

Rules of Life

NNCI Annual Meeting - November 2 and 3, 2021

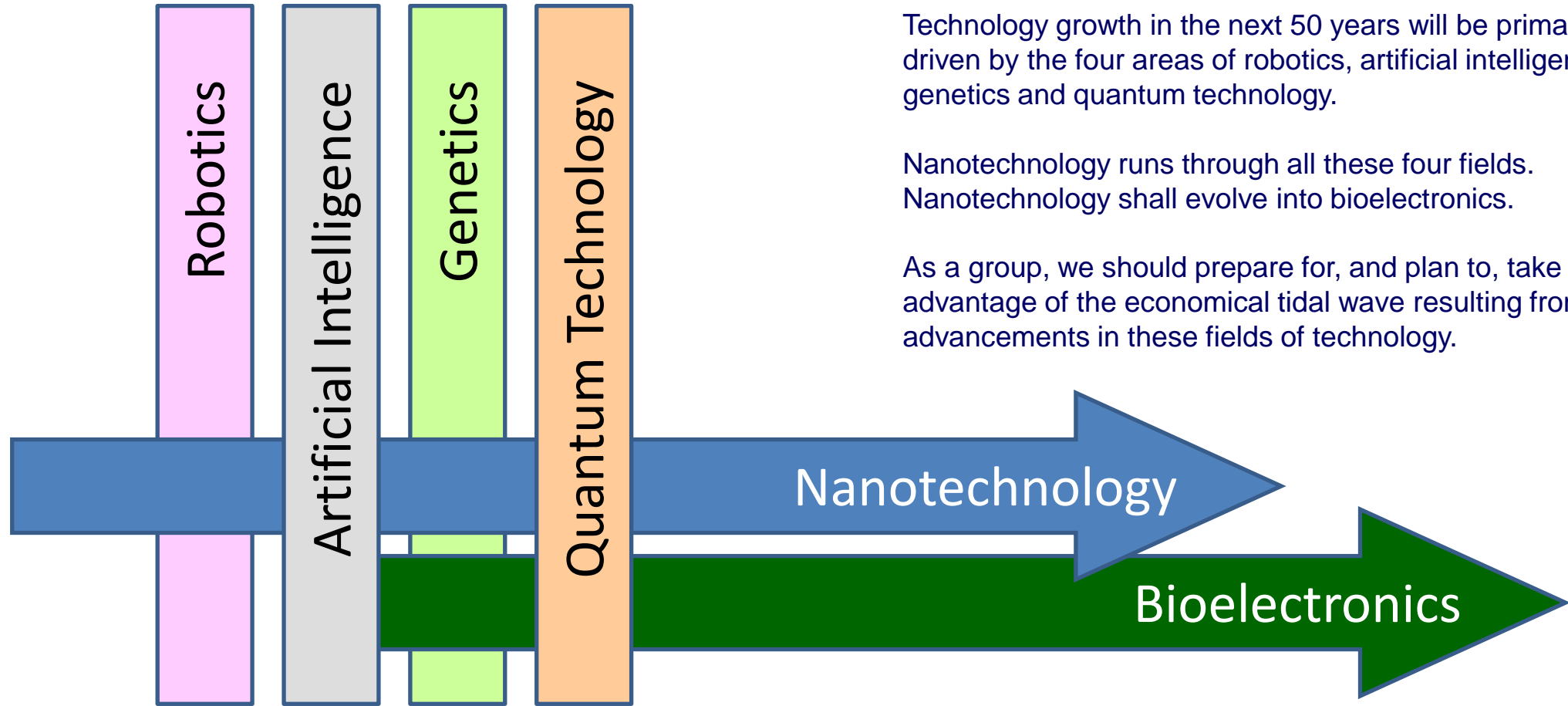
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Slide 1

