

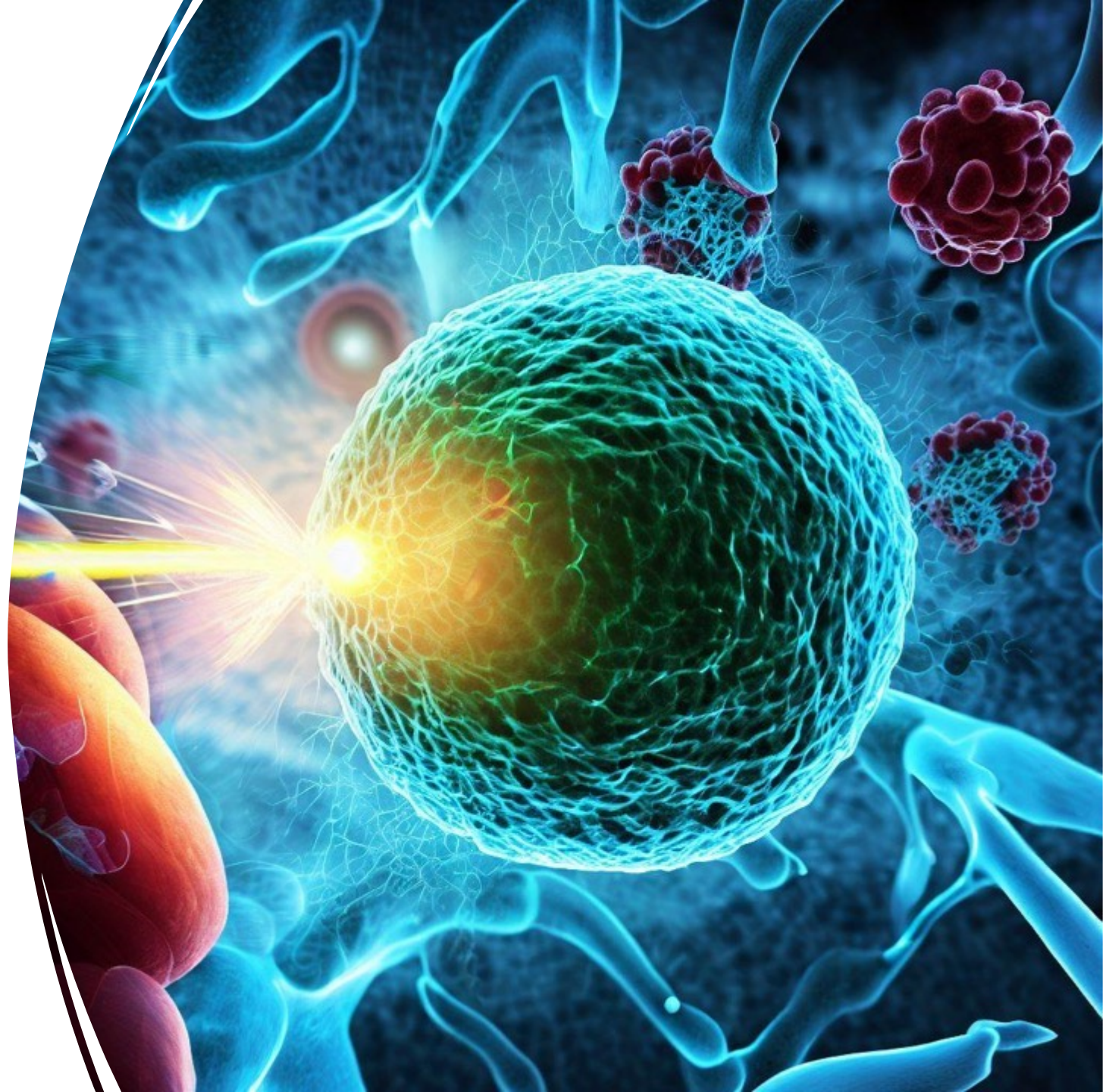
Tiny drones to target cancer, powered by Artificial Intelligence

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Founding Director, Global Health Catalyst at Harvard and Johns Hopkins
Chair, American Association of Physicists in Medicine GNAC**

OUTLINE

- Introduction
- Tiny Drones to Target Cancer
 - Bright Futures Prize at Harvard
 - (3 Best in Physics Awards by the American Association of Physicists in Medicine)



Introduction:

From Africa's Wakanda: From Imagination to reality



“Imagination is more important than knowledge”

Albert Einstein

Introduction: From Imagination to reality

- **2015:** BRight Futures Prize On Tiny drones to Target Cancer
- **3 Best in Physics** awards from the American Association of Physicists in Medicine (AAPM) on Tiny Drones to target cancer



Why tiny drones to target Cancer? Cancer Monster Stats!

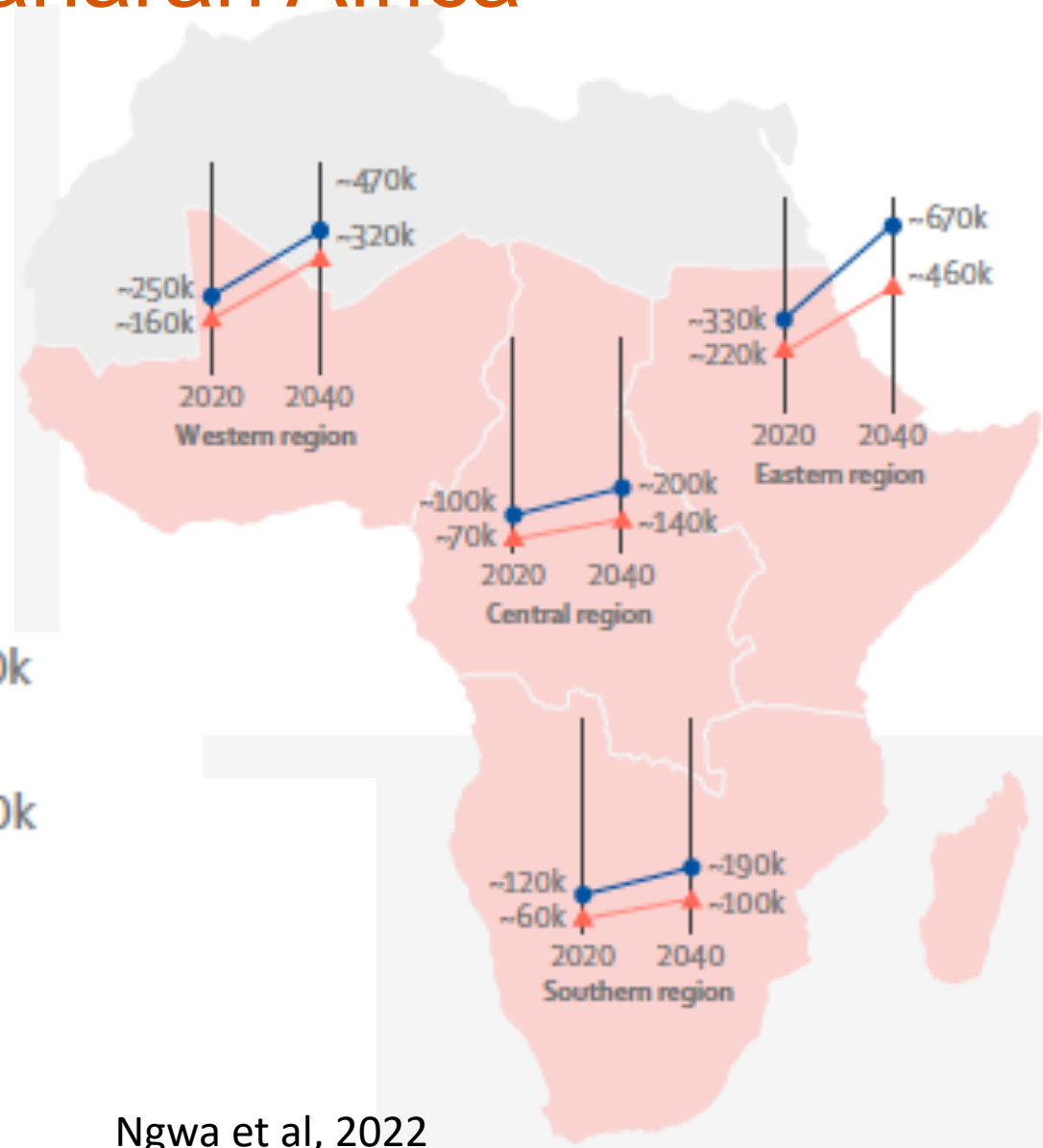
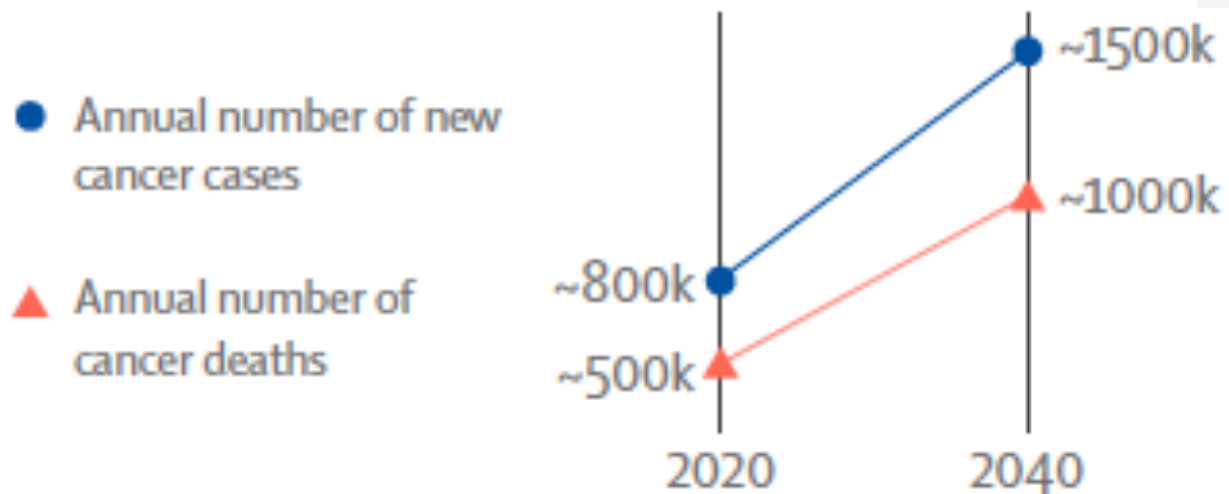
- **Lifetime Risk of Developing or Dying From Cancer**
 - Risk of developing: 1 in 2-3
 - Risk of Dying: 1 in 5
- **Over 14 million cancer cases a year**
- **Over 8 million deaths a year**
- **Economic impact over 2 trillion dollars**
- **Major Cancer health disparities:**
 - Poorer populations have no access to prevention treatment palliative care



