

HI  TEC 2024

Kansas City

July 29–Aug 1



Web-Based Simulation and Remote Access Visualization Tools for Engineering and Technology Curricula

July 31, 2024

Dr. Ahmed S. Khan

Fulbright Specialist Scholar

Ex. Dean of the College of Engineering & Information Sciences

DeVry University, Addison, IL

Dr. Atilla Ozgur Cakmak

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Dr. Sala Qazi

qazi@sunypoly.edu

In Memoriam



Dr. Sala Qazi

Emeritus Professor & Chair

School of Information Systems and Engineering Technology
State University of New York Institute of Technology (SUNYIT),
Utica, New York

Dr Sala (Salahuddin) Qazi was a Professor Emeritus at SUNY Poly. During his thirty-year tenure at SUNY Poly, he was chairman of the EET department, coordinator of the BS program in photonics, and **Director of the MS program in advanced technology, which he helped to develop.**

Dr Qazi authored numerous articles in the area of fiber doped amplifiers, wireless security, MEMS and photovoltaic energy. He also co-authored two books in the area of “Nanotechnology for Telecommunications” and “Solar Energy Systems and Technologies.” After retiring, he authored a book on “Standalone Photovoltaic (PV) Systems for Disaster Relief and Remote Areas.”

He was the recipient of several awards, including the William Goodell award for research creativity at SUNY Poly; he was recognized by the Mohawk Valley Engineering Executive Committee for engineering professionalism; and he forged closer relations with the IEEE Mohawk Valley section. He was a CO-PI for a conference on “High Capacity Optical Networking and Enabling Technology, [HONET]”. Dr. Qazi was a life member of IEEE and ASEE.



Atilla Ozgur Cakmak

*Assistant Professor of Electrical Engineering
School of Engineering, Seymour and Esther Padnos
College of Engineering and Computing
Grand Valley State University, Michigan*

Atilla Ozgur Cakmak graduated from Sabanci University, Istanbul, Turkey with a BSc degree in Microelectronics Engineering in 2003. He obtained his MSc degree in Computer Science and Electronics Engineering also from Sabanci University in 2005.

Dr. Cakmak earned his PhD degree from Bilkent University, Ankara, Turkey in 2012 from the Department of Electrical and Electronics Engineering. After a brief postdoctoral experience at Bilkent University within NANOTAM (Nanotechnology Research Center),.

Dr. Cakmak joined Penn State in 2013 as a postdoctoral researcher to work on thin film solar cells. Dr. Cakmak got promoted to Assistant Teaching Professor at Penn State within the Department of Engineering Science and Mechanics in 2018. He offered graduate and undergraduate level courses in the field of nanotechnology and nanofabrication.

Dr. Cakmak is now an Assistant Professor of Electrical Engineering in School of Engineering in Grand Valley State University, Michigan. Dr. Cakmak co-authored more than 20 papers in the leading journals in his expertise field of nanophotonics and microwave engineering.

Dr. Cakmak also contributed with educational publications to the field of nanotechnology and nanoscience. He is an editor of *Journal of Advanced Technological Education* and a guest editor of MDPI. He has also been contributing as a reviewer to various optics/photonics, applied physics and nanotechnology themed journals.



Dr. Ahmed S. Khan

Professor of Electrical Engineering

Fulbright Specialist Scholar

Ex. Dean of the College of Engineering & Information Sciences

DeVry University, Addison, Illinois

Dr. Khan has more than forty years of progressively responsible experience in instruction (online and onsite), applied research, curriculum development, program and institutional accreditation, management, and supervision of academic programs at DeVry University. Dr. Khan held many academic positions that include Senior Processor, Chair, and Dean of the College of Engineering & Information, DeVry University, Addison, Illinois, USA. Dr. Khan also served as the **National Curriculum Manager at the national headquarters of DeVry University, where he supervised and managed curriculum development and implementation of BSEEt & MSEE programs at 25 DeVry campuses located in the United States and Canada.** Dr. Khan received an MSEE from Michigan Technological University, an MBA from Keller Graduate School of Management, and his Ph.D. from Colorado State University. His research interests are in the areas of **Nanotechnology, New Teaching & Learning Techniques, and Social and Ethical Implications of Technology.** He is the author of many educational papers and presentations. **He has authored/coauthored many technical books, including the Science, Technology & Society (STS) series of books that include *Technology and Society: Issues for the 21st Century & Beyond* (used globally in the academic programs of more than 200 universities), and *Nanotechnology: Ethical and Social Implications*, to stimulate, inspire, and provoke awareness of technology's impact on society.** **Dr. Khan is a senior member of the Institute of Electrical and Electronics Engineering (IEEE), and a member of American Society of Engineering Education (ASEE).** Dr. Khan has also served as program evaluator for the accreditation agency ABET.

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Web-Based Simulation and Remote Access Visualization Tools for Engineering and Technology Curricula

Simulation and visualization tools promote students' understanding of phenomena at nanoscale.

This session will focus on application of web-based simulation tools and remote access visualization (RAIN, Nanohub, Physicell, Phet, CompuCell3D) for teaching, research, and collaboration in the areas of nanotechnology, material science, environmental science, electrical engineering, biological sciences, physics, chemistry, photonics, and other areas.

Educators can use these web-based tools to enhance students' learning of complex concepts at nanoscale without acquiring expensive equipment.

Simulation experiences at GVSU for photovoltaic applications will also be presented.