Technology growth in the next 50 years

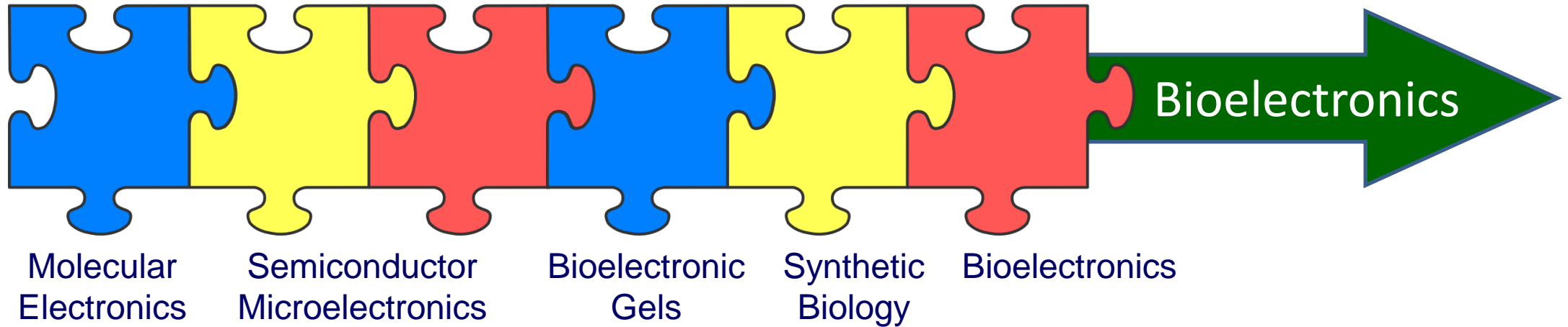


Technology growth in the next 50 years will be primarily driven by the four areas of robotics, artificial intelligence, genetics and quantum technology.

Nanotechnology runs through all these four fields. Nanotechnology shall evolve into bioelectronics.

As a group, we should prepare for, and plan to, take advantage of the economical tidal wave resulting from advancements in these fields of technology.

RoL is about understanding how living organisms work at a fundamental molecular level, then building new artificial organisms. Design and synthesize artificial molecules that nature did not think of making. Create complex systems based on these molecules.



Mark Ratner

Landmark paper of Mark Ratner and Arieh Aviram (15 Nov. 1974) "Molecular Rectifiers".
Chemical Physics Letters
29 (2): 277-283
1974

Semiconductor Microchips

Hitting fundamental limit

Transistor densities: ~100M per square millimeter
Transistor size: ~10 nm
Transistors in chip: ~10B

Human brain
86 billion neurons
12 Watts power

Molecular Electronics

Quantum interference enables single-molecule switch with high on/off ratio. Image Credit: Julia Greenwald and Suman Gunasekaran, Columbia Univ.

Bioelectronics

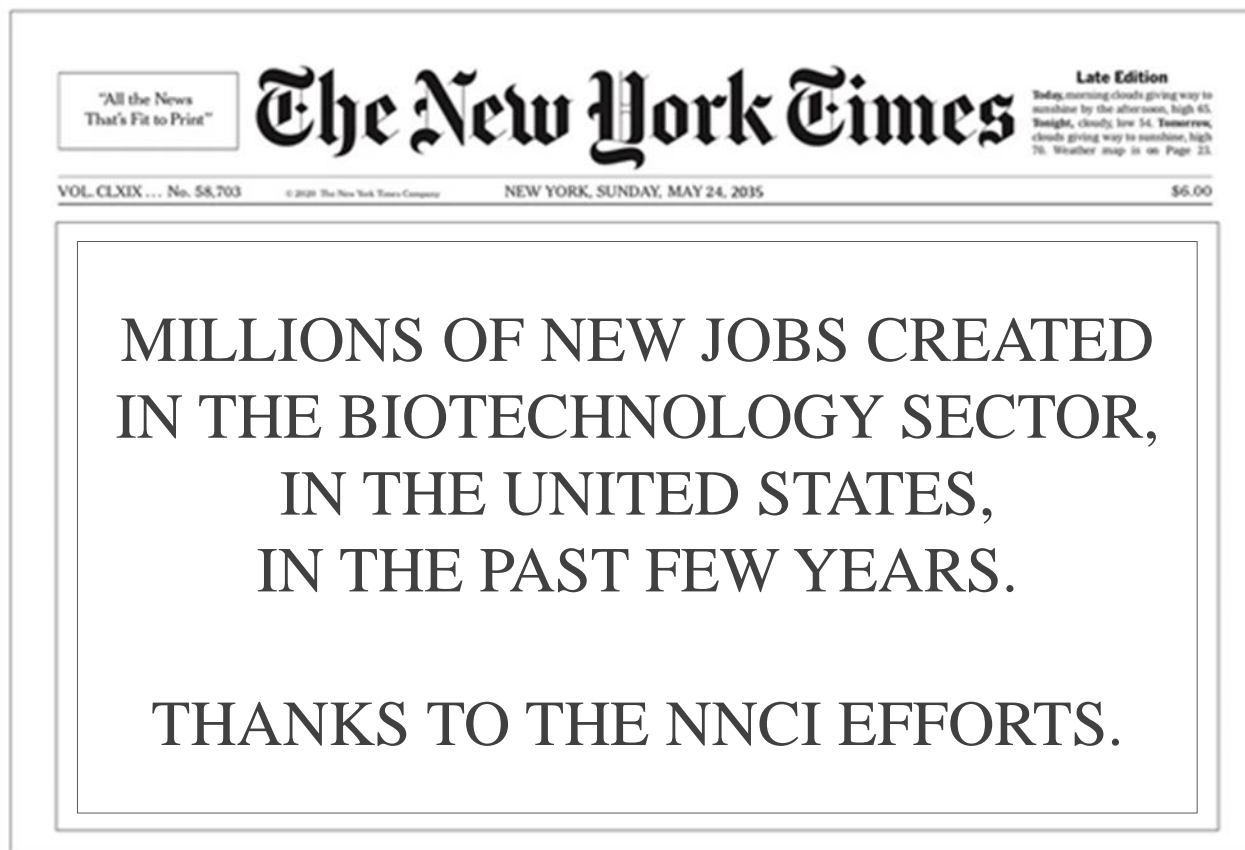
Bioelectronic microchips and bioelectronic computers