Source: Marvel Infinity war and American Cancer society

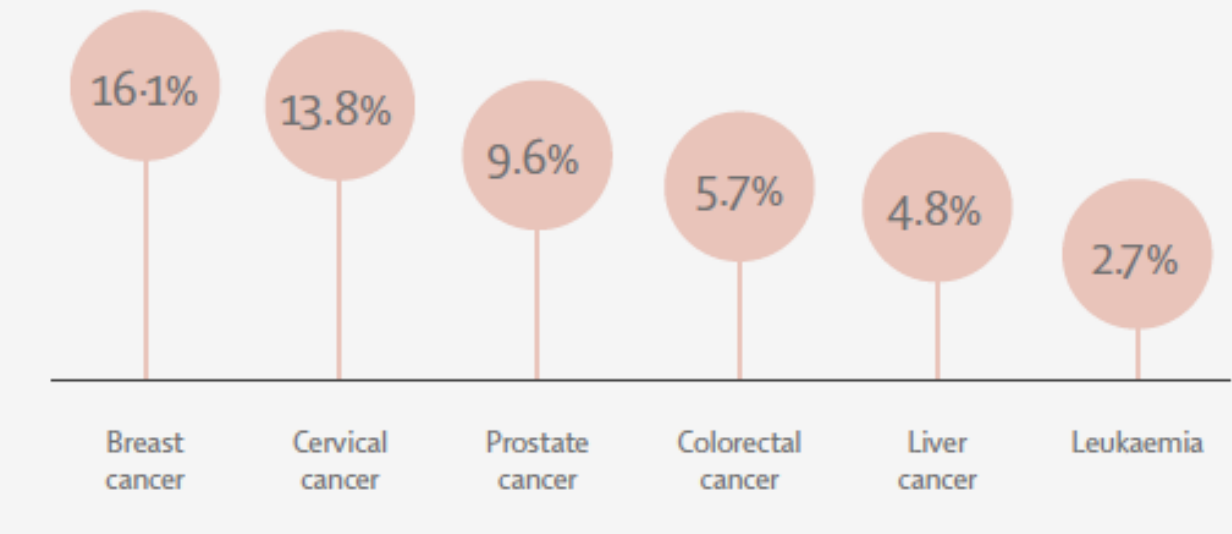
Monster Cancer Stats: Lancet Oncology Commission: Cancer in Sub Saharan Africa

- The challenge of cancer now faced by sub-Saharan Africa (SSA) is enormous; with high death rate
- Likely to worsen rapidly if adequate measures are not taken including through international collaboration





Highest incidence cancers



- Cancer in Africa is characterized by late stage at presentation, delayed diagnosis, limited access to treatment, and poor outcomes relative to other geographic regions
- Some estimates show, late-disease presentation varies from 30% in South Africa to 98% in Nigeria

Some Highlights of the commission report

- By 2050, almost 50% of the global cancer burden in children younger than 15 years will be in Africa.
- About 4 in 5 kids die when diagnosed with cancer in SSA compared with about 1 in 5 in the USA
- This is unacceptable!





Calls for urgent action:
Everyone can help!



Calls for urgent Action

- Action 1: precision cancer control planning
- Action 2: improving data acquisition and cancer registration
- Action 3: designing health-care systems that promote equity of access
- **Action 4: increasing cure and improving care**
- Action 5: effective palliation
- Action 6: building and maintaining the workforce
- Action 7: innovation and research
- Action 8: invest in telehealth

Cancer Moonshot 2.0: Extending the Cancer Moonshot Globally through collaborations



- Motivation: Using tiny drones to target cancer as low-cost technology/approach to increase access to cancer care/cure and reduce disparities in the USA and globally

BACKGROUND:

Current Major treatment options

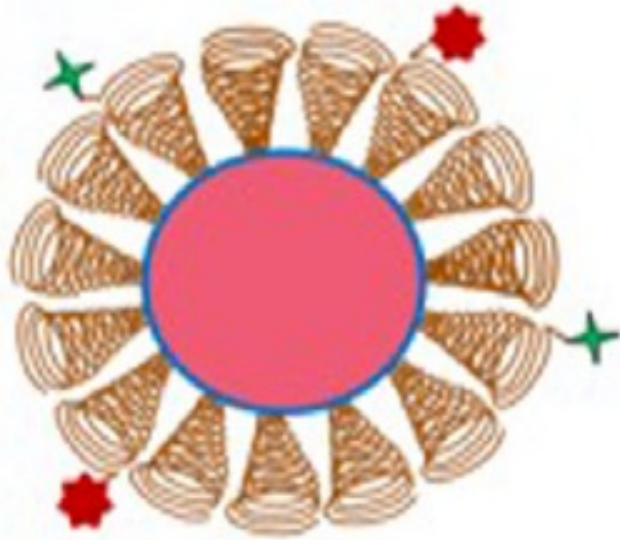
- **Surgery (Hulk?)**
- **Chemotherapy (Thor)**
- **Radiotherapy (Captain Marvel)**
- **Immunotherapy (Spider man)**
- **Nanotechnology: Black Panther**



Source: Marvel Infinity war

Nanodrones design

•Cross-disciplinary research collaboration: Physics, Engineering, Medicine, STEM



Nanoparticle drone

Capability:

- Targeted
- Stealth
- Emits missile-like electrons
- Can be imaged/tracked
- Carry drug payloads

References:

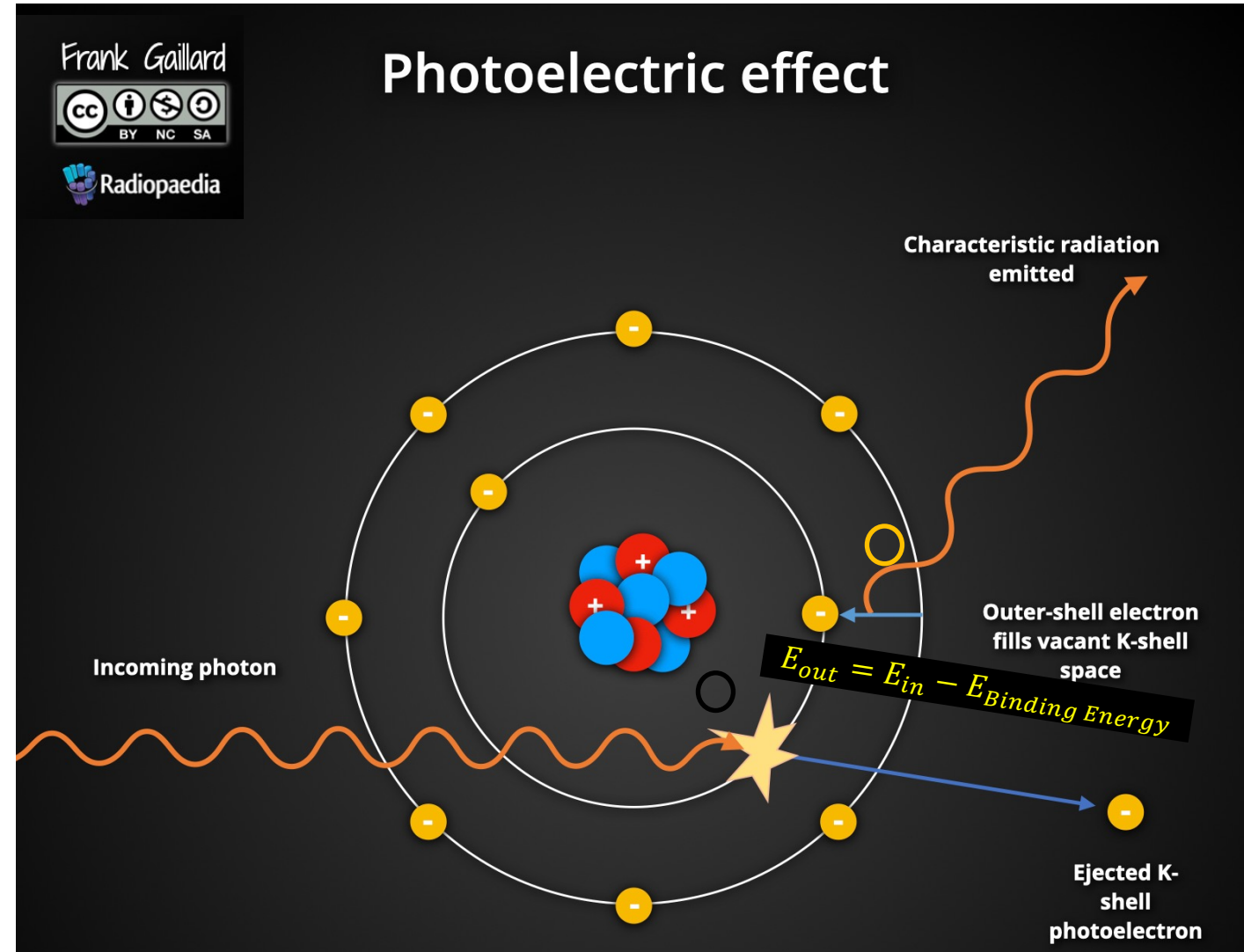
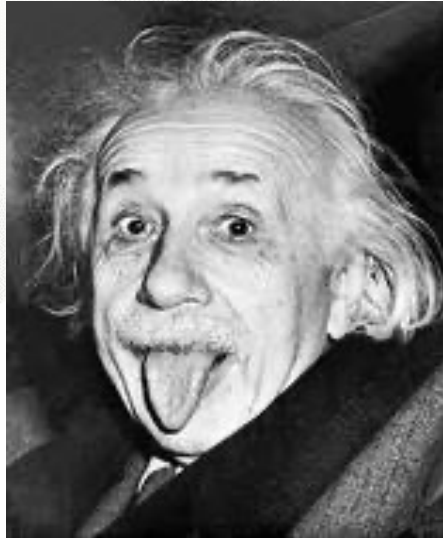
Nature Rev Cancer 2018
Lancet Oncology, 2022
Frontiers in Oncology 2017
Transl Cancer Res 2013
2(4):10.3978
Molecules 2020, 25, 2707;
Phys Med Biol. 2015 60: 703.
Radiat Res 2012 Dec;178(6):604-8
Med Phys 2013 Mar;40(3):031706
Nano Lett. 2015 Nov
11;15(11):7488-96

