things and make connections that increase their value still further. If they are judged on that experience as well as their biological fitness, it makes them even more attractive. Even a small initial difference can thus be amplified into something that just ain't—viewed from the bottom—fair.

Given all this, it is hardly surprising that the cosmetics industry has global sales of $280 billion. But can you really fake the unfakeable signal?

Dr Hamermesh's research suggests that you can but, sadly, that it is not cost-effective—at least, not if your purpose is career advancement. Working in Shanghai, where the difference between the ugliness penalty and the beauty bonus was greatest, he looked at how women's spending on their cosmetics and clothes affected their income.

The answer was that it did, but not enough to pay for itself in a strictly financial sense. He estimates that the beauty premium generated by such primping is worth only 15% of the money expended. Of course, beauty pays off in spheres of life other than the workplace. But that, best beloved, would be the subject of a rather different article.

18th-century climate change

The summer of acid rain

Molten iron raining down like cowpats; ice floes at New Orleans. The weather of 1783 was an extraordinary case of sudden climate change driven by atmospheric gases

“AROUND mid-morning on Pentecost, June 8th of 1783, in clear and calm weather, a black haze of sand appeared to the north of the mountains. The cloud was so extensive that in a short time it had spread over the entire area and so thick that it caused darkness indoors. That night, strong earthquakes and tremors occurred.”

Thus begins the eyewitness account of one of the most remarkable episodes of climate change ever seen. It was written by a Lutheran priest, Jon Steingrimsson, in the Sida district of southern Iceland. At nine o'clock that morning, the earth split open along a 16-mile fissure called the Laki volcano. Over the next eight months, in a series of vast belches, more lava gushed through the fissure than from any volcano in historic times—15 cubic kilometres, enough to bury the whole island of Manhattan to the top of the Rockefeller Centre.

Pentecost is the Christian festival celebrating the appearance of the Holy Spirit to the Apostles with the sound, the Bible says, “as of a mighty rushing wind” and an appearance “like as of fire”. But there was nothing metaphorical or festive about the winds and fire of the Laki eruption. It was the greatest calamity in Iceland's history.

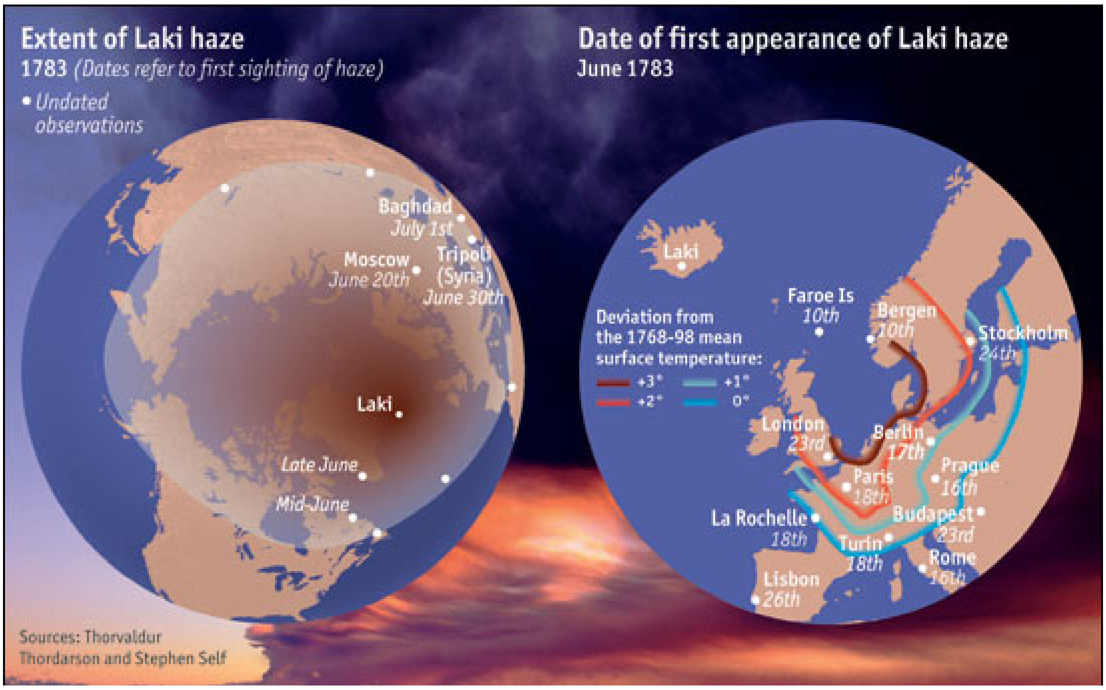
“The flood of fire”, Steingrimsson writes, “flowed with the speed of a great river swollen with meltwater on a spring day.” It was rather as if the world's largest steelworks had begun pouring molten metal all over the neighbourhood. When the lava stream ran into water or marshes, “the explosions were as loud as if many cannon were fired at one time.” When it hit an obstacle, such as older lava fields, great gouts of molten metal were flung in the air, splashing back to earth, he says, “like cowpats”. But the damage to Iceland was only the start of a much greater trail of destruction that was eventually to reach halfway round the world, from the Altai mountains of Siberia to the Gulf of Mexico.