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Web-Based Simulation and Remote Access Visualization Tools for Engineering and Technology Curricula

Web-Based simulation tools and remote access visualization provide viable platforms for teaching, research, and collaboration in the areas of **nanotechnology, material science, environmental science, electrical engineering, biological sciences, physics, chemistry, photonics** and much other areas.

These tools include:

- **RAIN (Remote Access Instruments in Nanotechnology)** 26 nodes for accessing visualization instruments
- **NanoHub** has 500+ simulation tools to simulate nanotechnology processes
- **Phet Interactive** offers Simulations for teaching Physical Sciences and Math
- **CompuCell3D & Physicell** offer flexible modeling platforms that allow simulations for biology, tissue engineering, and viruses including COVID19.



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Web-Based Simulation and Remote Access Visualization Tools for Engineering and Technology Curricula

Order of Presentation

- **Online Simulation and Visualization Tools**
 - NanoHub
 - Examples of simulations using nanoHub
 - Phet Interactive Simulations
 - Physicell
 - CompuCell3D
 - Examples of Simulation of Covid-19 Virus
 - RAIN: Remote Accessible Instruments for Nanotechnology
 - MYSCOPE: SEM & TEM
- **Use of Online Simulation Tools (SEM & TEM) at GVSU**

Conclusion

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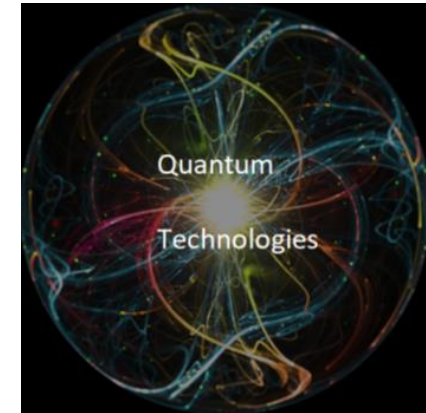
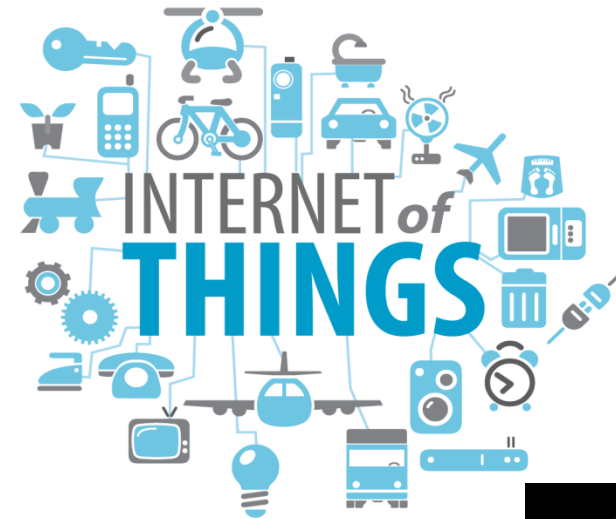


Web-Based Simulation and Remote Access Visualization Tools for Engineering and Technology Curricula

Emerging 4IR Technologies and New Demands on **Skill-sets** of Graduates

- The global marketplace seeks up-to-date technical knowledge and skills.
- The pace of technological change also imposes new challenges for faculty development and technical currency of academic programs.
- To be successful in the 21st century workplace, graduates must acquire digital-age technical literacy.
- Graduates are not only expected to understand the theory behind state-of-the-art technologies, but also exhibit *hands-on and analytical problem solving, expert thinking, awareness of social and ethical implications of technology, interpersonal skills, teamwork, and cross-disciplinary communication skills.*

Emerging Technologies



Emerging 4IR Technologies

Nanotechnology, Robotics and Artificial Intelligence (AI)



4IR
Diffusion of
Technologies



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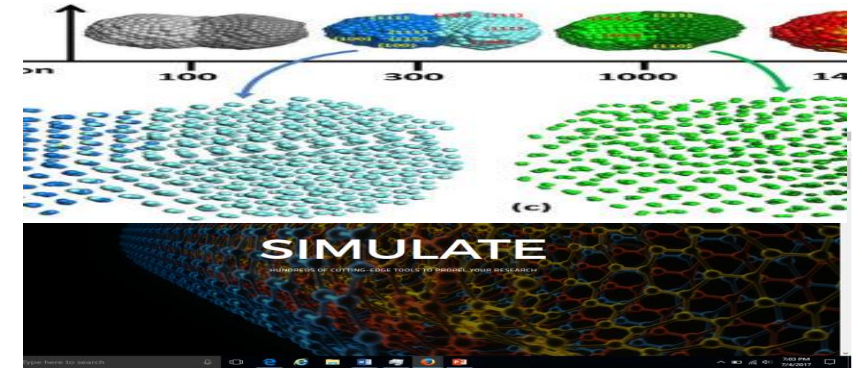
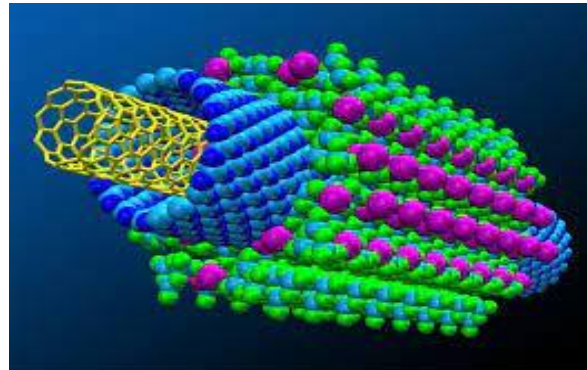
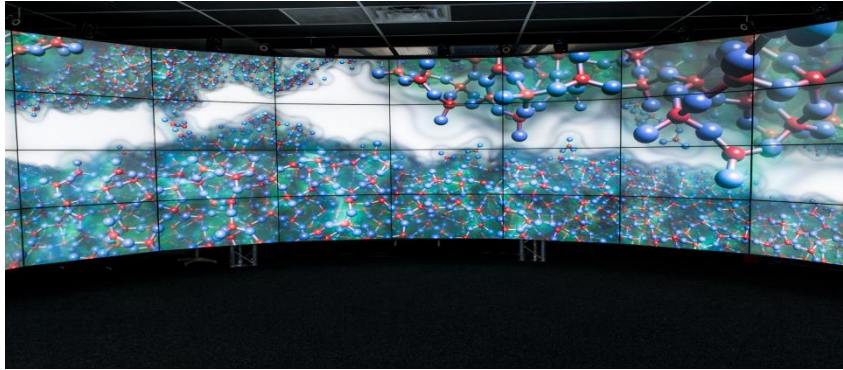


