BiomimeticMicroElectronicSystems

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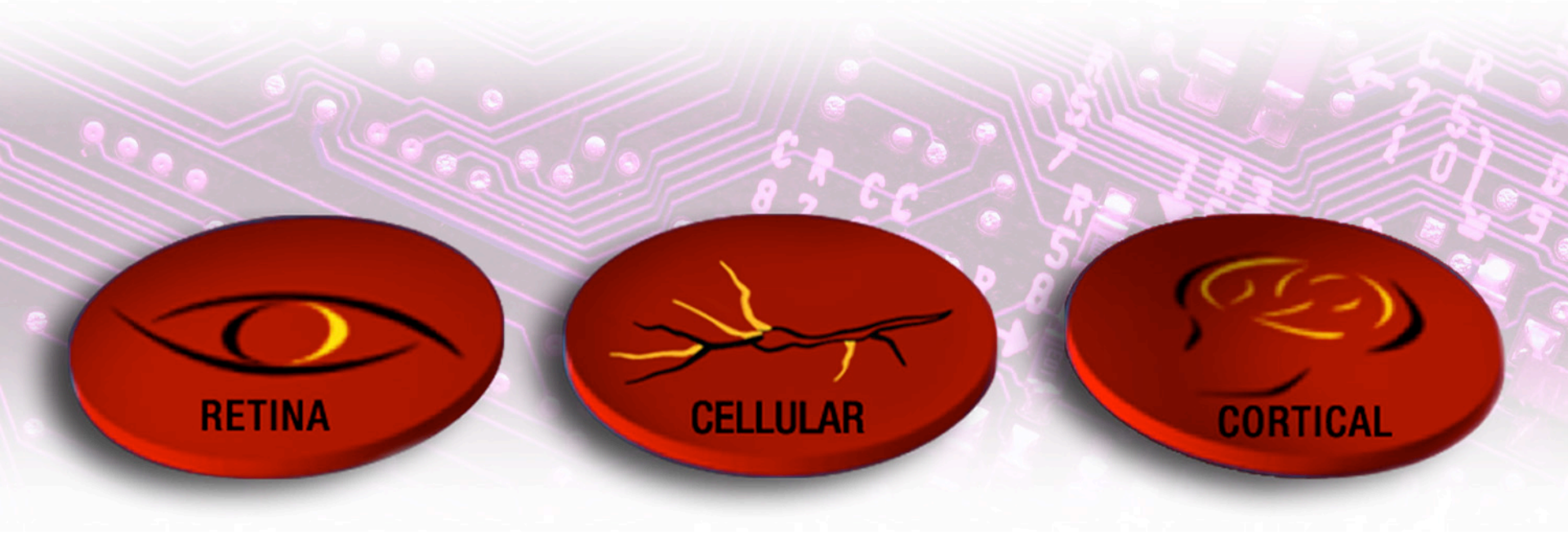
Vision of BMES ERC

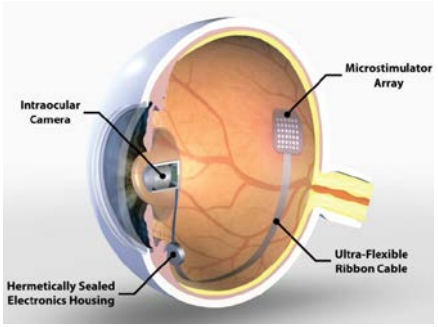


Biomimetic microelectronic systems will form direct high-density interfaces with the human nervous system to restore lost function

Goals of Testbeds

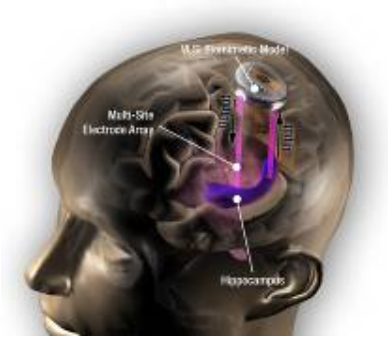
Retinal Testbed:

To research and develop a biomimetic microelectronic system to restore reading and face recognition to the blind



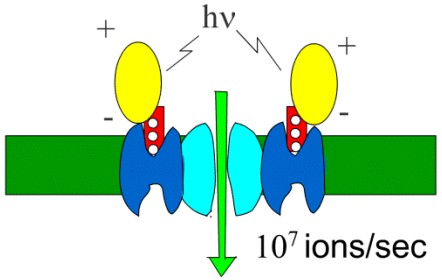
Cortical Testbed:

To research and develop a biomimetic microelectronic system to restore cognitive functions such as formation of new memories

