INNOVATIVE TRENDS AND BREAKTHROUGHS IN BIOMEDICINE

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KEY CATEGORIES

- Digital platforms
- Biological platforms
- Neuro-technologies
- Regenerative Medicine
- Post-Nanomedicine

Telemedicine

Digital Health / Artificial Intelligence improve access to health care

- Virtual visits available anywhere via mobile Apps: Affordable solutions
- Better quality of life for patients with chronic conditions

Future potential:

- Reduction of emergency room visits
- Resource optimization
- Health care access regardless of location and wealth

Image credit: www.jbmdl.jb.mil

Virtual Reality

Computer technology to create close to real life experiences

- Medical education and training
- Patient rehabilitation and recovery
- Disease diagnosis
- Scientific outreach

Future potential for pain management, mental health…

Image credit: singularityhub.com

Quantum Computing

First quantum computer for commercial use

- Unique computing power and speed
- Available to all users through internet connection

Future potential:

- Faster and optimized AI algorithms
- Support diagnoses, image processing, decision making, treatment optimization in healthcare

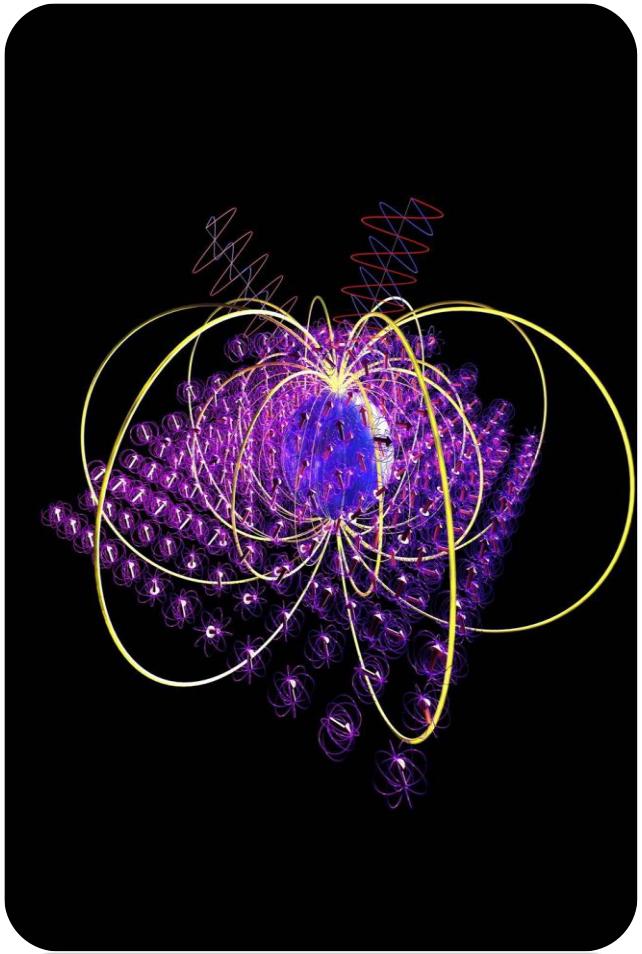


Image credit: www.jbmdl.jb.mil

Pharmacogenomic Therapy

Tailoring prescriptions according to genetic makeup

- Increase therapeutic effects and safety
- Many clinically approved for various cancers

Future potential for single cell sequencing in clinical trials to gain further information

Image credit: precisionmedicine.duke.edu

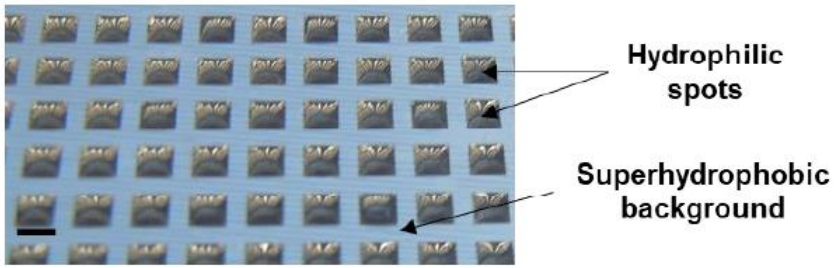
Project 'DropCellArray': New platform for screening of anti-cancer compounds on 3D tumor spheroids

European Research Council
Established by the European Commission

- Miniaturized platform made of an array of hydrophilic spots on superhydrophobic background

