who searched for images.

These results suggest that online images, and hence the online realm, are not only highly gendered, but that this gendered nature might also influence further gender bias in everyday life. Previous work shows that exposure to stereotype-confirming images negatively affects women's self-esteem and hampers their leadership aspirations, suggesting that gender-biased images can establish and reinforce gendered career choices[3]. Repeating the current study's measurements of unconscious bias using social categories other than occupations (for example, 'cousin') would enable a further exploration of the consequences of strong gender associations in online images. The authors' conclusions might also be strengthened by conducting the implicit association test with more participants and in different countries, or by further examining conscious (explicit) gender bias.

There are several lingering questions that are essential for future studies to address. What are the exact mechanisms that cause the Internet to become such a gendered environment with respect to online images? Could it be related to particular populations of Internet users, certain design choices or the transfer of existing offline imagery to websites? Once the exact mechanisms are known, what interventions could be put in place to ameliorate those dynamics? Answering these questions is imperative in an age in which images generated by artificial intelligence (AI) will probably become highly prevalent and widespread on the Internet. If these AI-generated images are based on online images that are already gendered, imagery found on the Internet might spiral into becoming increasingly gender-biased.

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Biomedical engineering

Light can restore a heart's rhythm

Igor R. Efimov

Implantable electric pacemakers save millions of lives worldwide, but they aren't perfect. A proof-of-concept study shows that using light to regulate a heartbeat might be a better option than existing strategies. **See p.990**

Life starts with a heartbeat and ends without it. This regular rhythm is set by the body's natural pacemaker: a collection of cells known as the sinus node[1]. When this node fails, cardiologists can implant an electric pacemaker to stimulate a person's heart back to a normal rate[2]. But standard pacemakers are powered by electrochemical batteries that have a limited life, and the devices are prone to electrode failure and interference from external electromagnetic fields[3]. On page 990, Li *et al.*[4] present a technique that uses the energy from light to stimulate the heart, which could offer a solution to these problems.

Heart muscle consists of cells that interact through chemical, mechanical and electrical signalling systems. The electrical coupling allows the entire muscle to be excited by enabling an electrical signal to spread rapidly from a single stimulation point. The other types of coupling have offered inspiration for alternatives to the standard electric pacemaker. Researchers have investigated the possibility of targeting specific proteins that can transmit the required signal mechanically or through changes in temperature or light. These sensors could be triggered non-invasively by light or ultrasound[5,6].

However, despite considerable efforts, these approaches are yet to yield clinically viable therapies. One obstacle is that both natural and genetically engineered molecular sensors are not sufficiently sensitive. Another problem is that existing devices are not sophisticated enough to interface well with human tissue. It has also proved difficult to achieve targeted and stable delivery of the genetically engineered molecular sensors to the heart.

An alternative tactic involves implanting biocompatible photoelectrochemical devices,

From the archive

Stephen Hawking proposes that black holes can explode, and William H. Bragg reflects on the perseverance of scientists.

50 years ago

Quantum gravitational effects are usually ignored in calculations of the formation and evolution of black holes … Even though quantum effects may be small locally, they may still … add up to produce a significant effect over the lifetime of the Universe … [I]t seems that any black hole will create and emit particles such as neutrinos or photons … As a black hole emits this thermal radiation one would expect it to lose mass. This in turn would increase the surface gravity and so increase the rate of emission. The black hole would therefore have a finite life … For a black hole of solar mass this is much longer than the age of the Universe. There might, however, be much smaller black holes which were formed by fluctuations in the early Universe. Any such black hole … would have evaporated by now. Near the end of its life the rate of emission would be very high and about 10^{30} erg would be released in the last 0.1 s. This is a fairly small explosion by astronomical standards but it is equivalent to about 1 million 1 Mton hydrogen bombs.
From *Nature* 1 March 1974

100 years ago

In what way do we hope to benefit by research? … There is so much … work to be done before the good observations come; it may be that weeks are spent in preparation and five minutes in making the actual measurement. It is all very humiliating; and the blunders one makes are very foolish … [O]ne redeeming feature is that … there is always the hope … every student … who strives to understand the workings of Nature by experiment … is paid by … discovery of a richer world. There is a fellowship between all who have tried to understand … [W]e must research, and with all our energy … [T]he spirit of research is like the movement of running water, and the absence of it like the stagnation of a pool. Scientific research, in its widest sense, … is an act of faith in the immensity of things.
From *Nature* 1 March 1924