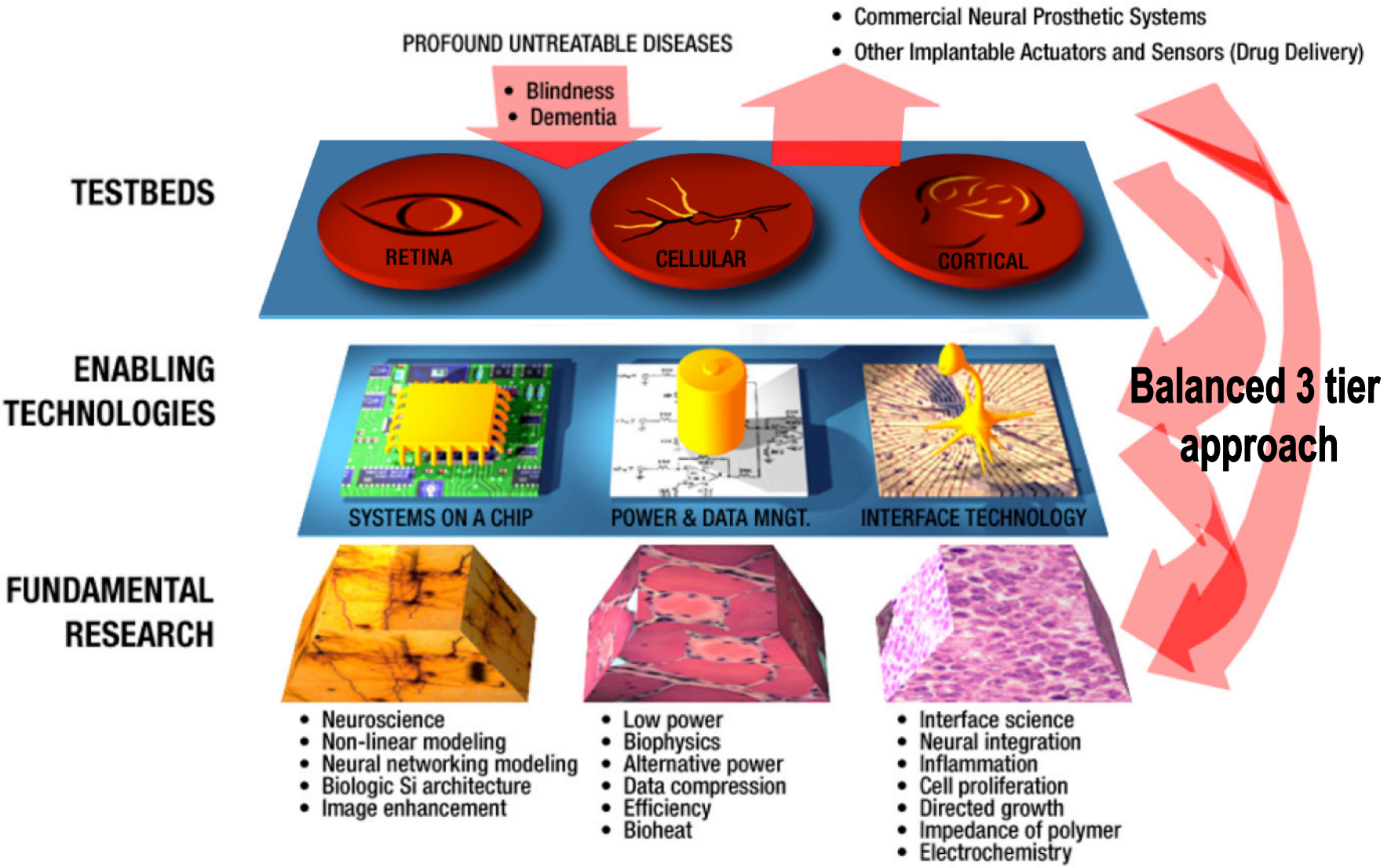


CellularTestbed:

To develop a photoactivated cellular switch to impart light sensitivity to neurons



Strategic Plan
Transformative Engineered System: Neural Prostheses



BMES: An Integrated Research Center (25 projects)

Reversible Attachment of a Retinal Prosthesis

Versatile Low-Power Amplifier for Biosensing

Histopathological Analysis of Brain Tissue after Chronic Implantation

MRI Compatibility

Intraocular Camera for Retinal Prosthesis

VLSI Mixed-Signal Module Integration

Nonlinear Dynamic Modeling of Prefrontal Cortex in NHP

Implant Power Recovery and Regulation

Chemical Surface Modification to Improve Adhesion

Multi-Channel CA3 Response Generator VLSI

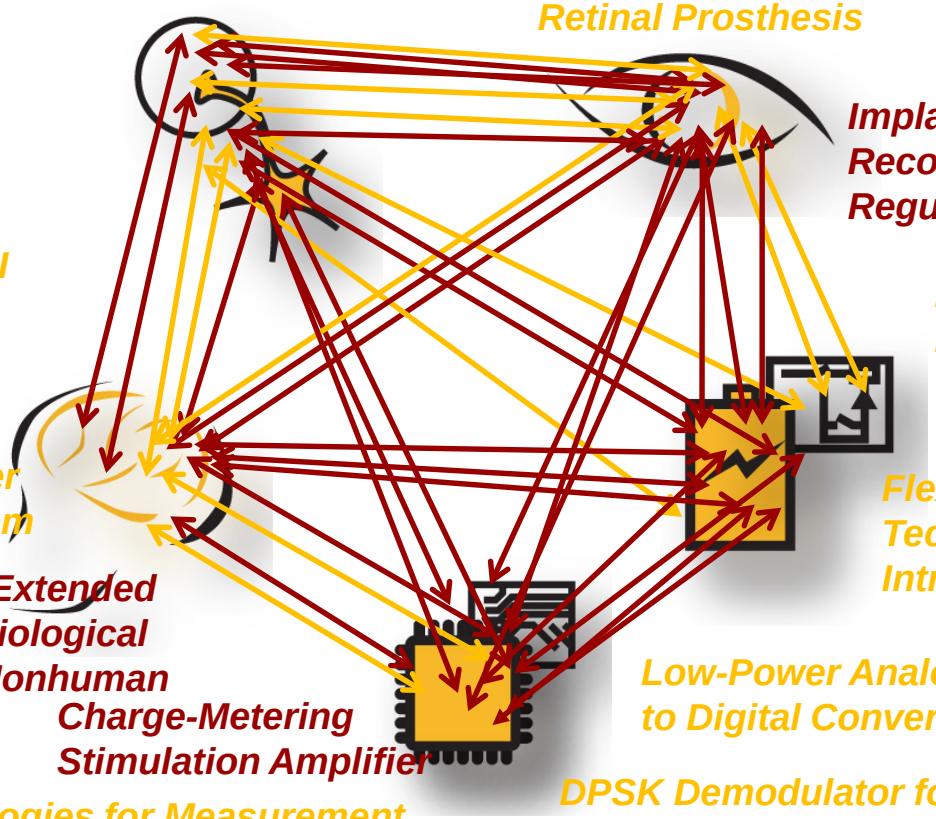
Electrical and Electomagnetic Interaction