⇩

microarray of homogeneous, separated and stable nanodroplets



Figures from Popova et al. *Small* **2019** 15 (25) 1901299

- Dispensing of cancer cells in each spot and incubation of hanging nanodroplets

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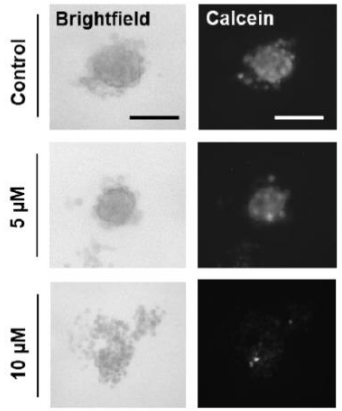
microarray of single 3D tumor spheroids, ready for treatment with anti-cancer drugs



Microscope images of HeLa spheroids treated with different concentrations of doxorubicin

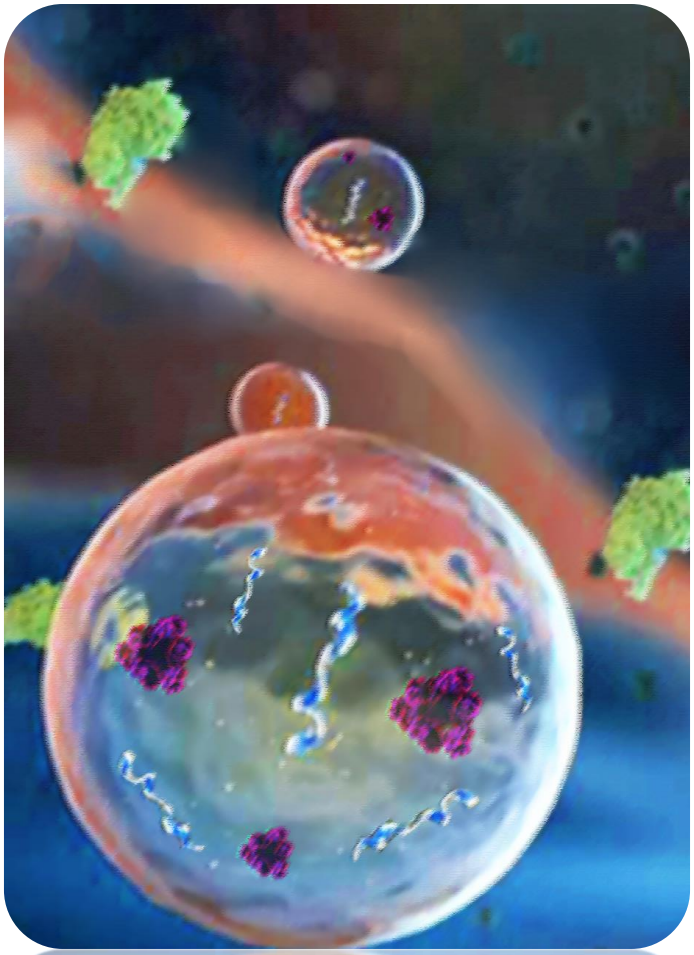
PI: Pavel LEVKIN
HI: KIT
Call: Starting Grant 2013

RNA(i) Therapy

Clinically approved RNA-based therapy

- Inherited genetic disease
- Silencing of gene that causes the disease
- Nanoparticle delivery

Future potential for many diseases (neurological, cardiovascular, cancer…) for interference and enhancement



Immunotherapy

Immunotherapy applications expand

- CAR-T cell therapy approved for lymphomas and childhood leukemia
- 2018 Nobel Prize (Physiology/Medicine)

Future potential:

- Potential universal strategy to cure many types of cancers
- Reduced recurrence and side effects
- More personalized treatments