Slide 3

*Wow, what an
incredibly complex
and advanced
bioelectronic
brain.*



*Yes, it all started
with the NNCI
biotechnology
initiative in 2025.*



The NY Times headline that I like to see.

NNCI - Research Communities - RoL

RoL - Research Infrastructure

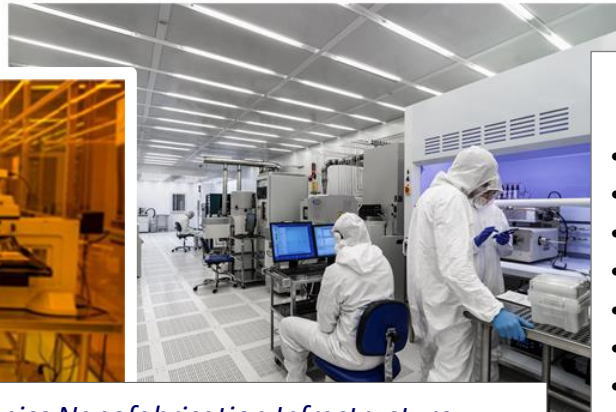
Development of Research and Industrial Infrastructure

During the 1970s and 1980s, the semiconductor microelectronics nanofabrication industry went through a rapid growth development phase as the infrastructure for semiconductor nanofabrication manufacturing became more readily available to research scientists and technology development engineers.

Today, the RoL related biotech research is entering that same phase of rapid growth development phase. For the benefit of our research scientists and development engineers, we need to **establish the infrastructure for the RoL related biotech research activities and technology development work.**

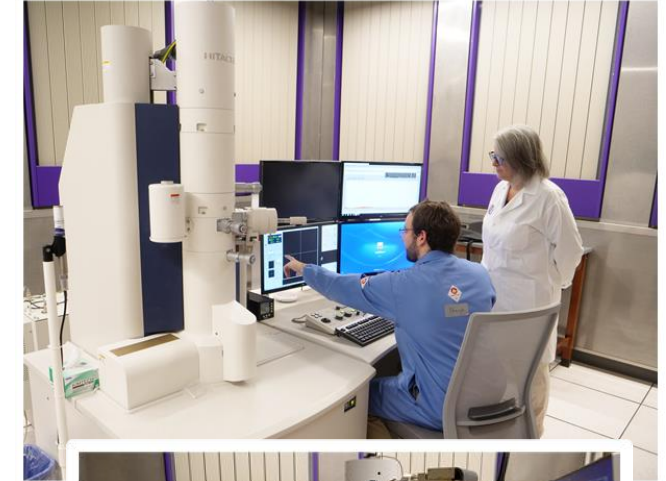


Semiconductor Microelectronics Nanofabrication Infrastructure



SHyNE Key Capabilities

- Electron Microscopy of Hard Material
- Electron Microscopy of Soft Biological Material
- Crystallography and X-Ray Characterization
- Pulsed Laser Deposition
- Bio-Nanotechnology
- Nanofabrication of Microelectronics
- Nanofabrication of Bioelectronics



