BY DANIEL CRESSEY AND EWEN CALLAWAY

TEAM SCIENCE

The Olympics is a vast experiment in human performance, sport technology and global travel. Nature *meets some of the scientists behind the scenes.*

Science has had a hand in every aspect of the Olympic and Paralympic Games. For the thousands of athletes, researchers have helped to develop training techniques, schedules, diet, equipment and doping checks. For the millions of spectators about to descend on London, they have contributed to urban planning, crowd control, public health and security. For the billions watching at home, they have shaped the technology that will measure athletic feats and beam them worldwide.

Yet those scientists toil in the background, understandably overshadowed by the sporting spectacle. Here, *Nature* profiles four scientists whose work will contribute to the giant human experiment that is the Olympic Games.

THE PSYCHOLOGIST

In 2000, the Spanish basketball team in the Paralympics learning-difficulties category swept the board to win all of their games and take gold. There was just one problem: many of the team were not intellectually disabled. After the scandal was revealed by an undercover journalist, the team was stripped of its medals, and anyone with a learning disability was excluded from the next two Paralympic Games.

This year, in London, they can return, in athletics, swimming and table tennis. Jan Burns, head of the Department of Applied Psychology at Canterbury Christ Church University, UK, is one of the key scientists responsible for ensuring that the athletes qualify for competition.

Intellectual disabilities are difficult to police because, unlike most physical disabilities, they are not always obvious. In the wake of the Spanish fiasco, the International Paralympic Committee and Inas, the international federation for para-athletes with an intellectual disability, sponsored an international research group to solidify the criteria for 'eligibility' (existence of a disability), and 'classification' (impairment of ability to play the sport).

Burns, a specialist in intellectual disability, joined the research group in 2009 and became head of 'eligibility' at Inas. "She had an incredible interest in the interaction and the application of these psychological concepts in this kind of an environment," says Peter Van de Vliet, the medical and scientific director of the International Paralympic Committee, based in Bonn, Germany. The criteria Burns helped to develop have paved the way for intellectually disabled athletes to return to the Paralympics.

According to the rules now, an athlete is eligible if he or she has had a developmental delay before the age of 18; has an IQ of no more than 75; and has a 'significant limitation' in adaptive behaviour such as social skills. Eligible athletes are then subjected to a battery of tests to show that they classify as disabled for a specific event. A swimmer, for example, would first be assessed on skills that are generically useful in sports, such as reaction time. Then his or her swimming performance would be compared with that of other athletes. Burns points at research showing that people with intellectual disabilities tend to take more strokes to cover a given distance, so classifiers will video swimmers in competition and assess their stroke ratio to see whether it falls within the 'bandwidth' of disabled swimmers. All this has to be comprehensively documented and reviewed by multiple researchers so that the system is robust against fraud.

Burns is currently working a hectic schedule juggling her Paralympics work, her regular academic job and huge interest from the world's media. "I'm currently going through and checking everybody's file, making sure we know enough about everybody who's come through the system," she says. During the Paralympics, which run from 29 August to 9 September, "I'll be around ensuring that the classification goes well and to be on hand if we do have any issues".

Work is already under way to see whether more sports can be added for the 2016 Paralympics in Rio de Janeiro, Brazil. This involves working out the skills that athletes need to play a sport, and how intellectual disabilities might affect performance — for example, pattern recognition might be relevant to the complex plays in some team sports. The early betting is that the Rio Paralympics will include rowing and will give a second chance to the game that started the story: basketball.

LET THE GAMES BEGIN
Science and the Olympics
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O. SCARFF/GETTY

Christiaan Bartlett will be part of a huge team manning a 24/7 drug-testing lab north of London.

THE DOPING DETECTOR

In this summer's 100-metre sprint, Usain 'Lightning' Bolt will attempt to hold onto his title of 'world's fastest man' against a younger and currently fleeter Yohan Blake. Yet one of the fiercest battles in the Olympic Games will play out in a giant, custom-built suburban laboratory in Harlow, 35 kilometres north of the Olympic village. Here, anti-doping experts will apply the most sophisticated tools in their molecular arsenal in the seemingly Sisyphean pursuit of those athletes who take performance-enhancing drugs.