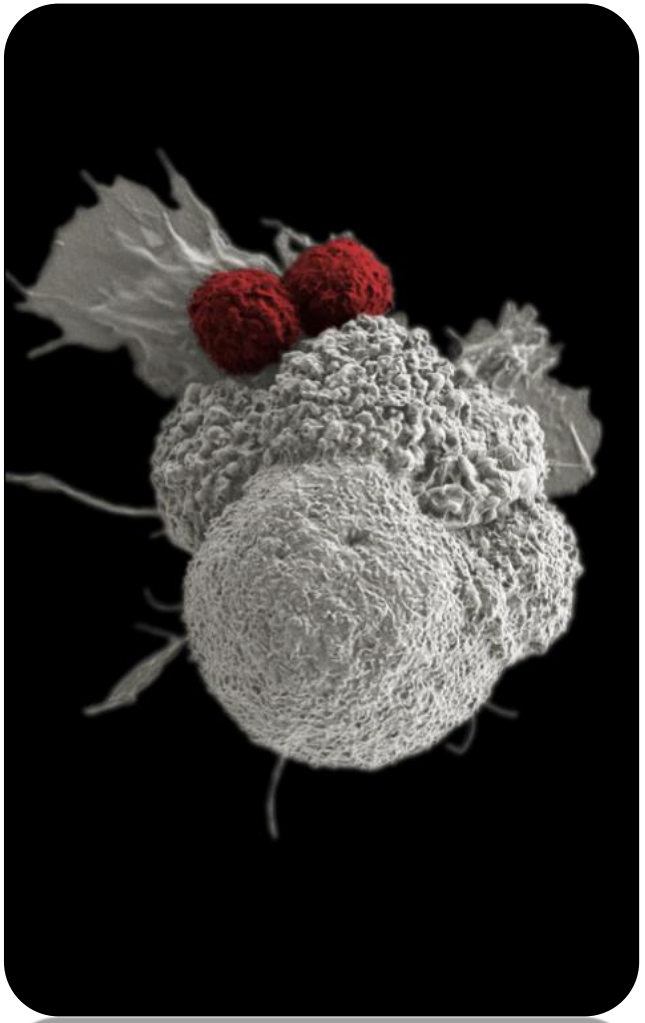


Image credits: NIH Image Gallery, Elena Serda, Duncan Comprehensive Cancer Center at Baylor College of Medicine, National Cancer Institute, National Institutes of Health

‘PeptiCRad’: Personalized oncolytic vaccines for cancer immunotherapy

European Research Council
Established by the European Commission

ERC Consolidator Grant
Principal Investigator: **Vincenzo CERULLO**
Host Institution: **University of Helsinki**