There are two sorts of volcanic eruptions, explosive and effusive. The well-known sort is explosive. It has the greater force. Explosions of this sort destroyed Pompeii and star in Hollywood films. Their sheer power throws volcanic gases and ash far into the stratosphere (the higher reaches of the atmosphere), where they absorb incoming radiation and cool the earth until they dissipate after two or three years. The eruption of Krakatoa caused record snowfalls round the world.

Effusive volcanic eruptions are different. They simmer with less force, but produce a greater volume of debris. Laki belched out clouds of volcanic gases 80 times greater than Mount St Helens, though Mount St Helens had much greater explosive power. But because Laki was weaker, three-quarters of the gas reached only as far as the lower atmosphere (the troposphere), the level at which rain, ordinary clouds and surface winds are carried. The gases included enormous quantities of sulphur dioxide; at its peak, the eruption produced as much in two days as European industry produces in a year. Part of this dissolved in the vapour of the clouds to form sulphuric acid. Within a few hours, the Laki volcano had produced a vast plume of acid rain, brooding over the skies of southern Iceland.

In the normal course of events, the prevailing winds would have blown this poisonous plume northwards, towards the Arctic Circle. But the summer of 1783 was not normal. A stable ridge of high pressure had settled over north-east Europe, pulling the winds, and the Laki cloud, south-east, towards the European mainland.

What happened next can be recreated in great detail because in the late 18th century diaries were fashionable among the newly literate middle classes and the circulation of newspapers was rising even in small towns; there was also growing scientific interest in the natural world, with educated amateurs keeping detailed notes of natural phenomena. From such records, one can track the course of the Laki cloud literally day by day (see map).



On June 10th wrote Sæmundur Magnusson Holm at the University of Copenhagen, falling ash coloured black the deck and sails of ships travelling to Denmark. The same day, a Lutheran priest in Norway, Johan Brun, reported that falling ash had withered the grass and leaves in Bergen. Six days later, Anton Strnadt reported that "the dry fog" came up over the river Moldau into Prague while Nicolas von Beguelin reported its first appearance in Berlin the day afterwards. "The sun", he wrote, "was dull in its shine and coloured as if it had been soaked in blood."

By June 18th the winds seem to have been blowing the cloud south and west. Robert de Lamanon, a French botanist and explorer, wrote from Laon, in northern France, that "the fog was cold and humid, with the wind coming from the south, and one could with ease look at the sun with a telescope without a blackened lens." De Lamanon said fog—"such as the oldest men here have not seen before"—first appeared that day in Paris, Turin and Padua, from where Giuseppe Toaldo wrote that the whole of northern Italy was covered by the haze and smelled of sulphur.

