Development of microneedle technology for drug delivery in the laboratory, classroom, clinic and board room

Mark R. Prausnitz
Georgia Institute of Technology

Outline of talk

In the classroom

- pharmaceutical education at Georgia Tech

In the laboratory

- design and fabrication of microneedles

In the clinic

- human clinical trials

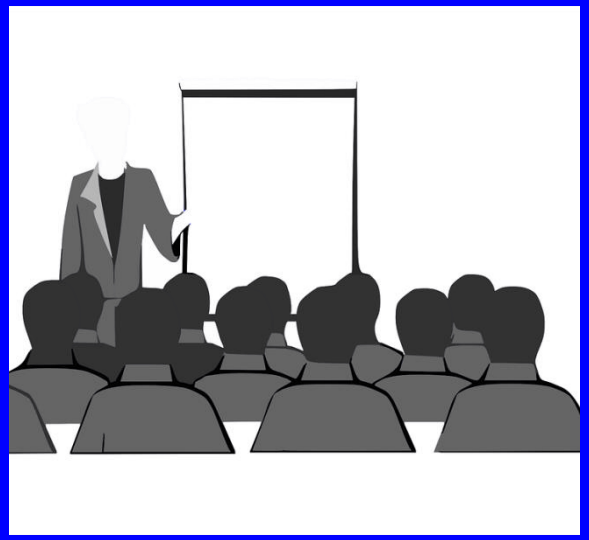
In the board room

- formation of new companies

Outline of talk

In the classroom

- pharmaceutical education at Georgia Tech



Classes for undergraduates and graduates

Plant trip to pharmaceutical industry

Training grant for doctoral students

Undergraduate/Graduate Student Semester Course

DRUG DESIGN, DEVELOPMENT, AND DELIVERY:

An Interdisciplinary Course on Pharmaceuticals

MARK R. PRAUSNITZ AND ANDREAS S. BOMMARIUS
Georgia Institute of Technology • Atlanta, GA 30332

For the past five years, Georgia Tech's School of Chemical and Biomolecular Engineering (ChBE) has offered an innovative interdisciplinary course in drug design, development, and delivery, also known as the D4 course. This course was developed due to changes in chemical engineering education over recent years, as well as needs within the pharmaceutical industry for an interdisciplinary approach to the development of novel drugs and formulations. It is offered as part of the biotechnology option track, an undeclared option, and undergraduates from other departments interested in pharmaceuticals. As discussed below, a balanced interdisciplinary mixture of students is assured through admissions restrictions.

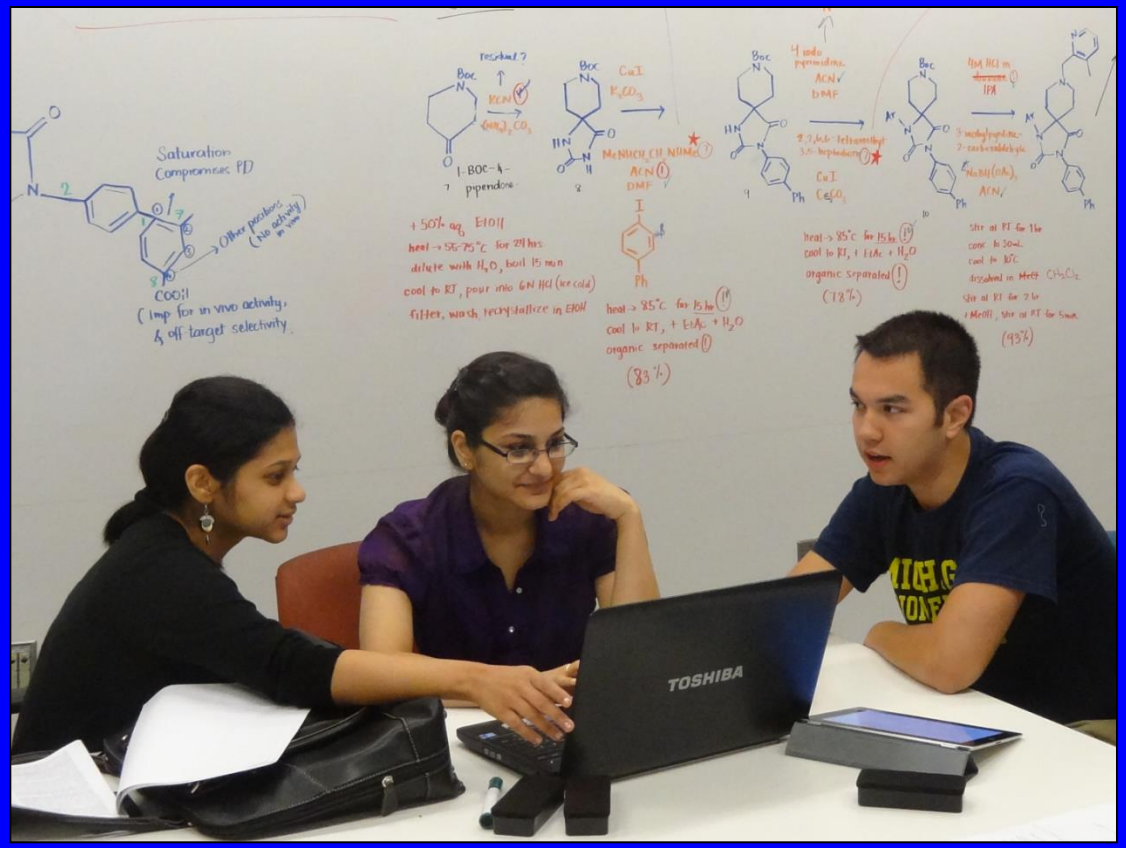
This article aims to provide information on the D4 course's structure, its contents, and the instructional philosophy behind it, with the hope that this framework may be directly useful to others or might be adapted to other courses geared towards the pharmaceutical and other industries.

MR Prausnitz and AS Bommarius (2011) **Chemical Engineering Education** 45:47-52

Graduate Student Short Course

Pharmaceutical development: from drug lead to drug product

Georgia Tech, Mercer, Emory and Georgia State

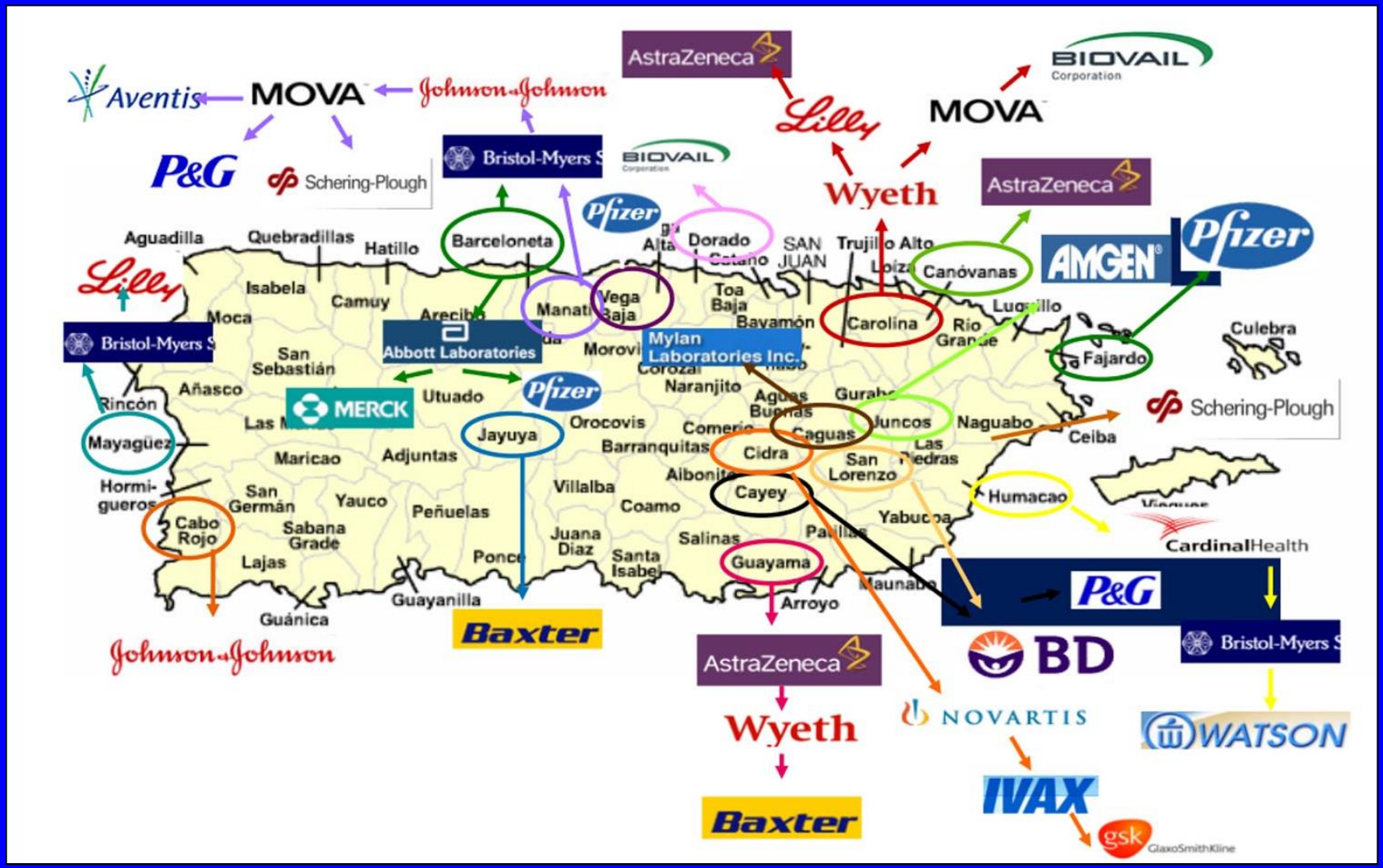


Pharmaceutical Industry Plant Trip

Abbvie, Amgen, Bacardi, Eli Lilly, J&J, Medtronic, Merck, Pfizer, Wyeth

Pharmaceutical Industry Plant Trip

Puerto Rico



GAANN Fellowship Program

U.S. Department of Education
Graduate Assistance in Areas of National Need

2004 – 2013

~120 one-year fellowships to doctoral students in
BMED
CHEM
CHBE

Outline of talk

In the laboratory

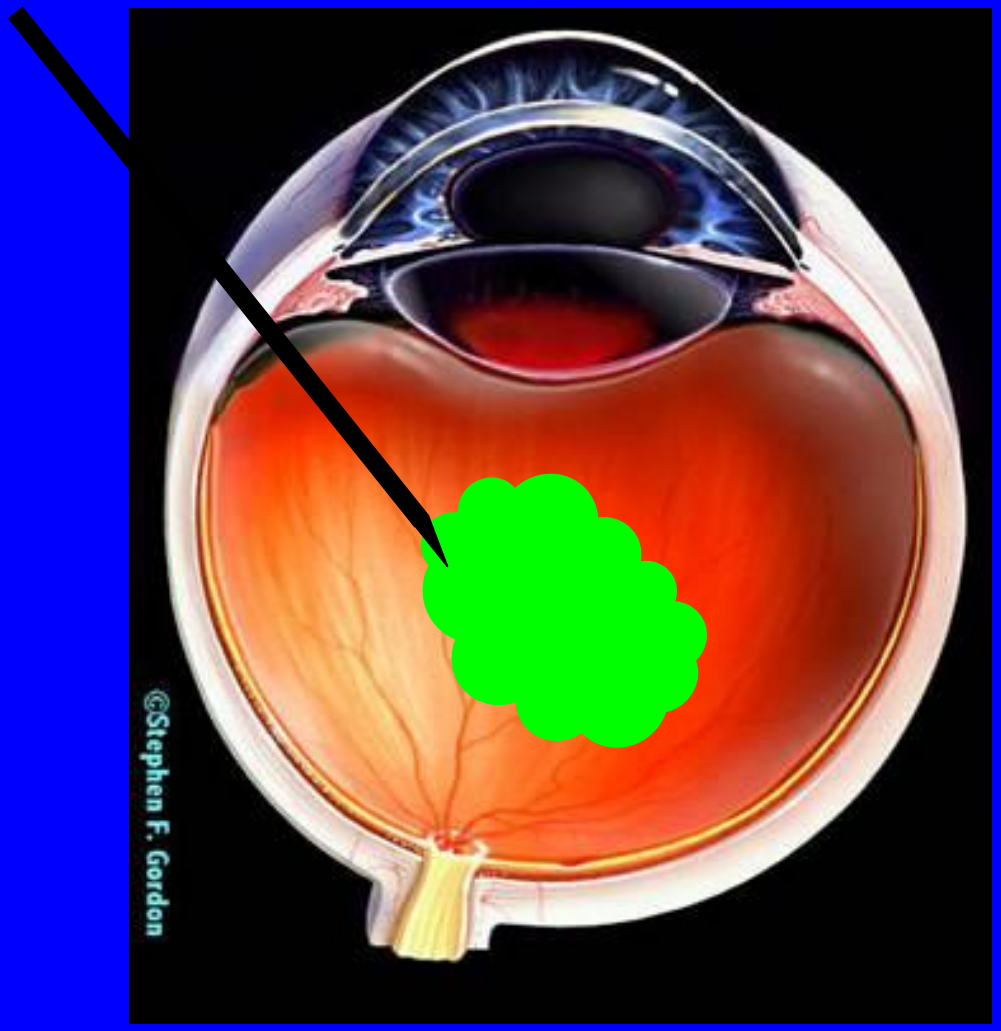
- design and fabrication of microneedles

