population, overcrowded hospitals, rampant use of antibiotics in agriculture and increased international travel all contribute to the development and spread of multidrug-resistant diseases. You won't have to catch a superbug to be part of the problem. Resistance factors can spread while hidden inside non-pathogenic bacteria.

Hopes for a new wonder-drug are slim. "Antimicrobial development and immunotherapy appear to have frozen," says Stephanie Dancer, a consultant medical microbiologist at NHS Lanarkshire, and a specialist in the subject. "There are economic reasons for this, since short-term anti-infectives do not generate much profit, but it is also possible that there are only a finite number of microbial targets accessible for antimicrobial exploration." Antibiotics require decades-long R&D, and the meagre profits they generate offer little incentive for pharmaceutical companies to invest in them. Moreover, new drugs will ultimately fail just as their forebears did.



SENSITIVE ARTIFICIAL SKIN

Amputees will be able to feel through their prostheses with artificial skin developed at Technion - Israel Institute of Technology. The flexible material. comprising gold nanoparticles on a PET substrate - the plastic used for drinks bottles - detects pressure, humidity and temperature. Previous skins were limited to detecting pressure. Sensitivity can be tweaked by changing the thickness and material of the substrate, which offers potential applications in construction.

An alternative is to try to manage bacterial populations rather than wipe them out. The practice of dousing patients in antibiotics creates an environment that favours superbugs. But without such advantages, drug-resistant bugs can be beaten by their less hardy cousins. Populations of harmful bacteria also can be ousted from their environment by encouraging "friendly" bacteria to take their place, with the help of inoculations and probiotics. And, as many bacteria species only enter a pathogenic phase when population density is high enough, quorum-sensing blockers can trick these bugs into believing they don't have the numbers to mount an infection.

Inevitably, forgotten and ignored treatments will also be looked at again. Phage therapy, in which bacterial-killing viruses are introduced to the body like packs of hunting dogs, is back in the spotlight. Also under investigation are treatments which augment the immune system by complementing it with synthetic versions of the body's host defence peptides, or by helping it to identify pathogenic bacteria.

But the body is not the only battleground. Hospital design will have to be rethought, with a greater emphasis on hygiene and infection control. Increased levels of sunlight, closely managed air flow and passive cleansing measures such as antimicrobial surfaces can all reduce the numbers of bacteria living locally. The presence of panresistant bugs will sharpen the demand for isolation wards, and eventually we may see the revival of sanatoriums to house patients suffering untreatable infections.

"You can't expect governments to commit to building infection-proof hospitals in the current economic climate," says Dancer. "They require good evidence, or most likely a tragic outbreak of untreatable infection, before resources will be found."

For now, we need to make the most of the antibiotics we have. Better and more rapid diagnostics will alleviate the practice of prescribing broad-spectrum antibiotics in favour of more targeted medicine. Ultimately, we need a change in behaviour. We can't rely on antibiotics to suppress infectious diseases indefinitely. And tackling superbugs will demand huge levels of international co-ordination. "Successful interventions in one part of the world will be compromised by control deficits in another," warns Dancer. When it comes to global pandemics, we're all in this together. Frank Swain is the creator of SciencePunk

## SOLDERING WOUNDS

Gold nanoparticle and elastic polypeptide protein-solders will make tearing less likely when laser-sintering tissue.



## **Geocaching leads** to vaccine reform

worldwide is broken. But a treasure hunt will help real-time tracking. By Tom Cheshire



hat has long been a favourite game for geeks will in 2014 start saving children's lives. Geocaching, a global treasurehunt that has been

running since May 2000, now has more than six million players, who follow clues and GPS co-ordinates to find more than two million "caches", or secret locations, around the world. When they find a cache, players write a note to other gamers on the (physical) paper in the cache and also annotate it online. Now the game is being used to help children in the developing world receive the vaccines they need.

"Every 20 seconds, a child dies from a vaccine-preventable disease," says Seth Berkley, CEO of Gavi Alliance, a publicprivate health organisation that increases access to immunisation in poor countries. "One of the reasons for this is that [distribution] systems in the developing world were set up in the 60s and haven't really been modernised. Today, people still keep track of vaccines using pencil and paper, and the feedback loops of the vaccines moving through the system are extremely slow," Records of which children have had what vaccine are also patchy.

"So my question was," says Berkley, "how do we use modern tools to leapfrog over this system to one that could give us real-time data?"

This year he presented the challenge at TED in California. The idea excited Catherine Mohr, a senior director of medical research at Intuitive Surgical, a robotics-company and a keen geocacher.

Berkley needed a global method for tracking vaccines, which central coordinators as well as local doctors could access in offices and on mobile devices. The system needed to let people write notes, indicate when a vaccine was administered, and ideally store GPS information

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of where the vaccine needed to go next. It would also need to be asynchronous, for regions that have limited connectivity. And it had to be robust, resistant to tampering, and open.

"I just thought – they're trying to go geocaching!" Mohr remembers.