The lab will screen for dozens of stimulants, steroids and other banned substances. Christiaan Bartlett, a senior scientist at the King's College London Drug Control Centre, which is running the Harlow lab, will direct the testing for biological drugs such as the blood-boosting hormone erythropoietin (EPO) and human growth hormone. Anti-doping science is notoriously — some say unnecessarily — secretive; Bartlett says that he cannot reveal what drug-detection techniques will be rolled out at the London games. All he will disclose is this: "We've got the most sophisticated equipment, we spent the past year or so developing and validating new techniques that will give us increased sensitivity in all of our areas."

The first challenge for Bartlett and his 150 or so colleagues lies in handling the sheer volume of urine and blood that Olympic and Paralympic athletes will be required to submit for testing during the games — collected from as many as 7,000 athletes days before and immediately after sporting events. Samples will arrive hourly, with one part prepared for testing and the other frozen as a back-up, and the lab will run around the clock to turn around most tests within a day. Bartlett has already decamped from his home in south London to live closer to the lab, and he knows that his weekends won't be spent watching sport.

The vast majority of the tests he oversees will come back with an all-clear. If the King's lab turns up any banned substances, scientists there will immediately inform the International Olympic Committee and other sport authorities, who will initiate an investigation and possibly disciplinary action.

Legitimate drugs are one target for Bartlett, who worked previously in food sciences and toxicology. Pharmaceutical companies such as Roche, Amgen and GlaxoSmithKline now routinely share information about drugs in their pipelines that could potentially be used by athletes. Months after the US Food and Drug Administration approved a new class of red-blood-cell boosters called CERAs in 2007, anti-doping scientists had developed a test for them. The test came too late for the Beijing games the following year, but retrospective testing stripped the men's 1,500-metre winner, Rashid Ramzi, of his gold.

Increasingly, dopers are turning to illegal labs in India, China and elsewhere that crank out drugs such as EPO that have been tweaked chemically to evade testing. Bartlett says that his team is ready. The test for EPO, for example, is designed to detect any forms of the protein made using genetic engineering, because these tend to be less acidic than the natural stuff.

Athletes participating in the London Olympiad will be the most heavily tested in the history of the games, but will that make them the cleanest? Bartlett is cautiously optimistic. Many countries screen their athletes before departing for London, and some sports have begun to use 'biological passports' that chart characteristics of athletes' blood over time, looking for changes that might signal illicit performance enhancement, even when a substance such as EPO cannot be found. "The general message is: athletes, if you're coming to London, beware," Bartlett says.

THE FLUID MODELLER

At the Beijing Olympics in 2008, athletes smashed 25 world records in swimming, more than in any other sport. Many gave the credit to high-tech swimsuits, which cut down on drag. But after Beijing, the international body that governs competitive swimming introduced rules that limited the advantage that could be gained from swimsuits, leaving athletes looking for other ways to gain an edge. British swimmers turned to fluid-dynamics researcher Stephen Turnock.

Turnock's speciality is hydrodynamics, particularly in ship design. It wasn't a huge leap to study how air or water flows around the human body, and for the past three years he has directed the Performance Sports Engineering Laboratory (PSEL) at the University of Southampton, UK. The lab previously worked with the British cycling team to devise more aerodynamic riding positions, which may have played at least a small part in the 14 medals that 'Team GB' cyclists brought home from Beijing. Swimming needed similar help, he says. "What British swimming lacked was an understanding of what the hydrodynamic forces were during the swimming processes."

Applying a scientific approach to swimming performance has proved a challenge, however. "With cyclists, you put someone in a wind tunnel and say 'What's your best position to lower your resistance?'," says Turnock. "It's a complex process to get the instrumentation right but that's a relatively simple bit of fluid dynamics because, typically, most of a position of the cyclist and the body is relatively fixed." But with swimming, a whole range of factors come into play, including roll along the length of the body, movement of the arms and the legs, forces that are transmitted from limbs to water and the effects of water pressure and movement in turn on the shape of the body. "There are so many variables and it's all happening quite quickly in a very noisy environment. It is very difficult to repeat exactly the same conditions every test run," says Turnock. "By the time you've got all that

London bound: researchers will use flight itineraries to predict the risk of disease outbreaks during the Olympics.