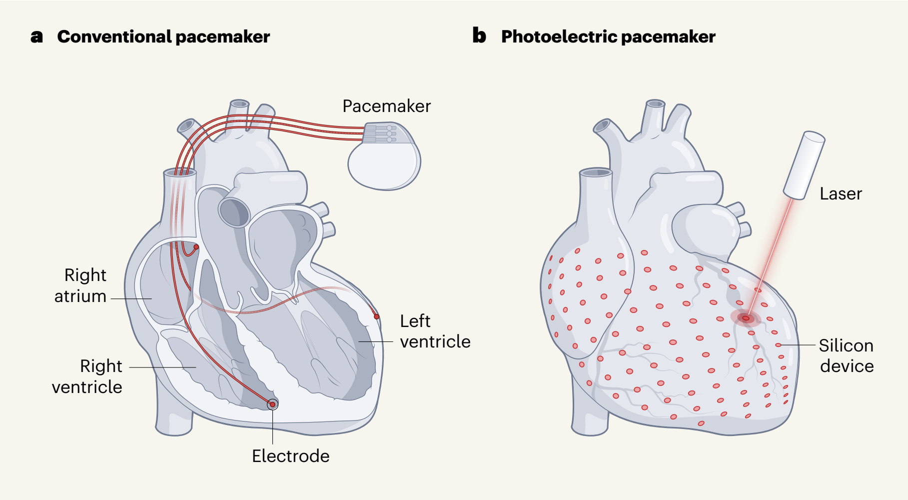

Figure 1 | Improving pacemaker design with light. **a**, In the best conventional pacemakers currently available, the device is connected to electrodes that pace contraction of the right atrium or the right and left ventricles using electrical stimuli. This strategy can lead to asynchronous contraction, and can otherwise fail owing to a limited battery life and the unreliability of electrodes. **b**, Li *et al.*[4] propose an alternative pacemaker that can stimulate the heart at several sites non-invasively using silicon, which is photoelectric, meaning it can convert light energy from a laser or a light-emitting diode into an electric current. The authors' proof-of-concept design successfully paced a pig's heart *in vivo*.

which convert energy from light into an electric current. More than a decade ago, a silicon-based photoelectrochemical device was proposed as a prosthesis for people with damaged retinas[7]. Members of the same research group as Li *et al.* then came up with a set of design principles for interfacing such devices with various biological targets[8].

In the present work, Li *et al.* produced a proof-of-concept device that uses laser light to generate an electric current in a silicon device that is designed to be implanted at the surface of the heart muscle. The authors tested the device on isolated heart cells, as well as on an intact heart that had been removed from a rat. They then showed that they could use the device to stimulate a mouse's heart *in vivo*. Finally, Li *et al.* demonstrated that their device could reliably pace a pig's heart, either during open-heart surgery or after an endoscopic operation.

As part of the characterization of their device, Li *et al.* mapped the 3D distribution of the electric current that was generated below the surface of the heart muscle. The current's effect on the heart can be understood by quantifying an 'activating function' that stimulates the heart muscle through a set of virtual electrodes[9–11]. The authors' 3D map enables calculation of this activating function, which can then be used to optimize the energy and waveform characteristics of the light required for clinical application.

One of the key challenges of implantable pacemakers is that they can cause the different parts of the heart to contract out of sync. Unlike a healthy heart, which is stimulated by the body's conduction system, a heart that is controlled by a pacemaker is stimulated by electrodes that are usually implanted in the right atrium or ventricles (Fig. 1a). Although the electrical signal travels rapidly through the whole organ, this localized stimulation can result in asynchronous excitation, leading to out-of-sync contractions. Various resynchronization devices add a left ventricular electrode, preventing and mitigating heart failure in such cases[12]. However, these devices either target only a few sites in the heart or they require precise implantation of one electrode at a specific point in the conduction system.

Li *et al.* say that this problem can be overcome by stimulating the heart at several sites using a network of their silicon devices (Fig. 1b). However, it is unclear how these devices will be joined together, and how they might be implanted in a beating heart.

"Implantable pacemakers can cause the different parts of the heart to contract out of sync."

There are other engineering challenges to be surmounted. First, the heart is surrounded by a layer of fat. Will implantation involve penetrating this fat and anchoring the device to the muscle? Or will the device and its light source be delivered through a vein to the heart's interior?

Second, the implantation of a foreign body might induce a physiological response, which could lead to Li and colleagues' devices being encapsulated with fibrous tissue, as was the case for early implantable electric pacemakers[13]. Third, and perhaps most importantly, it is not yet clear how the authors plan to deliver light to the heart, to which access is complicated by the rib cage and lungs.

In the authors' proof-of-concept experiments, the hearts were exposed, providing easy optical access to the heart surface. This makes it possible to stimulate several silicon devices with light. But a heart is usually covered with many layers of tissue, which scatter light. For this reason, the light used in Li and colleagues' strategy would either have to be generated by light-emitting diodes in the devices themselves or be directed to the heart from a remote source through light guides[14]. Both approaches have the same problem as conventional electric pacemakers: the devices can be rejected by the body, or otherwise fail. Ideally, if there is a way of stimulating Li and colleagues' devices through the rib cage, external light sources could be incorporated into a wearable device. However, the device's sensitivity might prove insufficient for this solution.

With all of these hurdles still to be cleared, it is difficult to predict when or whether photoelectric stimulators, such as the one designed by Li and colleagues, will prove to be more robust than conventional electric pacemakers. However, the authors' exciting proof of concept shows the enormous potential that the technology holds, and suggests that photoelectric devices could eventually transform a range of therapies, including those requiring neural, muscular and cardiac stimulation.

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