Targeted drug delivery in the eye

Skin vaccination with a microneedle patch

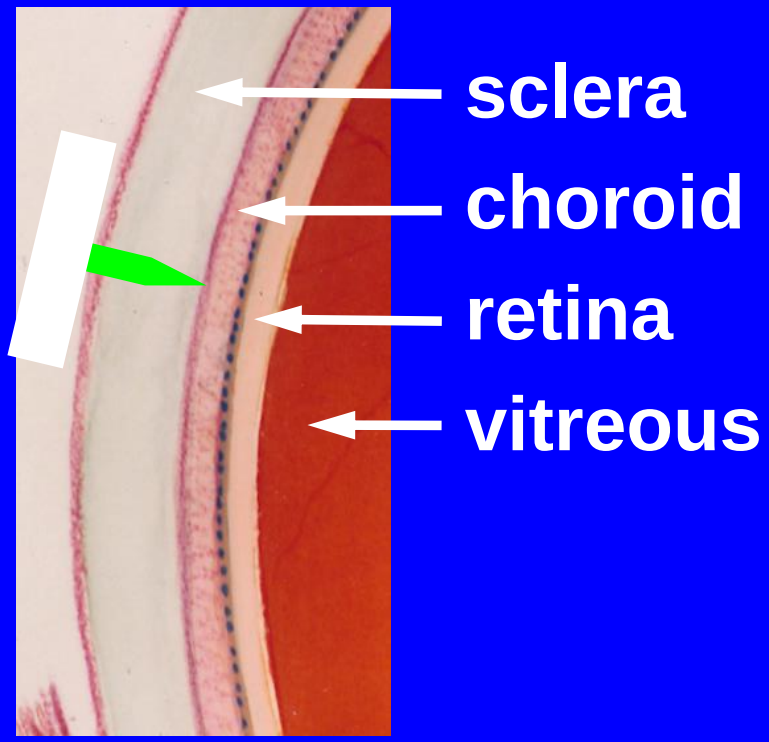
Intravitreal injection is poorly targeted

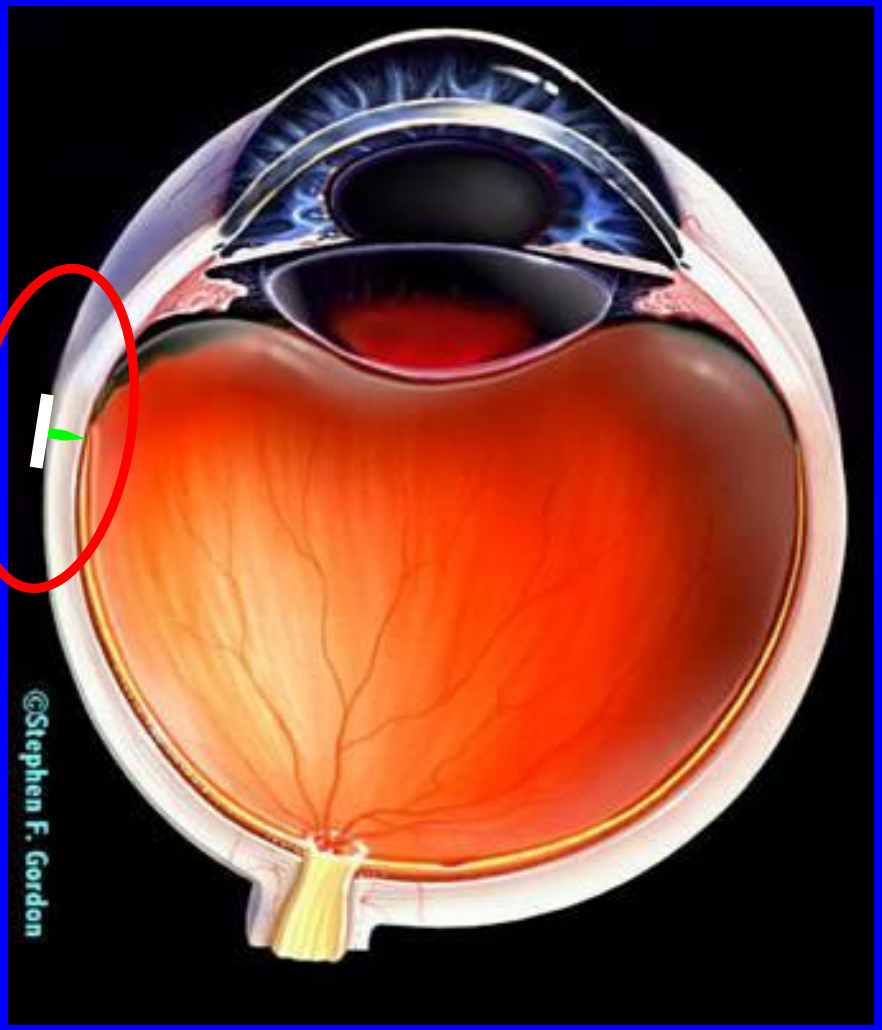
Intravitreal injection is poorly targeted



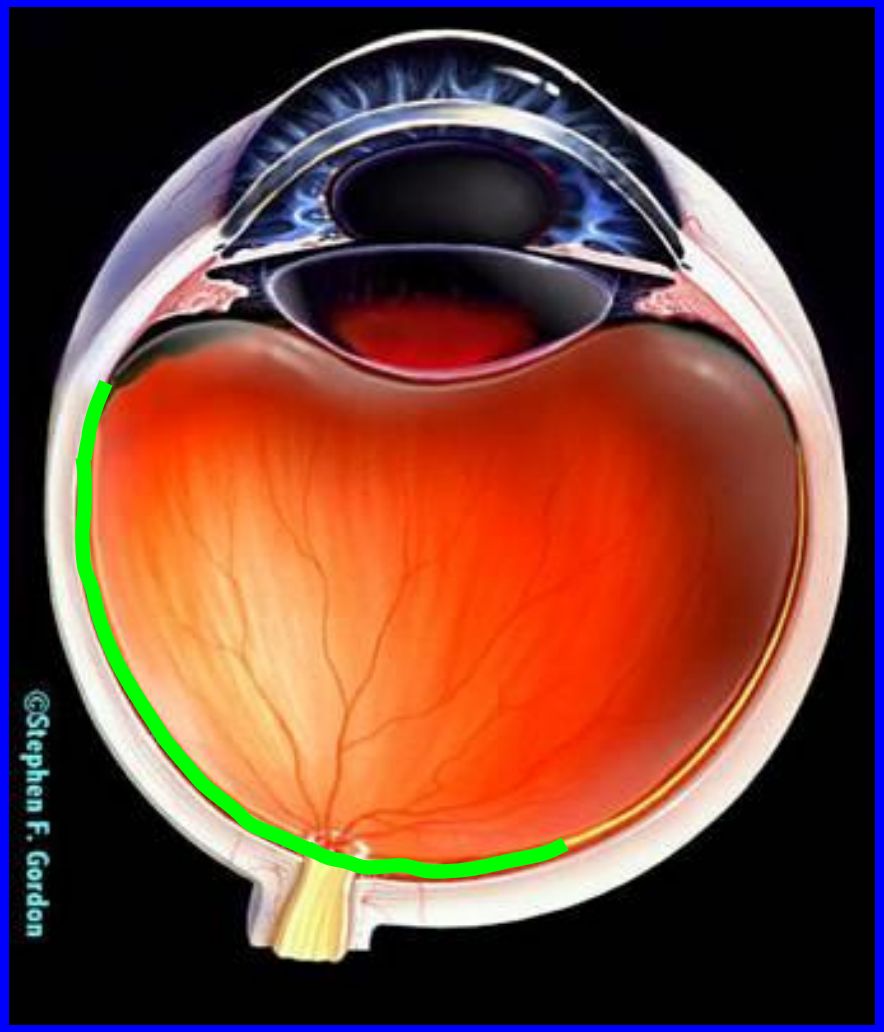
Intravitreal injection is poorly targeted