Bright Futures Prize at Harvard Medical School

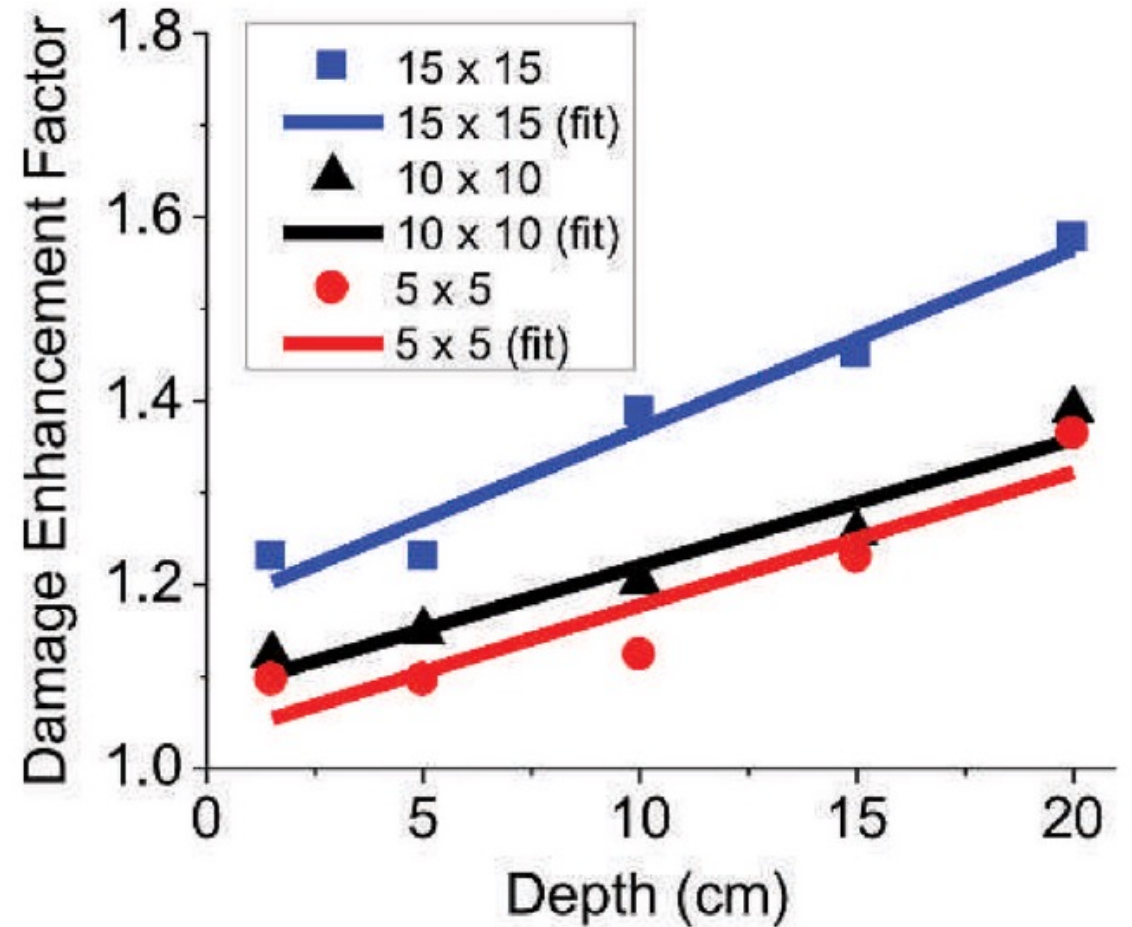
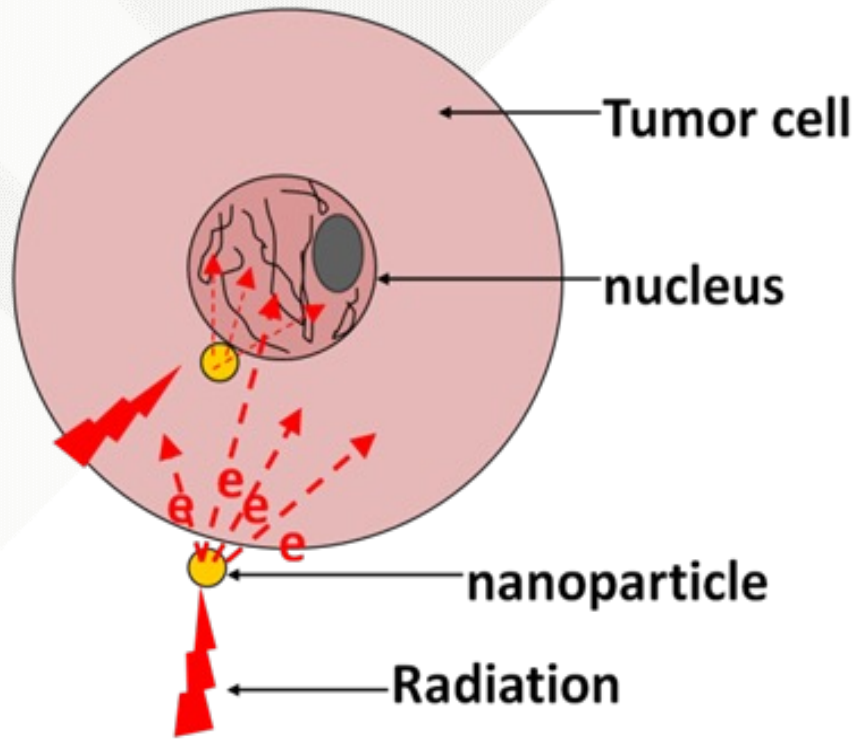
NIH Research Excellence Award

Three Best in Physics Awards by the American Association of Physicists in Medicine

Introduction: Nobel Prize in Physics: The Photoelectric Effect

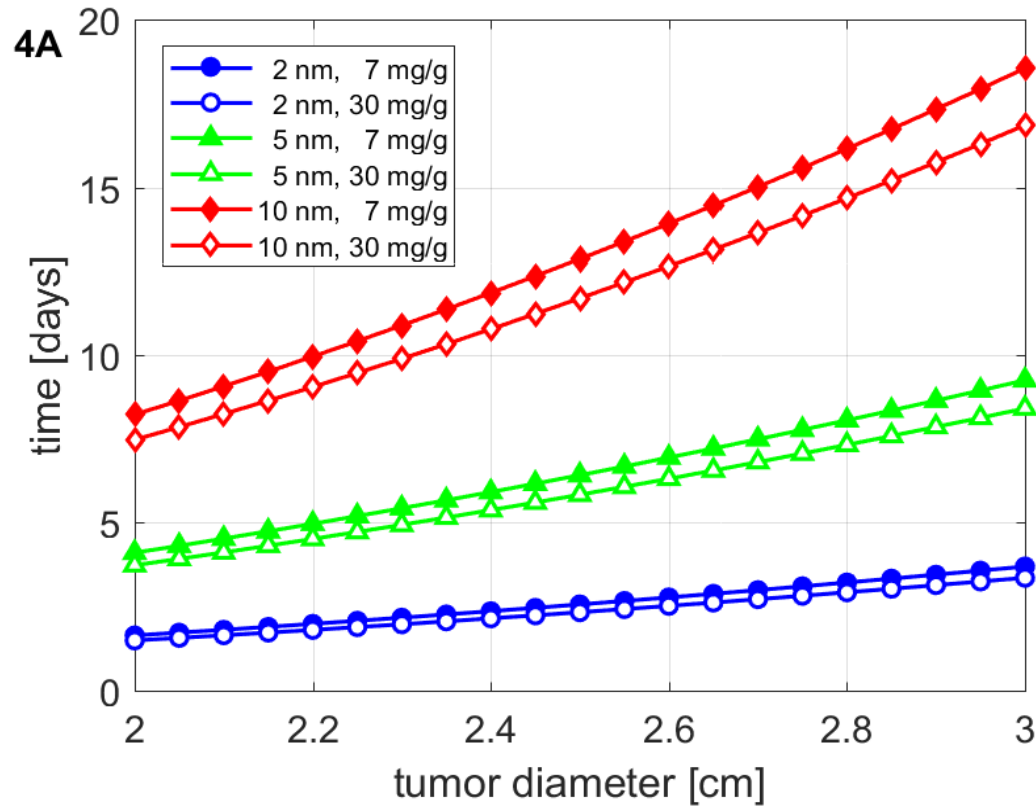


Introduction: Biophysics and the photoelectric effect

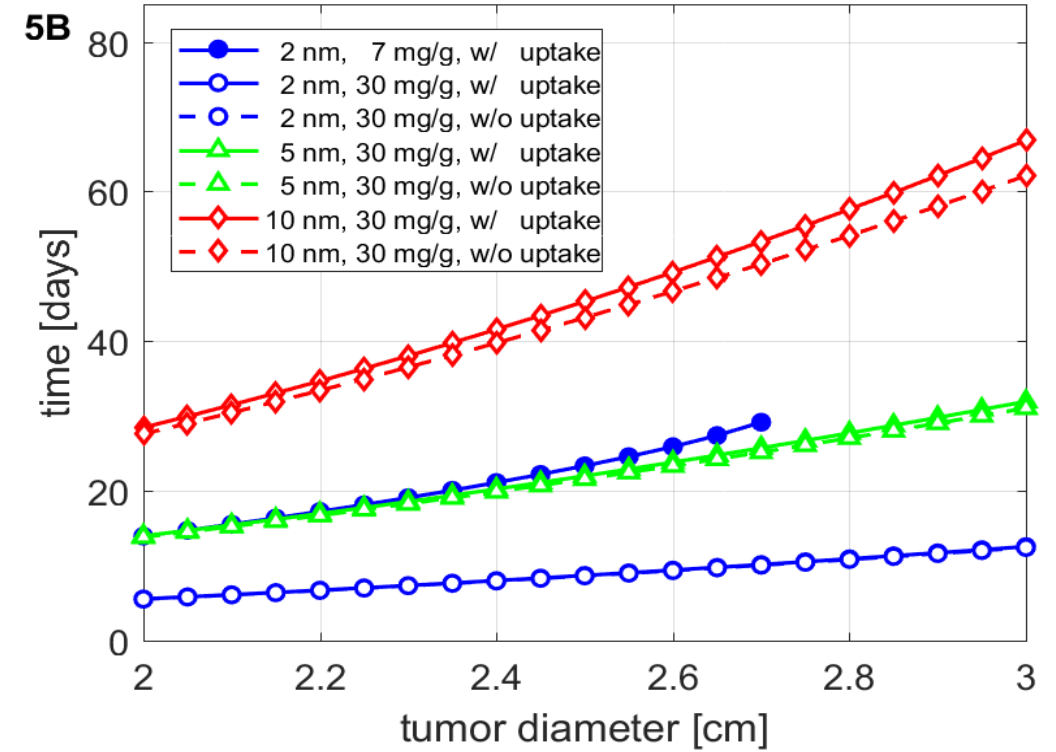


- Monte Carlo simulations and AI predict level of damage damage/mutations enhancement

Nanoparticle drone Artificial Intelligence



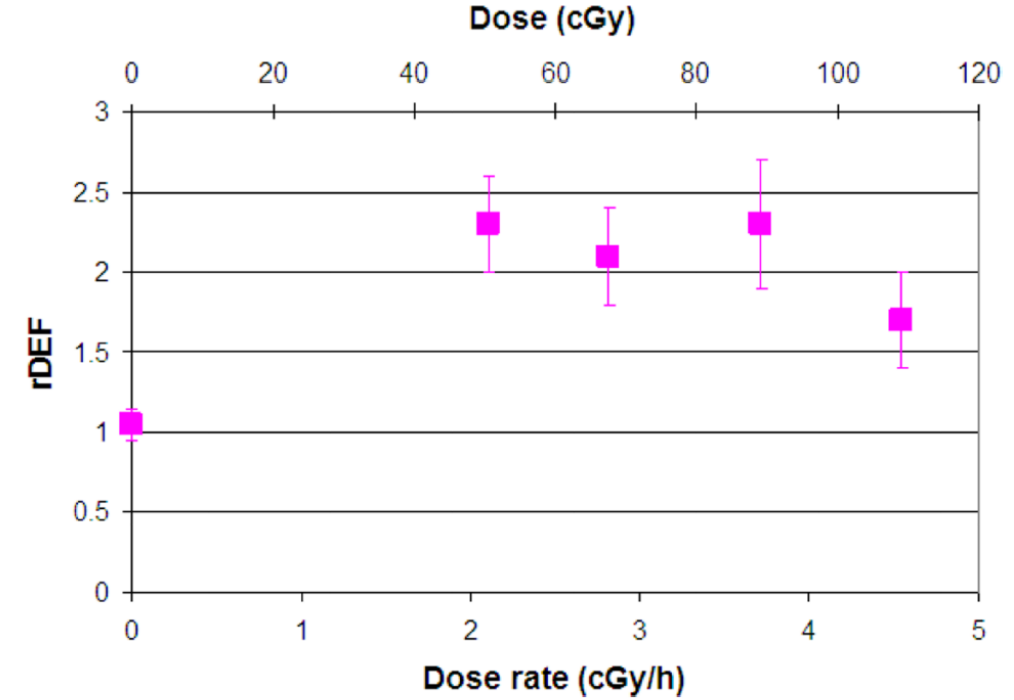
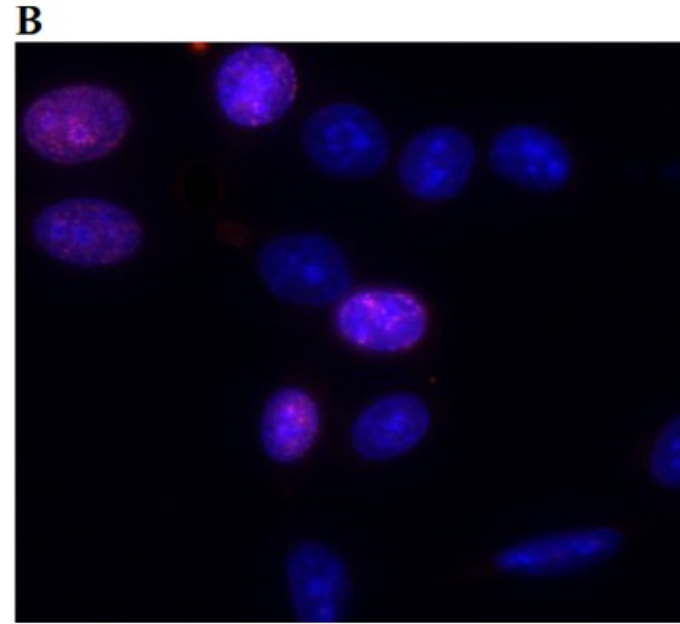
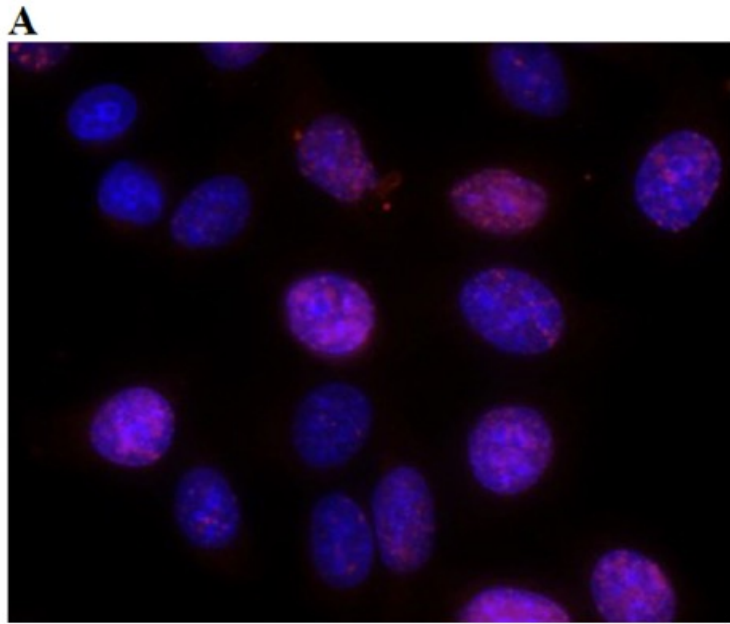
Photoacoustic imaging