Mohr has recently been working with Groundspeak, the organisation that runs geocaching, and its API, to develop a proof-

of-concept application that will track vaccines. In 2014 she and GAVI Alliance will be piloting the system in various developing-world countries, piggybacking on Groundspeak's servers. If successful, vaccine-caching will be rolled out globally on a separate, parallel network. Thanks to millions of geeks, millions of children will be receiving their vaccines on time.

Tom Cheshire is WIRED's associate editor

# Medical training gets gamified

Simulators will transform surgical instruction – while helping students to retain their competitive edge. By Tom Cheshire



osing a life in a videogame is no big deal – which is why they appeal to doctors. *Patient Rescue* by TruSim lets medical students understand their patients' discomfort better by feeling the pain they feel. The same company's *Triage Trainer* helps them prioritise complex emergency responses.

In 2014, surgeons will be doing much of their training in the virtual world, too, using programs developed by Mimic, a Seattle software firm; Simbionix, an Israeli medical-training company; and Intuitive Surgical, makers of da Vinci, a multi-armed, scalpel-wielding robot controlled remotely by a surgeon through a console.

"We use virtual reality and computergenerated scenarios for surgeons to train," says Brian Miller, senior director of advanced product development at Intuitive Surgical. "Prior to the simulator, surgeons would have to set up the entire da Vinci system in the operating room, put the instruments on and so on. This removes the need for that: flip one switch and start training." The Intuitive Surgical training system is a "backpack" that attaches to the same console used in actual operations. This provides the processing power for the surgeon to explore a computer-generated environment through the da Vinci's 3D viewer.

The system's main uses are currently for training motor- and cognitive-skills, according to Miller. Surgeons can improve their robo-aided aim by picking up virtual tacks, for instance. And the computer can also come up with challenging scenarios for doctors, creating virtual complications. Users get precise feedback: "We have a computer between the surgeons and instruments, so we can track all of the motions. You get time to complete, economy of motion and so on."

Other programs currently being developed give instant feedback: if a doctor applies too much pressure to a virtual patient, his instruments will glow red. Remote training also means that students can be taught by experts from different institutions geographically far apart.

Intuitive Surgical first prototyped the simulators in 2011 but next year marks a step change for the product. "We're getting more realistic environments - the photo



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realism is more like a camera image as opposed to a 90s videogame." (Miller says the smoke effects from cauterising soft tissue are now particularly impressive.)



at Stockholm's Karolinska Institute will deliver drugs and help pinpoint cancers. And its software will also help qualified surgeons plan and prepare for an operation. A program developed by Simbionix lets surgeons take pre-operative images of patients and merge them with virtual environments, so they can plan procedures.

Simulation will also guide R&D: the company will use the software to prototype designs for future medical instruments for the da Vinci system, "to determine whether there's a path for an actual product".

Miller plans to take the simulator to conferences and run competitions between surgeons. "They really get into the leaderboards," he says. Surgery is getting closer to videogames in more ways than one. *Tom Cheshire is* WIRED's associate editor



#### MICROBUBBLE HEART IMAGING

Heart attacks will be easier to diagnose and treat using tiny gas-filled bubbles that travel through the bloodstream to the point of damage. Introduced intravenously, the microbubbles. developed at GE Global Research. reflect soundwaves. giving paramedics at the scene a very-high resolution ultrasound image of the patient's heart. They could then be burst by changing the sound's acoustic setting to release anti-clotting agents at the point they are needed.



### BIOSENSING TATTOOS

A simple temporary tattoo will tell athletes soldiers and others involved in strenuous activity when they are about to hit the "wall' - the sudden energy drop caused by lactate levels in the blood becoming too high. Developed by a team at the University of California, San Diego, the electrochemical biosensor monitors lactate levels in the subject's sweat and alerts them when they approach the danaer zone. Currently, lactate monitoring involves blood tests.

## INSTANT HIV TREATMENT Thanks to recent medical inroads, the prospect of an Aidsfree world is no longer a theoretical one. By Damien Brown



t last, some good news regarding HIV/Aids in Africa: more people than ever are being treated with safer, cheaper and increasingly effec-

tive drugs, and we are now on the verge of bringing the spread of the virus down – using currently available treatments.

Today, more than seven million Africans living with HIV/Aids are receiving antiretroviral therapy (ART), an increase of almost 100-fold in less than a decade. Drug costs have decreased from \$10,000 (£6,320) per person annually to less than \$100 - the results of increased funding and a series of legal and trade decisions allowing poorer countries to access generic or discounted medications.

Newer treatments are also improved. Side effects are fewer, and tripletherapy combinations are increasingly provided as a single tablet, meaning improved adherence and lower potential for the emergence of drug resistance. Therapy is being started earlier and patients are living longer: rather than rescuing a broken immune system, we're preventing its deterioration. In line with this, the World Health Organisation recommended in July 2013 that ART be commenced when the CD4 (lymphocyte white cell) count drops below 500, rather than the previous cut-off of 350. Nine million more people are now eligible for ART in resource-limited countries, bringing the total to 26 million - about 75 per cent of the world's HIV carriers. Not all those eligible will immediately receive treatment, however: funding and health-system shortfalls mean millions won't, at least not for years; but there is consensus that this is what we should strive for.

But despite this rapid progress in treatment, we're losing the battle on a broader front: for every person who commences Medicine