The first mention of the haze in Britain came on June 22nd when Henry Bryant wrote to the Norfolk Chronicle that "there was an uncommon gloom in the air, with dead calm and very profuse dew." Gilbert White, a Hampshire clergyman, noted in his diaries for the 23rd that "the blades of wheat in several fields are turned yellow and look as if scorched with frost."

By June 26th Leonhard Euler, a Swiss mathematician, reported a "dry fog" in St Petersburg. By the end of the month, the cloud had reached Moscow and

Tripoli in Syria, according to a Dutch professor, S.P. van Swinden, whose "Observations on the Cloud which Appeared in 1783" says that "a very thick haze covered both land and sea; the sun could be seen rarely, and always with a bloody colour, which was rare in Syria." Finally, on July 1st, the haze appeared at Baghdad and in the Altai mountains, according to a geologist, Ivan Michaelovich Renovantz, who reported unseasonable frosts in Central Asia.

By then, back in Europe, the cloud had thickened. This was not a plume like that from Chernobyl, which appeared in one vast belch, spread over Europe and blew away. After its initial effusion, Laki erupted again, more violently, on June 11th and with still greater force on the 14th. Ferenc Weiss, a Hungarian meteorologist, was right to speculate that "the thick fog was being continually replenished". There were to be ten big eruptions between June 8th and the end of October, followed by a series of rumblings that exhausted themselves only in February 1784.

As the cloud approached western Europe, it was sucked down in a spiral pattern towards the Earth's surface, producing a thick haze near ground level. By mid-summer, the "dry fog" had settled on Europe like a blanket; it was to stay there throughout the summer.

Europeans reacted in different ways. Steingrimsson was in no doubt: the eruption was "the Lord's chastisement". On the fourth Sunday after Pentecost, with the lava advancing down the valley towards his church "which was shaking and quaking from the cataclysm", he gathered his flock for Sunday service, as usual. "Both myself and all the others in the church were completely unafraid," he writes. "No one showed any signs of leaving during the service, which I had made slightly longer than usual." On emerging, the congregation found that two rivers, blocked by the lava flow, had changed course and poured down, dousing the lava and stopping it yards from the church door. (Two centuries later, Icelanders created the same obstacle by artificial means to save a town threatened by another eruption.) "From this day onwards the fire did no major damage to my parish in any way."

"The miracle of the fire sermon" became well known and sermons on the freakish cloud common. "You stare at the sky and at the horizon veiled in dark exhalations," Johann Georg Gottlob Schwarz admonished his audience in Alsfeld, Germany. "The Lord speaks daily to us and reveals in Nature his omniscience."

The end is nigh

The expressions of faith were driven partly by alarm, even terror. “Some fear to go to bed, expecting an Earthquake; some declare that [the sun] neither rises nor sets where he did, and assert with great confidence that the day of judgment is at hand,” wrote an English poet, William Cowper. Parishioners near Broué, in northern France, dragged their priest out of bed and forced him to perform a rite of exorcism on the cloud. After rains brought temporary relief in Antwerp, the Gazette van Antwerpen reported that public prayers were held to bring more.

Alarm and misapprehension were not confined to the illiterate. The British government, fearing a plague outbreak, drew up plans to close the ports to traffic from the continent. Nor were popular fears mere superstition. The parish records of the English midlands reveal a spike in the number of deaths during July and August 1783, though summer is normally the time of lowest mortality in agricultural societies. Around 23,000 more English people died than would have been expected that year, doubling the normal death toll. In France, on some estimates, 5% of the population died that summer. Unusually, the deaths included young men and women working in the fields, breathing polluted air in stifling heat.