Magnetic Resonance imaging

Predicting time to target/interactions and tumor kill or treatment response

Introduction: Biophysics and the photoelectric effect

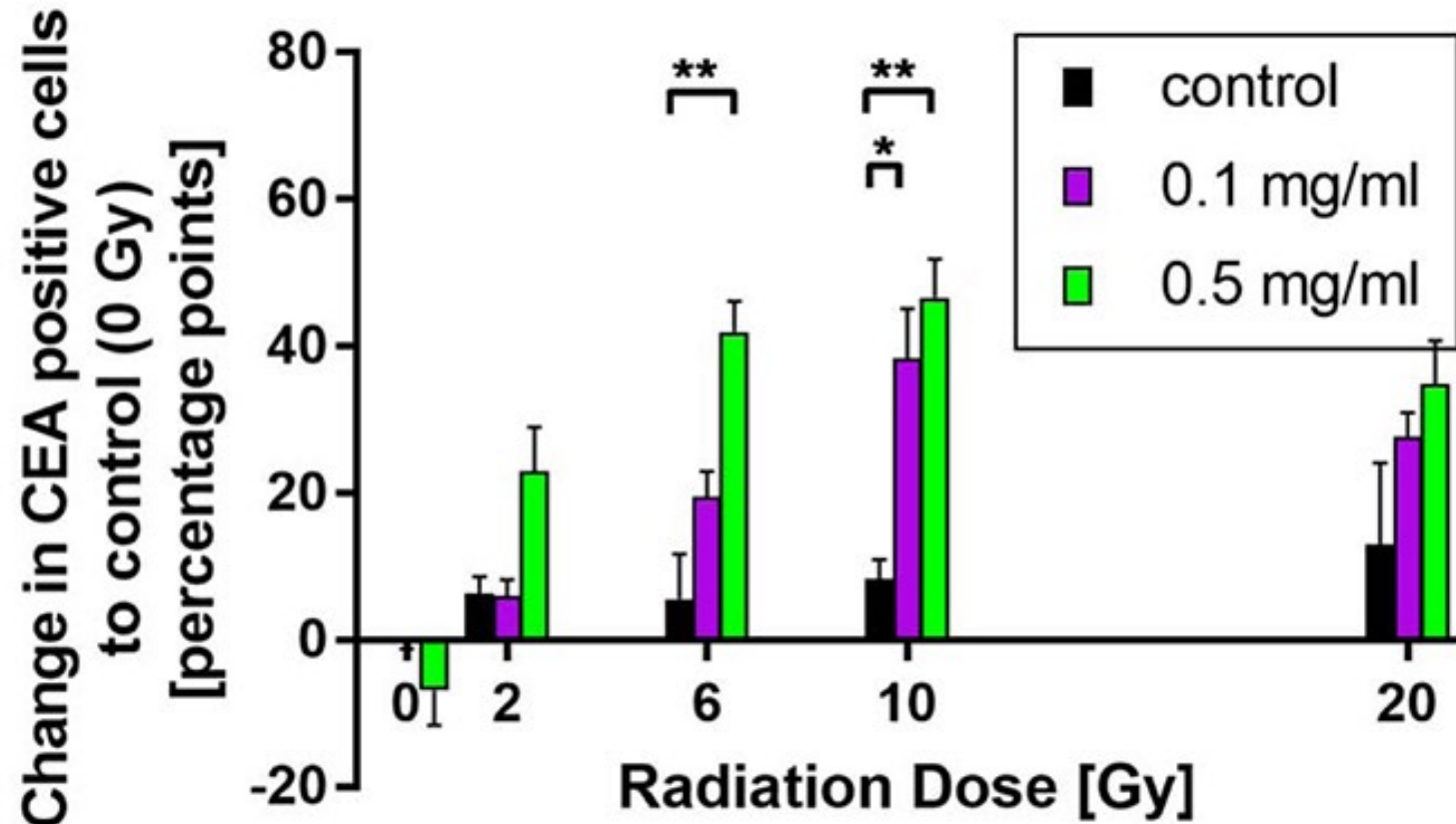


Residual γ H2AX fluorescence images obtained for cells incubated A) with AuNP and B) without AuNP

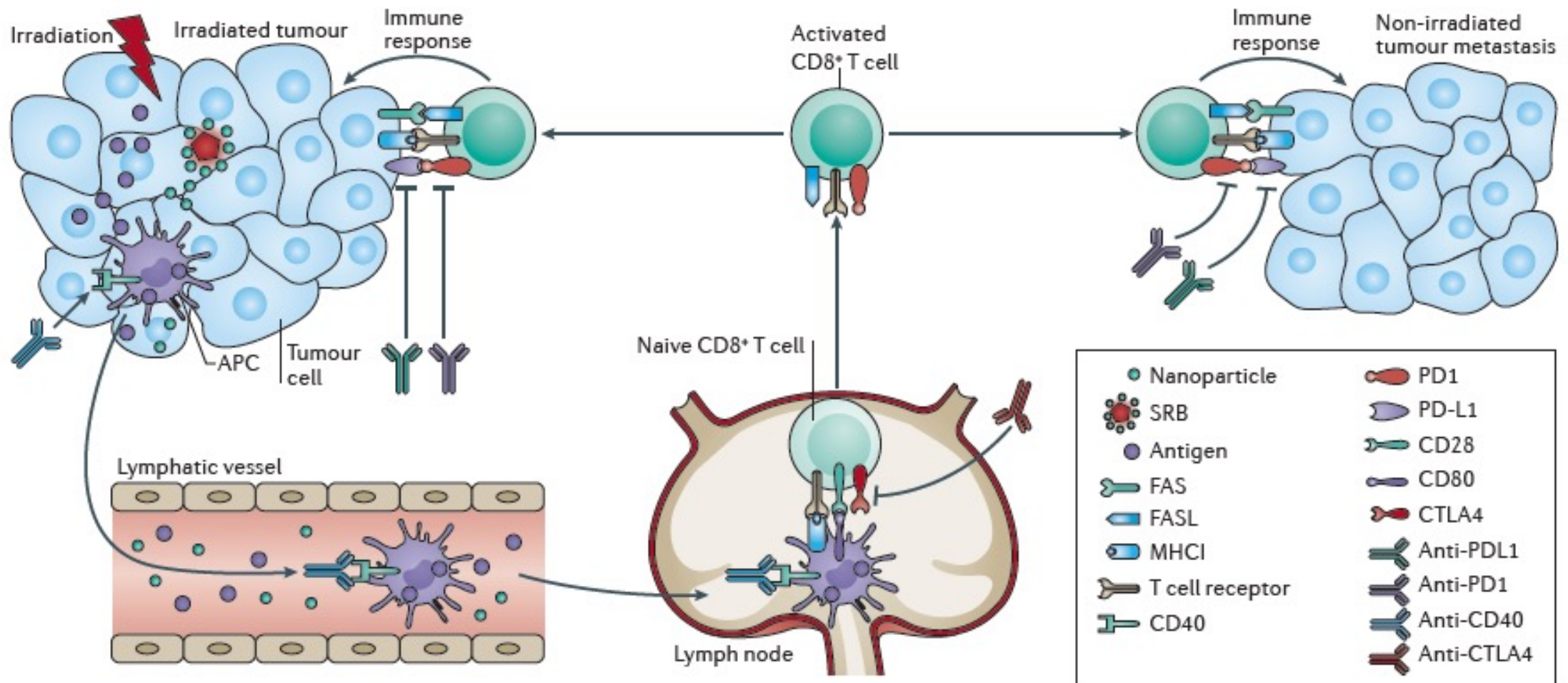
- In vitro experiments confirm DNA damage enhancement

Introduction: Biophysics: protein expressions on cells

- **Increased expression of Carcinoembryonic antigen (CEA) following irradiation in presence of nanoparticles (NPs).**



Method: How tiny drones would work



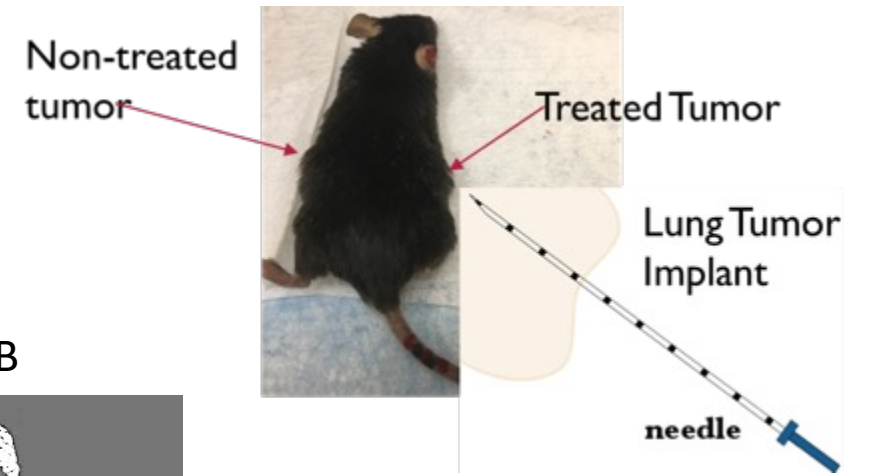
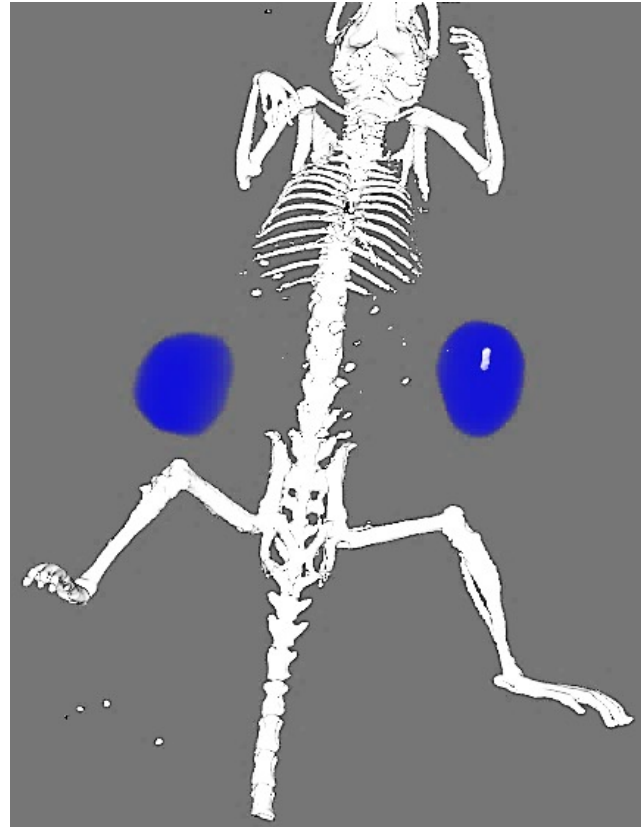
Tiny drones = SRB