Ultra Low Power Integrated Circuits for Medical Implants

Pt/Ir Microelectrodes with Improved Charge Injection

Dual Band Wireless Power and Data Telemetry System

Flexible Parylene-Based Technologies for an Intraocular Retinal Prosthesis



Ceramic Microarrays for Extended "Conformal" Electrophysiological Recordings in Rats and Nonhuman Primates

Neural Signal Processing Using ICA

Low-Power Analog to Digital Convertor

Charge-Metering Stimulation Amplifier

High-Density Microstimulator for Implantable Devices

DPSK Demodulator for Dual Band Telemetry System

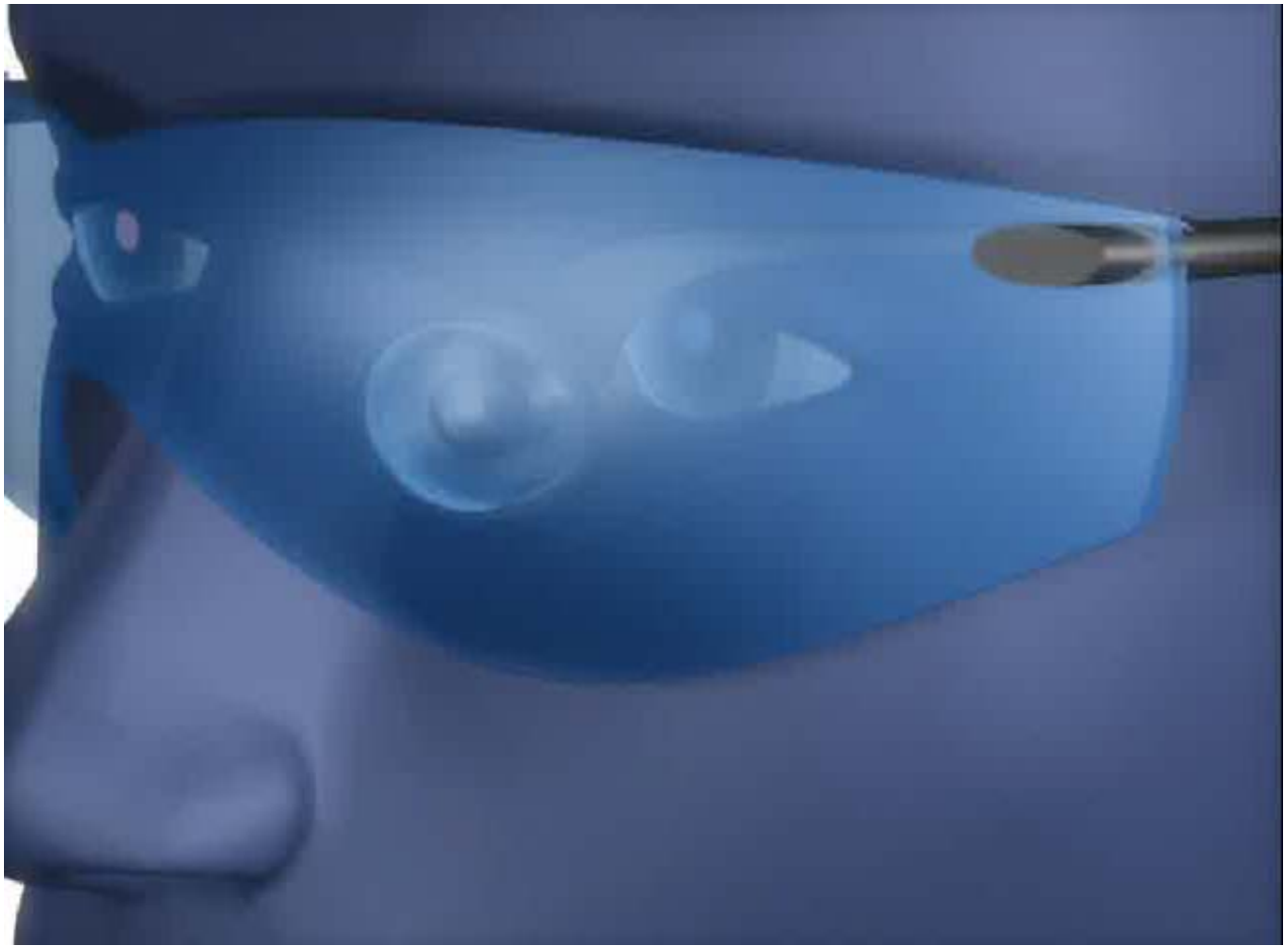
Flexible Polymer Technologies for Measurement of Mechanical Strains in Neural Prostheses