Web-Based Simulation and Remote Access Visualization Tools for Engineering and Technology Curricula

Key Challenges

- Teaching, Learning and Research in new and emerging technologies require state of the art laboratories equipped with expensive equipment and associated support facilities.
- However, such facilities also require large financial resources and time restraints to implement the requirements.
- Use of Online Simulation and Remote Access Visualization Tools enhance students' learning and teaching of new and complex concepts without physically using required expensive equipment.

Learning through Visualization and Simulation at the Nanoscale



Simulation offers many advantages:

- (a) allowing the user to modify system parameters and observe the outcomes without any harmful side effects
- (b) eliminating component or equipment faults that affect outcomes
- (c) supporting users progress at their own pace in discovery and understanding of concepts and issues,
- and (d) enhancing the presentation of “dry” concepts by integrating theory and practice



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Learning through Visualization and Simulation at the Nanoscale

Nanohub.org

- Computing Cloud located at Purdue University
- 500+ simulation tools & apps
- 1.4 million users Worldwide
- 6500 resources

Crystal Viewer Tool Nanohub.org





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Learning through Visualization and Simulation at the Nanoscale Nanohub.org...Creating a User Account

The screenshot shows the nanoHUB website's registration page. At the top, there is a navigation bar with the nanoHUB logo, menu items (EXPLORE, PUBLISH, COMMUNITY, ABOUT, SUPPORT), and links for Login, Sign Up, Help, and Search. The main heading is "Create New Account".

Under "CONNECT WITH", there are three options:

- With Institutional Credentials**: Includes a note: "If your US institution is not listed in the dropdown but is part of InCommon, ask us to add it! Otherwise, use one of the other options below."
- Sign in with Google**
- Sign in with CILogon**

Below these is a separator: **OR**

Under "CREATE A NANOHUB ACCOUNT", the "Username" field is highlighted with a red "required" label.

On the right side, there are two informational boxes:

- A blue box stating: "You can choose to log in via one of these services, and we'll help you fill in the info below." Below it is the link: "Already have an account? Log in here."
- A white box with a grey border stating: "Usernames cannot be changed. If this poses a serious problem or raises concerns please contact our support." Below it is the text: "Password may be changed any time after account creation."



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Making Data and Simulation Pervasive

Model & Simulate

USE FOR RAPID EDUCATION AND RESEARCH

500+ APPS
Tools
Most Popular

MORE

Learn & Teach

STRUCTURED, GLOBALLY USED RESOURCES

Simulation-Powered Curricula
Curated Education Materials
Courses
Lectures

MORE

Develop Software

ASSEMBLE YOUR OWN COMPONENTS

Jupyter
Linux Workstations
Engines / Frameworks
Machine Learning

MORE

Share & Publish

JOIN 3,000+ CONTRIBUTORS

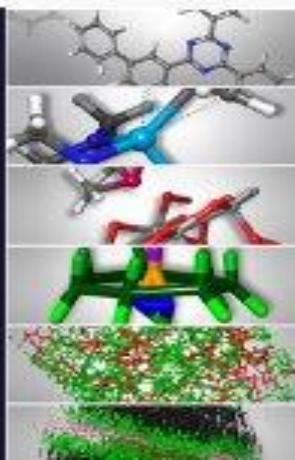
Teaching Materials
Lectures
Tools / Apps

MORE

Learn about molecular modeling for Materials Science through nanoHUB partner, Schrödinger!

Use code **NANOHUB1** and receive a 10% discount.

[Sign up for their online courses](#)



Organic Electronics

Homogeneous Catalysis

Surface Chemistry

Pharmaceutical Formulations

Polymeric Materials

Consumer Packaged Goods



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Model & Simulate

Rapid Education and Research



500+ Apps for Everyone

READY-TO-USE, INTERACTIVE, SELF-CONTAINED

- Nanoelectronics (Map View)
- Materials
- Photonics
- Most Popular

[MORE](#)



Tools for Development

ASSEMBLE YOUR OWN COMPONENTS

- Jupyter
- Linux workstation
- UQ
- Machine Learning
- Rapture I/O and GUI building

[MORE](#)



Tools for Experts

CONFIGURE & CUSTOMIZE SIMULATIONS

- Materials
- Electronics
- nanoBIO
- Nano Manufacturing

[MORE](#)



Engines / Frameworks

COMPUTATIONAL SCIENCE COMPONENTS

- Materials (MD, ab-initio, ...)
- Electronics
- Photonics

[MORE](#)