METHODS: From imagination to reality

Small Animal Radiation Research Platform (SARRP)



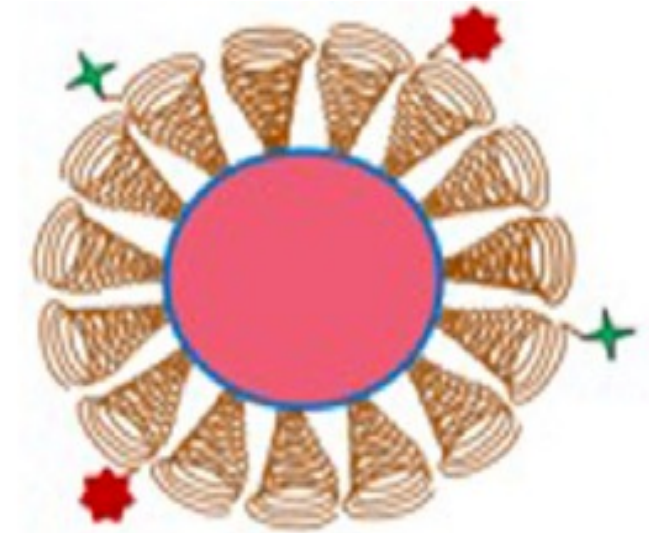
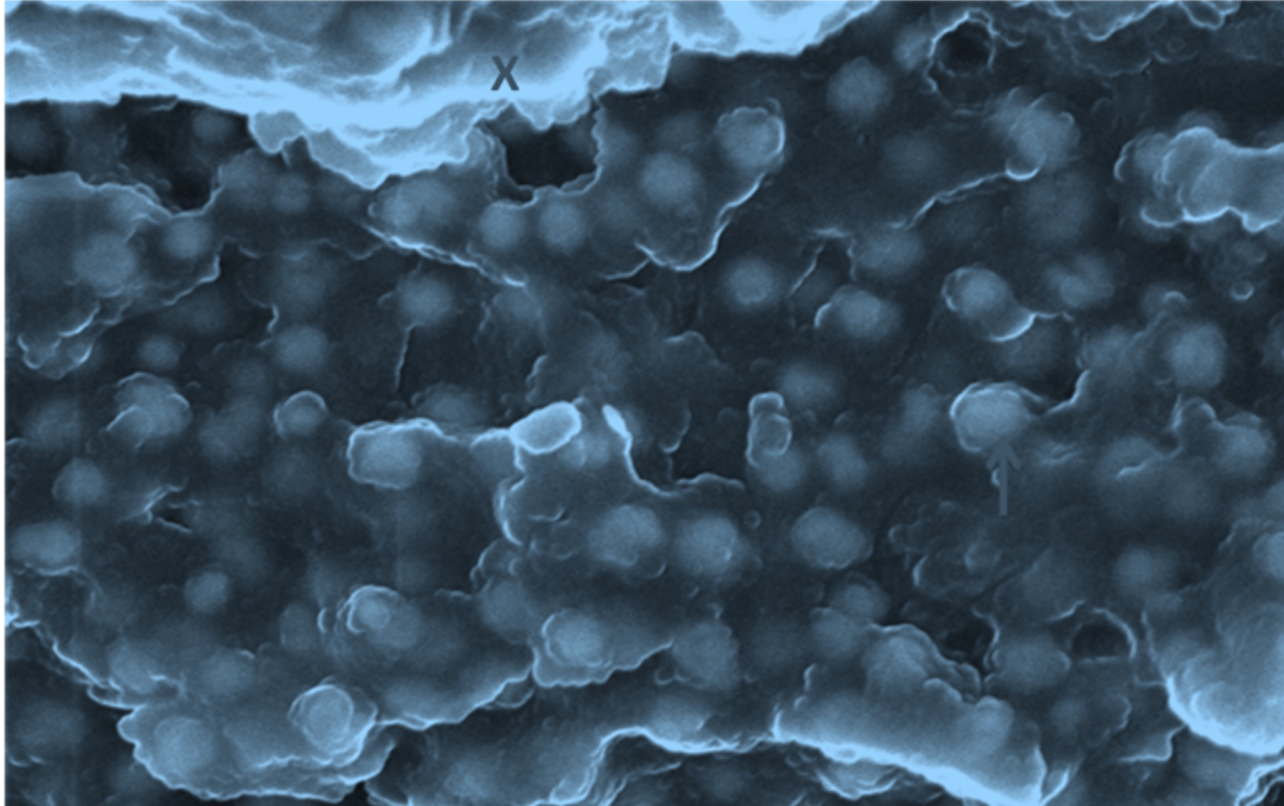
CT image of mouse implanted with MRB



