NANOMAGNETIC ACTUATORS FOR NEUROMODULATION

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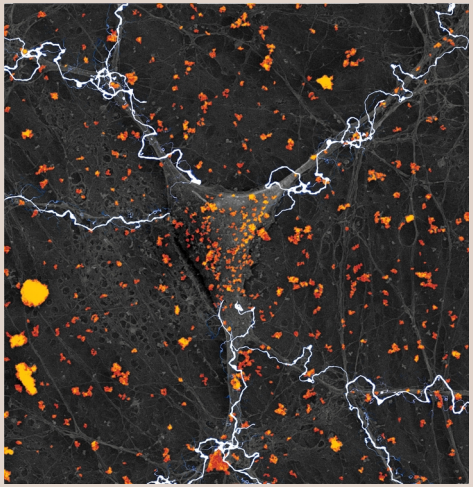
Stimulation of cell signaling and differentiation



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- *Guntnur R., et al., Soft Matter, 2021, 17, 2530-2538.*
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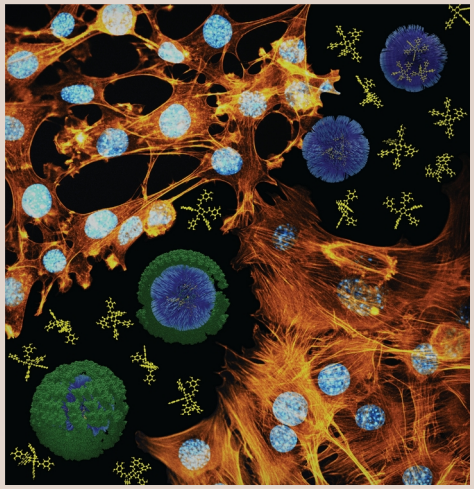
- *Gomez A., et. al., CMBE Journal, 2023.*

MACROMOLECULAR
BIO-INTERFACES

Controlled drug delivery



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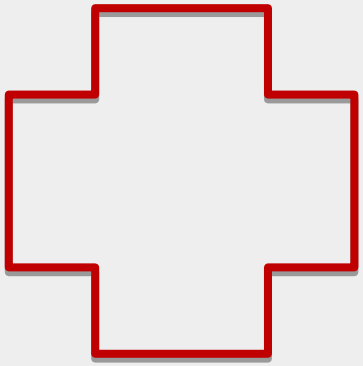
Bioelectronic Medicines



Bioelectronics
Emerging area of medicine that uses *miniaturized implantable devices* to deliver electrical stimulation to nerves to control wide range of bodily functions

Electroceuticals
Type of bioelectronics aimed at *replacing pharmaceutical* therapy

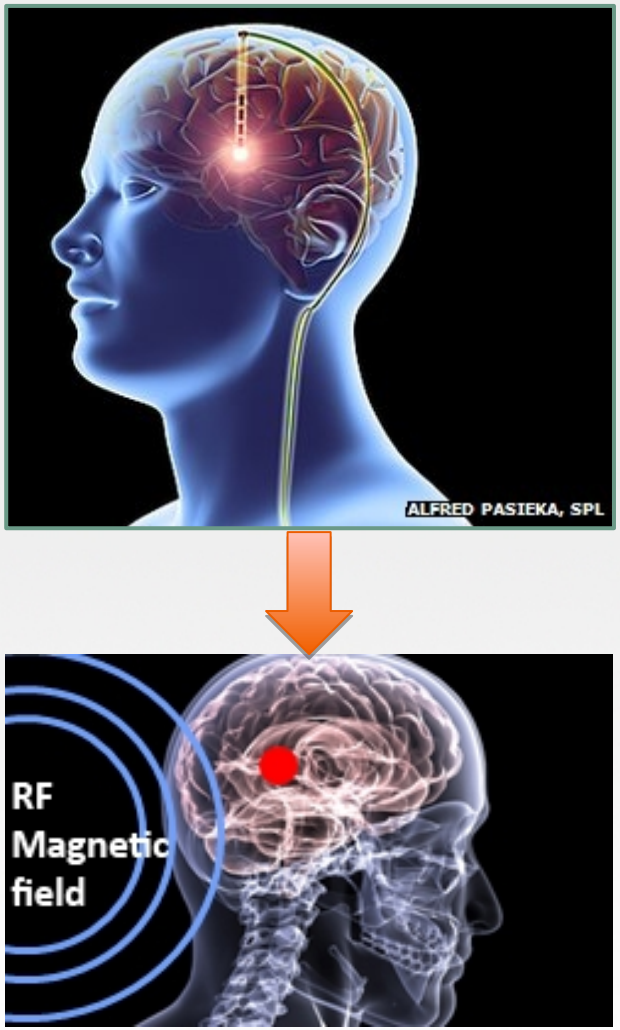
- Represents a **multimillion-dollar** opportunity with **$15,000 million dollars market in 2020 and expected to grow to $23,000 million dollars by 2026**

- *Medtronic, Roche, Siemens AG, Abbott, Honeywell International, Beckman Coulter, Life Sensors, Bioelectronic Corporation, Avago, Omnivision Technologies, Sotera Wireless, etc*.