EU contribution: € 2.0 million
Project runs from 2016 – 2021

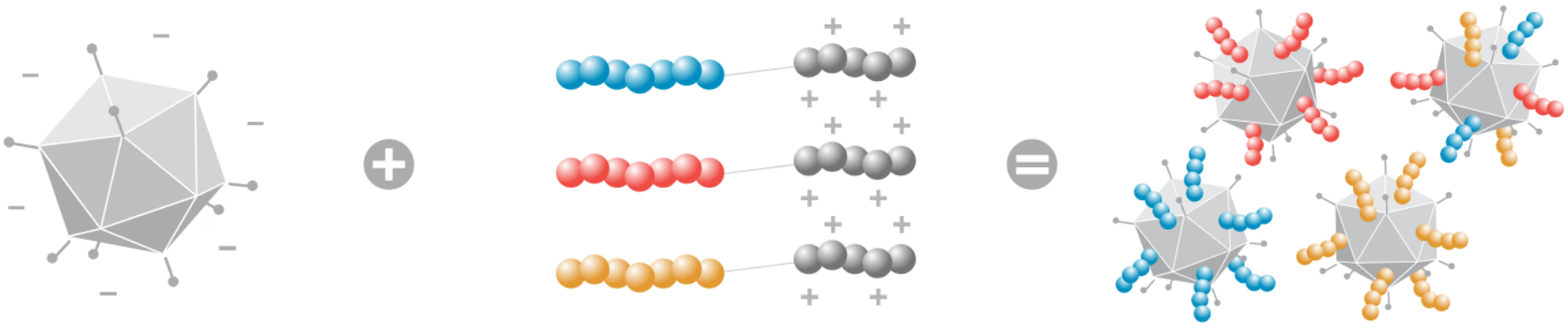
Oncolytic adenovirus

Tumor-specific peptides

Poly-lysine

Patient-specific treatment

PeptiCRAd

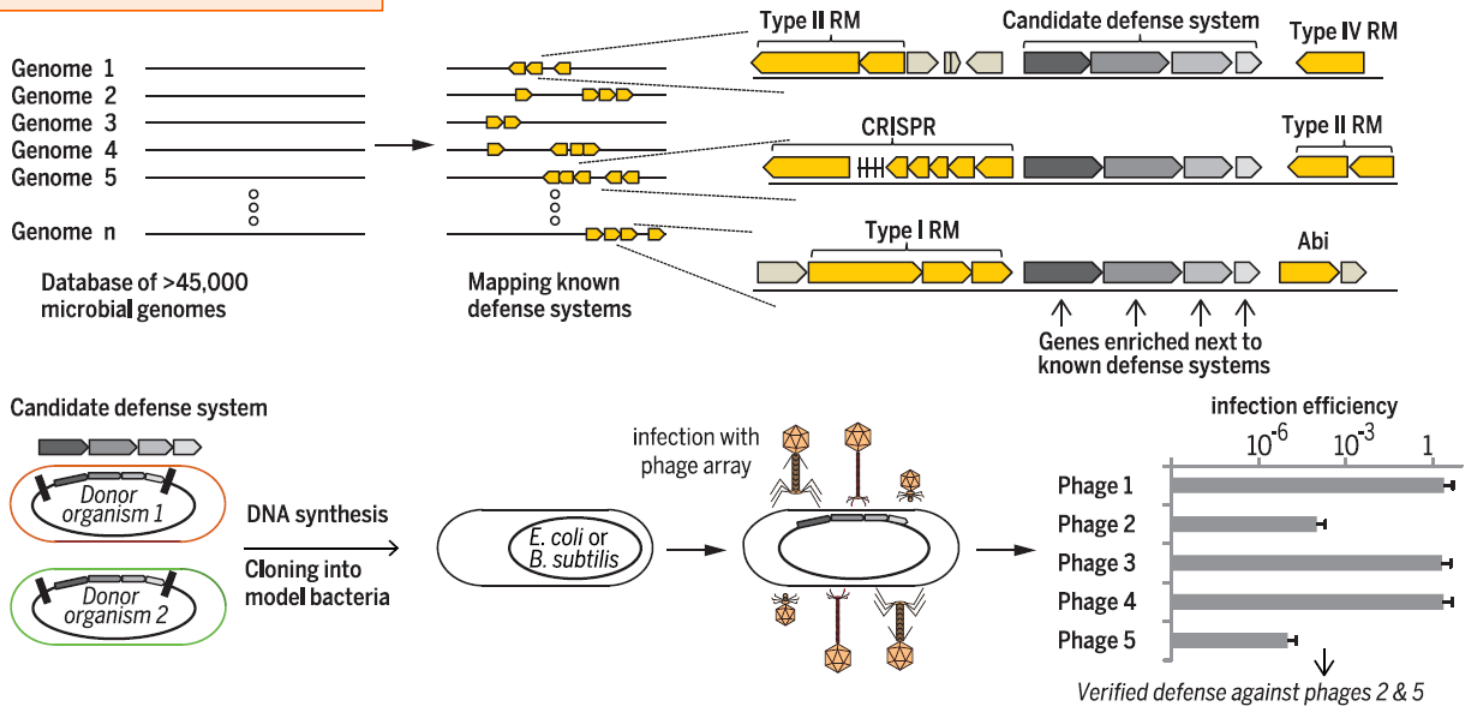


Ylösmäki et al., *Molecular Therapy* **2018**(26)2315

‘PhageResist’: Novel anti-phage defense mechanisms in microbial pan-genome

ERC Consolidator Grant
Principal Investigator: Rotem SOREK
Host Institution: Weizman Institute
EU contribution: € 2.0 million
Project runs from 2016 – 2021

European Research Council
Established by the European Commission



A pipeline for systematic discovery of defense systems. Microbial genomes (more than 45,000 in the current study) are mined for genetic systems that are physically enriched next to known defense systems such as restriction-modification and CRISPR-Cas. Candidate predicted systems are cloned into model bacteria, and these bacteria are then infected by an array of phages from various families to determine whether they provide defense.

Figure taken from: S. Doron, S. Melamed, G. Ofir, A. Leavitt, A. Lopatina, M. Keren, G. Amitai, R. Sorek (2018) Systematic discovery of antiphage defense systems in the microbial pangenome. Science 359: eaar4120.