Courtesy to: Marina Horn, Katja Mombaur, IWR from Universität Heidelberg

Do
Statistical Analysis

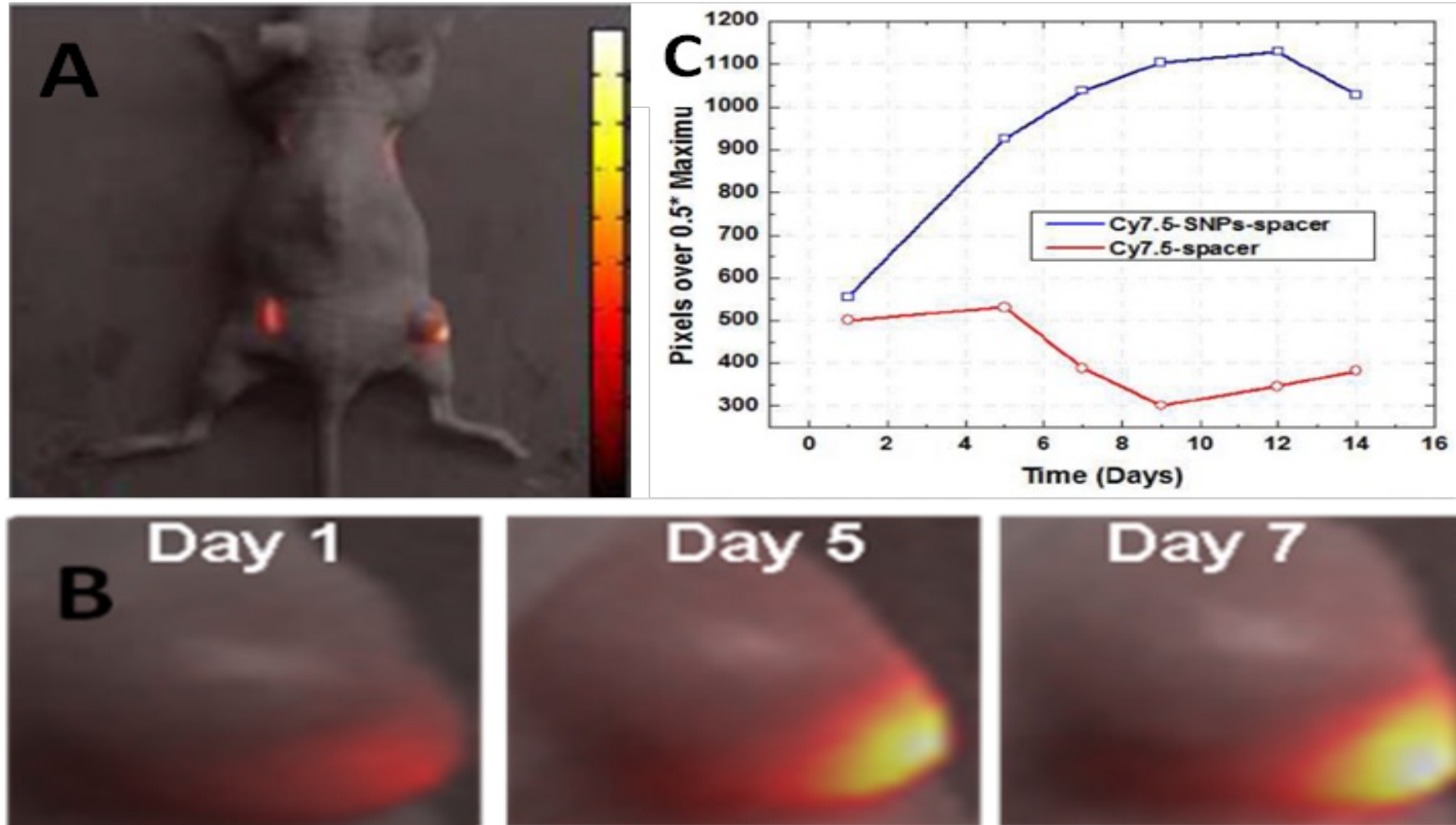
RESULTS: Making tiny drones real



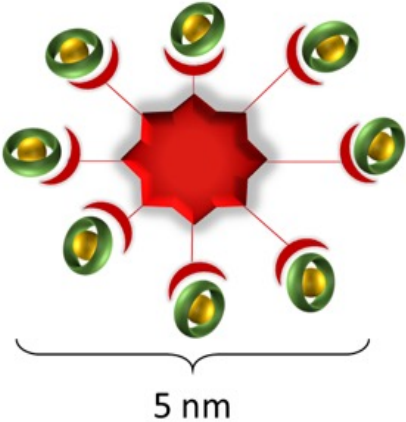
Nanoparticle drone

TEM image of Biomaterial drone
loaded with nanoparticles

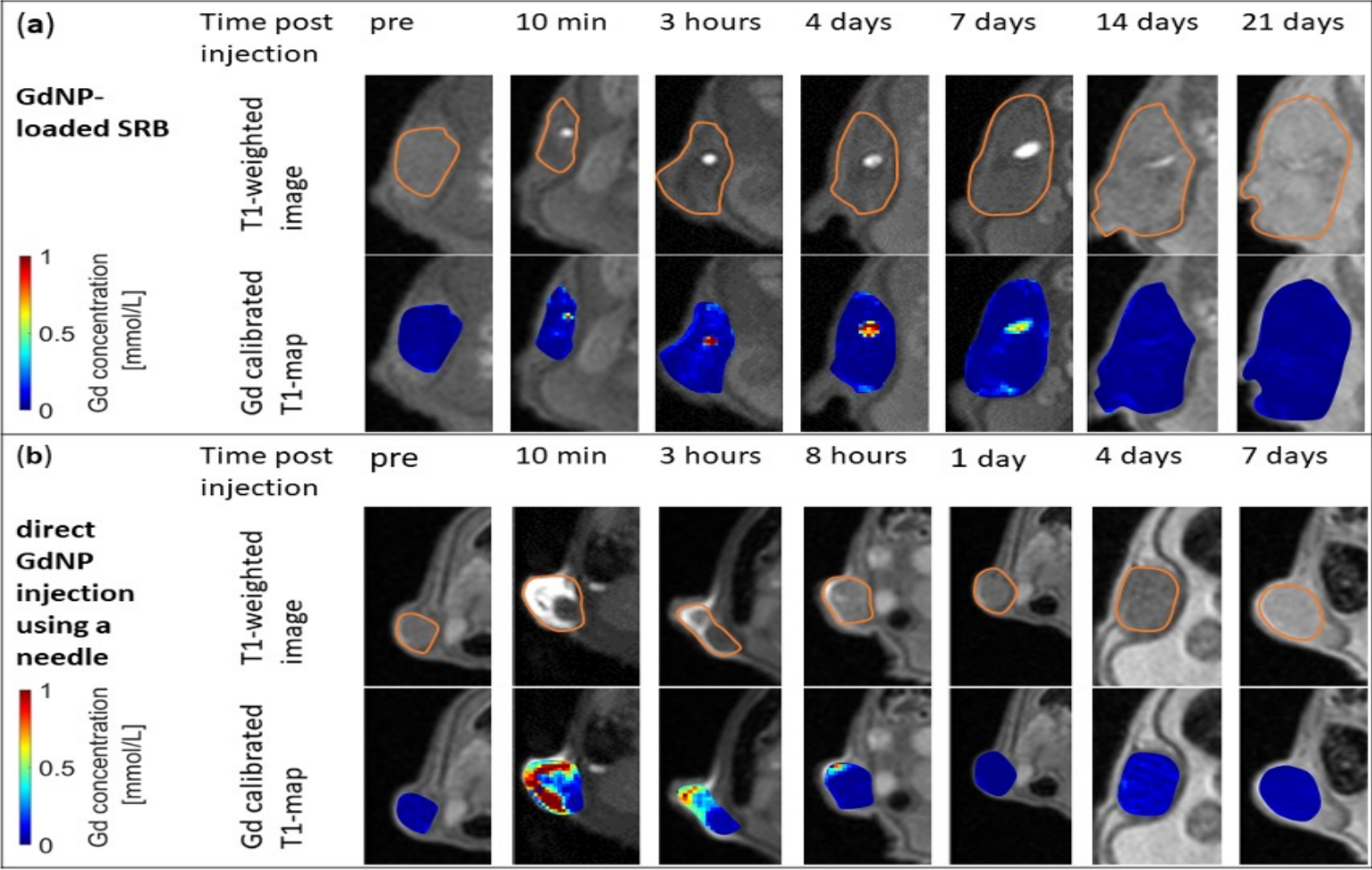
RESULTS: Making tiny drones to target cancer real



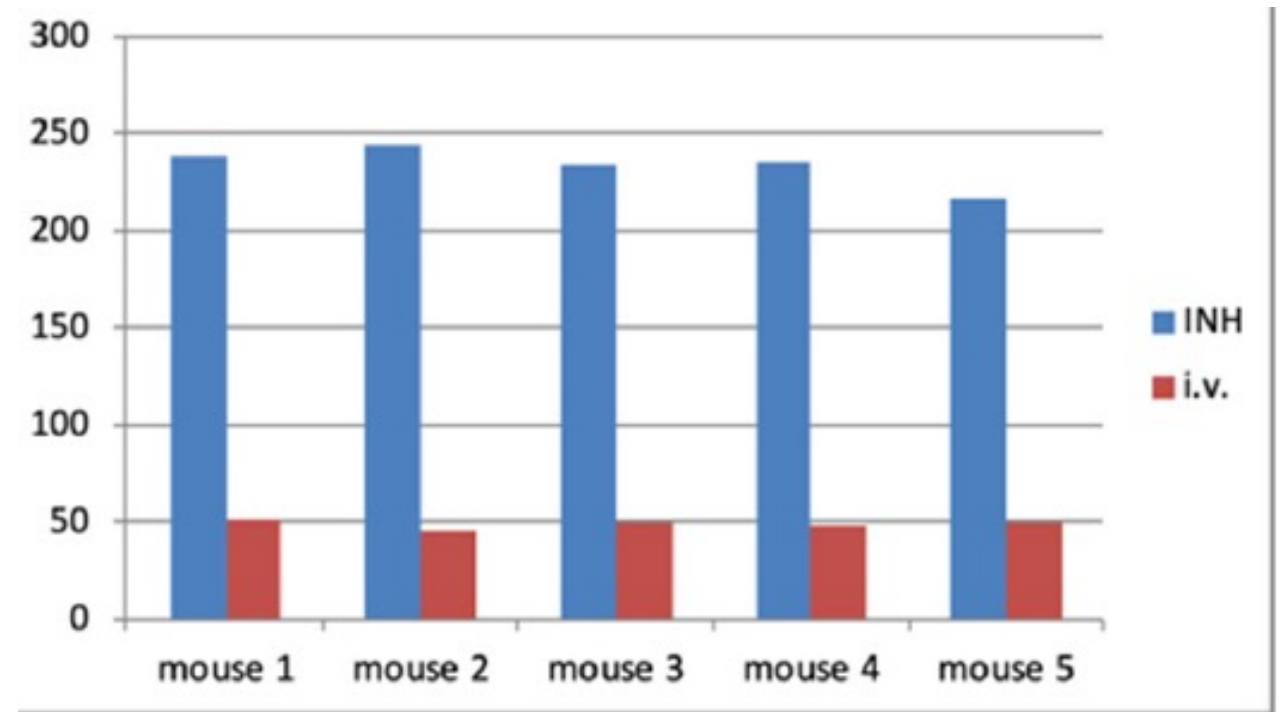
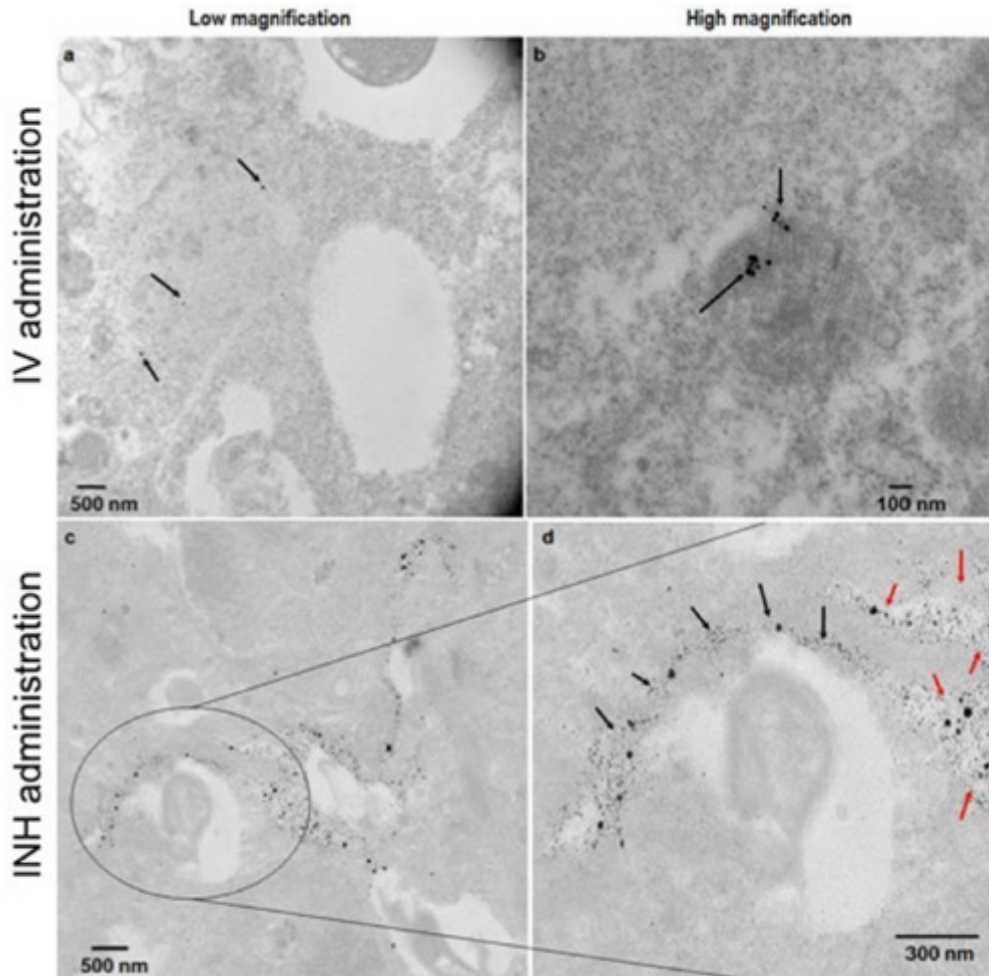
Nanodrones can Provide CT and MR imaging contrast in tumors



Ngwa et al. Nanomaterials 2020



Nanodrones targeting lung lesions with high efficacy and minimal toxicity via pulmonary delivery (INH)



