Unmanned aircraft

The fly's a spy

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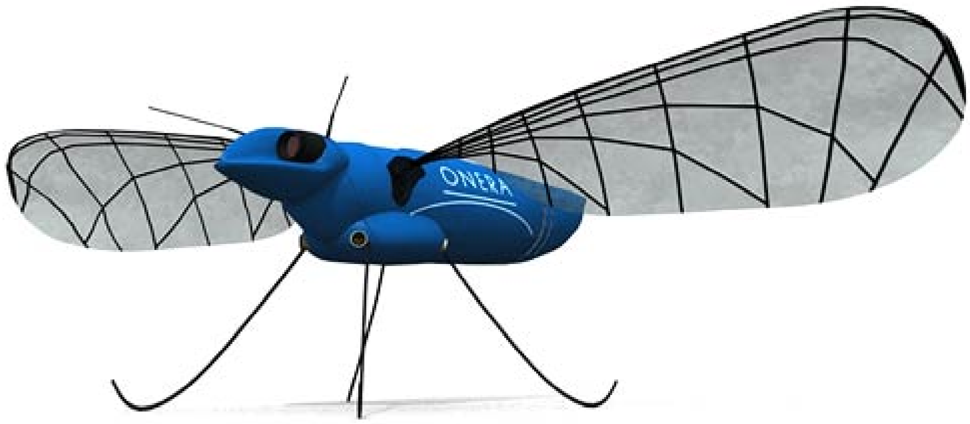
A new type of flying machine is watching you



Onera

JUST below a half-opened garage door a tiny device can be seen at the feet of someone lurking in the shadows. It looks like a blue dragonfly. Then its miniature wings begin to flap as it slips under the door and darts along the street. After rising through the air it stops to hover outside the window of a building several storeys high. There is an opening on the roof, and it slips inside. As it flits from room to room its video-camera "eye" transmits pictures to a screen on a remote-control unit strapped to the wrist of its clandestine operator.

This is not a scene from a James Bond film, in which 007 tests a new device from "Q", but an animated video produced by Onera, France's national aerospace centre, to explain REMANTA, a project to develop the technologies needed for miniature robotic aircraft. More bug-like flying devices are being developed in other research laboratories around the world. A few are already small enough to be carried in a briefcase; others are the size of a jet fighter and need a runway for take-off.

Having evolved from military use, drones, or unmanned aerial vehicles (UAVs), are taking to the air in increasing numbers for public-service and civilian roles.

They are being operated by groups as diverse as police, surveyors and archaeologists. A UAV helped firemen track the blaze that recently ravaged southern California. The most immediate advantage of a UAV is cost: operating even a small helicopter can cost $1,000 an hour or more, but the bill for a drone is a fraction of that. However, the growing use of UAVs is causing a number of concerns.

The first is safety. Last month America's National Transportation Safety Board (NTSB) completed its first-ever investigation into an unmanned-aircraft accident. Pilot error was blamed for the crash in Arizona in April 2006 of a 4,500kg (10,000lb) Predator B, a type of UAV used by American forces in Iraq and Afghanistan. It was being operated by Customs and Border Protection when its engine was accidentally turned off by the team piloting it from a control room at an army base. No one was hurt, but the NTSB issued 22 recommendations to address what Mark Rosenker, its chairman, described as "a wide range of safety issues involving the civilian use of unmanned aircraft."

The second concern is privacy. UAVs can peek much more easily and cheaply than satellites and fixed cameras can. Although it is possible to peer into someone's back garden with Google Earth, the images are not "live"—some are years old. Live satellite images can be impaired by clouds and darkness. A UAV, however, is more flexible. It can get closer to its target, move to new locations faster and hover almost silently above a property or outside a window. And the tiny ones that are coming will be able to fly inside buildings. Before long paparazzi will put cameras in them to snatch pictures of celebrities.

