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'Epidermal electronics' tattoos: a giant step forward for cyborgs

A new skin patch that can monitor heart and brain functions could be used to enhance the body's well-being, reports Roger Highfield.



Purely medicinal? Tattoos, or 'epidermal electronics', could be a regular feature at the surgery



By **Roger Highfield**
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One day soon, your doctor might prescribe you something that looks like a colourful temporary tattoo. But when you apply it to your skin you'll end up with more than an interesting pattern. Your epidermis will be coated with a gossamer-thin layer of electronics. In the short term, this tattoo will be used to monitor your well-being. But in the long term it could be used to enhance your body as part of a remarkable new phase in human evolution, one foreseen by Edgar Allen Poe in the 19th century.

The immediate potential of these patches was outlined last month at the annual American Chemical Society meeting in San Diego, by Dr John Rogers of the University of Illinois. He told the meeting that he sees these rub-on "epidermal electronics" as a new way for doctors to monitor patients. These skin patches can detect and record a series of signals to check the health of brains, hearts and muscles without tethering the owner to bulky machines using electrodes glued with gels and tape, or even needles.

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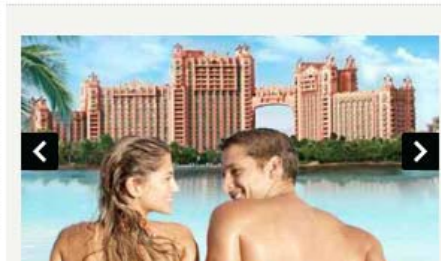
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The patches, encased in water-soluble plastic, are transferred to the skin just like a temporary tattoo-transfer, with a backing that peels off. Their wearers can't feel them because they cling on to the skin by feeble electric forces between molecules (named van der Waals forces, after the Dutch physicist who first described them in 1873).

Better still, for the style-conscious at least, they can be covered with a real temporary tattoo and protected with a water-repellent spray so that they last for several days. Yet they can contain electronic circuits needed to monitor **health** status along with wireless capabilities that can be used to transmit data to the patient's mobile phone and on to the doctor's surgery.

The clever part was taking the brittle silicon used to build electronics and fashioning it into wires just a few billionths of a metre thick. These can give the electronics a flexibility that matches that of skin and can stretch and bend as people go about their business.

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The latest patch developed by Dr Rogers's team can both measure muscle activity and stimulate those muscles so they could be used for rehabilitation. But Dr Rogers envisages broader applications – from monitoring sporting performance to seeing how hydrated your skin is with solar-powered epidermal electronics.

Which brings us back to Edgar Allan Poe. In an 1839 short story, *The Man That Was Used Up*, Poe told the tale of a wounded soldier whose body was rebuilt using synthetic parts, including the "handsomest pair of whiskers under the sun". This was an early account of what we now know as a cyborg, short for "cybernetic organism", a term coined in 1960 by Manfred Clynes and Nathan Kline in an article about the advantages of merging technology with the human body to help astronauts to survive in space.

What I find fascinating is the way that cyborgs have stealthily evolved on Earth. In popular culture, humans and machines are usually seen as separate, from the films of Arnold Schwarzenegger to the forthcoming movie *Robot and Frank*. They are often pitted against each other. This summer will see the 100th anniversary of the birthday of the British artificial intelligence pioneer Alan Turing, and there will be much talk of his influential test of synthetic minds in which a "chatbot" is deemed intelligent if it can fool us into thinking that it's human from its written responses (the "Turing test").

Yet all the while, humans have steadily fused with devices such as pacemakers, contact lenses, prosthetics, insulin pumps and cochlear and retinal implants. "For years, techno-futurists worried about a doomsday moment when electronic brains and robots got to be as smart as us," said Dr Andrew Nahum, senior keeper at the **Science** Museum.

"But take a look at the museum's collections and you can see how we always exploit new technical leaps to suit ourselves, so that the rise of ever-smarter machines does not mean a world of us or them but an enhancement of human capabilities in a subtly integrated way."

Researchers are now looking at exoskeletons to help the infirm to walk, and implants to allow paralysed people to control limbs. Some are even discussing how to enhance brain power by electronic plug-ins. And, of course, there's now also the prospect of smart skin, thanks to the efforts of Dr Rogers's team in Illinois.

Forget about the rise of cyborgs, or indeed the Borg of *Star Trek* and the Cybermen of *Dr Who*. Millions of cyborgs walk among us already. Within a few decades, it won't be so easy to tell humans and machines apart.

Roger Highfield is the Director of External Affairs, National Museum of Science and Industry



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