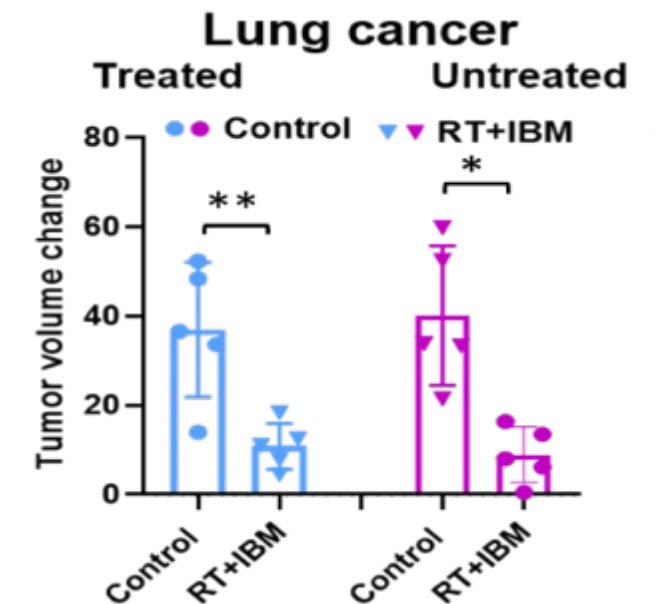
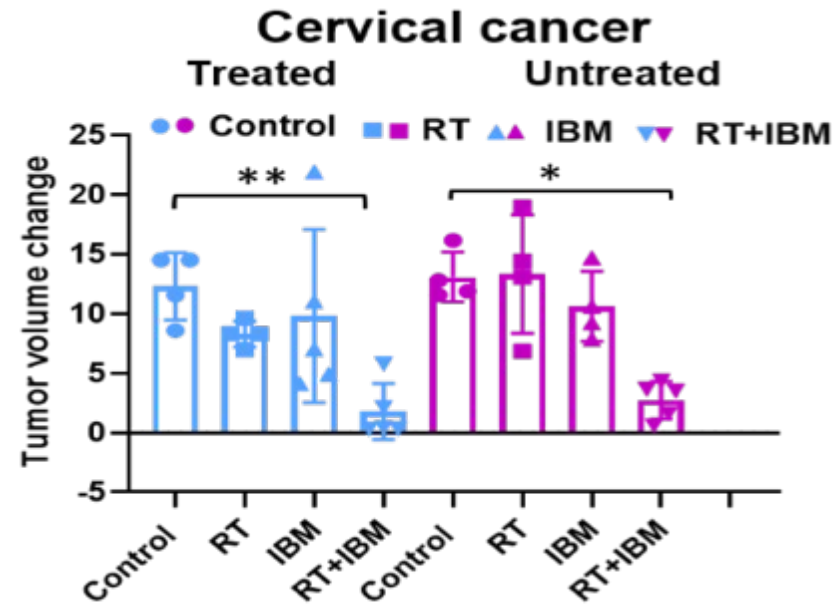
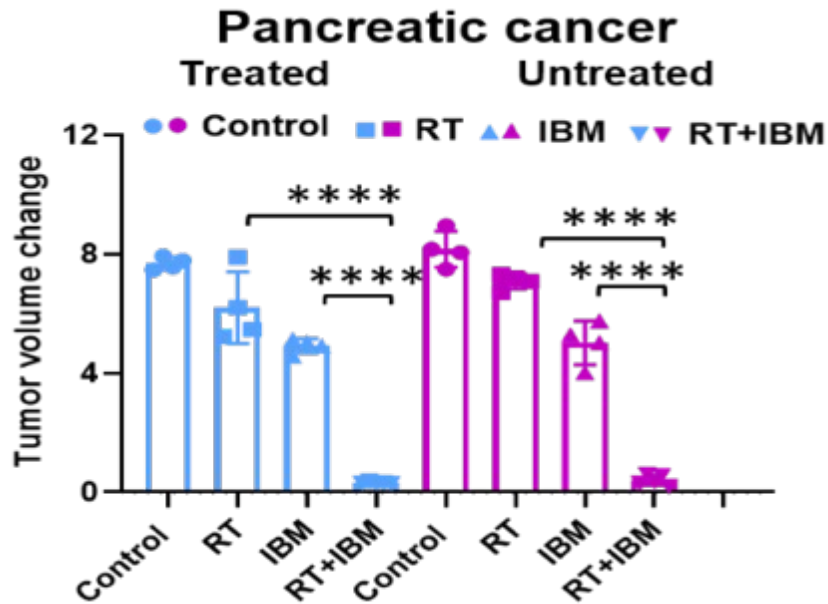
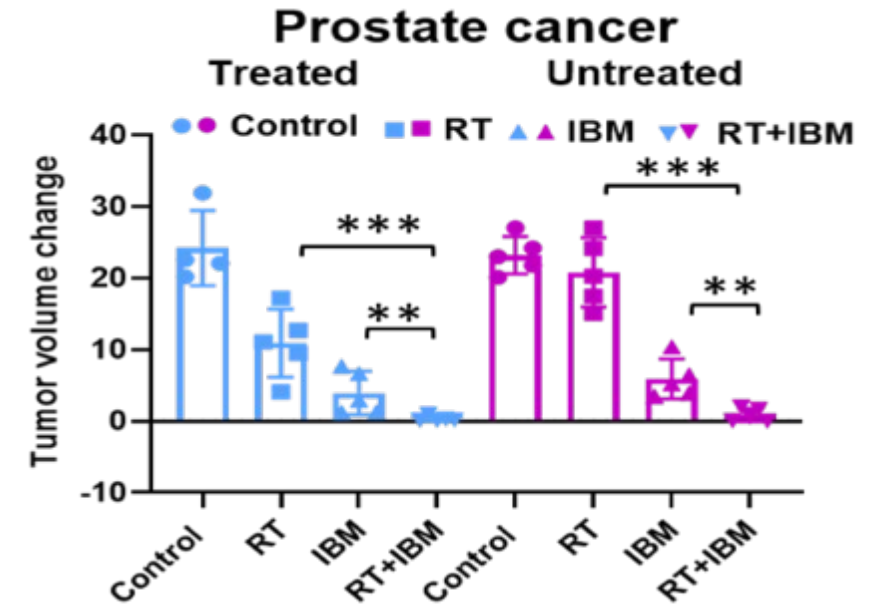
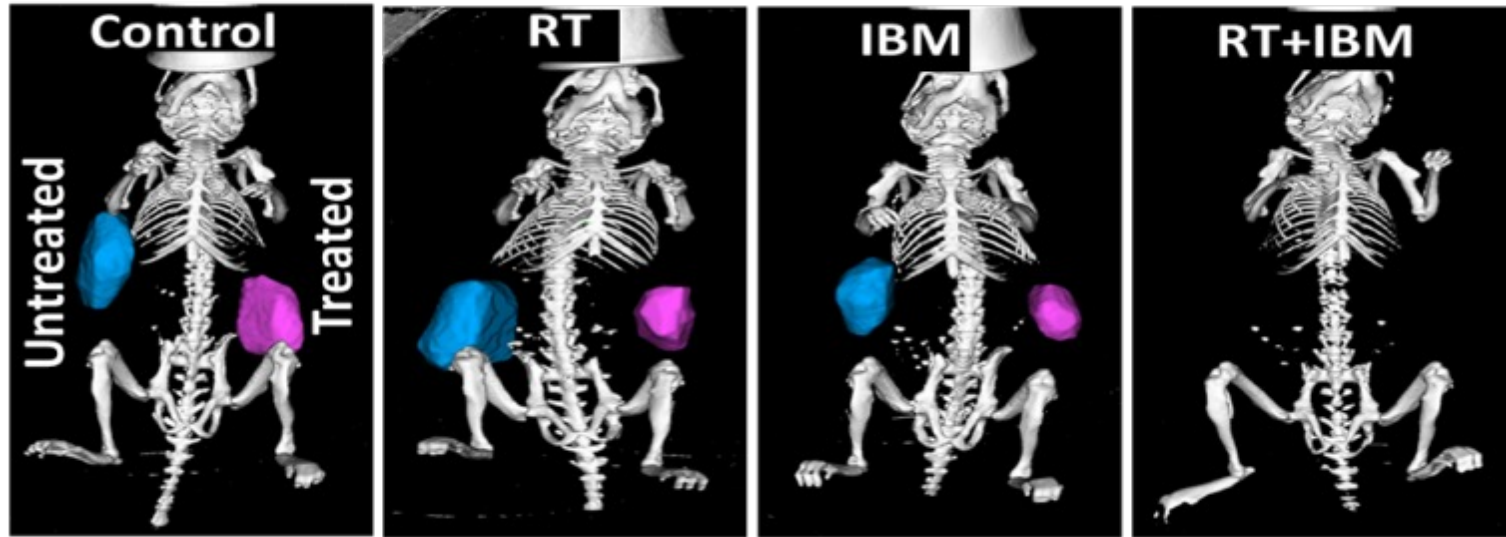
References:

Front Oncol. 2017; 7: 208.

Molecules 2020, 25, 2707

Phys Med Biol. 2015 Sep 21;60(18):7035-43.

Effective across other tumor types



RESULTS: It is real: Development of immunologic memory

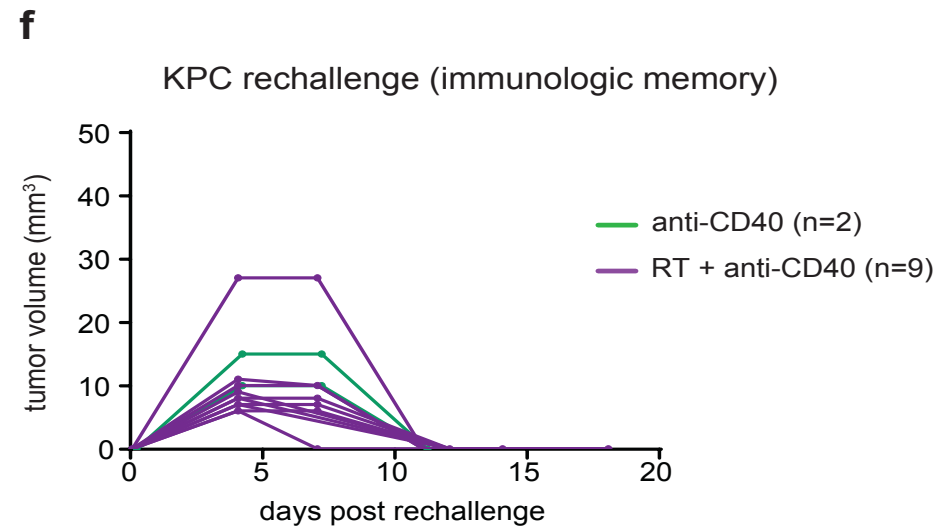
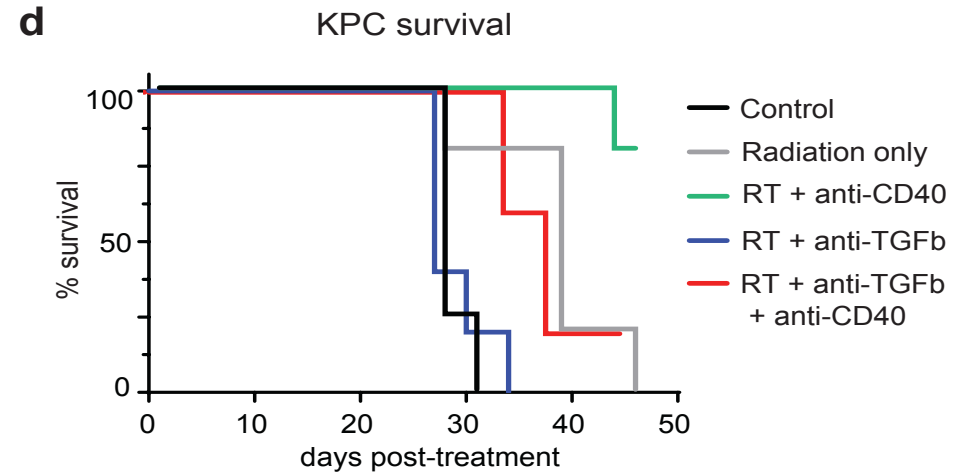
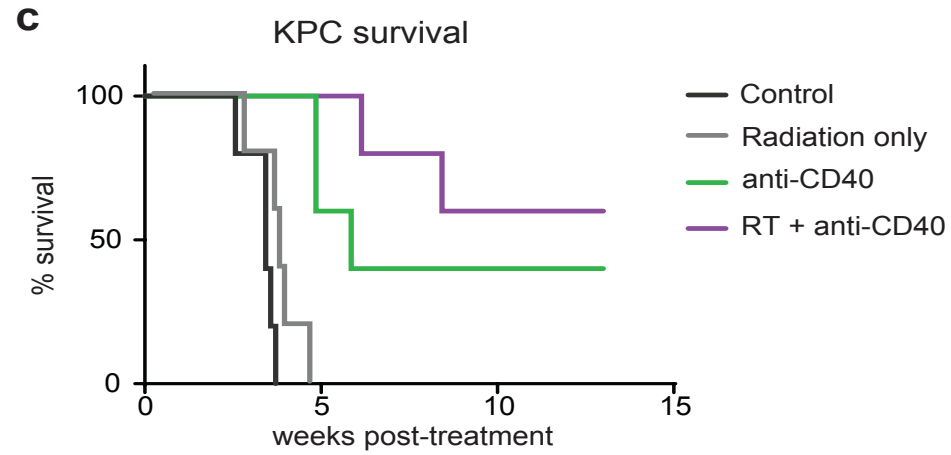
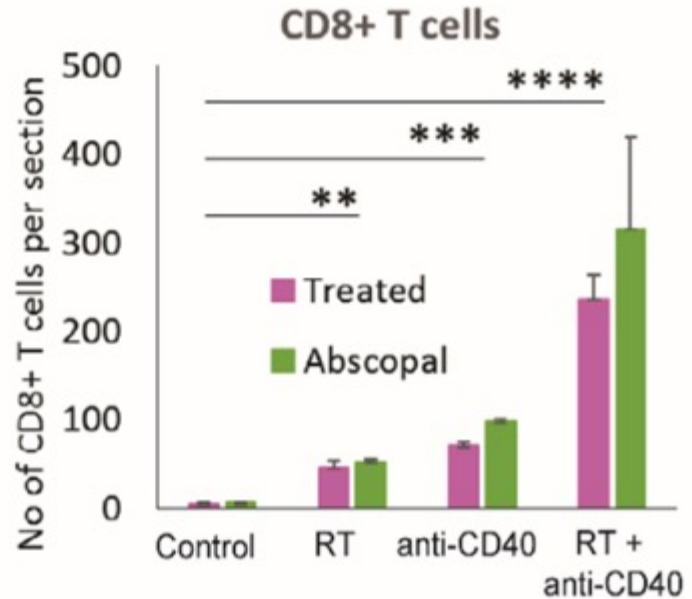
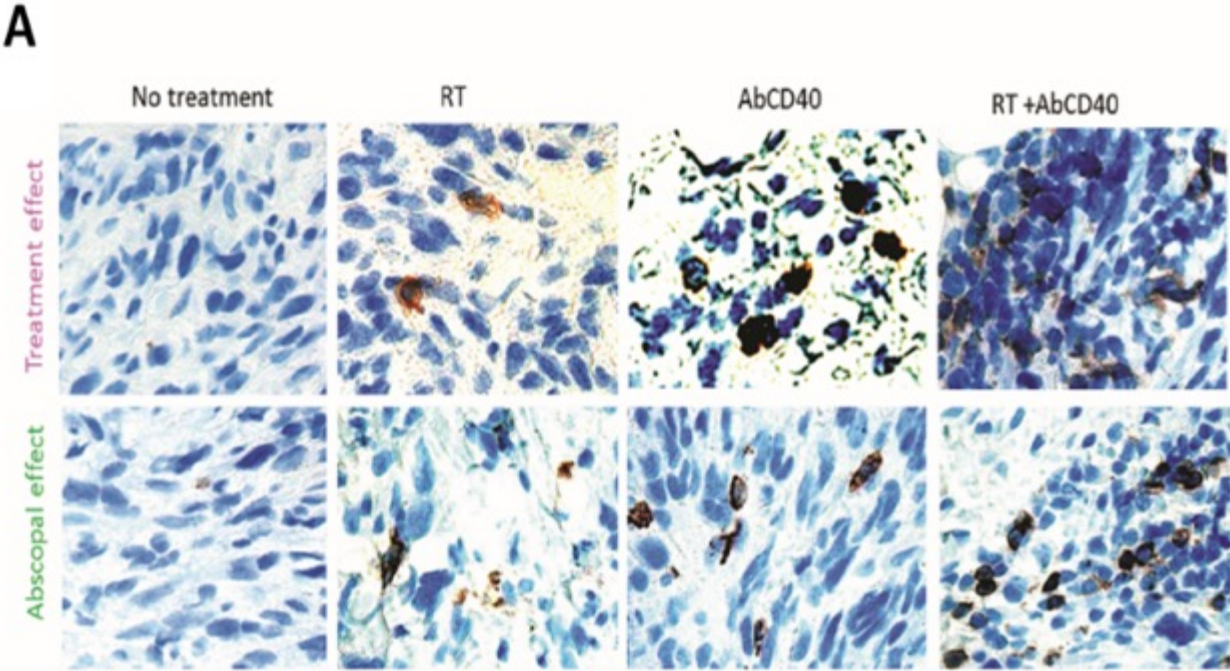