Synthetic Gut Microbiome

Engineered bacteria to break down amino acids

- In clinical trials for disease that result in toxic buildup (patients lack necessary enzyme)

Future potential:

- Treatment of various gastrointestinal conditions
- Engineering of other microbiomes (e.g. urobiome)

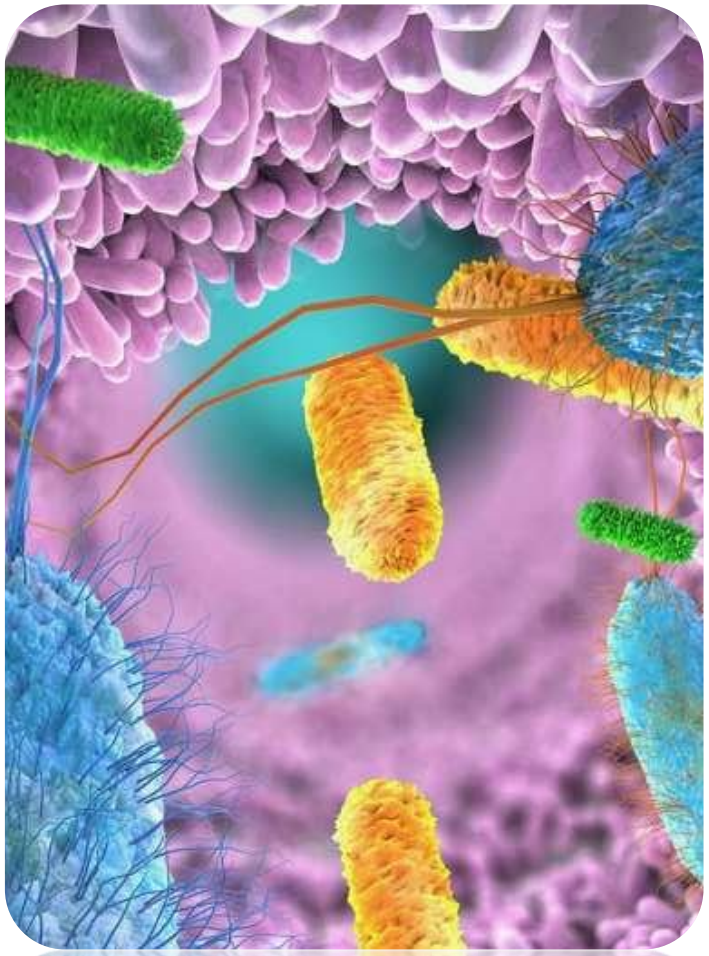


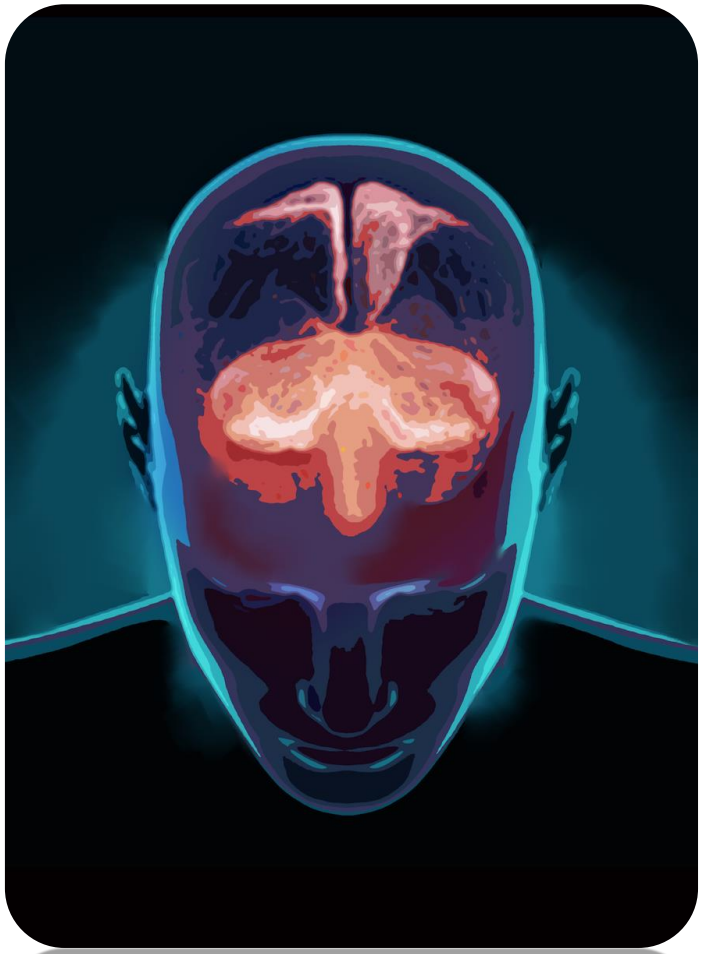
Image credit: phys.org

Stroke Diagnosis

Clinically approved device to detect brain bleeding

- Uses low-power electromagnetic waves to measures fluid volume asymmetry

Future potential to distinguish between neurological conditions (stroke, trauma…)