Advanced Packaging for Electronic Medical Implants

Retinal Code of Natural Images

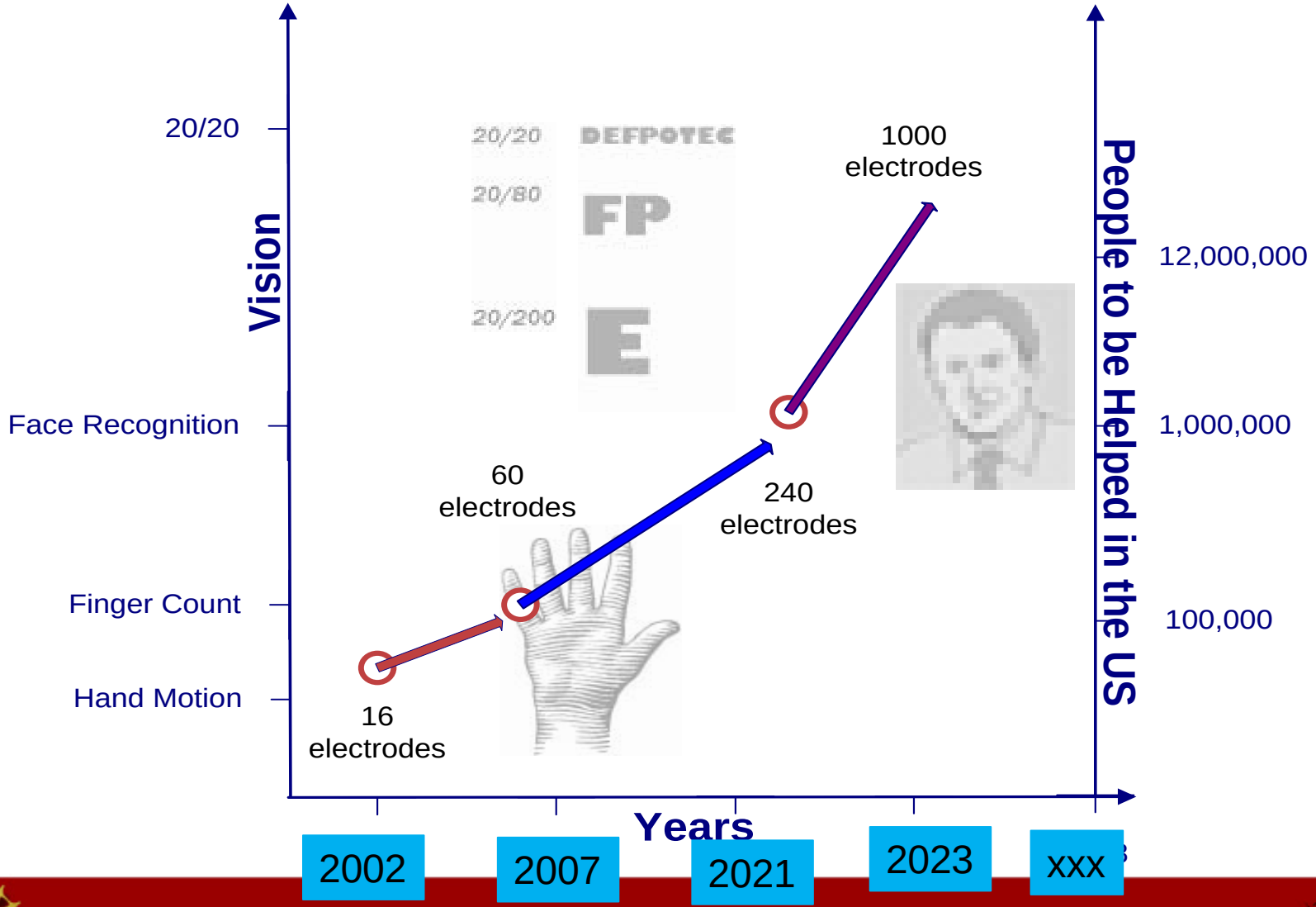
Microcomputer-based Artificial Vision

Restoring Vision to the Blind
Artificial Retina System



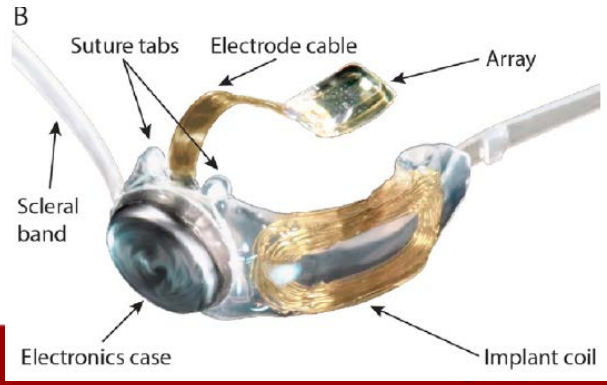
Artificial Retina Timeline

Progress of the Artificial Retina



Argus II Retinal Prosthesis
Second Sight Medical Products, Inc.