Unmanned aircraft have been around almost as long as powered flight. In the first world war they were used as flying bombs and by the second as radio-controlled targets and for reconnaissance missions. In Afghanistan and Iraq they have also been fitted with missiles.

In more recent years the development of unmanned aircraft has become a process of technological democratisation. Lightweight construction materials, engines, microelectronics, signal-processing equipment and navigation by global-positioning satellites (GPS), are all getting more sophisticated, smaller and cheaper. As a result, so have UAVs.

Flown from afar

A Predator, including ground equipment, costs around $8m. It is capable of operating in harsh conditions for more than a day. Even though a Predator may be flying over a remote part of Iraq, it is more than likely being controlled by pilots working in shifts and sitting in front of a video screen thousands of miles away at an air force base in America. Smaller, lighter and simpler UAV reconnaissance systems are being developed for troops in the field. These can be hand-launched, which reduces the need for remote-control piloting skills. Landings can be as simple as cutting the engine once the UAV has returned from its pre-programmed mission, at which point it flutters down to earth on a parachute.

Some hovering types can land automatically. One such device is made by Microdrones, a German company. Their flying machine looks like a small flying saucer with four rotor blades on stubby arms. It is not much bigger than the laptop computer used to program its flight and monitor what it is looking at. It can stooge around for about 20 minutes carrying video and infra-red cameras. Some police forces have started to try it out. Earlier this year British bobbies used one to keep an eye on a music festival, busting people for drug offences and catching others breaking into cars.

The Los Angeles County Sheriff's Department, which operates more than a dozen helicopters, has experimented with a foldaway UAV. It has wings and an electric engine, and can be assembled in minutes for hand-launching. It has a flight time of around 70 minutes. At around $30,000 all in, it is a lot cheaper than another new helicopter at around $3m.

Scientists are using UAVs to help with experiments. The Scripps Institute of Oceanography in San Diego flew a fleet of them in stacked formation over the Maldives in the Indian Ocean last year. They were collecting air samples simultaneously from different altitudes for research into the effects of global warming.

In time, UAVs are likely to be employed for all sorts of jobs for which the use of an aircraft big enough to carry a pilot would be too dangerous, impractical or too expensive. Surveyors, for instance, could use a hovering UAV to inspect the walls of a tall building in a crowded city. A television station could use one to show traffic conditions. And as with all new technologies, unmanned vehicles will have uses that have not yet been imagined.

Already, the technology is so easily available that you can build a basic UAV for around $1,000 from model-aircraft parts, the innards of a GPS unit and a Lego Mindstorms robotics kit—just as Chris Anderson has done. Mr Anderson, the editor of WIRED magazine, has set up a website for other DIY-makers of low-cost UAVs.

Not surprisingly aviation officials are watching things closely. “We have just entered a new era, and we have got to be concerned about protecting persons and property,” says Nicholas Sabatini, who is in charge of aviation safety at America's Federal Aviation Administration (FAA).

As the difference between sophisticated model aircraft equipped with auto-pilot systems and cameras and commercial UAVs blurs, the FAA is reconsidering its guidelines for model-flyers. At the moment these basically amount to keeping unmanned planes in sight at all times and away from people, buildings and other aircraft. Britain's Civil Aviation Authority is working with various industry groups to see what new rules may be needed. As a spokesman points out, UAVs will range from large jet-powered machines capable of flying across the Atlantic to tiny devices, so regulations will vary too depending on their size, weight and speed. Below a certain size, unmanned aircraft could be impossible to regulate. Nor would regulation do much to remove a chilling worry: that a UAV could be used as a weapon, to carry explosives or a biological agent.

Blown away

The smallest UAVS are the most intriguing because they will be able to fly in places where it was never thought aircraft could venture. Just how small might these machines be? The REMANTA bug has a total wingspan of less than 15cm (six inches). It flies by flapping its wings a bit like an insect. This means it needs less power than helicopter-type rotors and should be better able to withstand being blown off-course by wind, says Agnès Luc-Bouhali, a member of the project team.