Brain-Spinal Interface

Breakthrough neurotechnology for treating paralysis and injury

- Wireless implantable brain-spinal interface system design for durable implant
- Clinical trial restores patient control on previously paralyzed leg muscles

Future potential:

- Cure for spinal cord injuries
- Paralysis recovery

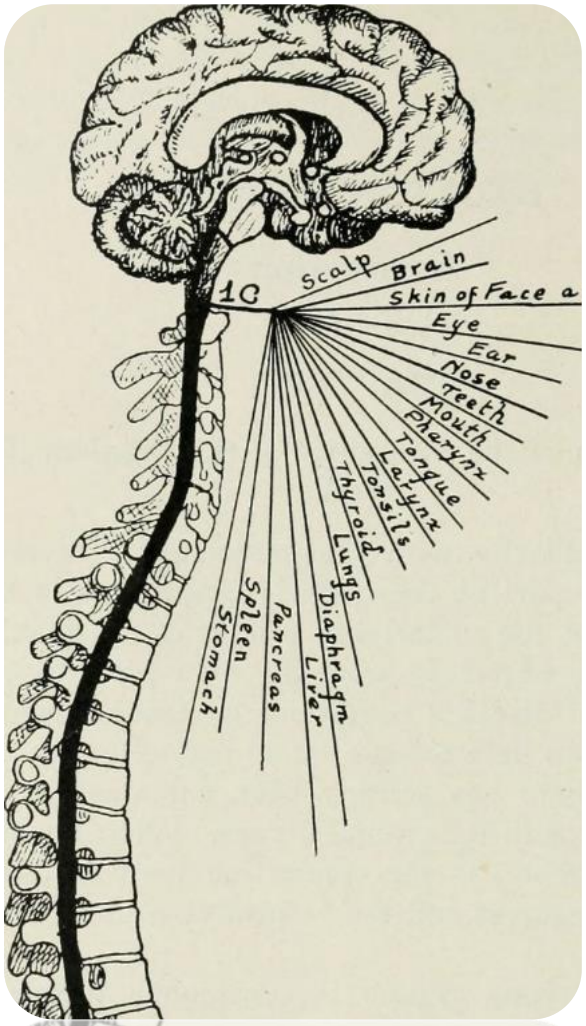


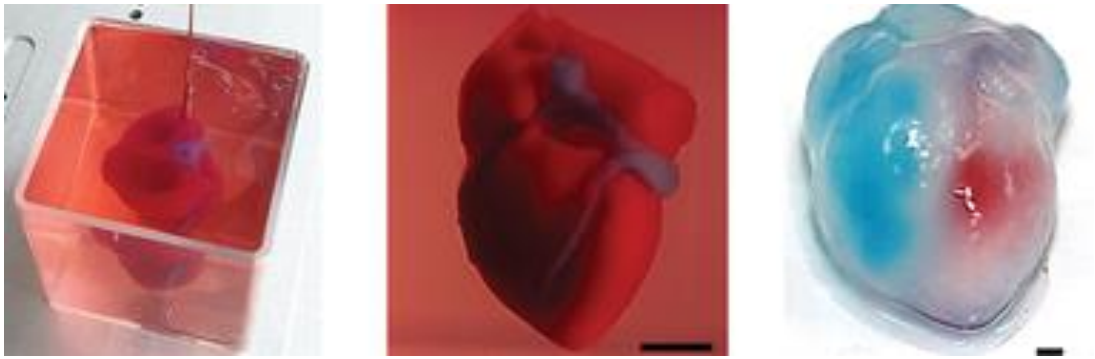
Image credits: "Principles and practice of spinal adjustment; for the use of students and practitioners" (1915)

‘SmartCardiacPatch’: Mini 3D-printed personalized heart

European Research Council
Established by the European Commission

ERC Starting Grant
Principal Investigator: **Tal DVIR**
Host Institution: **Tel Aviv University**
EU contribution: € 1.5 million
Project runs from 2015 – 2021