- **Only FDA approved Retinal Prosthesis to date**
- 6x10 micro-fabricated electrode array
  - Polymer substrate
  - High surface area platinum
- Improved mobility demonstrated in multi-center clinical trial (n=30)
- Letter reading in majority of subjects
- Implant can be controlled while in MRI

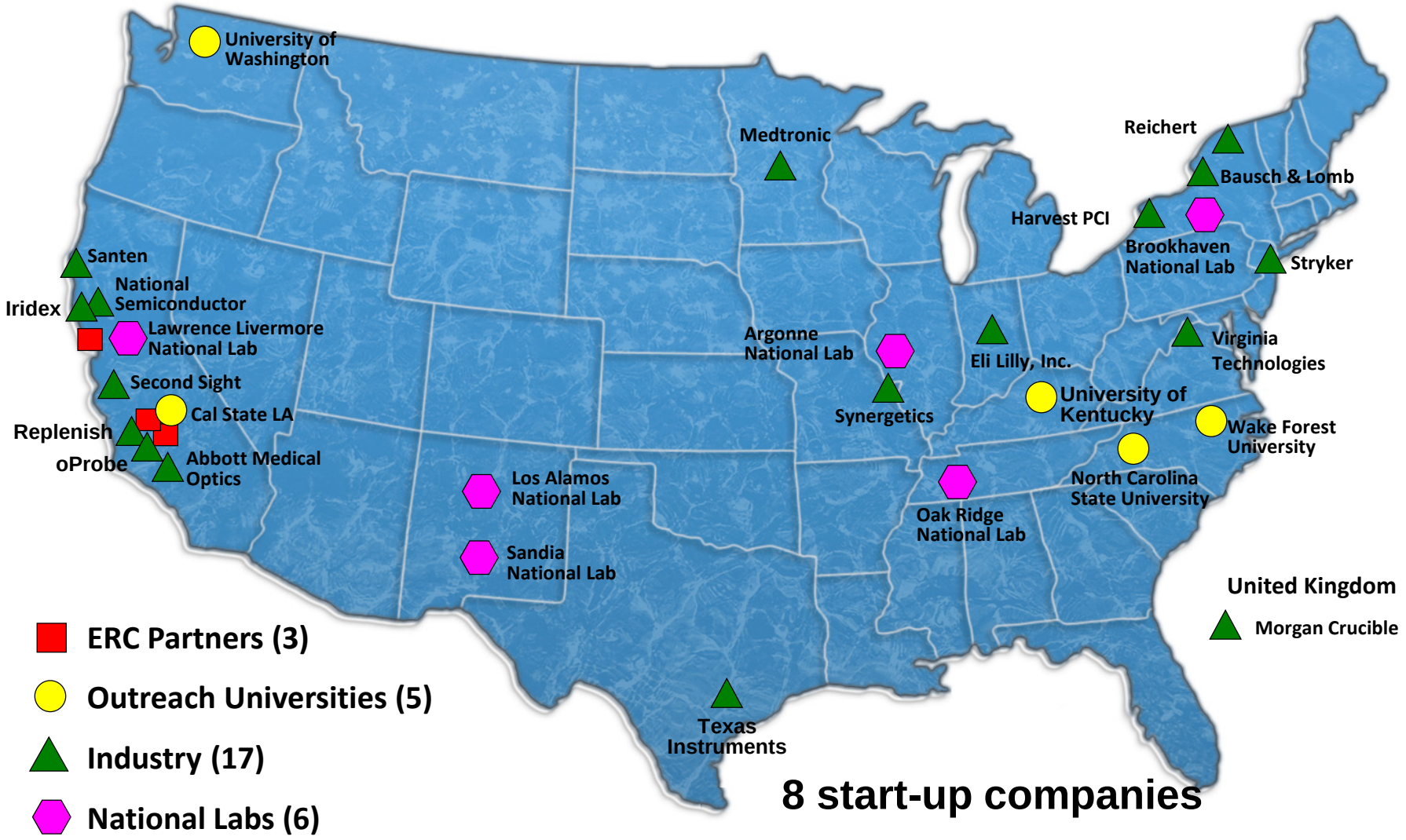


Blind Patient Recognizing Letters With The Retinal Implant

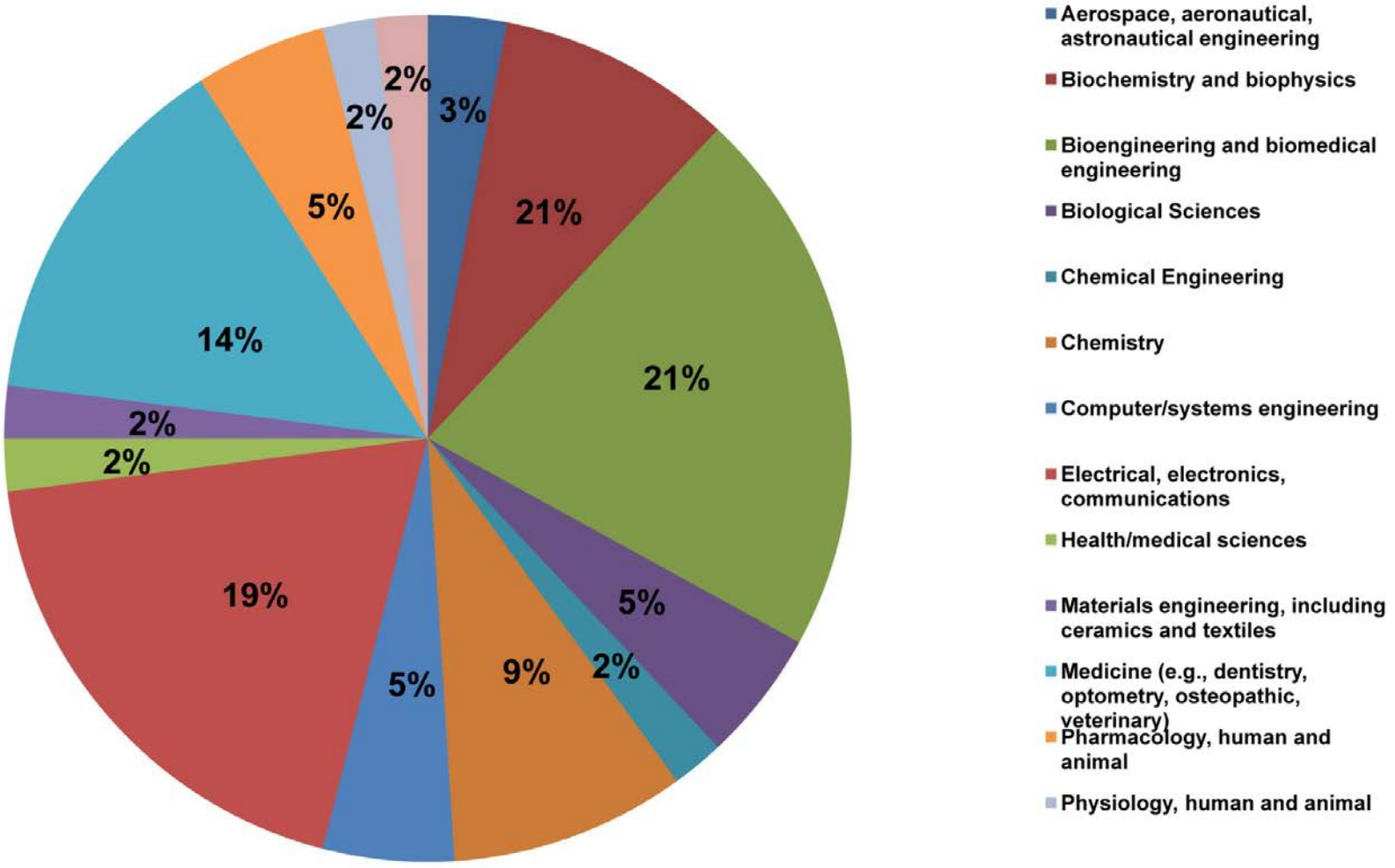
Retinal Prosthesis Video (orientation and mobility)

Blind patient using Argus II retinal implant in an ambient environment
Courtesy BBC TV

BMES ERC:
A Model of University – Industry Partnership



Interdisciplinary Team (14 disciplines)



BMES Education Program
Curricular Initiatives: BMES-related Courses (14)

a) BME-201: "Biomedical Engineering Practice"

- Translation of bioengineering principles and methods into real-world applications in the industrial and clinical settings, with special emphasis on neural prosthetics and medical device design. Total enrollment: 72 student

b) BME-350 Biomedical Engineering Industrial Project *(UG)* *Total enrollment: 24*

- Preparation for industrial internships

c) BME-414 Rehabilitation Engineering *(UG)* *(revised course)* *Total enrollment: 200*

- Introduction to neuromuscular biomechanics & clinical rehabilitation

d) BME-451 Fundamentals of Biomedical Microdevices *(UG)* *Total enrollment: 88*

