Device

CellPress

Editorial

A softer touch for biological systems

In this June issue of *Device*, we have a number of papers that highlight an important aspect of how device engineering with living systems has evolved recently. As usual, there's a wide array of topics covered in this issue, from a perspective on battery-free cardiac pacemakers to soft robots for fluid manipulations all the way to the device physics of superlubric materials in "slidevices" (a particularly fascinating topic that should certainly be part of any modern device engineer's reading list). However, one thing that ties many of these manuscripts together is the challenge of interfacing technology with living materials. We'll have a dedicated special issue on translational bioelectronics later this year (see our Call for Papers page for details if you're interested), but looking at this specific angle in the context of these works is of value for what it can show us about how inventing robust methodology is key to the invention process.

Take, for instance, Mehmet Toner's paper in this issue on cryoprotectant loading during a key step of the human *in vitro* fertilization (IVF) process. The long story made short is that when the oocyte—also referred to as an "egg" cell—is extracted from the patient, it cannot simply be frozen but must be first surrounded by a type of cryoprotectant liquid to ensure that both the freezing and thawing process can be undertaken without destroying the cell's integrity. This is one of the first true bottlenecks in the IVF process when discussing overall success of the procedure; not only do these incredibly valuable cells need to survive the freezing process, but also, the process that applies the cryoprotectant is very mechanically taxing to the oocyte, leading to many specimens that are functionally non-viable due to any number of failure points. Traditionally, automated systems for handling cells struggle with manipulating samples like this—a common issue in liquid-handling robotics is shearing cells, for instance—and as a result, this process is currently carried out by hand, with an extremely experienced technician carrying out the procedure in a very low-throughput manner. Coupled with operator-to-operator variability (let's hope that your technician didn't overdo the coffee this morning!), the cost of IVF in both time and money is very much tied to this early preservation step. Having spoken to an increasing number of my peers who have chosen IVF for their own family planning, I have observed that the emotional toll of these failed procedures and lost samples is non-trivial.

So then, what is the solution? Toner and co-workers took a hard look at how the interfaces in a microfluidic device would interact with the cell in transit and designed a system that fully eschewed electronics in favor of fluidic logic. This sort of "flow computing" is something we've discussed in the past in the context of wearable and haptic devices, but the application here allows the device to engage with the cell essentially just using pneumatics. By avoiding motors and syringe pumps, soft materials forming fluidic transistors control precise timing to ensure that the oocyte is not only loaded gently but also that the timings are tied to the system's fluid pressure rather than an external force—think of it like carrying a balloon using pillows rather than a pitchfork. The result is an inexpensive device that greatly standardizes the process of oocyte loading and improves the success rate of the procedure, which will be a huge relief to anyone looking to cryopreserve their own reproductive cells in the future.

This work emphasizes that rethinking traditional electronics in otherwise "solved" problems can bring about significant benefits to the end user: the patient. Another paper in this issue from Zhou Li and co-workers describes a soft supercapacitor that is fully biodegradable *in vivo*. This is another work that looks to a problem that is technically addressable with traditional electronics but has taken advantage of cutting-edge materials to advance patient outcomes—in this case, when using electronics during a surgical procedure, such as the administration of an implantable device, power is typically needed in the living system. While there have been myriad efforts to develop novel methods of powering these devices, most mature technologies end up requiring some sort of external tether or wireless power solution. These solutions tend not to be indefinitely biocompatible and so the patient will require a second operation to remove them. Saying nothing of the grief of living with such a device, every surgery comes with its risks, and thus, a power solution that could simply be excreted would be quite desirable. To address this, Li and co-workers developed a fully biodegradable, flexible supercapacitor that exhibited impressive capacitance, power density, and energy density with a lifetime of approximately one month, after which it simply dissolves away and is excreted. The details in the paper are worth reading, but the key to their work was developing soft materials that mimic the biological tissue that they reside in; the softer materials make the device better tolerated during its service lifetime, and its biodegradability ensures that the patient doesn't need additional surgeries to see it on its way.

The connecting thread between these studies and several others is the emphasis on looking to materials science when we're evaluating these complex problems, especially when they interface with biological systems. In this issue and throughout the history of the journal, we've shown how a keen eye toward materials science and cell biology has proven critical to challenging prevailing notions of what can and cannot work to ultimately improve patients' lives. What other assumptions have we made based on traditional mechanical and electrical engineering that should be rethought? Can we devise new actuation methods by observing how cells operate in their natural state? Do the biomechanics of living systems inform us how we might design devices that move more naturally with our bodies? Often ‘‘bioinspired’’ and ‘‘biomimetic’’ are thrown around like buzzwords, but I would not be surprised if the next generation of electronics looks a lot more like a cell colony than a computing cluster.

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https://doi.org/10.1016/j.device.2025.100838