Suprachoroidal delivery is highly targeted

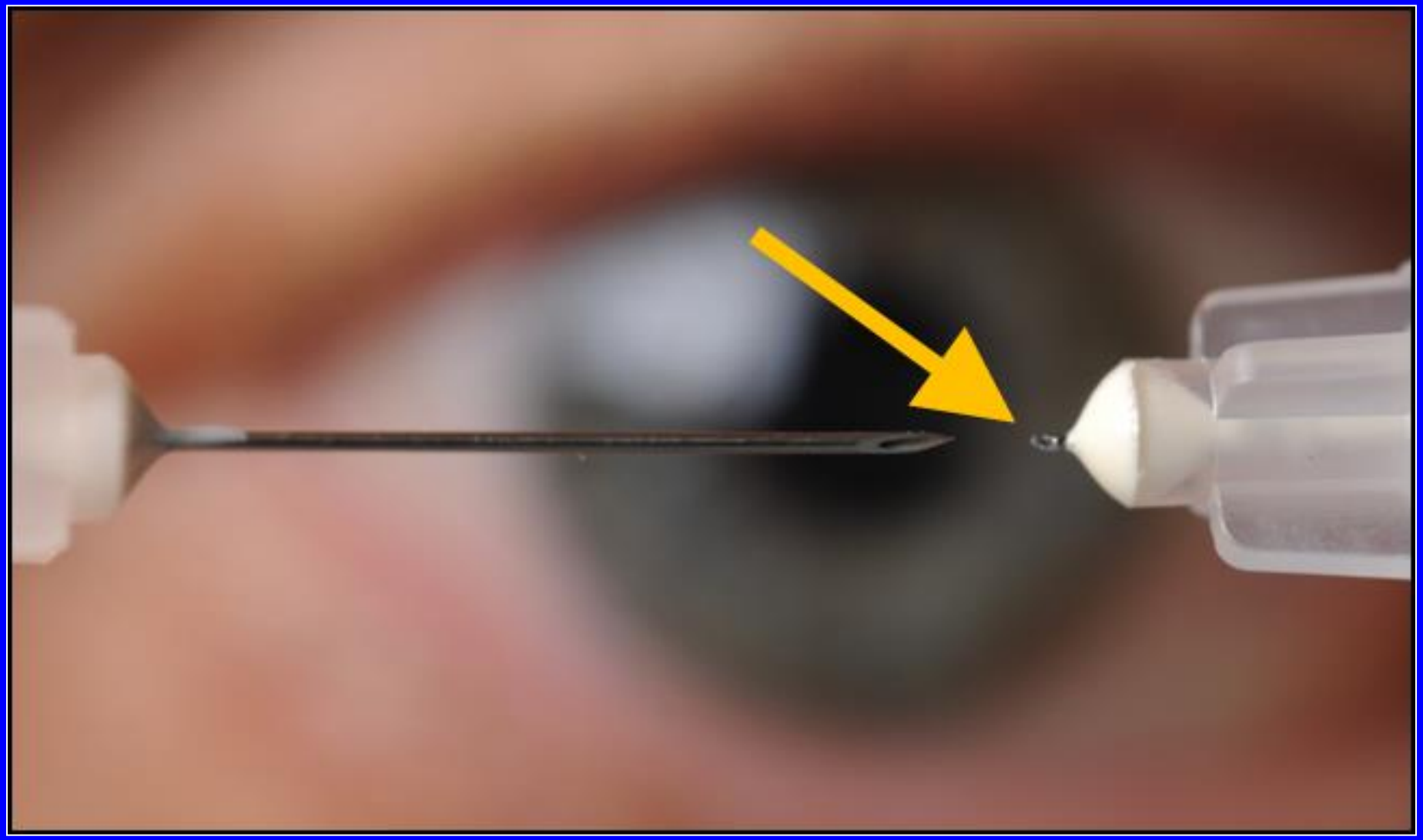




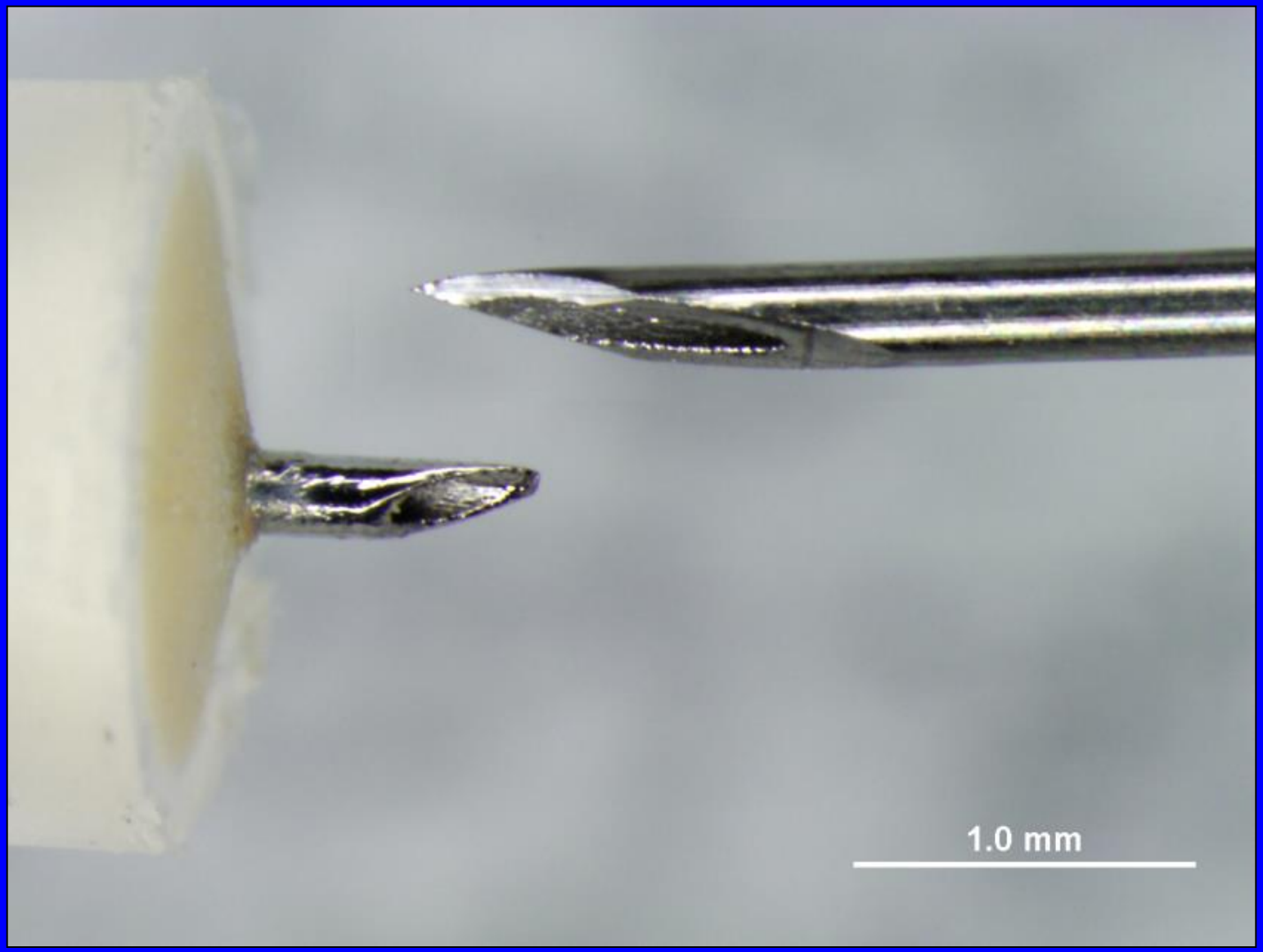
Suprachoroidal delivery is highly targeted