- Introduction to bio-MEMS and biomedical microelectronics

e) BME-452 Introduction to Biomimetic Neural Engineering *(UG)* *Total enrollment: 51*

- Survey of neural implants and BMES-ERC research areas

f) BME-505abL Laboratory Projects in Biomedical Engineering *(Grad)* *Total enrollment: 157*

- Lab rotations in BMES-ERC labs

g) BME-552 Neural Implant Engineering (Grad) *Total enrollment: 94*

- Advanced studies in implantable neural prostheses (retinal, brain)

h) BME-575L Computational Neural Engineering *(Grad)* *Total enrollment: 78*

- "Hands-on" exposure to computational models in neuroengineering

i) BME-670 Early Visual Processing *(Grad)* *Total enrollment: 50*

- Low-level visual processing (retina, LGN, phototransduction)

j) BME-671 Late Visual Processing *(Grad)* *Total enrollment: 42*

- High-level visual processing (cortex, computer vision, psychophysics)

k) EE/BE185 MEMS Technology and Devices *(Grad)* *Total enrollment: 120*

l) EE 273 - Implantable Neural Implants *(Grad)* *Total enrollment: 78*

m) EE 485 Biomedical Instrumentation *(Grad)* *Total enrollment: 35*

n) EE486 Biomedical Signal Processing *(Grad)* *Total enrollment: 21*

BMES K-12 Outreach Program
Create and Sustain a Pipeline

Science for Life (SFL): Grades 3-5

247 students, 11 teachers, 87 mentors,
369 contact hours per year

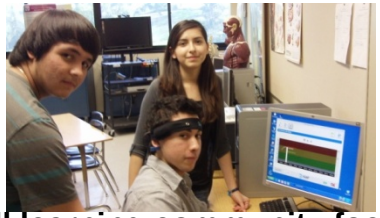
Bringing the BMES ERC into the classroom