Such a device can fly and be controlled remotely, but it could not yet conduct a mission like that portrayed in Onera's video. “Today, that is a dream,” admits Ms Luc-Bouhali. But the team is working on it. Miniaturising power sources and sensors, and fitting REMANTA with systems to operate semi-autonomously in order to avoid obstacles such as walls are the main areas of future research and development.

Such concerns also occupy researchers at Harvard University. They are working on a fly-like robot which weighs only 60 milligrams (0.002 ounces) and has a wingspan of just three centimetres—about the size of a real fly and so most unlikely to be noticed. This means going beyond scaling down existing components, like electric motors, and trying entirely new manufacturing processes. The Harvard “fly-bot” has flown, but so far only on a tether from which it gets external power.

A different approach is being tried by a team at Britain's Portsmouth University working with a company called ANT Scientific. Next summer the group will enter a robotics competition to be held at a British army urban-warfare training centre. The Portsmouth team is working on a UAV small enough to fit on a hand. Charlie Barker-Wyatt, a member of the university group, says all he can reveal about the device is that it contains sensors, can remain airborne for about 15 minutes, has a range of 500 metres and flies like a “hovering and spinning frisbee”.

Such tiny devices are of less concern to safety officials than bigger UAVs that would cause damage if they hit an aeroplane or crashed to the ground. Until now UAVs have mostly been confined to conflict zones, no-go military areas or remote places. Some operate under the same guidelines as for model aircraft. But they are not welcome in “controlled” airspace, where manned aircraft fly under air-traffic control. The FAA's Mr Sabatini says his agency does not want to stifle their development, but insists it must at the same time maintain safety standards. This means larger UAVs could be considered “experimental” aircraft and allowed to operate in closely controlled circumstances. But until they have some ability reliably to detect and avoid other aircraft they will have to keep clear of controlled airspace.

Some bigger systems operate like manned aircraft even in remote areas. The “pilots” of the Predator that crashed in Arizona were in contact with air-traffic controllers. But NTSB officials were still concerned about UAVs being flown too much like a computer game rather than as they would be if their pilots were on board.

Strict operating conditions for bigger UAVs might suit aviation firms, which are used to regulation and face competition from unmanned aircraft. Evergreen, a big aerospace group based in Oregon, has set up a UAV operation within its helicopter division. It offers relatively large and sophisticated systems for use in long-range operations, like checking on oil rigs, search and rescue, and wildlife monitoring.

Medium-sized systems might also have to be regulated, especially if used commercially. In the case of the smallest UAVs, the genie is already out of the bottle. When such devices are so small they might not even be noticed it would prove extremely difficult to regulate their use.

Unmanned aircraft will become more common, but how they swarm will depend on how safely they are used and how people react to the invasion of privacy. Some UAV missions may not be very welcome at all. “It smacks of Big Brother if every time you look up there's a bug looking at you,” reckons the FAA's Mr Sabatini. Time to buy a good fly swat, perhaps.

Public health

To avoid the Big C, stay small

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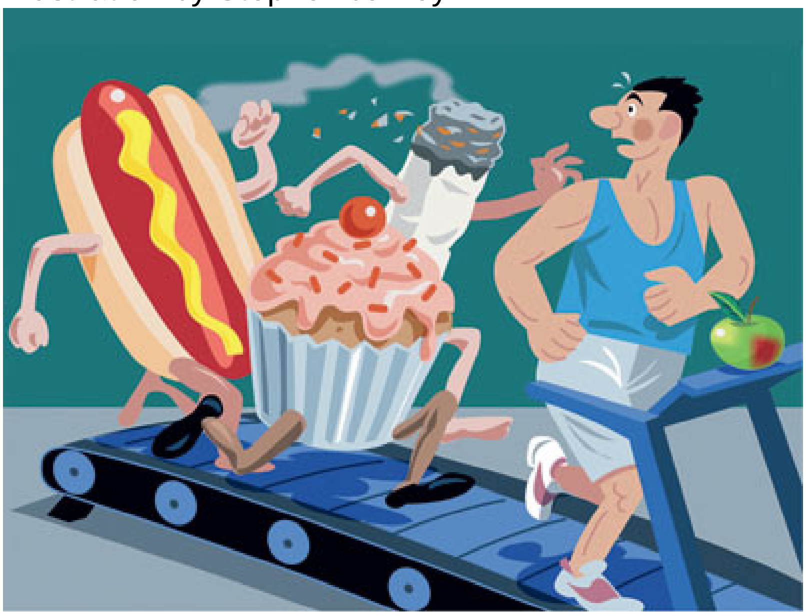
The best ways to prevent cancer look remarkably like those needed to prevent obesity and heart disease as well