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Develop Software

Assemble your own components



Developer Kits

ASSEMBLE YOUR OWN RESEARCH FLOW

- Jupyter Notebooks
- Linux workstation
- Rappture I/O and GUI building



Workflows

GO BEYOND A SINGLE SIMULATION

- Uncertainty Quantification
- Machine Learning
- Pegasus Docs & Example



Engines / Frameworks

COMPUTATIONAL SCIENCE COMPONENTS

- Materials (MD, ab-initio, ...)
- Electronics
- Photonics

[MORE](#)



Documentation

NANOHUB/HUBZERO SOFTWARE STACK

- Tool Development Workshop
- Rappture BootCamp 2014
- Rappture Docs
- Tool Developers (submit, paths etc)

[MORE](#)



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Share & Publish

Join 2,000+ Contributors



Why / Impact

BUILD REPUTATION AND HELP OTHERS

- [Web-of-Science & Google Scholar Citations](#)
- [Notable Quotes](#)



Apps, Tools, & Data

R&D FOR YOU AND ENABLE OTHERS

- [How to Overview](#)
- [Start a Tool Publication](#)



Video Lectures / Courses

TEACH OTHERS

- [Best Practices](#)
- [How To: Advanced Video Editing for nanoHUB](#)
- [Submit Video Here](#)



Teaching Materials

TEACHING MATERIALS

- [Submit Text Documents](#)
- [Submit Animations](#)



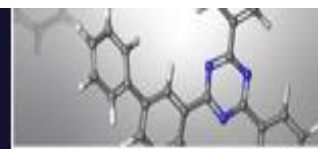
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Learn about molecular modeling for Materials Science through nanoHUB partner, Schrödinger!

Use code **NANOHUB1** and receive a 10% discount.

Sign up for their online courses



Organic Electronics



Homogeneous Catalysis



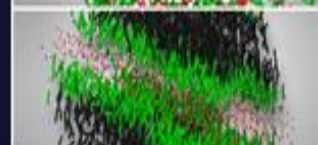
Surface Chemistry



Pharmaceutical Formulations



Polymeric Materials



Consumer Packaged Goods

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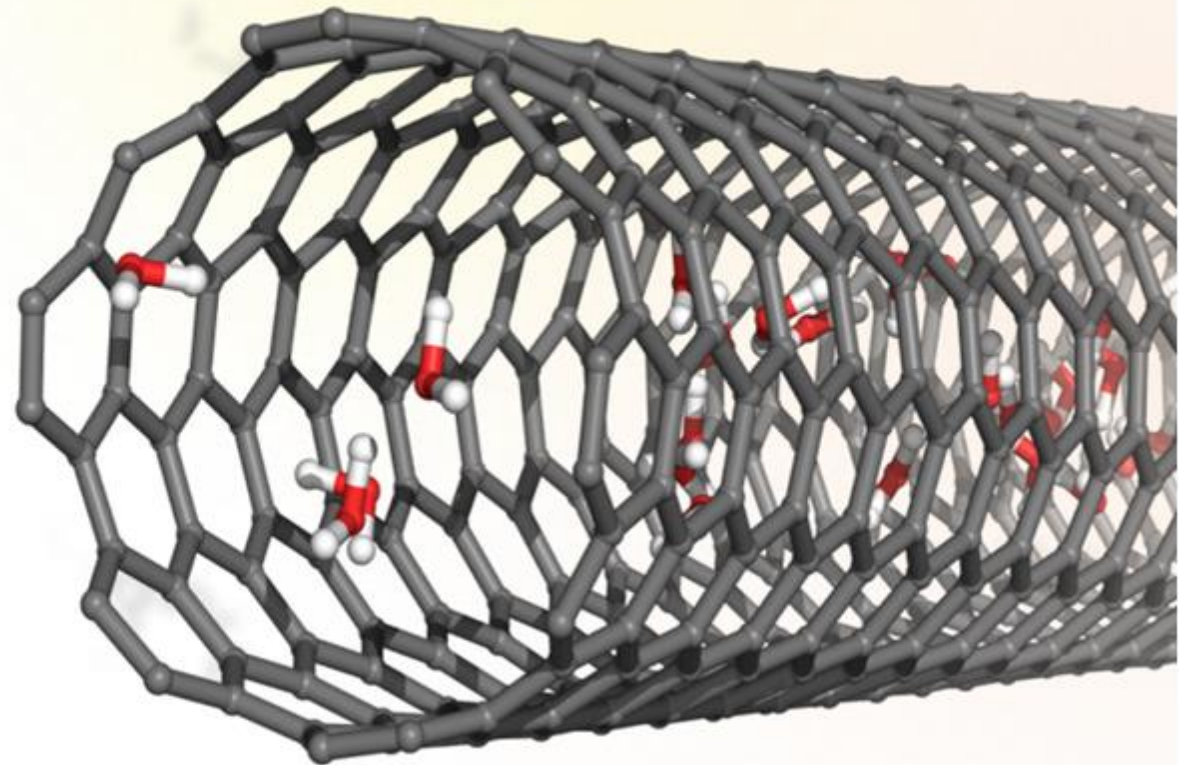
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MATERIALS SCIENCE

Online certification courses

Level up your skillset with hands-on, online molecular modeling courses using industry-leading technology.