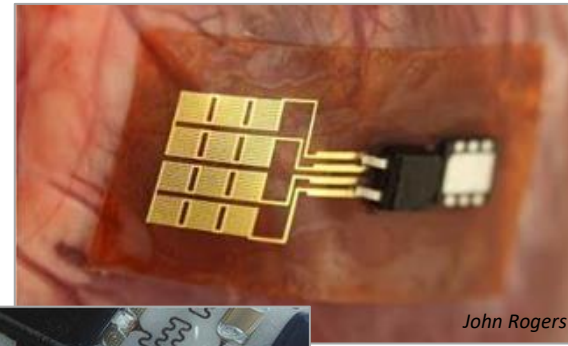
Biotechnology Research and Development Infrastructure

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RoL proposed research areas:

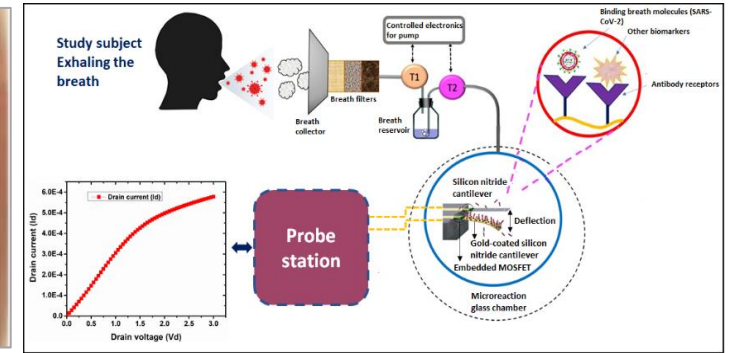
- Synthetic Biology
- Diagnostics and Sensors
- Imaging and Materials Analysis

Flexible Electronics for Non-Invasive Diagnostics



John Rogers

Nanomechanical Sensors for Non-Invasive Diagnostics



Electron Microscopes and X-Ray Characterization for Imaging and Materials Analysis



John Rogers

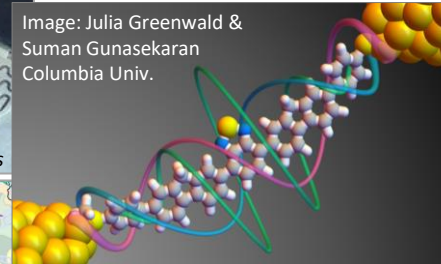
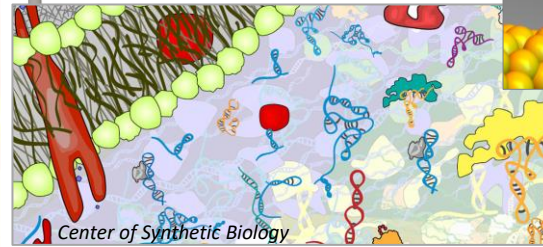
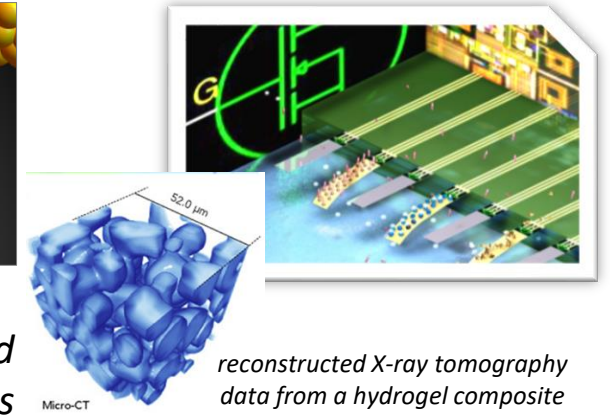


Image: Julia Greenwald & Suman Gunasekaran Columbia Univ.