Illustration by Stephen Jeffrey



EVERY day there are new stories in the tabloids about the latest link, sometimes tenuous, sometimes contradictory, between cancer and some aspect of lifestyle. If this is a recipe for confusion, then the antidote is probably a weighty new tome from the World Cancer Research Fund (WCRF). It is the most rigorous study so far on the links between food, physical activity and cancer—and sets out the important sources of risk.

Individually (except for smoking) these risks are quite small. However, many a mickle makes a muckle, and in total they add up to something significant. Roughly speaking, smoking is responsible for a third of cancers (smoking 20 cigarettes a day increases your risk of lung cancer 20-fold), poor food and lack of exercise result in another third, and other causes account for the rest. Some of this last third are known: genetic predisposition, ultraviolet sunlight, pollutants such as pesticides, and other factors including cosmic radiation and a naturally occurring radioactive gas called radon. But the picture is undoubtedly incomplete.

Risk analysis

How to reduce cancer risk (excluding smoking)

Body fatness	Be as lean as possible within the normal range of body weight, BMI 21-23
Physical activity	Be physically active, e.g. brisk walking at least 30 mins a day
Foods and drinks that promote weight gain	Limit consumption of energy-dense foods. Average energy intake should be 125kcal/100g of food. Avoid sugary drinks
Plant foods	Eat mostly foods of plant origin: fruits & non-starchy vegetables at least 600g a day
Animal foods	Limit intake of red meat, no more than 300g a week Avoid processed meat including bacon and ham
Alcoholic drinks	Limit alcoholic drinks, two a day for men and one a day for women
Preservation, processing and preparation	Limit consumption of salt to less than 5g a day. Avoid mouldy cereals and pulses
Dietary supplements	Aim to meet nutritional needs through diet alone
Breastfeeding	Mothers to breastfeed; children to be breastfed
Cancer survivors	Follow the recommendations for cancer prevention

Source: World Cancer Research Fund

The research has taken six years, involved nine research institutes, and examined more than half a million publications — which were whittled down to 7,000 relevant ones. From these, the new guidelines spring. Few come as news (see table), but the most surprising is the degree to which even being a bit overweight is a risk. One of the most important things a person can do to avoid cancer is to maintain a body mass index (BMI) of between 21 and 23. According to the WCRF's medical and scientific adviser, Martin Wiseman, each five BMI points above this range doubles the risk of post-menopausal breast cancer and colorectal cancer.

For those unfamiliar with BMI, it is calculated by dividing a person's weight in kilograms by the square of his height in metres. Until now, a healthy BMI has been thought of as being between 18.5 and 24.9. The report implies that this range should be narrowed. It is not enough to avoid being clinically obese, or even just a bit overweight. To minimise your risk of cancer, you have to avoid getting fat at all.

Indeed, paying attention to what you eat and drink seems to be the report's watchword. The list is depressingly familiar from injunctions relating to what is coming to be known as metabolic syndrome (obesity, late-onset diabetes, high blood pressure, heart disease and kidney failure, which are starting to look like symptoms of a single, underlying problem). Why cancer and metabolic syndrome might be connected is not yet clear. Cancer is caused by mutational damage to genes that otherwise hold a cell's reproductive cycle in check, and thus stop that cell proliferating. Metabolic syndrome, as its name suggests, seems to be related to the way cells process fats and sugars. There may be no direct link. But it may be that metabolic syndrome involves the production of growth-stimulating molecules that help cancers along.