Research Experience for Teachers (RET): Grades 6 -12

Middle and High School teachers translate BMES ERC lab experience into classroom curriculum

Engineering for Health Academy (EHA) : Grades 10 -12

72 students, 3 teachers, 16 mentors, 9 USC labs per year



A small learning community focused on BME

Informal Family Education (SFL and EHA)

113 students and family members, 6 teachers, 18 mentors at the California Science Center and Bravo High School

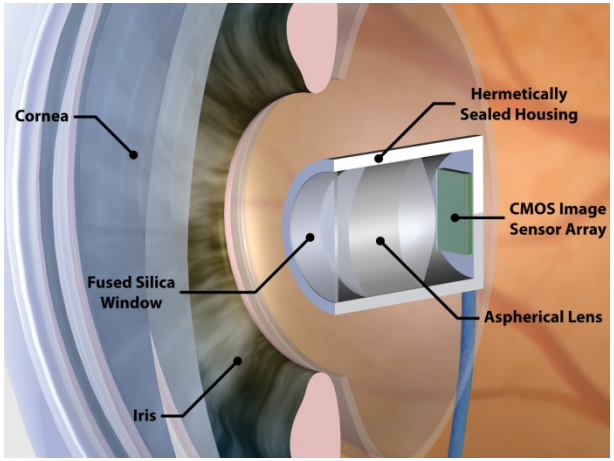
2,193 K-12 Student have been impacted over 8 years

BMES Technology Track Record

Annual BMES
Productivity Over
Lifetime of Center

Advanced Imaging Technologies for Retinal Prostheses

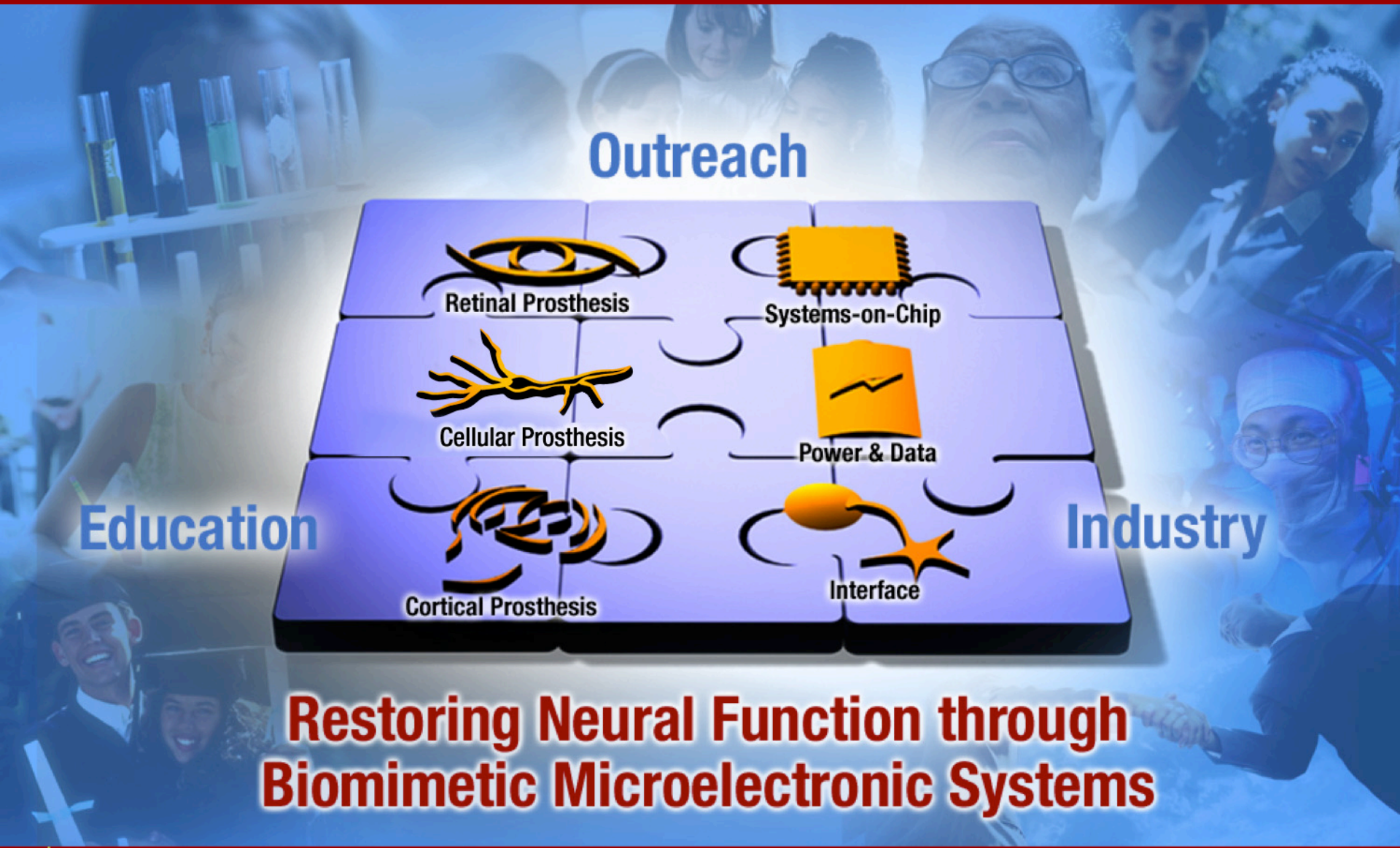
- **Integration of intraocular camera with haptic elements and new flex cable system (in progress)**
- **Demonstration of novel implantable sensor technology for early detection of breaches in hermeticity**