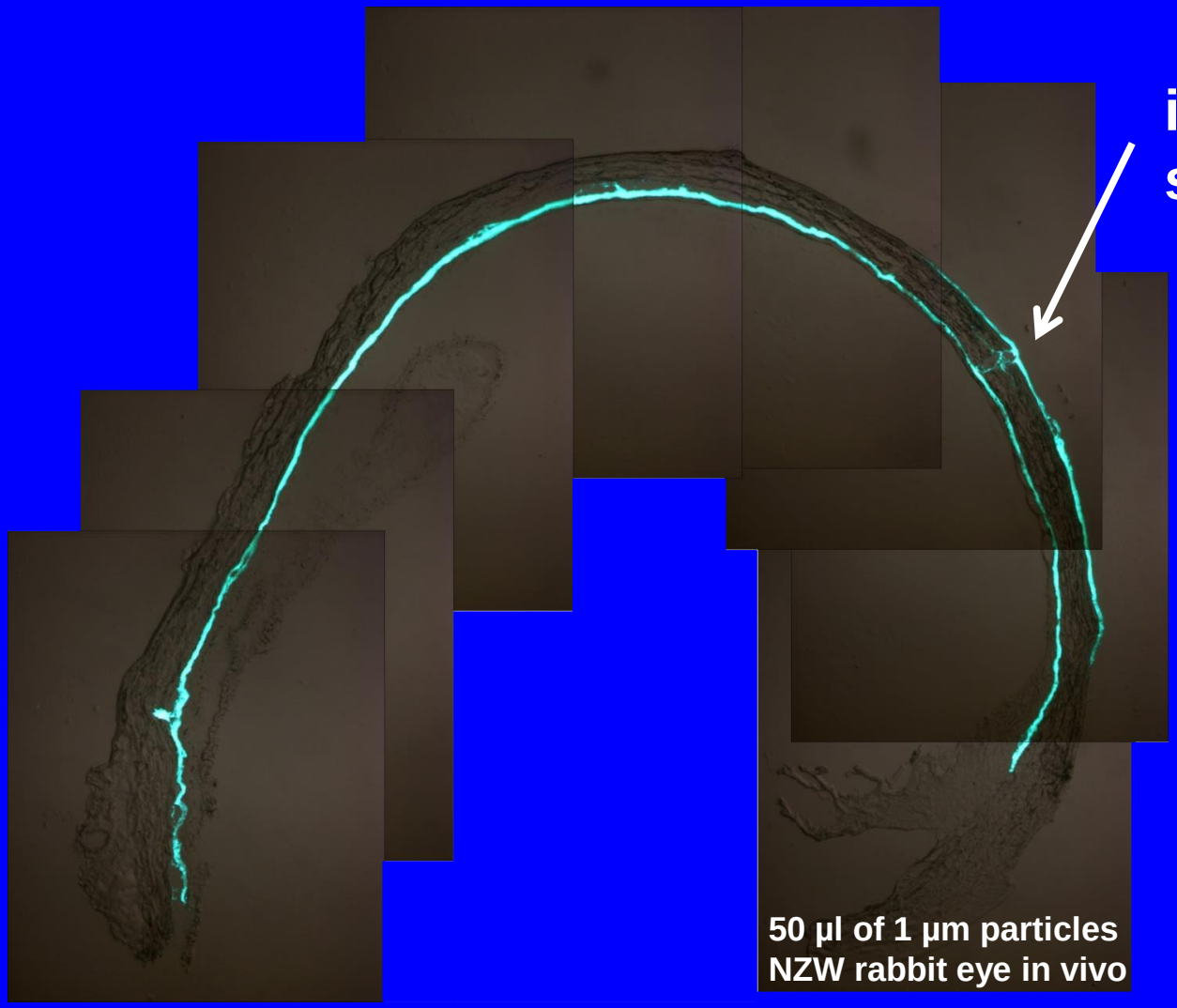
Hollow microneedle to target SCS



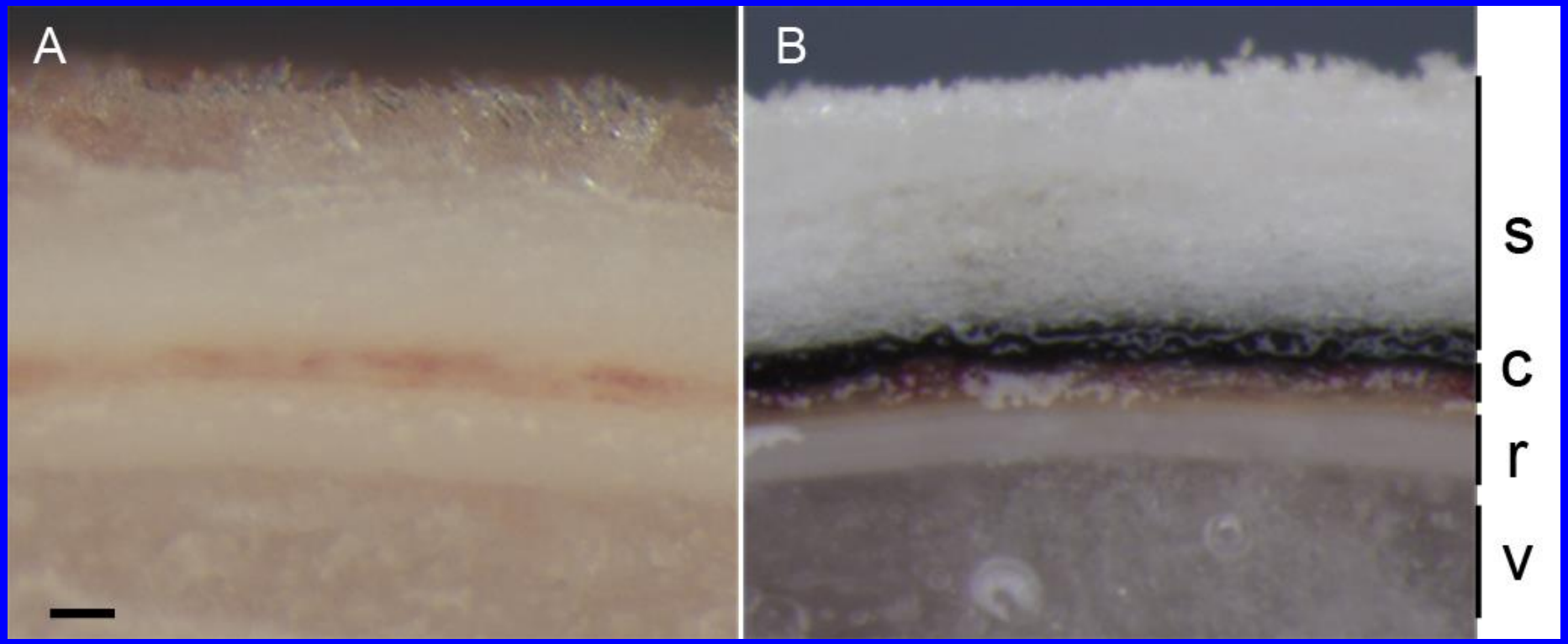
Hollow microneedle to target SCS



Injection targets suprachoroidal space



Injection targets suprachoroidal space



untreated

after suprachoroidal injection of India ink

Outline of talk

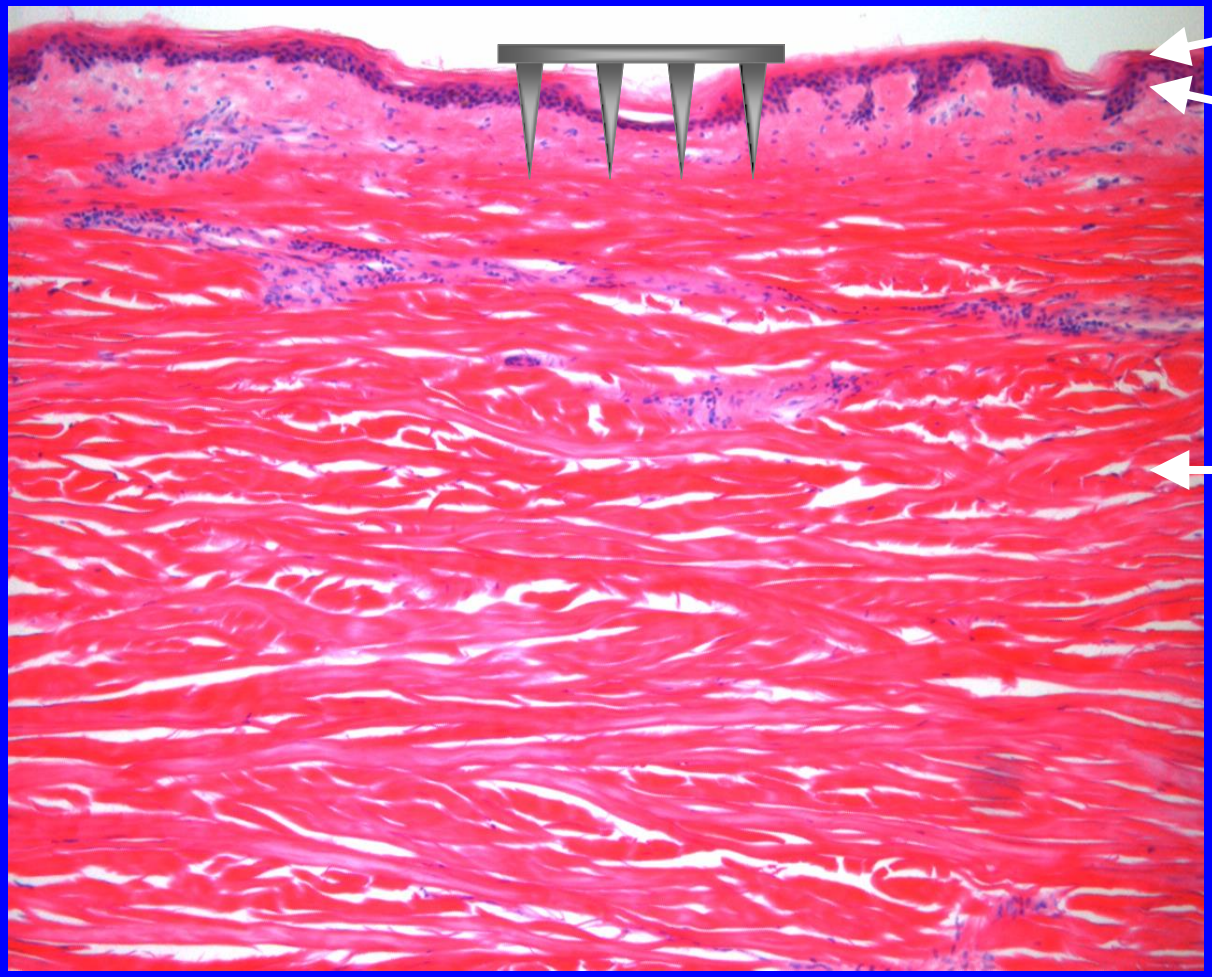
In the laboratory

- design and fabrication of microneedles

Targeted drug delivery in the eye

Skin vaccination with a microneedle patch

Microneedle patches target vaccine delivery to the skin

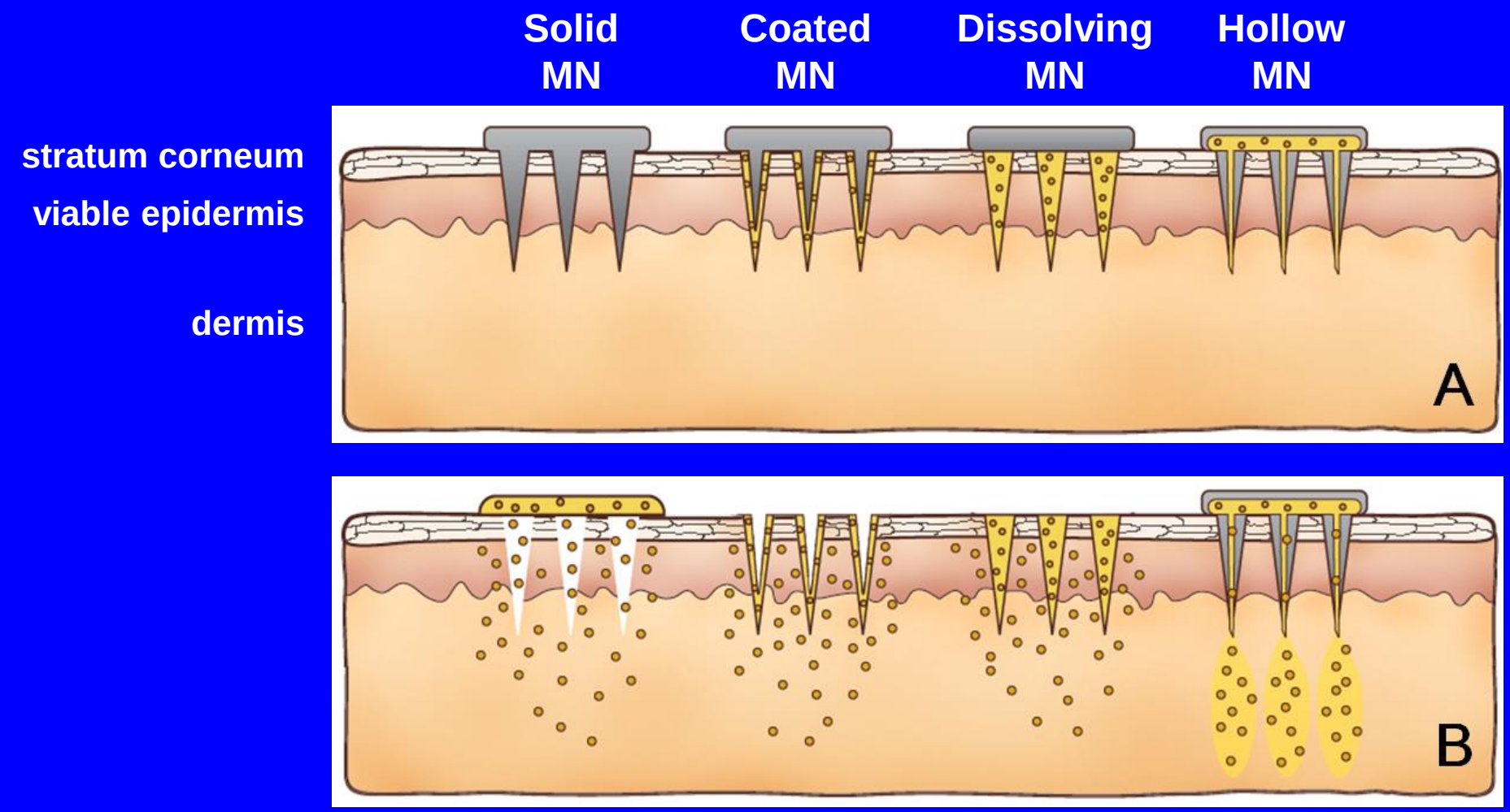


Stratum corneum

Viable epidermis (Langerhans cells)

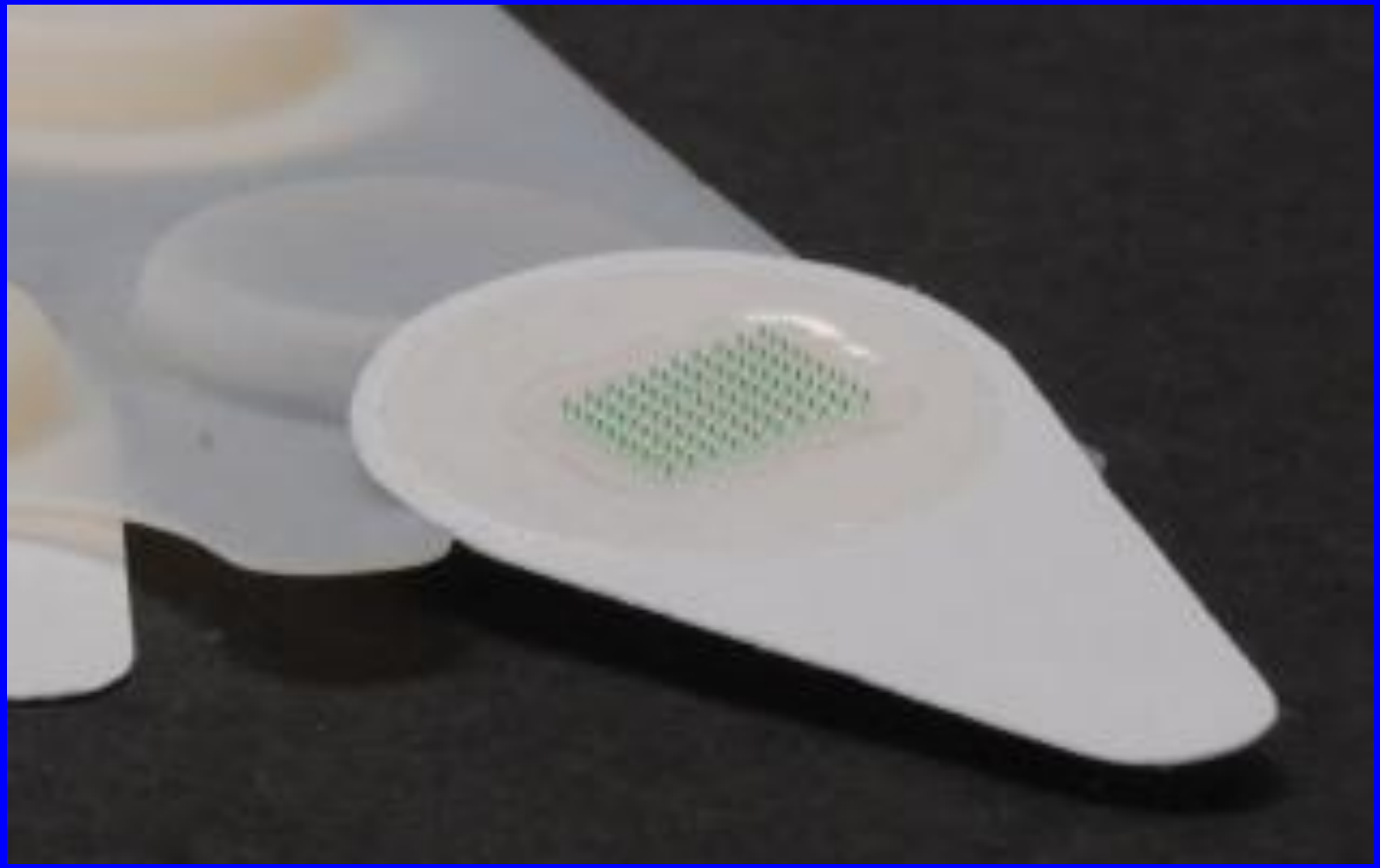
Dermis (dermal dendritic cells, lymphatic drainage)