SOURCE: BIO.DIASPORA AT ST MICHAEL'S HOSPITAL, TORONTO

uncertainty in there it's quite challenging."

The team at the PSEL devised some technical solutions. Its main system is based around a portable winch, which pulls a swimmer through the water fractionally faster than they would normally swim, a technique called overspeeding. Working at pools in which top British swimmers train, Turnock's team measured the tension in the winch line to assess changes in water resistance, and the researchers videoed lap after lap to see how, for example, adjusting posture or even the position of a swimming cap might change water flow and speed. "We can examine what they've done pretty much as soon as the swimmer gets out of the pool," says Turnock, who says that the information is all fed back to coaches and athletes.

Turnock's team has also been tackling some broader questions about training. Using the winch system, a willing team member and a full-body wax, he explored how body hair affects resistance in the water. (Answer: smoother is faster.) The group is also using computer modelling of the musculoskeletal system to work out how to improve the efficiency of swimming strokes.

Turnock's work with Britain's swimmers wrapped up well before the start of the games. But he hopes that what he has learned about the hydrodynamics of human bodies might feed back into his work on marine systems, such as designing rudders that adopt a more hydrodynamic shape under water stresses. He also improved his own swimming and, he says, "I can shout learned things at my children when they learn to swim now."

THE DISEASE TRACKER

Kamran Khan will not be anywhere near London during the games. The medical researcher will be sitting thousands of kilometres away at the University of Toronto in Canada. But he will be watching.

Organizers have predicted that several million people, from all over the world, will descend on London — along with their viruses and bacteria. Khan is part of an international team that is testing strategies for predicting the spread of diseases, such as some potential new strain of flu, as the crowds arrive.

In all probability, they will see nothing; but it's the 'what if' that keeps Khan awake. Disease outbreaks have been associated with mass gatherings in the past, including a spike in measles around the 2010 winter Olympics in Vancouver, Canada, and an influenza outbreak linked to a Catholic youth festival in Sydney, Australia, in 2008. "With as big a mass gathering as the Olympic Games we want to think about the potential for health threats, particularly for infectious diseases, to move around the world," says Brian McCloskey, the UK Health Protection Agency's national lead for the Olympics.

To assess those threats, Khan will be using the Bio.Diaspora project, which he has been running since he set it up in 2008. This web-based computer program brings together information on billions of flight itineraries, allowing researchers to see how people are moving around the world. To gauge the risk of those people carrying a pathogen, it will link up with disease surveillance information collected in real time during the games, such as by the HealthMap project at Children's Hospital Boston in Massachusetts, which trawls through news, reports from health-care systems and social-media chatter for signs of emerging infectious threats. If, for example, a new form of flu emerges in China, Khan can piece together a picture of the disease's spread and use it to predict the likelihood of an outbreak reaching London. This type of early warning might give health officials crucial extra time to warn the public and take preventative action.

In fact, the Olympics will be a major test of the utility of Bio.Diaspora and global-health systems during a mass gathering, says McCloskey. "It could be that it doesn't add a lot of value or it could be that it's critically important," he says. "We don't know the answer until we've done the experiment."

Khan hopes that the data on the global flow of people can inform the growing field of 'mass-gathering medicine', the study of the public-health risks posed by religious rallies, music festivals and sports events, which are attracting more people than ever before and from more-remote places. He likens global transport to "a network of arteries around the world. There are people moving through those arteries, there's a sort of physiology. And that normal physiology is disrupted or changed by certain types of events," he says. "These events have potential implications for global-health security, and we need to understand them better." ■

Daniel Cressey *and* **Ewen Callaway** *are reporters for* Nature *in London.*