In Japan, the famine was so severe that special crews had to be hired to clear the roads of the dead

In general, though, “the Connoscenti”, (Cowper's term) sought rational explanations for the haze, rather than the consolations of religion. A French naturalist was the first to connect the fog to volcanic activity in Iceland in a lecture at Montpellier as early as August 7th. In Paris, meteorologists “desirous of making some observations of the atmosphere, had a sort of kite flown to a great height after which it was drawn in, covered with innumerable small black insects.” In an apparent attempt to allay panic, a French astronomer, Jerome de Lalande, wrote a paper arguing the unusual weather was “nothing more than the very natural effect from a hot sun after a long supersession of heavy rain” (he was wrong). Everywhere, educated men left detailed descriptions of the cloud cover; of the unusual appearance of the sun (“ferruginous” said White; “the face of a hot salamander” said Cowper); and of the scorching of leaves and grass and the state of the harvest and livestock.

By the end of October, the last of the big eruptions at Laki was over, and the haze began to dissipate, blown by the autumn winds. It was the end of the cloud but not the end of the damage. One of the gases the volcano threw up was fluorine, which fell quickly back to earth as hydrofluoric acid. In Iceland, this had horrible results. “The horses lost all their flesh,” Steingrimsson wrote, “the skin began to rot off along the spines. The sheep were affected even more wretchedly. There was hardly a part on them free of swellings, especially their jaws, so large that they protruded through the skin…Both bones and gristle were as soft as if they had been chewed.”

Half the horses and cattle and three-quarters of the sheep on the island died. As famine took hold, social bonds began to fray. To protect his remaining cattle, Steingrimsson slept in the cowshed “since thieves were on the prowl.” In all, a quarter of Iceland's population was to die of starvation, including Steingrimsson's beloved wife of 31 years. “When I lost my wonderful wife”, he writes, “everything, so to speak, collapsed around me.”

In Europe, the summer of 1783 had been unusually warm, the warmest recorded in England before 1995. White called the season “an amazing and portentous one, full of horrible phenomena”, and complained of the abnormal number of wasps. The heat may have been a short-term greenhouse-gas effect from high concentrations of sulphur dioxide. Or it may have just been natural variation.

What is more certain is that, high in the atmosphere, the volcanic gases reflected away some of the sun's radiation even after the cloud had dissipated at lower levels. This back-scattering was to have a bigger impact on the climate than the summer cloud itself. The winters that followed the Laki eruption were freakishly cold.

At the time, some people suspected the volcano might be to blame. Benjamin Franklin, then America's ambassador to Paris, wrote to the Literary and Philosophical Society of Manchester that “[the sun's] effect of heating the Earth was exceedingly diminished. Hence the surface was early frozen. Hence the first snows remained on it unmelted. Hence the air was more chilled. Hence perhaps the winter of 1783-84 was more severe than any that had happened for many years.” In speculating upon the cause, he wondered “whether it was the vast quantity of smoke, long continuing to issue during the summer from Hecla in Iceland [near Laki]”. It was.

On average, temperatures in Europe during 1784 were about 2°C below the norm of the second half of the 18th century; and the closer to Iceland, the bigger the impact. Iceland itself was almost 5°C colder than normal and saw the longest period of sea ice around the island ever recorded. Berlin and Geneva, about 1,300 miles away, were 2ºC below normal, whereas the anomaly in Vienna, 1,700 miles from Laki, was only 1.5°C. Stockholm and Copenhagen, the nearest cities at just over 1,000 miles distant, saw temperatures drop by over 3°C.

Beyond Europe Laki's biggest influence seems to have operated over the greatest distances. The light-scattering effects of volcanic gases in the upper atmosphere reduced the amount of solar energy reaching the Earth and disrupted the normal relationship between temperatures both at the upper and lower levels of the atmosphere, and between the poles and the equator. These are the engines of the weather. Disruptions to them weakened the westerly jet streams, altered the monsoons and affected the weather throughout the northern hemisphere.