[SEE AVAILABLE COURSES](#)



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Materials Science

Course bundle

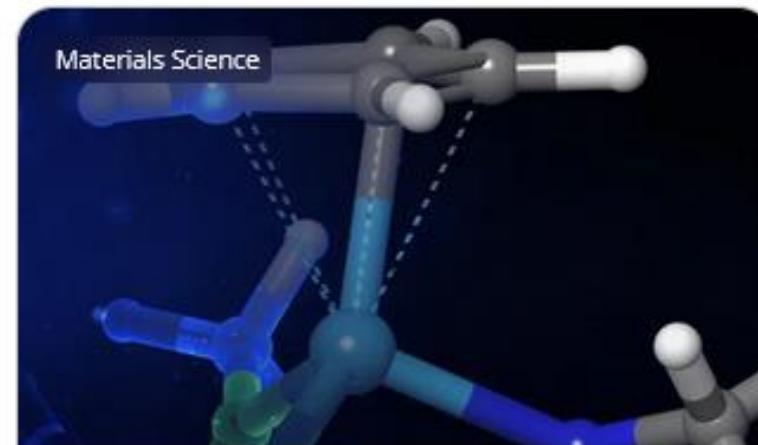
Access all materials science courses with a single, discounted registration



Materials Science

Pharmaceutical formulations

Molecular and periodic quantum mechanics, all atom molecular dynamics, and coarse-grained approaches for studying active pharmaceutical ingredients and their formulations



Materials Science

Homogeneous catalysis and reactivity

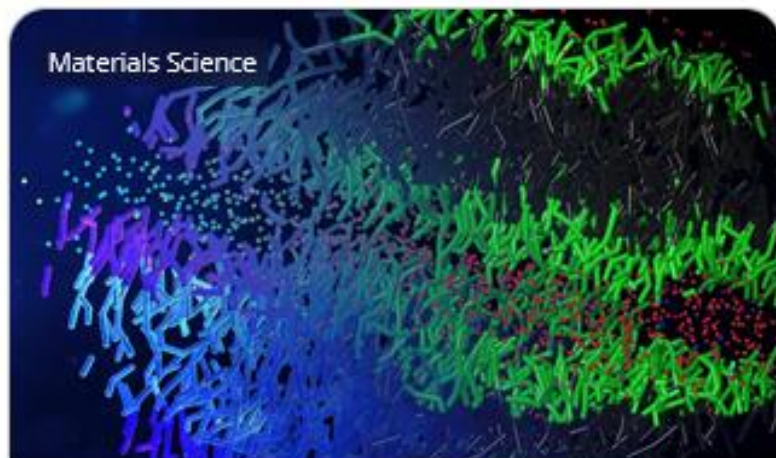
Molecular quantum mechanics and machine learning approaches for studying reactivity and mechanism at the molecular level



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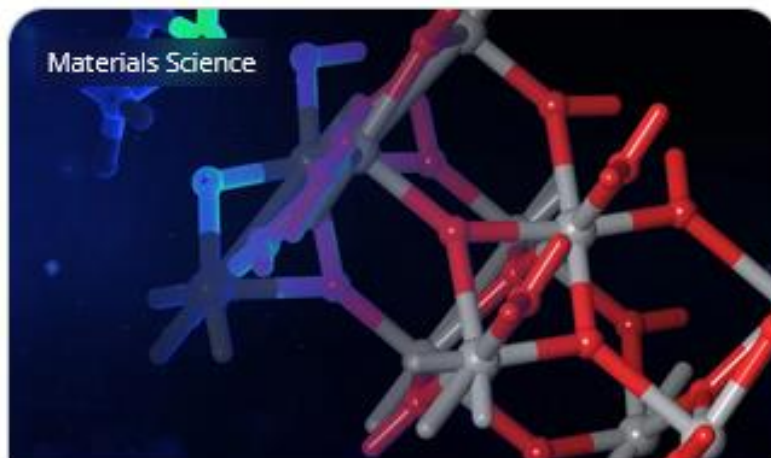
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Materials Science

Consumer packaged goods

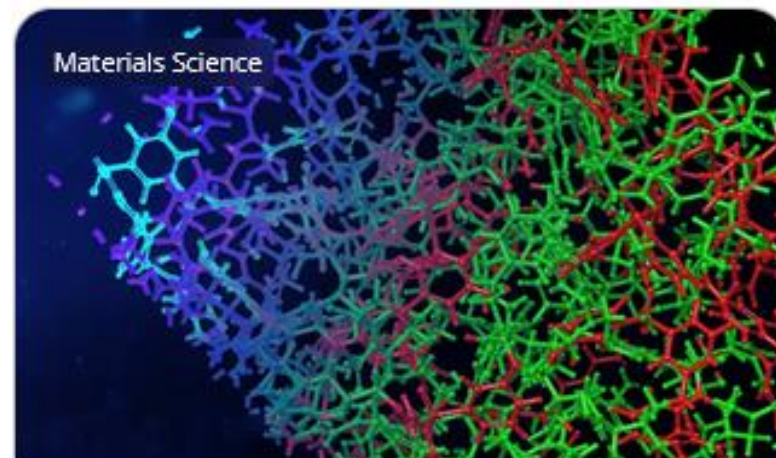
All-atom molecular dynamics, coarse-grained, and machine learning approaches for studying materials integral to the formulation of CPG



Materials Science

Surface chemistry

Molecular quantum mechanics, periodic quantum mechanics, and machine learning approaches for studying atomic layer processing and heterogeneous catalysis



Materials Science

Polymeric materials

All-atom molecular dynamics and machine learning approaches for studying polymeric materials and their properties under various conditions