Vaccine delivery mechanisms using microneedles

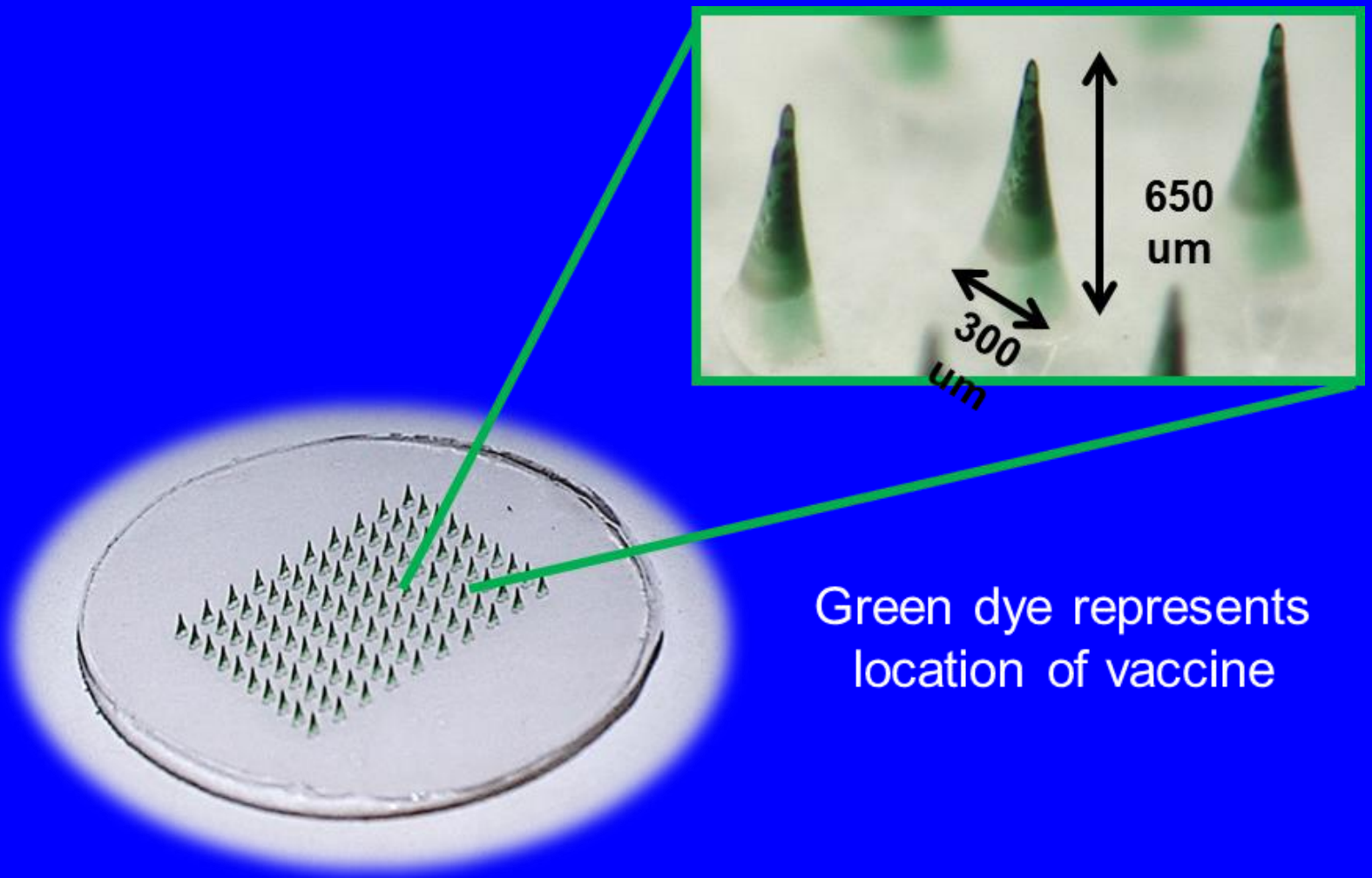


Dissolving microneedle patches

Dissolving microneedle patches



Dissolving microneedle patches



Green dye represents location of vaccine

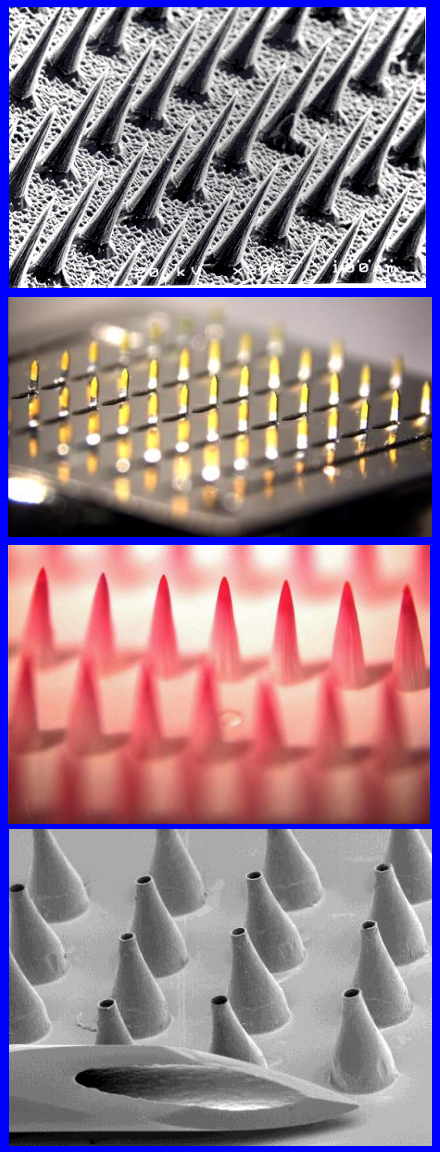
Microneedles meet public health needs

Manufacturing

Transportation and storage

Patient administration

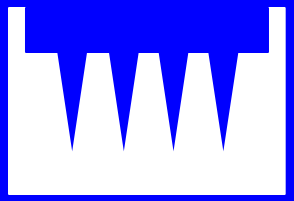
Waste disposal



Microneedles meet public health needs

Manufacturing

Low-cost fabrication



Prepare microneedle mold

Transportation and storage

Patient administration

Waste disposal

Microneedles meet public health needs

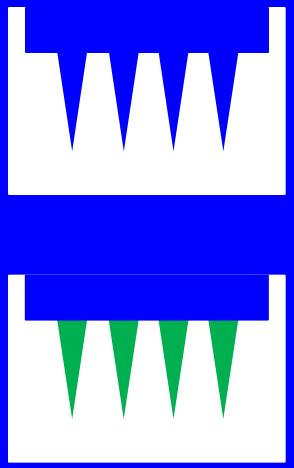
Manufacturing

Low-cost fabrication

Transportation and storage

Patient administration

Waste disposal



Cast antigen formulation into micromold cavities

Microneedles meet public health needs

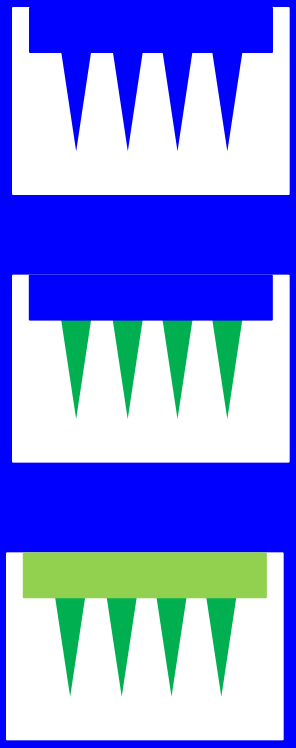
Manufacturing

Low-cost fabrication

Transportation and storage

Patient administration

Waste disposal



Cast matrix formulation onto micromold surface

Microneedles meet public health needs

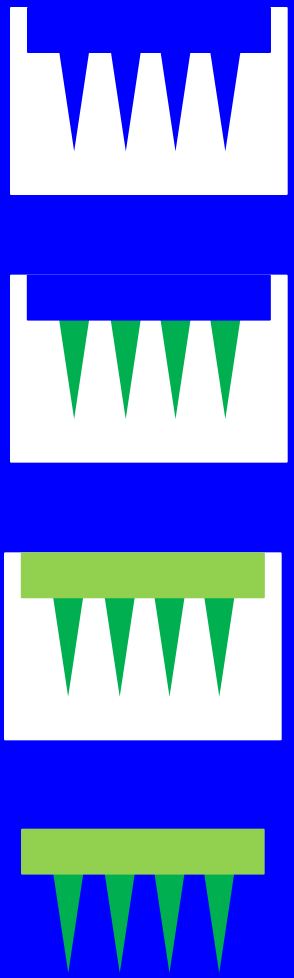
Manufacturing

Low-cost fabrication

Transportation and storage

Patient administration

Waste disposal



Dry and remove microneedle patch

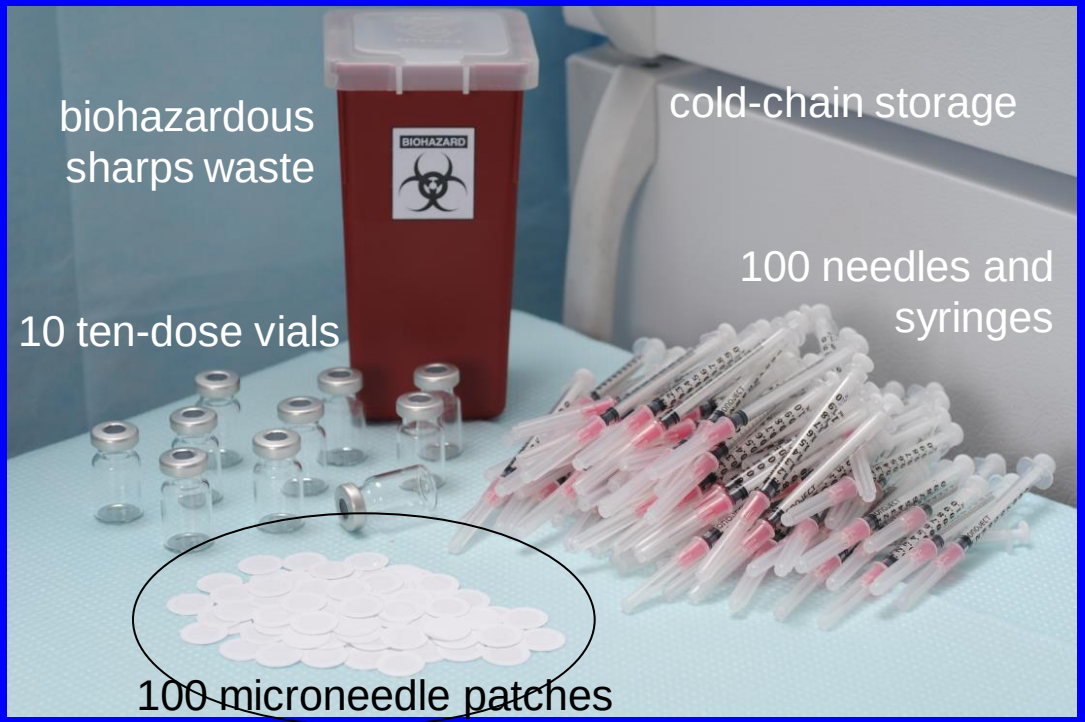
Microneedles meet public health needs

Manufacturing
Low-cost fabrication

Transportation and storage
Small package size

Patient administration

Waste disposal