Adapted from 'Bioelectronic jump-start the next wave of device therapeutics' by McKinsey & Company 2019

Treatment of Major Neurological Disorders

Deep Brain Stimulation (DBS)



- Mechanically invasive
- Non-specific cell type
- Surgical and electrochemical complications
- Unknown molecular mechanism

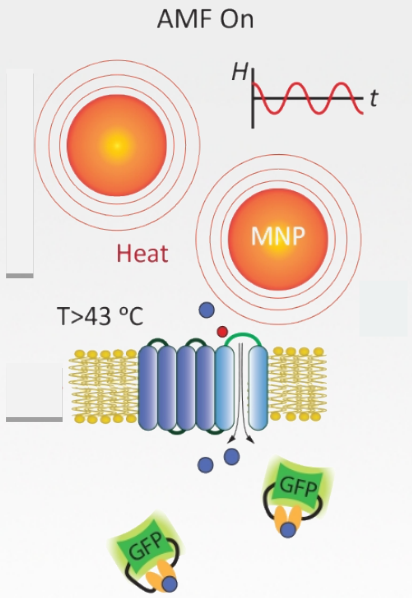
- Magnetic fields interact weakly with tissue due to low magnetic susceptibility
- Magnetic nanoparticles work as transducers of magnetic fields

Hergt, et. al, J. Mag. Mag. Mat. (2006)
http://www.treatment4addiction.com/drugs/society/teen-brain/

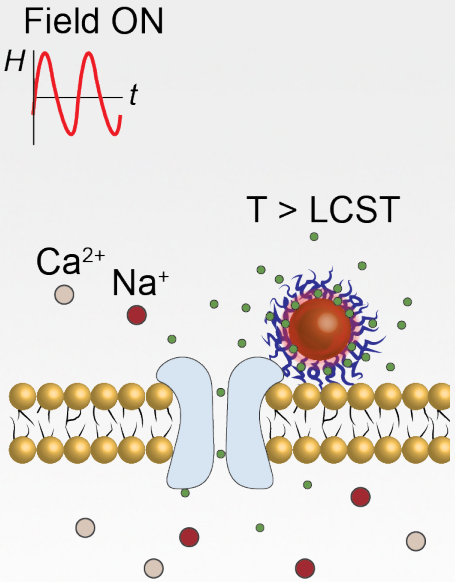
Nanomagnetic Actuators

Synthetic **magnetic nanomaterials coupled to channel proteins**, which respond to stimuli *(heat, mechanical strain, electric fields, and chemical interactions)*. In response, the channel proteins open allowing influx of ions, such as Ca^{2+} or Na^{+}, **triggering action potentials in neurons**.

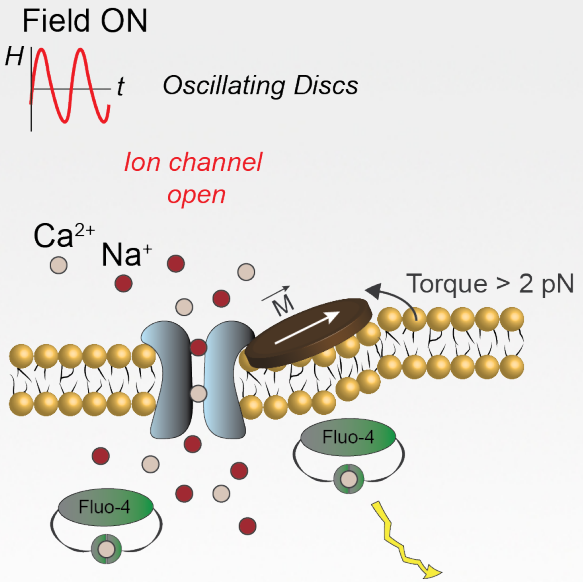
Thermal cues



Chemical cues



Mechanical cues



Christiansen M. G., et al., Annu. Rev. Neurosci,., 42, 271 (2019)
Romero G., et. al., Nature Reviews, 2, 92 (2022)