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Materials Science

Organic electronics

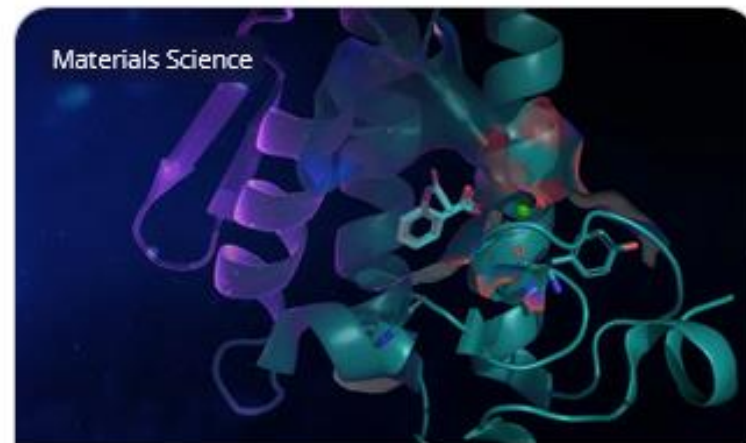
Molecular quantum mechanics, all-atom molecular dynamics, and machine learning approaches for studying challenges in OLED design and discovery



Materials Science

Battery materials

Molecular and periodic quantum mechanics, all atom molecular dynamics, and machine learning for studying battery materials and their properties under various conditions



Materials Science

Visualizing science with PyMOL 3

Learn how to unlock the power of movie making in PyMOL



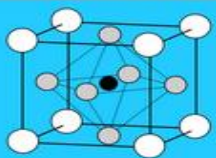
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Examples of Simulation Tools



Simulation Tools

- computational materials science
- materials properties
- materials science
- materials science education
- NCN Group - Materials Science

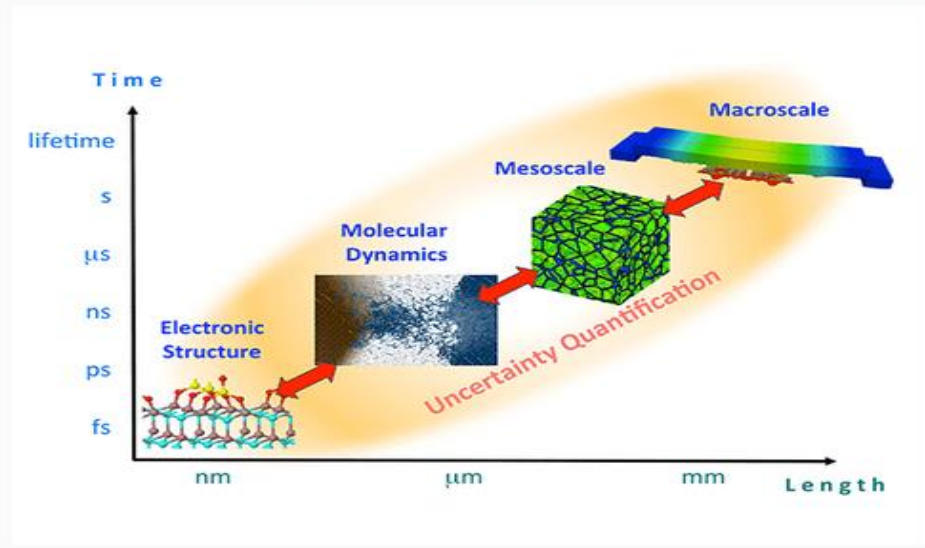
Click on a category of tools to go to a list of the corresponding tools.

Request Group Membership

- Overview
- Getting started
- Materials Courses and Tutorials
- Simulation-Powered Learning Activities
- MSE Webinars
- Online Molecular Modeling Courses
- Materials Demonstrations and Outreach Activities

Simulation Tools

Ab Initio and Electronic



You can also see the list of

[Materials Science Tool Engines and Community Codes installed in nanoHUB](#)