Microneedles meet public health needs

Manufacturing
Low-cost fabrication

Transportation and storage
Small package size
Possible thermal stability

Patient administration

Waste disposal

Microneedles meet public health needs

Manufacturing
Low-cost fabrication

Transportation and storage
Small package size
Possible thermal stability

Patient administration
No reconstitution

Waste disposal

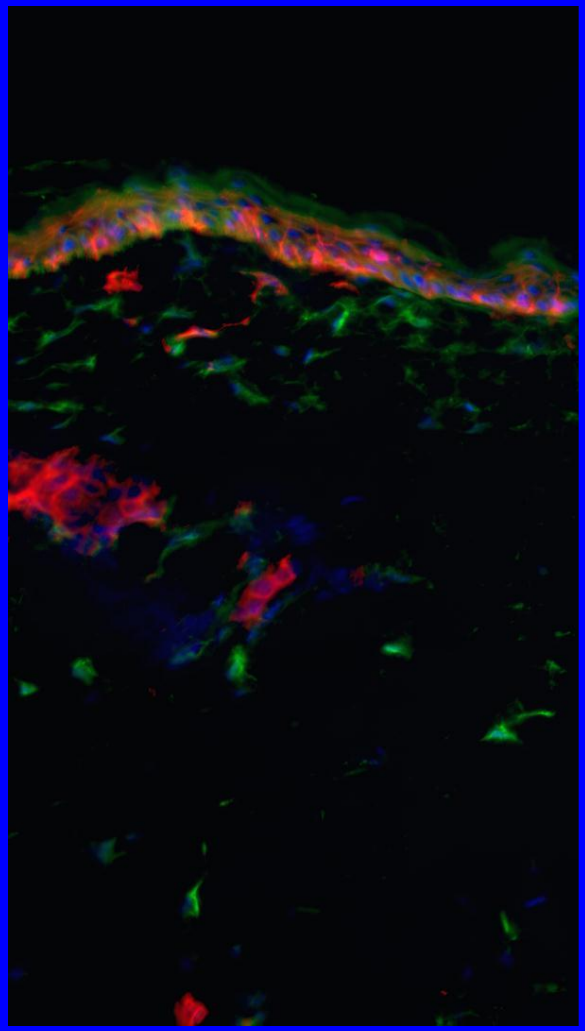
Microneedles meet public health needs

Manufacturing
Low-cost fabrication

Transportation and storage
Small package size
Possible thermal stability

Patient administration
No reconstitution
Possible reduced dose

Waste disposal



Microneedles meet public health needs

Manufacturing
Low-cost fabrication

Transportation and storage
Small package size
Possible thermal stability

Patient administration
No reconstitution
Possible reduced dose
Minimally trained personnel

Waste disposal

Microneedles meet public health needs

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No reconstitution
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Minimally trained personnel

Waste disposal
Difficult or impossible reuse

Microneedles meet public health needs

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Low-cost fabrication

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Patient administration
No reconstitution
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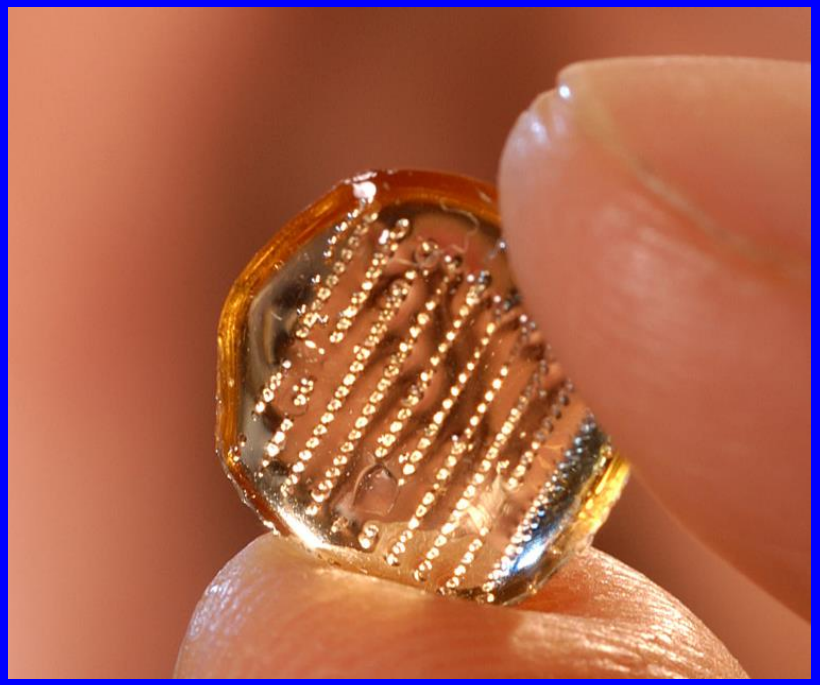
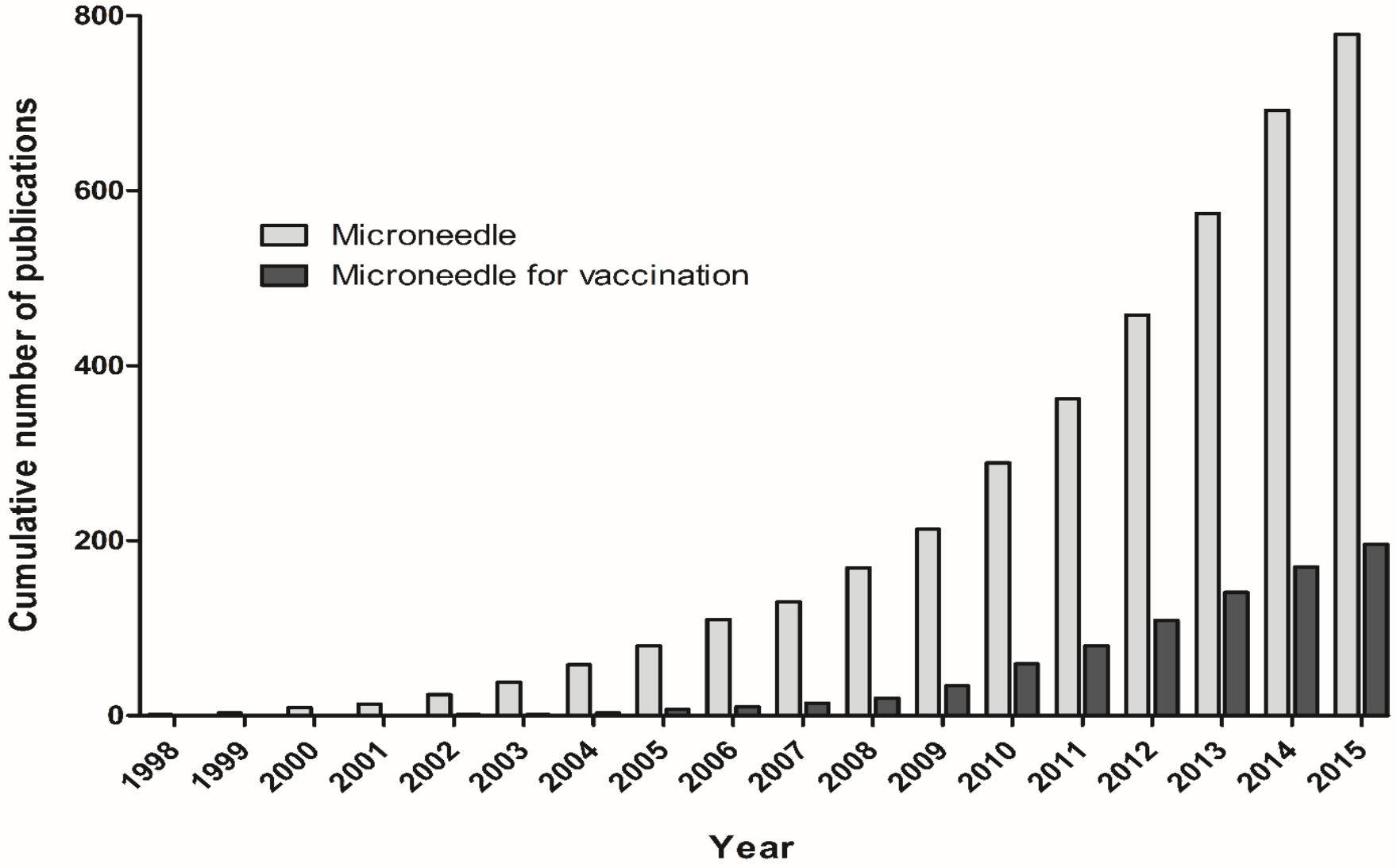
Minimally trained personnel