The eastern United States suffered one of its longest and coldest winters, with temperatures almost 5°C below average. George Washington, who had just disbanded his victorious army and retired to Mount Vernon, complained that he was "locked up" there by snow and ice between Christmas Eve and early March, while James Madison wrote from his home in Virginia that "we have had a severer season and particularly a greater quantity of snow than is remembered to have distinguished any preceding winter." The St Lawrence river froze for a dozen miles far inland. In Charleston, South Carolina, which nowadays grinds to a halt with a light dusting of snow, the harbour froze hard enough to skate on. Most extraordinary of all, ice floes floated down the Mississippi, past New Orleans and out into the Gulf of Mexico.

The eastern United States recovered fairly quickly, but places farther afield were not so lucky. Japan suffered one of the three worst famines in its history in 1783-86, when exceptional cold destroyed the rice harvest and as many as 1m people died. Special crews had to be hired to clear the roads of the dead. In Japan this famine is usually attributed to another volcanic eruption, that of Mount Asama, but its impact was small compared with Laki's.

Tree-ring evidence from the Urals, the Yamal peninsula in Siberia and Alaska all suggests northern areas had their coldest summer for 400 to 500 years. The oral history of the Kauwerak tribe of north-western Alaska calls 1783 "the year summer did not come"; the tribe was almost wiped out.

Because of disruption to the monsoons, rainfall in the Nile watershed was down by almost a fifth and in the Niger watershed by more than a tenth. In his "Travels through Syria and Egypt", Count Constantine Volney, a French orientalist, wrote that "the [Nile] inundation of 1783 was not sufficient, great part of the lands therefore could not be sown for want of being watered. In 1784, the Nile again did not rise to favourable height, and the dearth immediately became excessive. Soon after the end of November, the famine carried off, at Cairo, nearly as many as the plague." By January 1785, he says, a sixth of Egypt's population had either perished or fled.

In Europe, the Laki eruption was not to leave an indelible mark. Within a few years, weather patterns returned to normal and Europeans had forgotten the extraordinary "dry fog". But in retrospect, the eruption can be seen to exemplify certain truths about climate change.

Polluting gases can change global temperatures a lot (in this case by cooling, not warming). Volcanic gases can do as much damage as any amount of human activity. But the poisonous cloud was only part of the story. Weather patterns mattered too. Stable anti-cyclones brought the gas to earth in Europe and stratospheric currents then spread it over a third of the globe. And the connections between pollution and weather are complex and unpredictable: people at the time understood the link between the volcano and the haze, but not the connection with events the other side of the globe. Societies are hit very differently: the impact was modest in most of Europe, but devastating in Egypt, Japan and Alaska. Lastly, people react to environmental disruption in ways that are themselves disruptive.

As the Icelanders struggled to return to normal in the summer of 1785, the country's superintendent ordered the paupers of neighbouring districts to be moved to Steingrimsson's area, though there was no food. In desperation, he says, "we held counsel and decided to head east to the beaches. A single man who was there ahead of us, a farmer from Stapafell called Eirikur, had on that day clubbed 70 adult seals and 120 pups on the beaches. I held a service in Kalfafell in the finest weather we experienced during that time where all of us gladly thanked God for His mercy in so richly providing for us in this barren land and so agreeably removing all the famine and death which otherwise awaited."

Particle physics

Merry Christmas, Dr Heuer

The most prestigious job in physics is about to change hands

NAPOLEON once asked of a newly appointed general, “Has he luck?” Rolf-Dieter Heuer clearly does—and in Napoleonic quantities. At the moment, he is the research director of the German Electron Synchrotron, an important but local institution based in Hamburg. On December 13th, however, he was chosen to be the next director-general of CERN, Europe's main particle-physics laboratory.

Luckier still, he does not actually start his term for 12 months. By then, if all has gone well, he will be in charge of the best Christmas present that a physicist could imagine—the world's biggest particle accelerator. Inside it, he and the thousands of other physicists who work at CERN hope to find the secrets of the universe: dark matter, dark energy, extra dimensions, tiny black holes that evaporate in an eye-blink and the origins of mass itself.