Figure 5

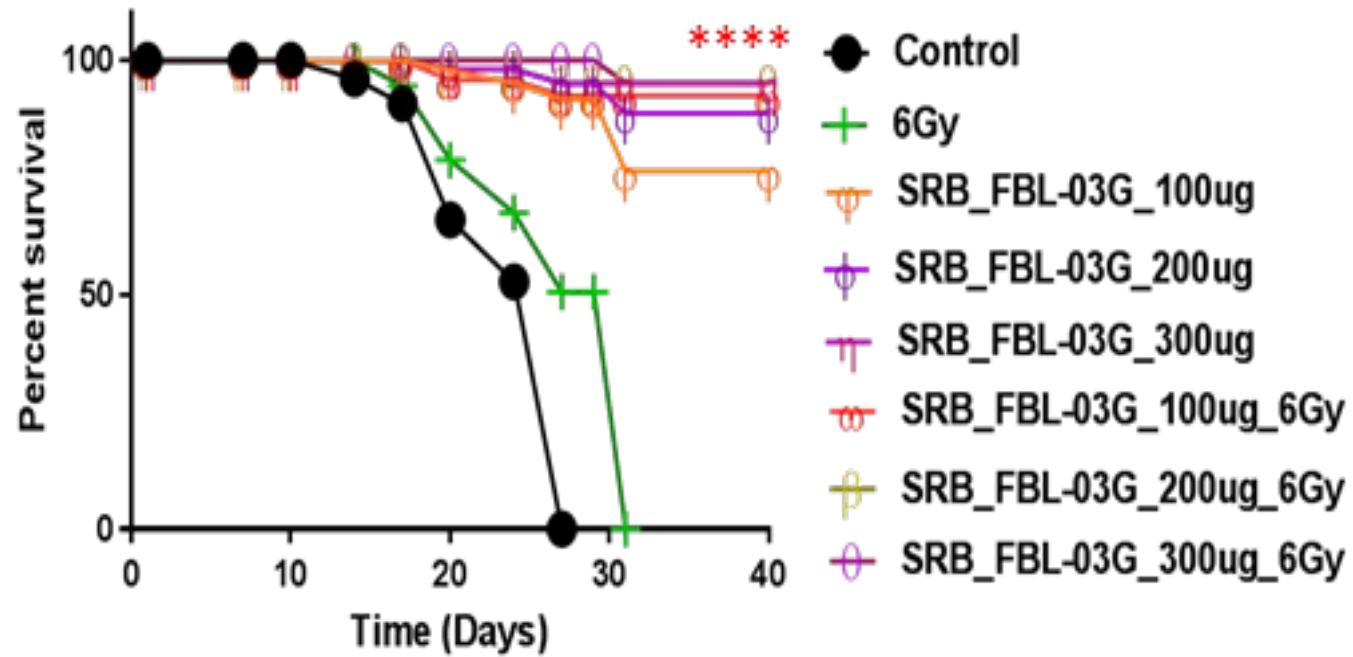
RESULTS: Combining more effective



2023: FDA approval for clinical trials on Tiny Drones to Target Cancer

Biomaterial drones target cancer, improve survival

Mice Survival Curves Comparing Different Concentrations of FBL-03G



Caflanone inhibits both local and metastatic pancreatic cancer

Impact: Tiny drones to target cancer approach Can increase access to care and reduce disparities

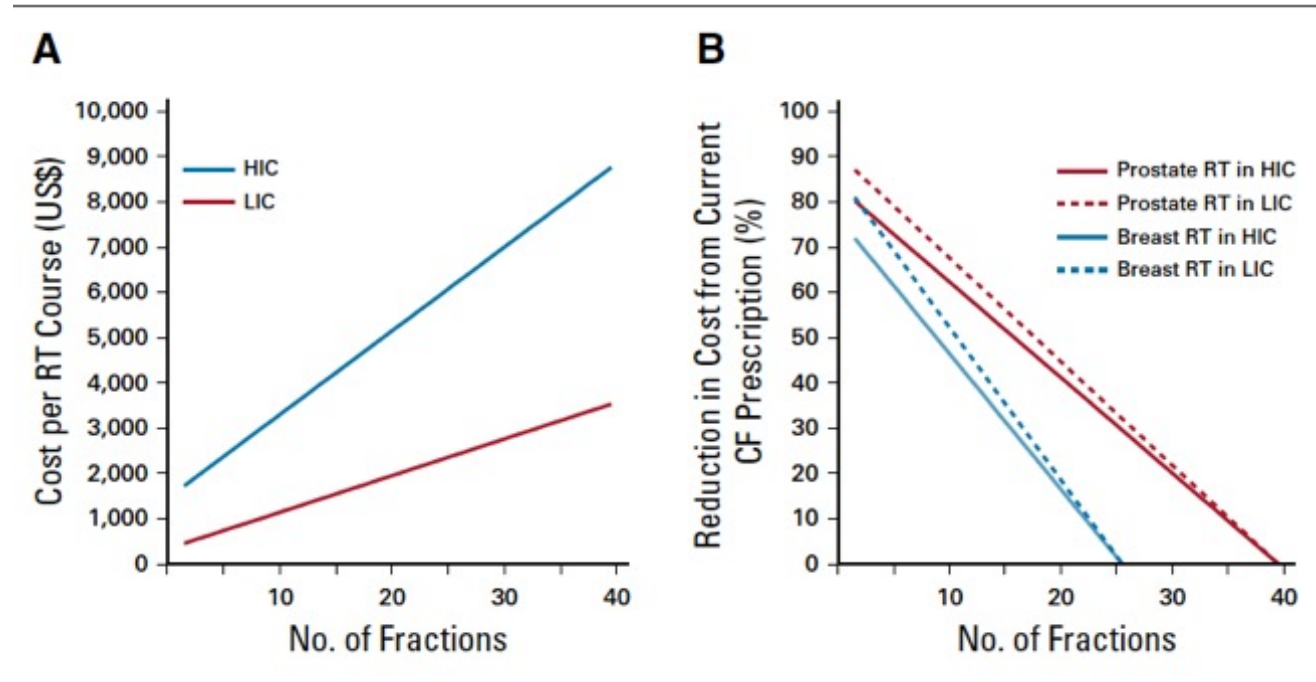
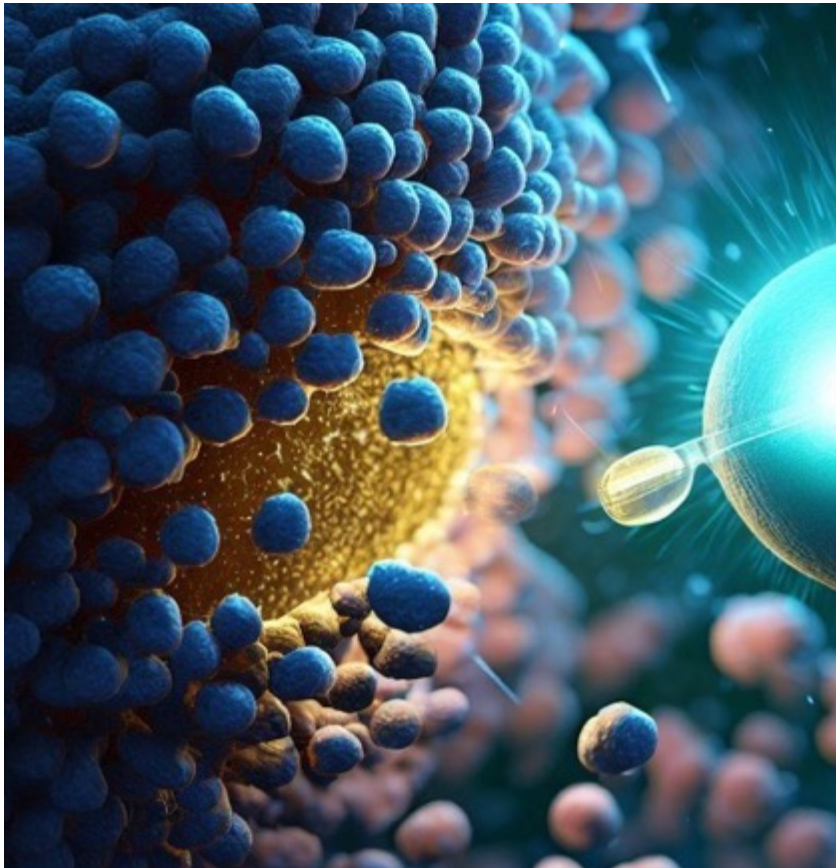


FIG 4. Graphs of (A) the estimated cost of an radiation therapy (RT) course per number of fractions delivered for high-income countries (HICs) and low-income countries (LICs) calculated by the Van Dyk et al model²¹; and (B) the estimated percent reduction in cost with changes in number of fractions for breast and prostate RT for HICs and LICs calculated by the Van Dyk et al model.² CF, conventional fractionation.

Reduce cost of treatment in the USA (HIC) and Low and Middle Income Countries (LIC)

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Thank you very much
for your attention !