Waste disposal
Difficult or impossible reuse

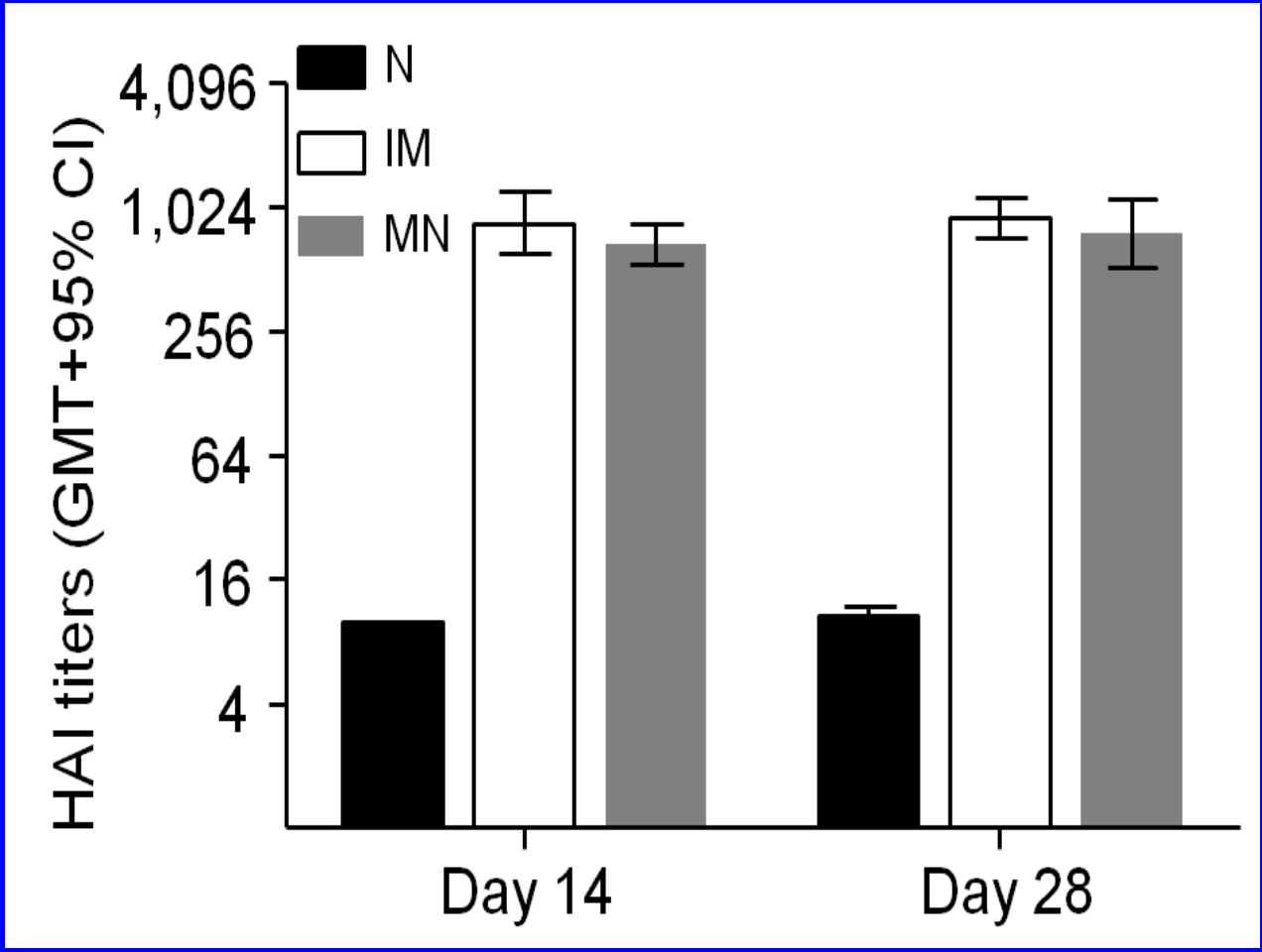
Reduced or no disposal volume

Microneedle research is increasing



Influenza vaccination

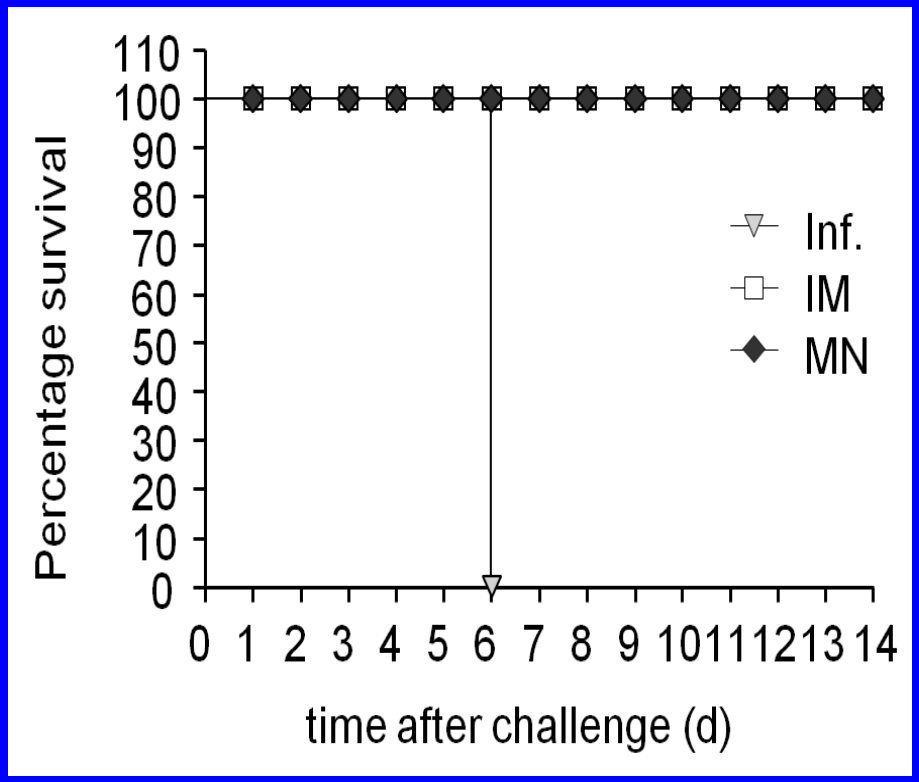
HAI response after H1N1 whole inactivated influenza virus vaccination in mice

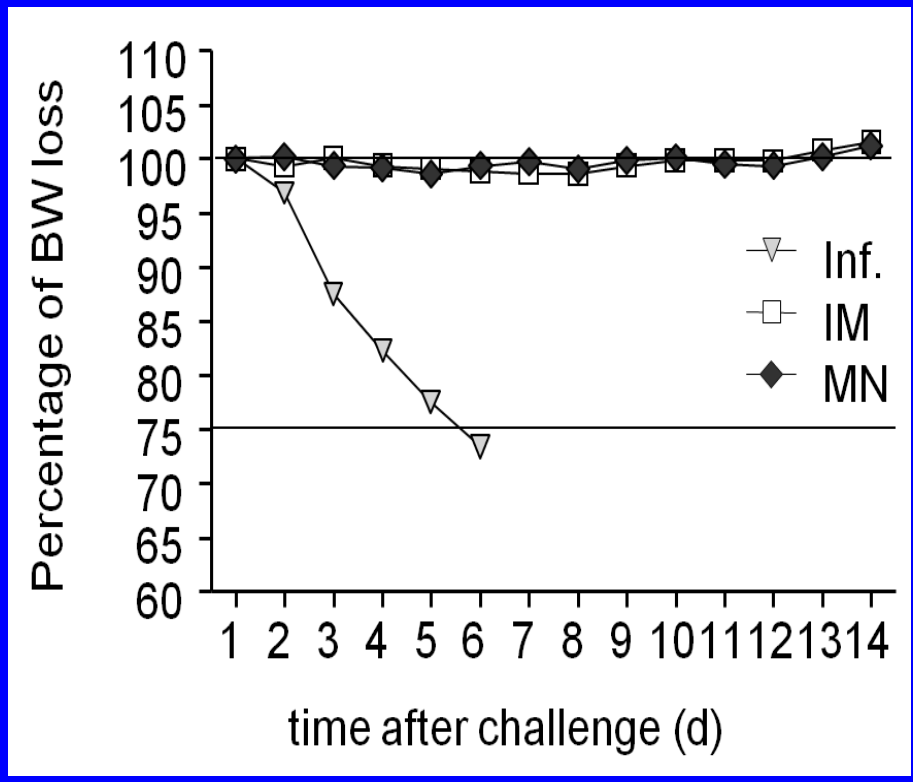


Sean Sullivan, Ioanna Skountzou, Richard Compans, Emory University

Influenza vaccination

Protection after H1N1 whole inactivated influenza virus vaccination in mice

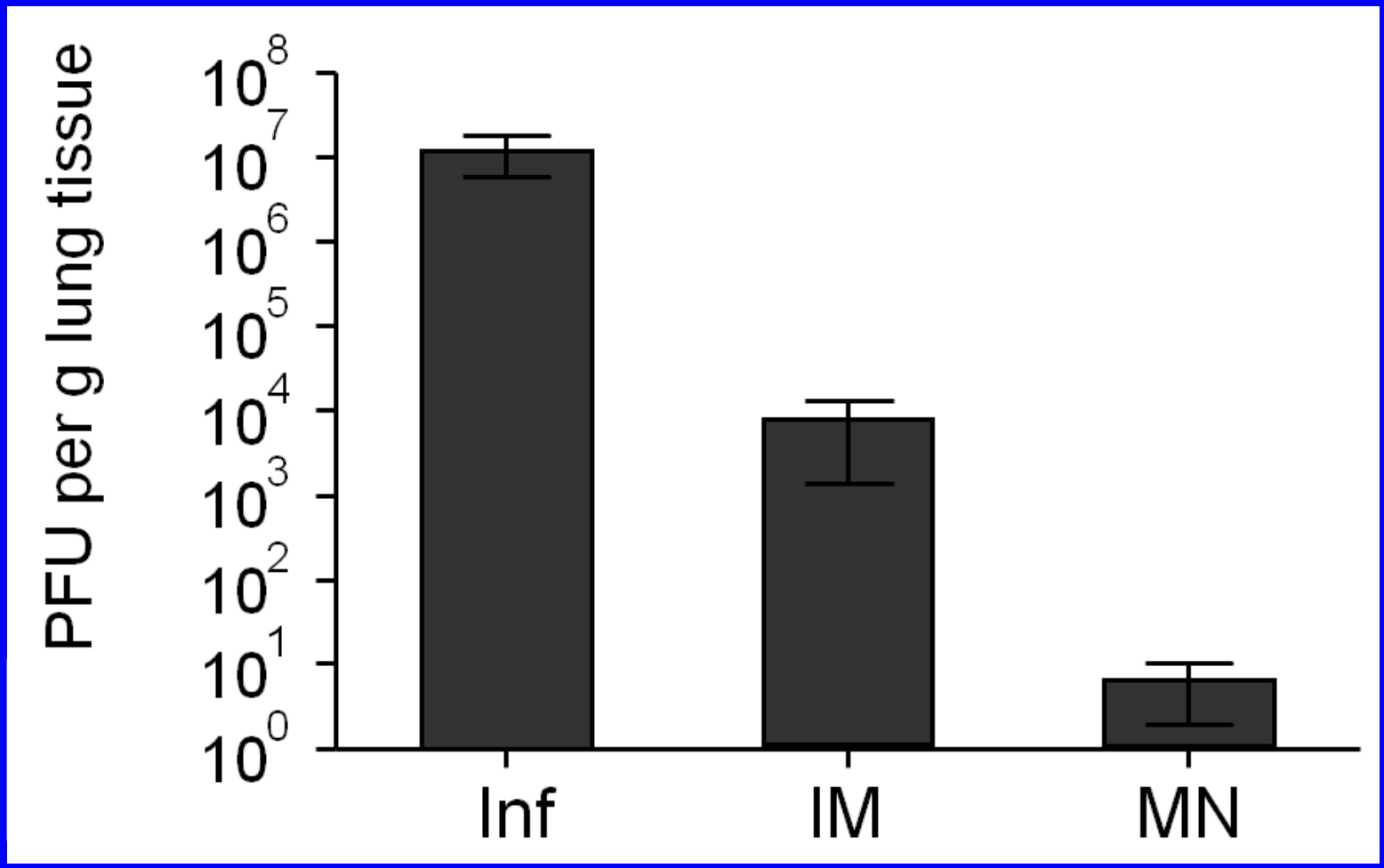




Sean Sullivan, Ioanna Skountzou, Richard Compans, Emory University

Influenza vaccination

Virus clearance from lung after H1N1 whole inactivated influenza virus vaccination in mice



Sean Sullivan, Ioanna Skountzou, Richard Compans, Emory University

Influenza vaccination

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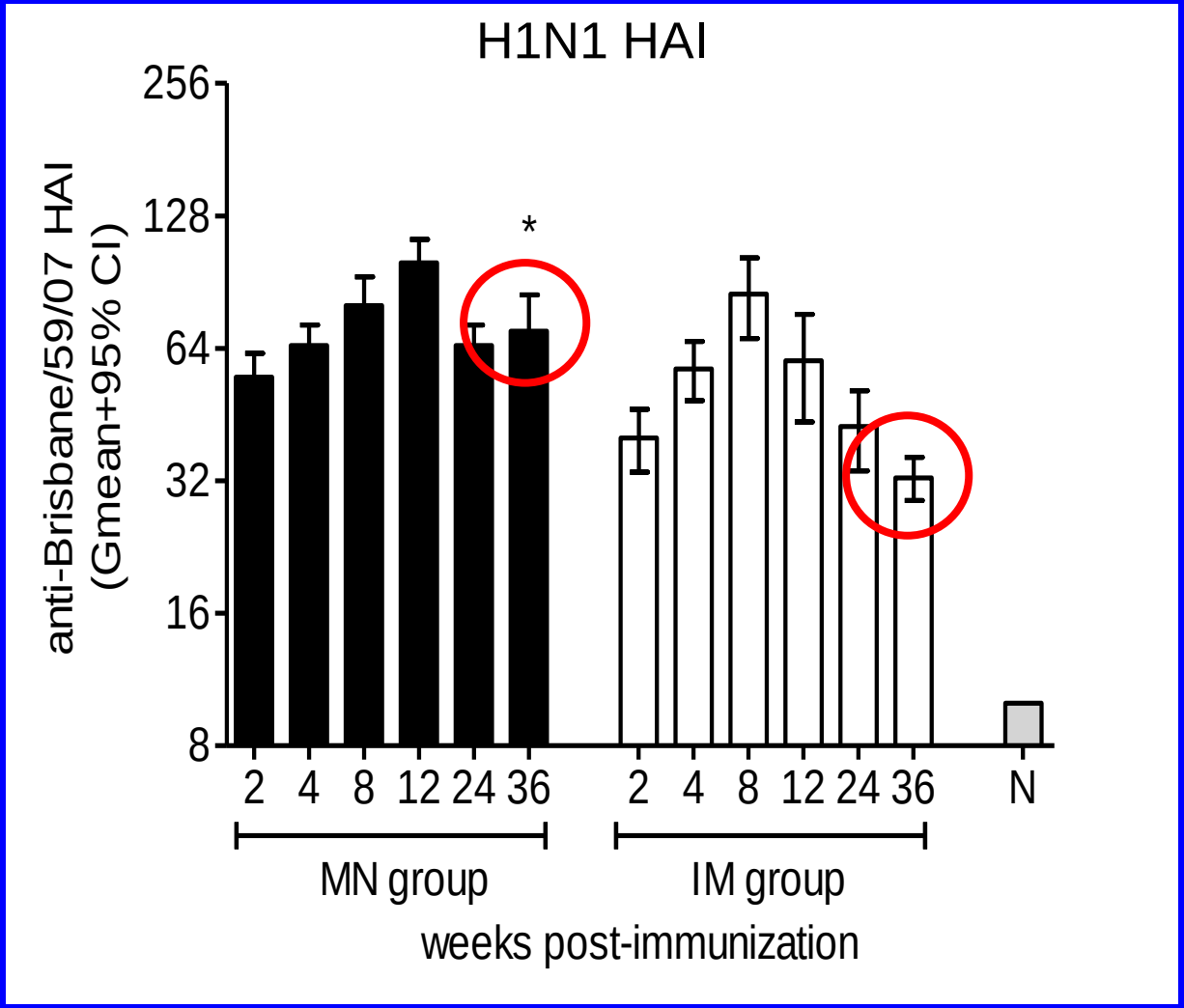