Dr Heuer's unlucky predecessor, Robert Aymar, has sweated out his own five-year term trying to get this behemoth of a machine, which is called the Large Hadron Collider (LHC), finished approximately on time and approximately on budget. Approximately, it looks as though he has succeeded. If all goes well, the LHC's first test run should happen in the summer, only two years late. Meanwhile, the creative financing techniques Dr Aymar employed to accomplish this—borrowing against future income in a way that the heads of pure-science projects rarely dare to do—seem to have worked, and not bankrupted the LHC as some more nervous people feared they might. Unfortunately for Dr Aymar, it is Dr Heuer who will reap the reward, for after a decade and a half in the wilderness since the United States abandoned its own plans for a giant accelerator, called the superconducting super-collider, the subject of particle physics is just about to get sexy again.

Standard deviations

The wilderness from which the field is emerging is called the Standard Model.

This description of the way the universe works was built up in the early 1970s. It links together, in a reasonably satisfying mathematical way, all of the known fundamental particles (electrons, quarks, photons and so on) and three of the four known fundamental forces (electromagnetism, and the strong and weak forces that shape atomic nuclei). However, it is not a complete explanation. The force of gravity, for instance, is not yet part of it. Nor has its explanation of the existence of mass yet been proved true. And it relies on a lot of mathematical fiddle factors that are disturbingly arbitrary. Also, it has hardly changed for 35 years, and physicists are getting bored with it.

The LHC exists to relieve that boredom. Though its first task—to find a particle called the Higgs boson—has been talked up endlessly, the Higgs is actually just unfinished business from the Standard Model. The Higgs is the missing element needed for mass to exist. Since mass clearly does exist, an absence of Higgs would be a real shock. But assuming it is there, as everyone expects, the exciting stuff will be what happens afterwards.

That journey beyond the Standard Model is what the LHC was really built for. The machine itself is a pair of ring-shaped pipes, each 27km long, buried 100 metres down in a layer of rock between Geneva and the Jura mountains. The pipes are surrounded by powerful magnets that guide and accelerate the particles within, so that they whizz round in opposite directions at close to the speed of light. This gives them enormous energy and, because energy and mass are two aspects of the same thing, enormous mass as well.

The collisions between these particles that are the purpose of all this engineering take place in four huge particle-detecting machines buried in caverns on the ring's circumference. The pipes—and the streams of protons they are carrying—cross in the middle of each of these machines. When the protons from opposing streams bash into each other, the alchemy of subatomic physics creates new, massive and generally unstable particles—of which the Higgs should be one example. These quickly decay into showers of daughter particles that shoot out through concentric layers of detectors made of materials such as liquid argon and the purest crystals of silicon available. Each layer is designed to measure the passage of a different class of daughter. By analysing the daughters, the nature of the massive parents that gave birth to them can be worked out.

All this happens fast. Very fast. When the LHC is running at full speed, each detector will have to deal with a billion collisions a second. That is way beyond what even the best modern computers can study thoroughly, so most are given a cursory glance and thrown away. The truly promising – a few hundred a second – are stored for future examination.

Unwrapping reality

The first big discovery probably will be the Higgs. But not necessarily. Theory suggests that something called a neutralino would require about the same amount of energy as a Higgs to make, and so it might turn up at about the same time. A neutralino is a very different sort of beast – one that promises to lead physics into the promised land that is called supersymmetry.

Supersymmetry brings hope that physics will be able to jettison the Standard Model's arbitrary fiddle factors. The price it extracts for doing so is to double the number of particles needed to make sense of the universe. Neutralinos are (or, at least, are predicted to be) the lightest and most stable of these new particles. And their stability means they may also solve a cosmological mystery, which is that a quarter of the universe seems to be made of dark matter that can be detected only by its gravitational interactions. Many physicists think this dark matter is made largely of neutralinos.