On the matter of the miscellaneous final third, Devra Davis, an epidemiologist at the University of Pittsburgh and the author of a new book* on cancer, argues that more attention needs to be paid to pollutants and chemical hazards. Few Americans, she says, are aware that the roofs of 35m homes may be insulated with material containing asbestos (which is linked to a cancer called mesothelioma). She observes that a forthcoming report from America's Government Accountability Office will criticise the government for its lack of public warnings about such risks.

There is also concern in America about the overuse of medical X-rays, especially in emergency rooms. Not many people, for example, are aware that computerised tomography (CT) scanning uses large doses of X-rays. A scan of a baby's head is equivalent to between 200 and 600 chest X-rays. However, Dr Wiseman says these risks account for a trivial number of cancers and guesses the remainder are also something to do with nutrition.

Risky business

With hazards everywhere, plus the complications of genetic predisposition and age, it is hard for someone to work out his actual risk of developing either cancer or metabolic syndrome. If that is a recipe for inaction—as it often is—there may be a solution in the form of a personalised health check-up called the PreventionCompass.

This system has been developed by the Institute for Prevention and Early Diagnostics (NIPED), a firm based in Amsterdam. It requires the customer to answer a detailed questionnaire about his way of life and to undergo a series of tests. It draws its conclusions by running the results through a “knowledge system”—a database that pools expertise from many sources.

Coenraad van Kalken, NIPED's founder, says his scientists have programmed in risk factors for cancer, cardiovascular disease, diabetes, kidney disease, lung disease, “burn-out”, depression and other psychological disturbances. The system can, for example, use family history and elevated levels of a particular protein in the blood to work out who should undergo a biopsy to look for prostate cancer. And because it looks at lifestyle as well as biochemistry, it could similarly suggest lower alcohol consumption and a colonoscopy to someone at risk of colorectal cancer.

In the case of this disease, and also breast cancer, such early diagnosis prevents a serious and incurable condition. Bob Pinedo, the director of the Free University medical centre in Amsterdam, told a symposium held by the European School of Oncology in Rome on October 26th that it costs € 250,000 ($360,000) to treat (not cure) a patient with late-stage colorectal cancer for 20 months. In the Netherlands, that would pay for 1,000 colonoscopies.

Given the rising costs of dealing with cancer alone—in America this is more than $100 billion a year—prevention and early detection look set to take off. In trials of the PreventionCompass that NIPED conducted last year, more than 75% of the staff of four Dutch companies volunteered to join the scheme. Moreover, occupational-health officers in these companies claim that more than half their staff actually made changes to their way of life as a result. Not bad for a system that costs about € 100 a year for each employee.

This year two large insurance companies, which provide corporate health-care, income and disability insurance to employees, are offering to lower the premiums of customers who sign up to the PreventionCompass. Next year, the plan is to extend the scheme more widely, by recruiting Dutch GPs to offer it to people from lower-income groups who do not have such private health insurance.

The message, then, is prevention, not cure. And it is a message that needs to be heeded across the world as poor countries grow wealthier and adopt the eating habits and sedentary lives of the rich. It is an irony that evolution has shaped people to enjoy fat, sugar and indolence—things in short supply to man's hunter-gatherer ancestors, and desirable in the quantities then available. Wealth allows them to be indulged in abundance. Unfortunately, human bodies have evolved neither to cope nor, easily, to resist.

Electric cars

Wingless migration

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Is the market now ready for small electric vehicles?

APTERA is certainly not the sort of name an old-school carmaker would give to its newest creation. Biologists will recognise it as the term for scuttling wingless insects—silverfish and suchlike. But Steve Fambro, the boss of the eponymous Californian company that plans to make and sell electric vehicles under this name, hopes they will soon be swarming over the state's highways.