Dimitrios Koutsonanos, Ioanna Skountzou, Richard Compans, Emory University

Outline of talk

In the clinic

- human clinical trials

IRB

Institutional Review Board

EMORY UNIVERSITY

cor prudentis possidebit scientiam

1836 1915

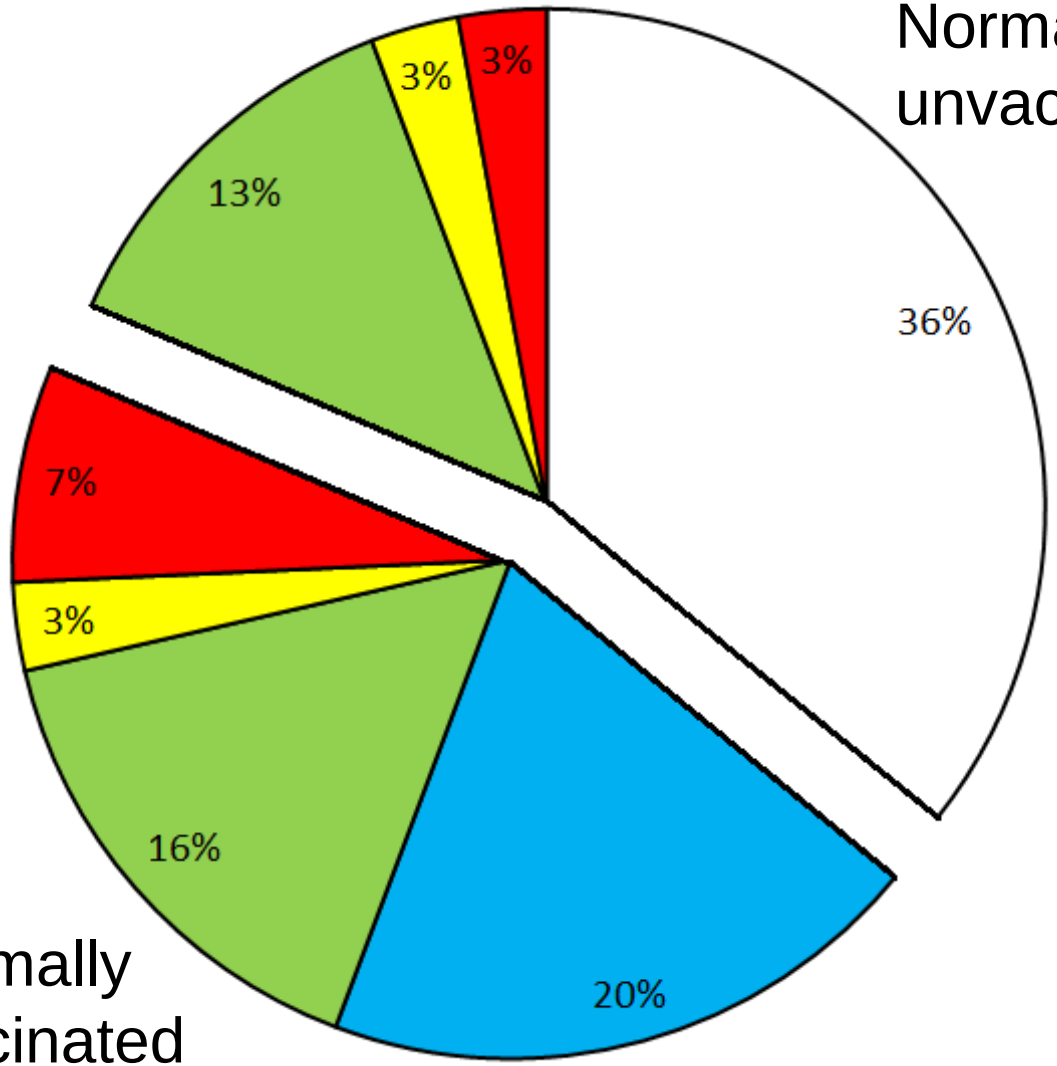
WHO

Human factors (on-going)

Influenza vaccination (2015-2016)

Polio vaccination (2017-2018)

Acceptability of influenza vaccination using a microneedle patch



James Norman

Inactivated polio vaccination clinical trial to begin in 2017

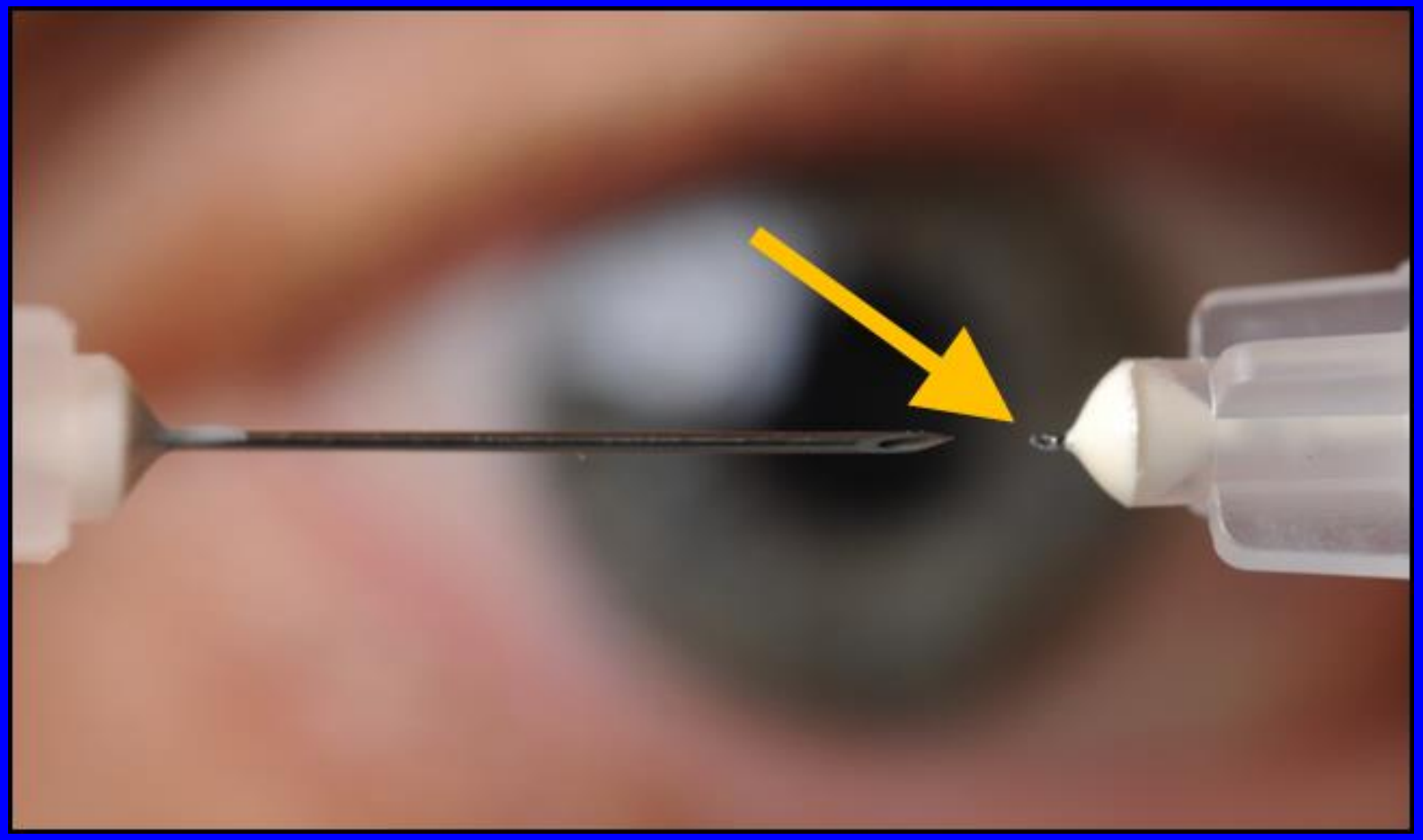
Outline of talk

In the board room

- formation of new companies

Mark Prausnitz is a co-founder and has a significant financial interest in Clearside Biomedical and Micron Biomedical.

Clearside Biomedical

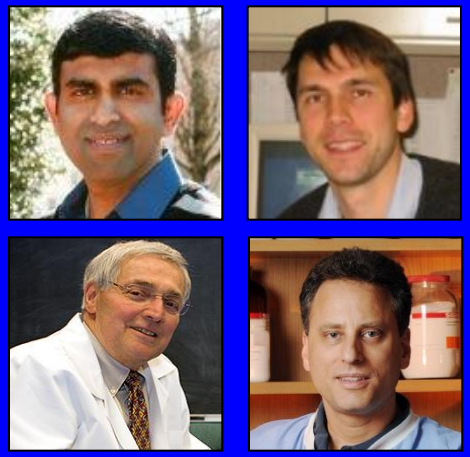


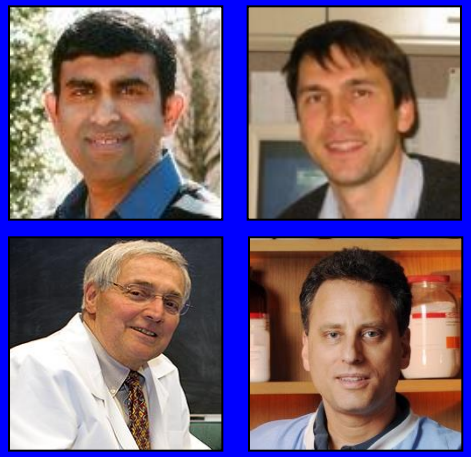
Clearside Biomedical

Georgia Institute of Technology

EMORY UNIVERSITY

CLEARSIDE BIOMEDICAL





Micron Biomedical

Micron Biomedical

Georgia Institute of Technology

Micron Biomedical






Summary of talk

In the classroom

- pharmaceutical education at Georgia Tech

In the laboratory

- design and fabrication of microneedles

In the clinic

- human clinical trials

In the board room

- formation of new companies

Questions?