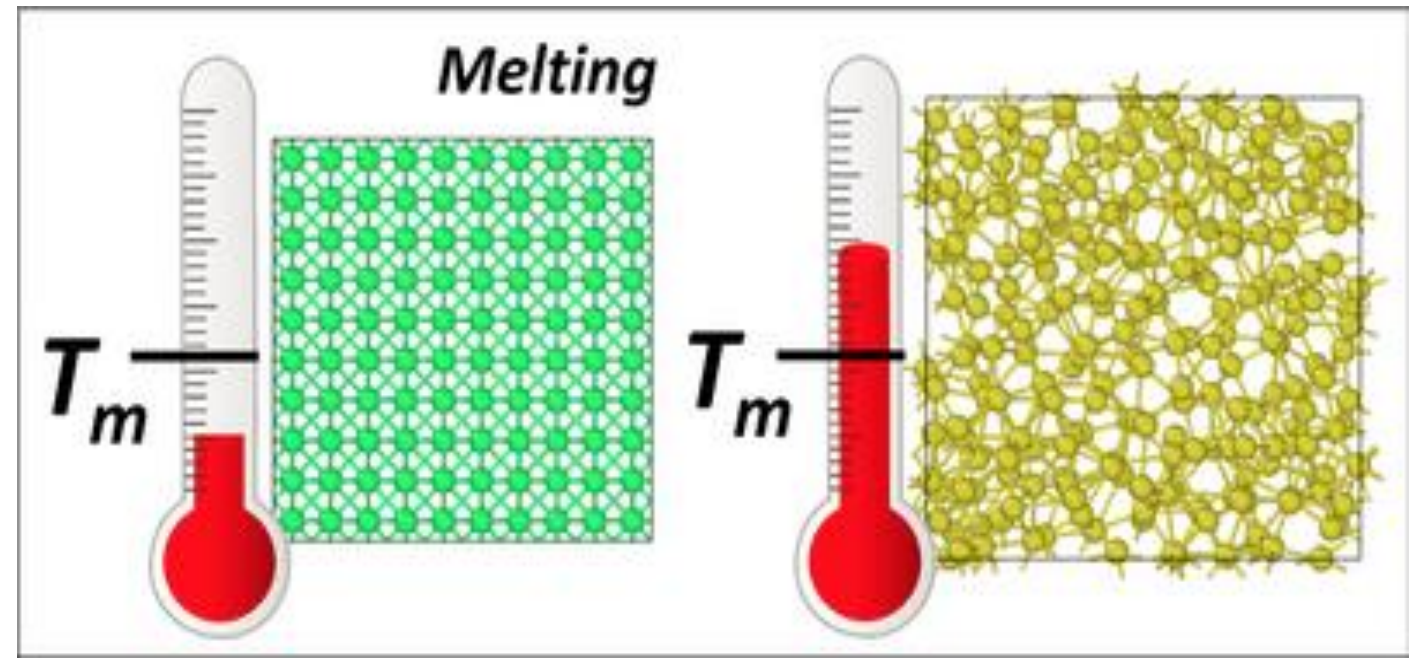
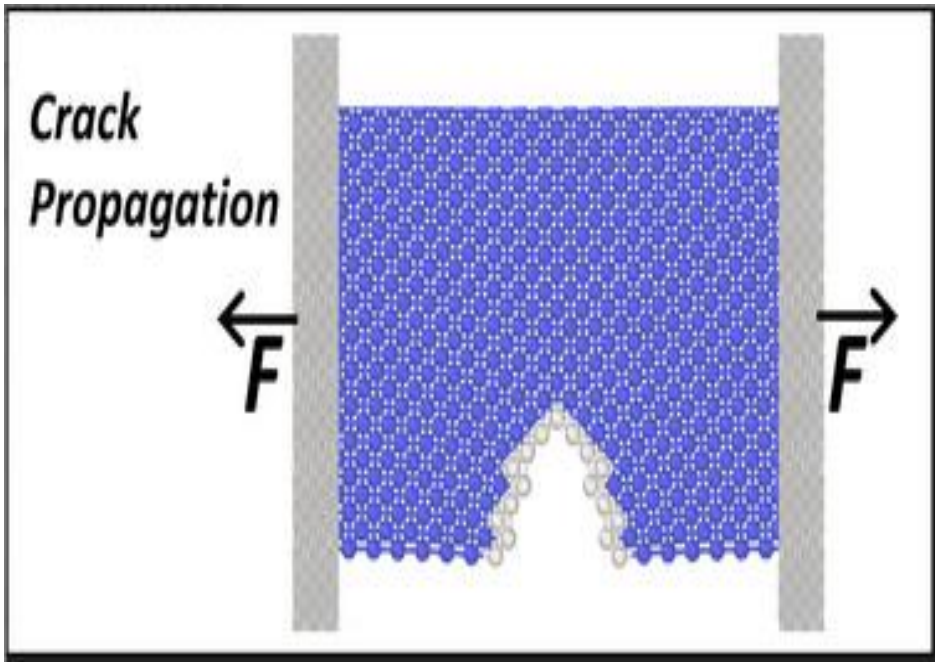
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Nanomaterial mechanics explorer

Examples of Simulation Tools

This tool is for those who would like to explore fundamental properties of materials such as *dislocations*, *crack propagation*, *nanowire tensile testing*, *melting* and the *martensite transformation* through atomistic Molecular Dynamics simulations.





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Nanomaterial mechanics explorer

Examples of Simulation Tools

This tool is for those who would like to explore fundamental properties of materials such as *dislocations*, *crack propagation*, *nanowire tensile testing*, *melting* and the *martensite transformation* through atomistic Molecular Dynamics simulations.

This set of tools will allow you to:

- visualize how dislocations either glide or nucleate in a crystal based on the applied stress direction relative to the Burgers vector, slip plane, and dislocation line.
- visualize how a nanowire deforms under uni-axial tensile loading, observe the process of yielding and necking, and simulate values of key engineering parameters such as the Young's modulus and yield stress. Visualize a defect in a Nickel(FCC) or Tantalum(BCC) that under uniaxial tension grows into a crack that will cause brittle fracture. Stress-strain curve, yield stress and yield strain are generated, and advanced options allow study of the brittle to ductile transition in BCC metals.
- visualize melting at the atomic level, and generate a radial distribution function. The effect of pressure on melting temperature can be studied.
- visualize a fast quench of two Ni-Al alloys, and identify the martensite transformation