Unlike Tesla, another boutique electric-vehicle maker from the Golden State, Aptera is aiming for the bottom end of the market. A Tesla sports car will set you back $98,000 (or it would if you could get your hands on one: Tesla has delayed shipment of its first 50 cars until next year). An Aptera, by contrast, starts at $26,900, and should be available this time next year. And instead of a Ferrari knock-off, you get a space-age tricycle. But Aptera and Tesla have things in common. They are both small (Aptera has 16 full-time employees, though that will grow; Tesla has 250). They were both started by people with no experience in the motor industry. And they are both aiming to start by roping in the eco-fashionistas of California, and then work outwards to the mainstream.

The name Aptera was chosen because the vehicle resembles a small, wingless aircraft. Its three-wheel design exempts it from onerous federal testing regulations. The outer shell is made of a carbon-fibre composite, rather than metal (though within this is a passenger-safety cell modelled on those used in Formula 1 racing cars and constructed from aluminium and steel trusses). The lines are wind-tunnel aerodynamic. And protuberances are kept to a minimum. Wing mirrors, for example, are replaced by a rear-facing camera with a 180° field of view and the exhaust valves are recessed to minimise turbulence. In the pure plug-in version, those valves are for waste heat from the electronics. There is also a petrol-electric hybrid, with a single-cylinder generator that extends the range from 200km (120 miles) to 1,130km. Top speed is 150kph.

One reason for the emergence of firms such as Aptera is that designing a new vehicle has become as much an exercise in software simulation as in metal (or even carbon-fibre) bashing. That enables the firm's engineers to do extensive development work — even things like crash-testing — on a computer. This is much cheaper than building endless prototypes and driving lots of them into walls. Another reason is the widespread availability of previously specialised components such as lithium-ion batteries. That means that an upstart such as Aptera can focus on the electronic brains of the vehicle and its final assembly, rather than having to make everything from scratch. It can thus, it believes, turn a profit without having to produce large volumes.

Automotive history is littered with failed attempts to build electric cars, and sceptics might think the latest batch will be no different. That there is a fashion for such vehicles, though, is hard to deny. Besides Aptera and Tesla — which are, in their different ways, the most conspicuous examples — Venture Vehicles of Los Angeles is proposing an electric version of the Dutch Carver three-wheeled motorbike, while Phoenix Motorcars of Ontario, California, has produced a sports-utility truck. Meanwhile, REVA, an Indian firm, and Think Global, a Norwegian one, are making two-door hatchbacks. Indeed, according to the Venture Capital Journal, about $220m has been invested in such small firms over the past year and a half.

Moreover, one of the perennial bugbears of electric vehicles — that there is no on-the-road infrastructure for recharging them — may soon be addressed. On October 29th Shai Agassi, a Silicon Valley technologist and entrepreneur, said he had raised $200m to build a network of stations at which electric vehicles can rapidly be recharged.

That would make a big difference. Other ambitious propulsion technologies, such as fuel cells, have got bogged down by questions about the infrastructure needed for fuel distribution. If Mr Agassi, or someone like him, has his way it seems possible that despite its name Aptera might actually fly.

Drugs and sport

How to cheat without cheating

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Athletes and the placebo effect

THE murky world of doping in sport may be about to get murkier still. Having spent decades trying to detect the use of performance-enhancing drugs, officials may soon be confronted with the paradoxical problem of detecting their non-use.

The reason for this paradox is the placebo effect: believing a treatment to be effective is sometimes enough to make it so. It is what lies at the heart of otherwise scientifically unproven fields such as homeopathy—and also, it must be said, at the heart of a lot of mainstream medicine. An analysis published a few years ago suggested that perhaps a third of medically approved drugs might be acting as placebos. And that thought led Fabrizio Benedetti and his colleagues at the University of Turin to wonder if the placebo effect might be important in sport, too. The answer is that it might.