That neutralinos feel gravity but not electromagnetism makes them hard to detect. (They also feel the weak nuclear force, but that, as its name suggests, is little help.) The way to find a neutralino, therefore, is to note everything else that comes out of a collision and see if any energy is missing. If that missing energy matches the expected energy of a neutralino, then that is probably what has escaped detection.

A similar trick will be used to look for gravitons – hypothetical particles that may carry the force of gravity. These, too, would be an extension to the Standard Model. Moreover, if their missing energies turn out to have a particular set of values, it will be evidence that they live part of their lives in a hitherto undetected fifth dimension (the other four being length, breadth, height and time). That, in turn, will cast light on the complex field of string theory, which is the best available “theory of everything”, even though it requires the existence of not five, but 11 dimensions.

Miniature black holes that evaporate in a hail of particles known as the Hawking radiation may also turn up in the detectors. That would allow Stephen Hawking, who predicted such radiation in 1974, to collect a much-deserved Nobel prize – just as discovering the Higgs would surely grant one to Peter Higgs, who realised the need for such a particle in 1964. (Nobel prizes are not awarded to theoreticians until their theories have been proved.)

Indeed, the Higgs itself may do more than merely create mass. Put a bunch of them together and they will repel one another in a way that takes the very fabric of space along with them. They could thus be the explanation for the sudden inflation that the universe seems to have undergone just after it came into existence. They could even help to explain another 70% of the universe whose nature is unknown—the dark energy that is pushing space apart even now.

With all this to play for, Dr Heuer is a very lucky man indeed. As long as the machine behaves, of course. If it does not—and when you are running something whose operating temperature is just above absolute zero, and which has the power consumption of a small town, you can never be sure—then the SFr6 billion or so (about $5 billion) it has cost will start to look rather pricey. And if that happens, then particle physics may find itself back in the wilderness for good.

British physics

Newton's law of funding

In Britain, fundamental physics is in a pickle

ISAAC NEWTON, besides being the founder of modern physics, was also master of Britain's mint. That is a precedent which many British physicists must surely wish had become traditional. At the moment, money for physics is in short supply in Britain. Having spent a lot of cash in recent years, physicists and astronomers are now finding they do not have enough money to use the very facilities they paid to have built.

On December 14th, for example, the British delegation to CERN, Europe's biggest particle-physics laboratory, abstained from a vote to increase the budget to make best use of the Large Hadron Collider (see article). A vote for a rise, British delegates said, would be a vote for job losses elsewhere in physics. The budget was carried nonetheless and Britain is obliged to pay up. Perhaps not coincidentally, the country's government had announced a few days earlier that it would withdraw from the International Linear Collider (ILC), an $8 billion project to build the successor to CERN's new toy. Since America seems almost certain to cut its ILC budget, too, this project looks to be in trouble.

Public funding for research in both particle physics and astronomy used to be handled separately from other bits of physics, as did the building and running of big British-based experiments. On April 1st 2007 these areas were brought together by the formation of the Science and Technology Facilities Council. The result has been that when a relatively mundane particle accelerator called the Diamond Light Source, in Oxfordshire, proved to be some £80m ($160m) more expensive than expected, the axe had to fall on other parts of physics.

The cuts in particle physics are, at least, to future spending. Britain's astronomers are having their current expenditure cut. They can no longer use one of the twin Gemini telescopes, based on Hawaii and in Chile, that British money helped pay for. British membership of telescopes in the Isaac Newton Group on the Canary Islands has also been cancelled, as has British involvement in ground-based studies of the sun.

The government's response to the outcry has been as predictable as the scientists' call for more money. It has announced a review of funding of physics. For their part, researchers hope the budget will not fall like Newton's apple did.

Grape genetics

Vine times

The pinot noir genome is sequenced. GM wine, anyone?

