

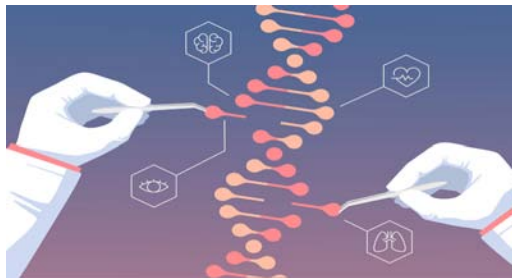
Biodigital Convergence

How will gene editing technologies like CRISPR affect you now and in the future?

The information in this pamphlet comes from **Policy Horizons Canada's** website where more information can be found.

(<https://horizons.gc.ca/en/home/>)

Policy Horizons Canada
360 Albert Street, Ottawa ON



From CRISPR to Prime Editor, the evolution of gene-editing abilities

Avalyne Diotte February 20, 2020

“CRISPR is a gene-editing technique that has revolutionized the field with major breakthroughs, especially since 2012.

While CRISPR offers a way to make specific alterations to genes more precise and affordable, the method is not perfect. The CRISPR technique has previously relied on locating a specific part of the genome, cutting both strands of DNA, and removing or replacing the severed part. But anomalies can arise in the repair process. **Some scientists have warned that unwanted or even dangerous mutations are possible. A new tool, developed in 2019, may refine and surpass existing CRISPR technology.** It is called prime editing and has a

reported 89% accuracy rate. Prime editing uses the CRISPR method with a **protein** that can generate new DNA...”

What is the biodigital convergence?

Policy Horizons | Horizons de politiques

July 29, 2021

“...**NARRATOR:** Digital technologies and biological systems are beginning to combine and merge in ways that could be profoundly disruptive to our assumptions about society, the economy, and our bodies. We call this the biodigital convergence.

Over the past 40 years the economy has transformed through digital evolutions in information technology, like the Internet, smart phone, applications, and big data analytics. The biodigital convergence could change the way we design and manufacture goods, revolutionize healthcare and agriculture, modify our environment, and even alter how humans evolve as a species...”

“...**PIERRE-OLIVIER:** ...The prospect of maybe being able to eliminate some diseases and also immunize the human body, even an entire generation, against some diseases. It’s also the possibility of personalizing humans in the future...”

Exploring Biodigital Convergence

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“...**Robots with biological brains and biological bodies with digital brains already exist, as do human-computer and brain-machine interfaces. The medical use of digital devices in humans,** as well as digitally manipulated insects such as drone dragonflies and

surveillance locusts, are examples of digital technology being combined with biological entities. By tapping into the nervous system and manipulating neurons, tech can be added to an organism to alter its function and purpose. New human bodies and new senses of identity could arise as the convergence continues...”

“*Table 1: New capabilities produced by the convergence of digital and biological systems*”

What new capabilities are opening up?	What combinations of biological and digital technologies allow this?	What is possible today?
New ways to change human beings – our bodies, minds, and behaviours		
Altering the human genome – our core biological attributes and characteristics	Advances in gene sequencing and editing, such as CRISPR/Cas9 Machine learning helps scientists predict which genes to target for editing	The world's first babies to have their genome edited born in China Molecular biology enhanced by tools from computer science
Monitoring, altering and manipulating human thoughts and behaviours	Neurotechnolog-ies read brain signals to monitor attention and manage fatigue Digital apps can help enhance brain health	SAP and EMOTIV collaborate to help SAP employees manage stress Americans spent \$1.9 billion last year on apps to keep their brains sharp
New ways to monitor, manage, and influence bodily functions, as well as predict, diagnose, and treat disease	Gene sequencing entire samples helps us to understand complex environments such as the	Guardant's liquid biopsy proves more accurate and faster than tissue biopsy in patients with lung cancer

	<p>human microbiome</p> <p>Digital devices can be worn or embedded in the body to treat and monitor functionality</p> <p>Machine learning can predict mortality and treatment outcomes</p>	<p>University of Waterloo researchers develop a self-powering sensor for medical monitoring</p> <p>Amazon patent will allow Alexa to detect a cough or a cold</p> <p>AI gives reliable coma outcome prediction</p>
<p>Creating new organs and enhancing human functionality</p>	<p>3D-printed tissues based on digital designs and production tools can create customized organs</p> <p>Biohacking with implanted digital devices to enhance bodily functions</p>	<p>Bioengineers successfully 3D printed structures that mimic lung tissue and blood vessels</p> <p>Lab-grown kidneys shown to be fully functional in animal recipients</p> <p>Implanted chips for a highly personal version of two-factor authentication</p>
<p>New ways to experience and interact with the world</p>	<p>Brain-machine interfaces that enable machines to be controlled through brain signals</p> <p>Prosthetics that use machine-learning algorithms to expand functionality and sensitivity</p>	<p>Neuralink announced an integrated brain-machine interface platform with thousands of channels</p> <p>Infinite Biomedical has its deep-learning-driven prosthetic control system approved by FDA</p> <p>FDA releases regulatory guidance on</p>

		<p>brain-controlled prosthetics</p>
<p>Creating new organs and enhancing human functionality</p>	<p>Machine-learning techniques for simulating protein folding and contributing to drug design</p> <p>3D printing tissue to test therapies</p> <p>Nanobots and nanomaterials can operate and precisely deliver drugs within living creatures</p> <p>Machine learning can predict the outcome of clinical trials</p>	<p>AI protein-folding algorithms solve structures faster than ever</p> <p>New Zealand scientists Shalini bio-prints tumour cells, hoping to grow tumours to see what treatments work best</p> <p>Tiny robots crawl through mouse's stomach to heal ulcers</p> <p>MIT researchers apply AI techniques to predict clinical trial outcomes</p>

The First US Law Targeting 'Biohacking'

Avalyne Diotte February 11, 2020

"In June 2019, California passed the first law in the United States targeting 'biohacking', the practice of do-it-yourself gene editing. Starting in January 2020, it will be illegal to sell CRISPR gene therapy kits without warnings that they are not safe to self-administer.

This is a weak signal that legislators are beginning to grapple with the fact that consumers can experiment with gene editing technologies without formal scientific training and outside licensed laboratories. Online biohacking videos have appeared on YouTube, showing how to self-administer CRISPR therapies to change the genes in some of their cells (such as arm muscles). Warnings about

this practice are one thing, but how to regulate and monitor it is another challenge entirely.

CRISPR gene editing allows for relatively precise changes to the genome of living beings, including humans. This could be a game changer for enhancing some human capabilities or addressing conditions that have a strong and identified genetic components. **Label warnings could be an attempt to curb enthusiasm and create a "proceed with caution" mindset. But if consumers perceive an opportunity to try an experimental cure, or enhance some desirable aspect of their bodies or minds, some may be willing to take the risk.**

Humans are very complex systems, and the consequences of experimental edits are not fully predictable in living organisms. In another weak signal, an experiment that successfully increased brain size in guppies negatively affected other systems. As an author reporting on the California bill notes: **"A big part of the problem is that our ability to manipulate DNA is shooting way ahead of our ability to really understand it."**

Bugbots: Harnessing insects

Avalyne Diotte February 20, 2020



"...Instead of building non-organic robots with the abilities of living things, we could use both digital and biological technologies to **exploit the exquisitely evolved capacities of existing organisms**. Insects with implants and biological modifications could be game changers in military, surveillance, environmental monitoring, search and rescue, and pollination..."