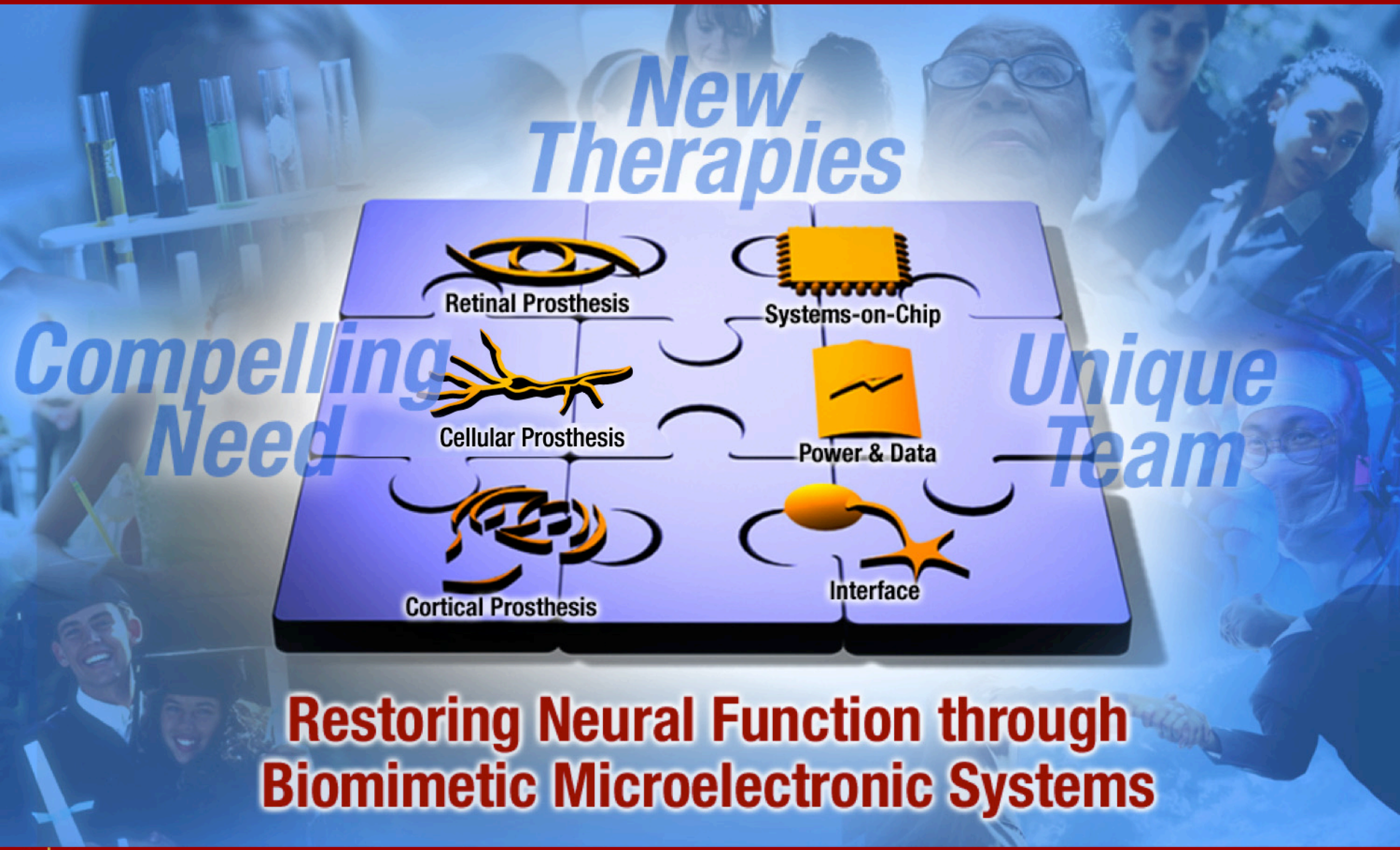
Intraocular camera with refractive lens and fused silica window

IOC with lens and image sensor awaiting haptic elements

BMES: The Interdisciplinary Convergence



BMES: The Interdisciplinary Convergence



Conclusions

- Biomimetic high density bioelectronic interfaces with neural systems are challenging but have unique advantages in restoring neural function to potentially millions of patients for whom there is no foreseeable cure

- Federal (e.g., NSF, DOE, NEI), State, Foundations/Philanthropic, and Commercial funding are critical to develop technologies into therapies and in doing so also train the required workforce to engineer and commercialize these technologies