World’s first engineered heart replete with cells, blood vessels, ventricles and chambers

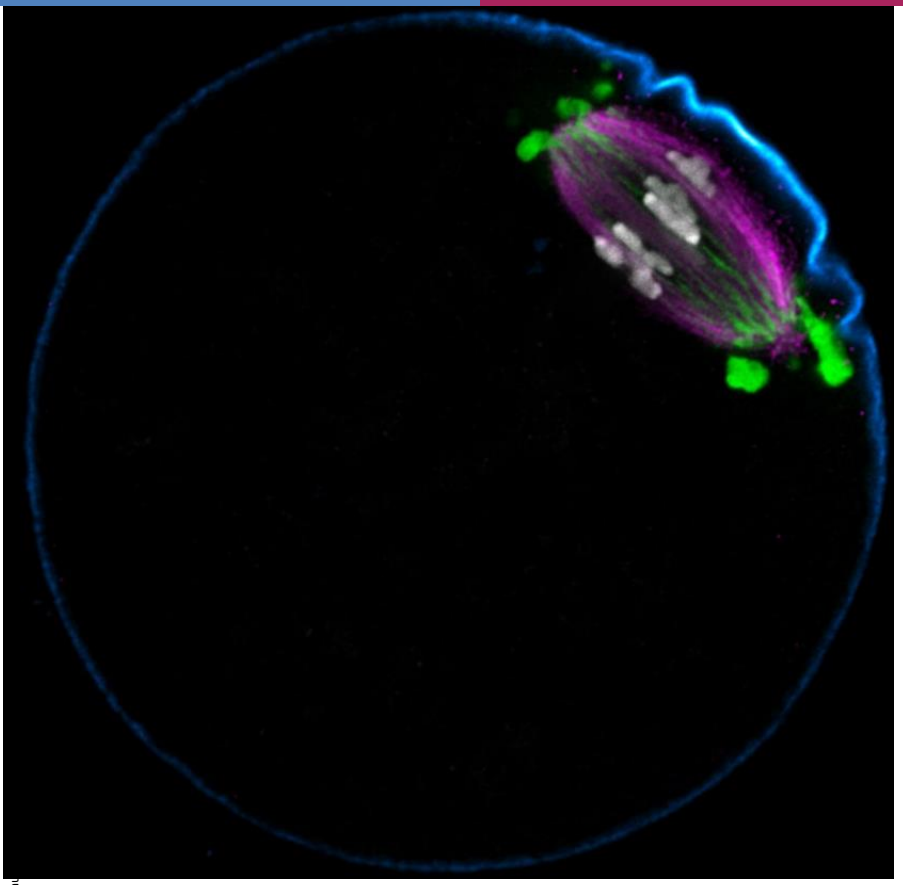


- Made from personalized, non-supplemented materials as bioinks for 3D printing
- Potential for transplantation (will not provoke immune response)
- Not yet an adult size functioning heart (it can contract, but not pump) !

Noor et al., *Advanced Science* **2019**(6)1900344

‘ChromOocyte’: Deciphering the maternal age effect to improve in vitro fertilisation treatments

European Research Council
Established by the European Commission



- The egg halves its set of chromosomes before fertilization
- To this end, the spindle (magenta) arranges the chromosomes (grey) in one plane before distributing them to the two spindle poles
- The newly discovered LISD (liquid-like spindle domain - green) organizes the spindle and ensures that the chromosomes are distributed correctly

Taken from: Chun So*, K. Bianka Seres*, Anna M. Steyer, Eike Mönnich, Dean Clift, Anastasija Pejkovska, Wiebke Möbius, Melina Schuh: A liquid-like spindle domain promotes acentrosomal spindle assembly in mammalian oocytes. Science 364, eaat9557 (2019)

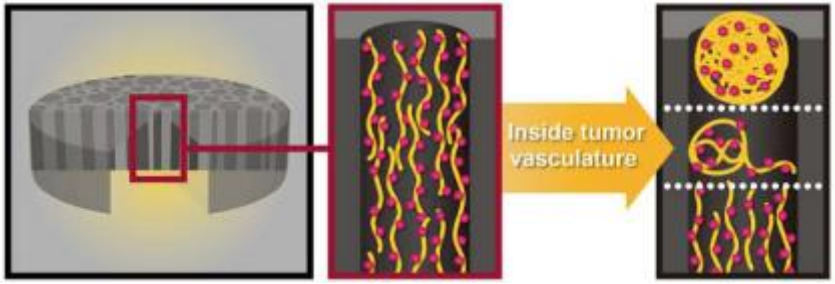
ERC Starting Grant
Principal Investigator: Melina SCHUH
Host Institution: Max Planck Society
EU contribution: € 1.5 million
Project runs from 2014 – 2019