THE battle between those who think character comes from nature and those who think nurture is the key is not confined to students of humanity. It lies at the heart of winemaking, too. For European growers, the variety of grape is important, of course. No one would mistake cabernet sauvignon for sangiovese or riesling for chardonnay. But grape varieties are normally propagated as cuttings; in other words, clones. What creates a wine's character, they argue, is the terroir—that mysterious combination of soil and microclimate that gives appellations contrôlées their cachet. In other words, the essence of a wine lies in its nurture.

Many New World winemakers would say phooey! to that. Where you grow your grapes matters—but no more than it does for any other crop. The true flavour is encoded in the genes and the consistency of a cloned crop is an asset. Environmental diversity is something to be resisted, not celebrated, since it masks the character of the grape and makes it difficult to produce a consistent product. It is not for nothing that the term “varietal wine” was invented in California.

As in the debate over human character, both sides have a point. But, again as in that debate, the naturist side of things is getting a boost thanks to the huge amounts of data on the role of genes that are flowing in. On December 18th that boost got bigger as the first full genetic sequence of a grape variety (pinot noir, as it happens) was published in the Public Library of Science. By unzipping pinot's genes, Riccardo Velasco of the Agricultural Institute of San Michele all'Adige, in Italy, and his team, have not only exposed many of the genetic secrets of this particular grape's flavours, they have also helped open the way for genetically modified wine.

In vino veritas

One surprising finding Dr Velasco made was the huge degree of difference, 11.2% in all, between pinot noir's two sets of chromosomes. Those sets of chromosomes come from the varieties originally crossbred to create the clone. These parental varieties must therefore have been very different from one another, for 11.2% is far more genetic variation than exists between, say, a chimpanzee and a human.

Dr Velasco's efforts have discovered a treasure trove of information for technologically oriented winemakers. His group has found hundreds of genes that encode enzymes which produce flavourings and aromatic compounds. That will help both those who want to make flavours more consistent and those who want to add novelty.

Knowing the pinot noir genome should also help people who would like to grow grapes in places now off-limits to them — either for climatic reasons or because local diseases would kill them. Florida is one example: it produces a few grapes for the table, but these are muscadines, a different species from those usually used for wine. Its wine production is a miserable one-tenth of one percent of the American market. The reason is that the state is home to diseases that clobber wine grapes. These include a bacterial infection called Pierce's disease, fungal infections such as mildews and rots, and viral diseases such as grape fanleaf virus and corky bark.

If Dennis Gray, a developmental biologist at the University of Florida, has his way, that will change. Dr Gray has been working for years on making vines resistant to these diseases by modifying their genes. This year he began field trials of grapes engineered to resist Pierce's disease and fungal infection.

Many people, though, hope that the problems of disease in grapevines may be solved without the sort of genetic modification that risks provoking consumer boycotts. Genetics may help here, too. An alternative to moving genes from one strain to another — the usual definition of genetic modification — is to create new varieties the traditional way by cross pollination, and then employ genetic-sequencing techniques to find out which progeny of such crosses have desirable combinations of genes in them.

Dr Gray is sceptical about this approach. When wild species of grape that have good disease resistance are bred with cultivated varieties possessing great qualities of flavour, he says, the result is almost always a wine of lesser quality that has only some of the desired disease resistance. Better, he thinks, to pick your genes precisely and deliberately engineer them into the target. Moreover, since the gene-products in question rarely turn up in the flesh of the grape (they are actually produced in the stems, root, leaves and seeds), the wine from a genetically modified vine should not contain them.

Whether that will be enough to persuade European consumers, raised on the mystery of terroir, remains to be seen—particularly as the benefits of disease resistance are reaped largely by producers. But a bottle of Californian pinot noir with genetically enhanced flavours might be attractive to those with jaded palettes. As a result, research into genetically modified wine is going on in the Old World, too—even in such stick-in-the-mud places as France and Italy. After all, as one of the characters in Giuseppe di Lampedusa's novel “The Leopard” observes, “if we want things to stay as they are, things will have to change.”