Synthetic Biology and Molecular Electronics



Center of Synthetic Biology

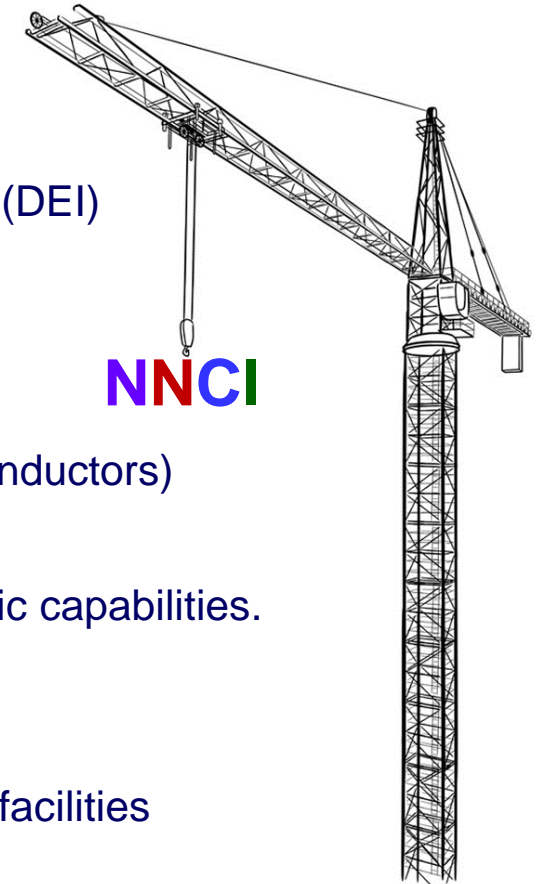


Micro-CT

reconstructed X-ray tomography data from a hydrogel composite

Images courtesy of Dr. John Rogers, Dr. Gajendra Shekhawat, Dr. Reiner Bleher at NU, and additionally by the IMSERC and the NUANCE Centers, and the Center of Synthetic Biology of Northwestern University Slide 7

- **Complex RoL technical theme:**
 - Need focused and targeted activities, with consideration to Diversity-Equity-Inclusion (DEI)
 - RoL NNCI webinar series - propose quarterly seminars and presentations
- **Research tools and infrastructure issues in RoL:**
 - Infrastructure for synthetic biology - nanofabrication infrastructure (remember semiconductors)
 - Diagnostics and sensing facilities - integrating biology with microelectronic fabrication
 - Imaging - unconventional fields and impact; ranging from super-resolution to cryogenic capabilities.
- **Education and workforce development:**
 - Technical theme seminars related to challenges, and solutions, for infrastructure and facilities
- **Public and Societal Outreach and Impact:**
 - Workforce development, community colleges and related learning and training institutions

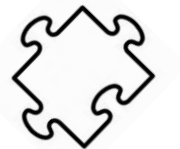
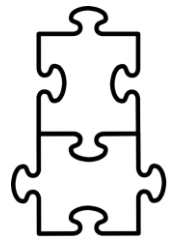


**Constructing
Infrastructure**

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RoL - Research - Roadmap - Education - Commercialization - Workforce Development

- Establish infrastructure for the RoL related research activities and technology development work.
- Collaborative effort to jointly construct a superior value proposition and roadmap. Develop consensus on research needs and opportunities. A coordinated, collaborative approach can expedite progress.
- Form relationships, and strategic partnerships, with industrial companies working in biotechnology fields (start-up companies as well as large companies).
- Facilitate the rapid transfer of technology from university laboratories to new product development centers of industrial commercial companies.
- Enable start-up companies, and facilitate their success. Greatest barrier of entry into market is infrastructure.
- Facilitate the success of young people in creating new high-tech companies.
- Successful workforce development involves actively reaching out to local colleges and schools and establishing meaningful collaborative long term relationships with them, in particular with local community colleges.
- Make opportunity available to young people. Show them what is possible. Ignite enthusiasm and hope.
- Play the role of the local scientific and scholarly community center within our community.



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NNCI - Research Communities - RoL

*... and then,
the atoms came together,
and the atoms formed a
complex new biomolecule
that never existed before.
And we watched this with
our powerful electron
microscopes.*



CHICAGO COMMUNITY CENTER

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NNCI - Research Communities - RoL

Thank you for your attention.

Kamran Mobarhan

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