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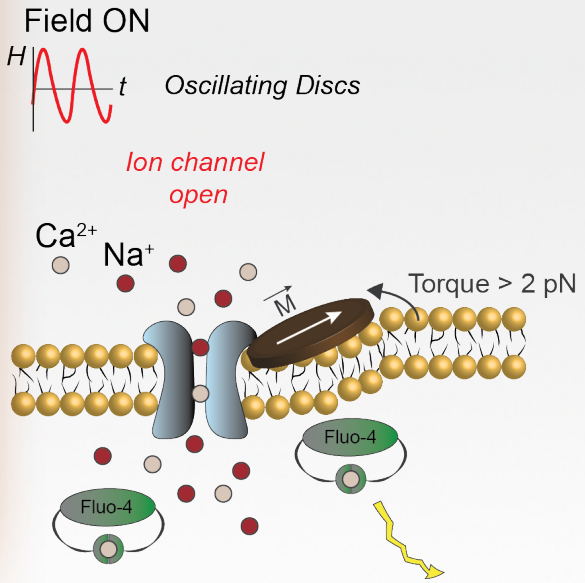
MAGNETIC HYPERTHERMIA CONCERNS

1. Potential **off-target heating** effects
2. Challenges in scaling **high-frequency AMFs** coils impede universal adoption of magnetic hyperthermia in biomedical research.

Mechanical cues



Christiansen M. G., et al., Annu. Rev. Neurosci,., 42, 271 (2019)
Romero G., et. al., Nature Reviews, 2, 92 (2022)

Polymeric Nanoactuators

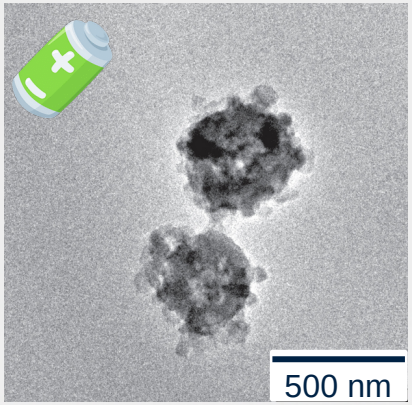
Electric cues for stimulation of activity and growth

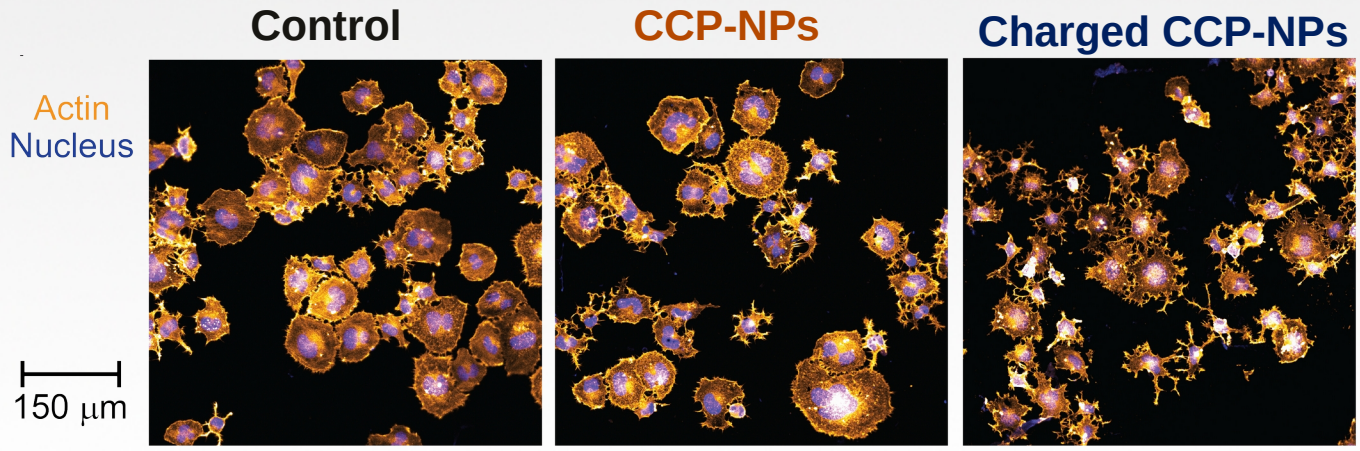
Biomimetic synthesized *conductive copolymer* 3,4-ethylenedioxythiophene (EDOT)-Pyrrole nanoparticles

-Pseudocapacitive behavior

-Good Conductivity

-High capacitance





Martinez-Cartagena et al., ACS Applied Nano Materials (2022)

Bioelectronic Medicines

Imagine a world where we treat deadly diseases with electricity instead of pills or chemo.

https://www.businessinsider.com/what-is-bioelectronic-medicine-2015-6

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THANK YOU

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