Every year the World Anti-Doping Agency publishes a list of prohibited substances and methods, divided into those prohibited at all times and those outlawed only during competitions. Dr Benedetti observed that morphine falls into the second category. Since it is a painkiller, denying it to athletes in training would be unethical. It is forbidden during competitions because its painkilling properties would give users an unfair advantage, but the effect is short-lived—unlike, say, that of anabolic steroids that build up muscles.

Killing pain, however, is one of the things that the placebo effect is best at. In 1999 Dr Benedetti himself showed that someone who is injected with morphine for two days in a row experiences a powerful analgesic response not only on those days but also on the next, if the morphine is replaced by a placebo without his knowledge. That led Dr Benedetti to wonder if the effect of legally administered pre-competition morphine might, perfectly legally, be carried over into a competition by giving a placebo.

In their new experiment, published this week in the Journal of Neuroscience, he and his colleagues simulated a sporting competition by pitting four teams of ten athletic young men against each other in a pain-endurance test. With a tourniquet strapped around one forearm, these men had to squeeze a hand-spring exerciser repeatedly until pain forced them to stop. Their scores, measured by the time they managed to keep going, were averaged over the whole team.

One of the teams received a morphine injection just before training sessions held two weeks and one week before the contest, and an injection of saline solution on the big day, along with the suggestion that it was morphine. Another received the same regime, but the saline was combined with naloxone, an opiate-blocking drug. The remaining teams received either no treatment at all, or the placebo on competition day alone.

Members of the team that received morphine followed by a placebo were able to endure significantly more pain during the competition than any of their rivals. In particular, those injected with naloxone did no better than the other two control groups. This finding supports the theory that placebos reduce pain by encouraging the brain to produce more natural opiates than usual.

Although hand-spring squeezing is not yet an Olympic sport, it is a good enough surrogate to suggest that these effects might be shown in real competitions, too. So the question is, how useful would Dr Benedetti's observations be, should they be taken up by an unscrupulous but legalistic coach?

That depends how cynical athletes really are. The placebo effect depends on what the recipient believes is happening, so he would have to think he was cheating, even though, strictly, he wasn't. Also, if the practice became widespread, it would be hard to maintain the fiction that the injection on competition day contained the drug. On the other hand, as Dr Benedetti observes, doctors have been getting away with giving placebos for millennia, and their patients still fall for it. Perhaps if it were sold to athletes as a form of homeopathy, they would not ask too many awkward questions.

Robot cars

A challenge, eh?

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From The Economist print edition

The competition to make a working robot vehicle has moved from the desert to the mean city streets

ONLY three years ago the world's most advanced robotic cars struggled to make their way around even basic obstacles such as large rocks and potholes in the road. Despite millions of dollars' worth of high-tech equipment, the vehicles managed to mimic little of what a human can do behind the wheel. Now, however, they can squeeze into parking places, flip on their indicators before making turns and even display the flair of a London taxi driver when merging into traffic.

This improvement in “autonomous vehicle technology”, as the jargon has it, is partly a result of prodding by America's defence department, which hopes a third of its ground vehicles will be robotic by 2015. To that end its research arm, the Defence Advanced Research Projects Agency (DARPA), has scaled back the traditional process of handing out large research grants and getting nothing useful in return. Instead, it has been running a series of grand prix for such vehicles. The prix in the latest, due to take place on November 3rd, is $3.5m—of which $2m will go to the vehicle best able to negotiate its way round Victorville, a former air force base in southern California, with $1m and $500,000 to those in second and third places.

The first of DARPA's Grand Challenges, in 2004, was a flop. The prize on offer then was $1m—winner takes all. The challenge was to follow a course 229km (142 miles) long across a desert using only the satellite-based global positioning system as a guide. That year, no one claimed the prize.