BrYet Pharma Product: ML-016, (a.k.a. iNPG-pDox)

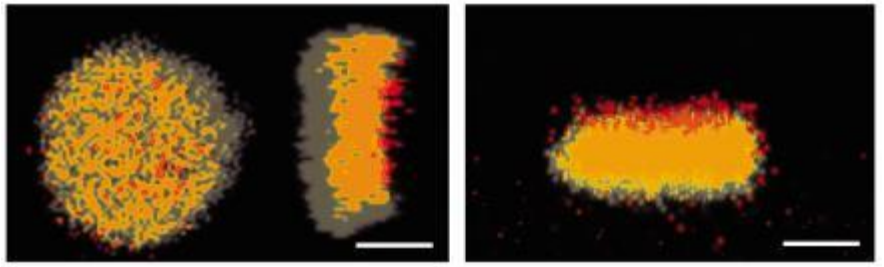
Scientific Approach and Validation:

1. Multi-component, sequential action, first-in-class therapeutic agent
2. Physics-based localization ("Targeting"); Transport Oncophysics
3. First target indication: TNBC with lung and liver metastases

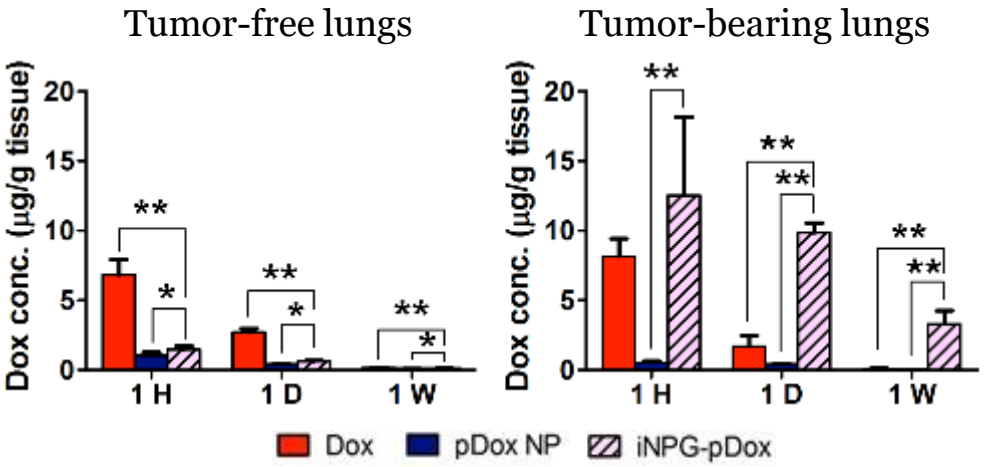
iNPG-pDox



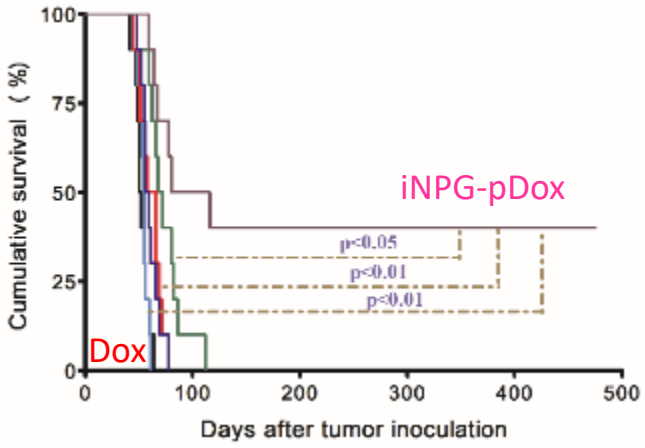
Drug nanoparticle self-assembly & release



Tumor tropism



Therapeutic efficacy



Nature Biotechnology 2016

Molte grazie! Thanks much! Danke sehr! Merci beacoup! Hvala! Muchas gracias! Obrigado!....

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