In 2005, the robots did much better. Stanley, Stanford University's modified Volkswagen Touareg, won the money; four other vehicles also finished the course. So this time, having allowed the teams an extra intervening year to tinker with their machines, DARPA has made the Challenge more challenging. Not only must entrants keep to the tarmac and obey the rules of the road, they must also avoid colliding with a number of other cars being steered round the base by stunt drivers.

The desert vehicles relied on radar, laser range-finders and speedy, cleverly programmed computers to avoid meddlesome objects while racing from point to point. The urban robots will use similar technology to accomplish much more difficult tasks. In effect, they will be taking the examination to receive a driving licence by demonstrating the ability to park in narrow spaces, slow down and indicate appropriately at junctions, and so on—as well, of course, as avoiding collisions.

Thirty-five teams are spending the week leading up to the event competing for 20 spots in the race. The favourites are Stanford and Carnegie Mellon University (whose car came second in 2005). As in a more conventional motor race, the logos of their sponsors—companies such as Google, Intel and Red Bull—cover almost every centimetre of their vehicles, reflecting millions of dollars in investments.

However, this is not a game that only the well-heeled can play. Indeed, the Stanford and Carnegie Mellon teams were small operations three years ago; as is usually the way, sponsorship followed success. Other academic entrants, such as the University of Louisiana at Lafayette, remain closer to the amateur spirit. And there are also ad hoc groups of enthusiasts such as Austin Robot Technology, which is composed of a mixture of workers at IBM, AMD and Sun Microsystems, and members of the University of Texas. There are even some corporate entries. The Oshkosh Truck Corporation, for instance, has modified some of its off-road military vehicles for the competition (with the aid, as it happens, of an additional $1m grant from DARPA).

Whether any of the entrants will stay the course and win a virtual driving licence remains to be seen. But if they do not do so this time, no doubt they will next, or maybe the time after that. The established mixture of competitiveness and amateur fair play will surely continue (teams routinely patch up each other's wrecks after a crash). And that seems to produce for DARPA what many millions spent on more run-of-the-mill research projects has failed to generate.

Bird migration

Blue light special

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Part of the avian compass needle has been identified

THE changing of the seasons sees millions of birds migrating over thousands of kilometres. How they find their way is a question that has perplexed biologists for decades. It is known that birds have built-in compasses attuned to the Earth's magnetic field. But how those compasses work and what they are made of have remained mysteries.

Part of the answer, however, seems to have emerged this week. As they report in the Public Library of Science, Henrik Mouritsen of the University of Oldenburg, in Germany, and his colleagues, think that proteins called cryptochromes are involved. These proteins are found in the eye, and they seem to tell a bird how its head is aligned with respect to the Earth's field, and thus which way to set off.

Cryptochromes are light-sensitive molecules. Dr Mouritsen focused on them because they are particularly sensitive to blue light. It has been shown experimentally that birds can align themselves to their normal migration routes in blue light but have trouble doing so in yellow or red, so the link seemed worth pursuing.

When hit by a blue photon, a cryptochrome molecule loses an electron. In theory, that electron could end up attached to a nearby flavin molecule, creating an unstable arrangement called a radical pair. This instability would be rectified by an electronic shift in the opposite direction, but the rate at which the shift took place would be affected by any magnetic field around. In principle, therefore, this rate of recovery could reveal information about the alignment of the Earth's magnetic field.

For that to happen, a bird would have to pan its head before it took off, just as a person might move his head to locate the direction of a sound. And, as Dr

Mouritsen found in 2004, that is what migrating birds do. What he did not know was whether avian cryptochrome molecules actually do form radical pairs with flavins, and if they do, whether those pairs last long enough for a bird to gather useful information when it pans its head.

To find out, he extracted cryptochrome from the eyes of some unfortunate garden warblers at a time when they would normally have been migrating. The molecules did, indeed, form radical pairs with flavin on exposure to light. What was more, those pairs last 1,000 times longer than the minimum needed for the birds to calibrate the signal from them against the Earth's field. That does not, of course, prove that cryptochrome is part of the compass mechanism, but it is pretty suggestive.