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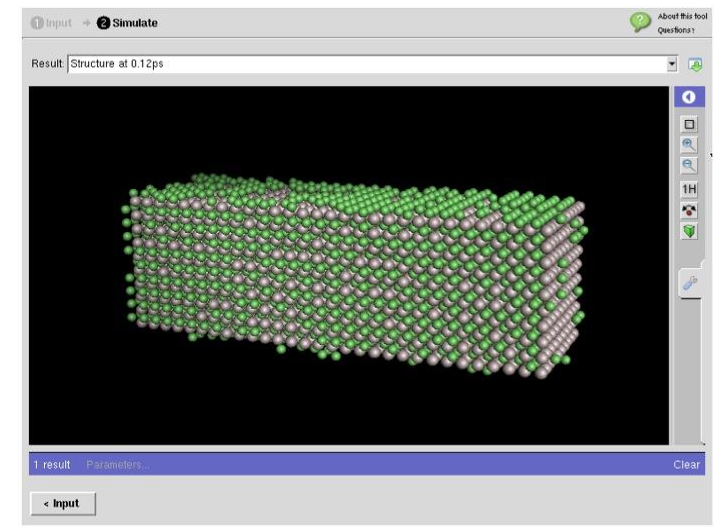
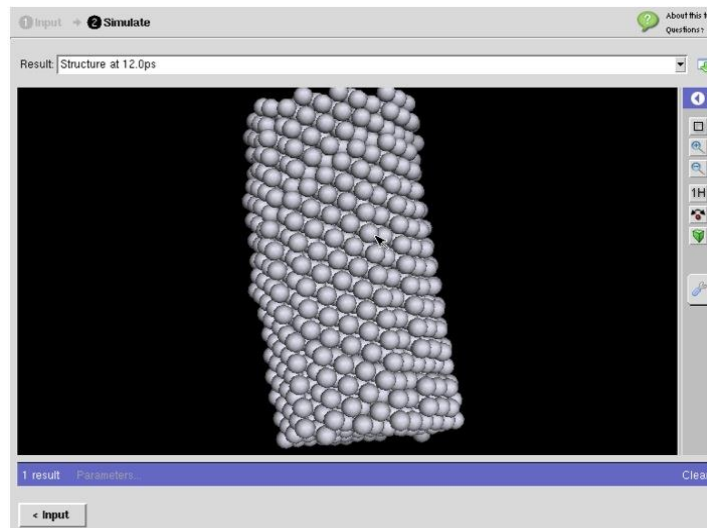
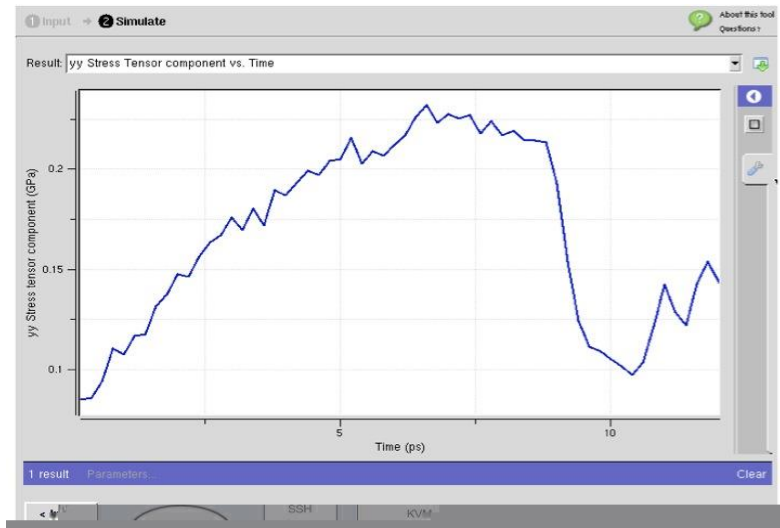
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nano-Materials Simulation Toolkit

Examples of Simulation Tools

The nanoMATERIALS simulation toolkit enables users to perform molecular dynamics simulations of materials using a variety of force fields as well as electronic structure calculations



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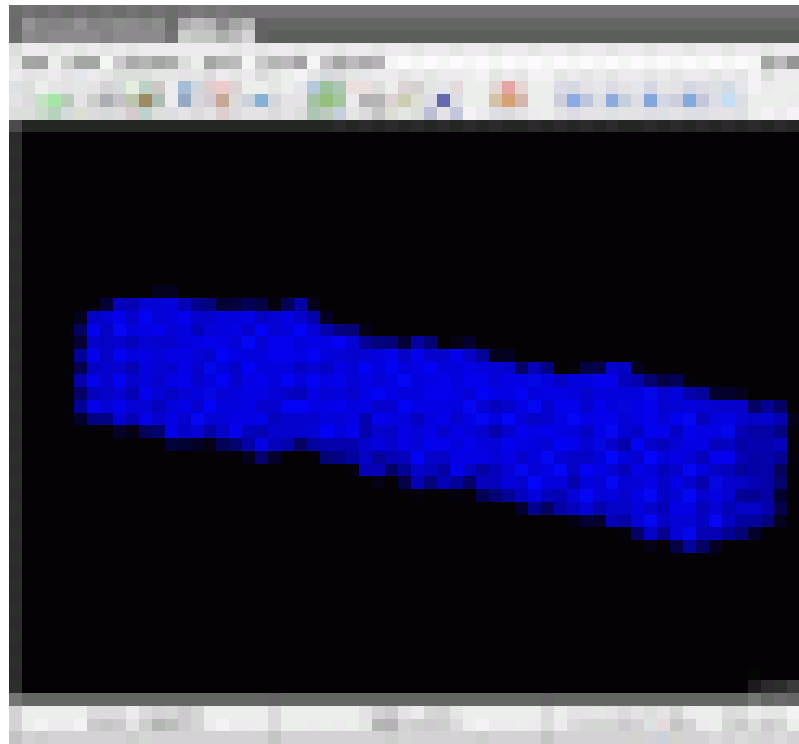
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Examples of Simulation Tools

Learning Module— Atomic Picture of Plastic Deformation in Metals

This learning module describes how this simulation tool can be used to teach concepts about plastic deformation to sophomore-level MSE students.



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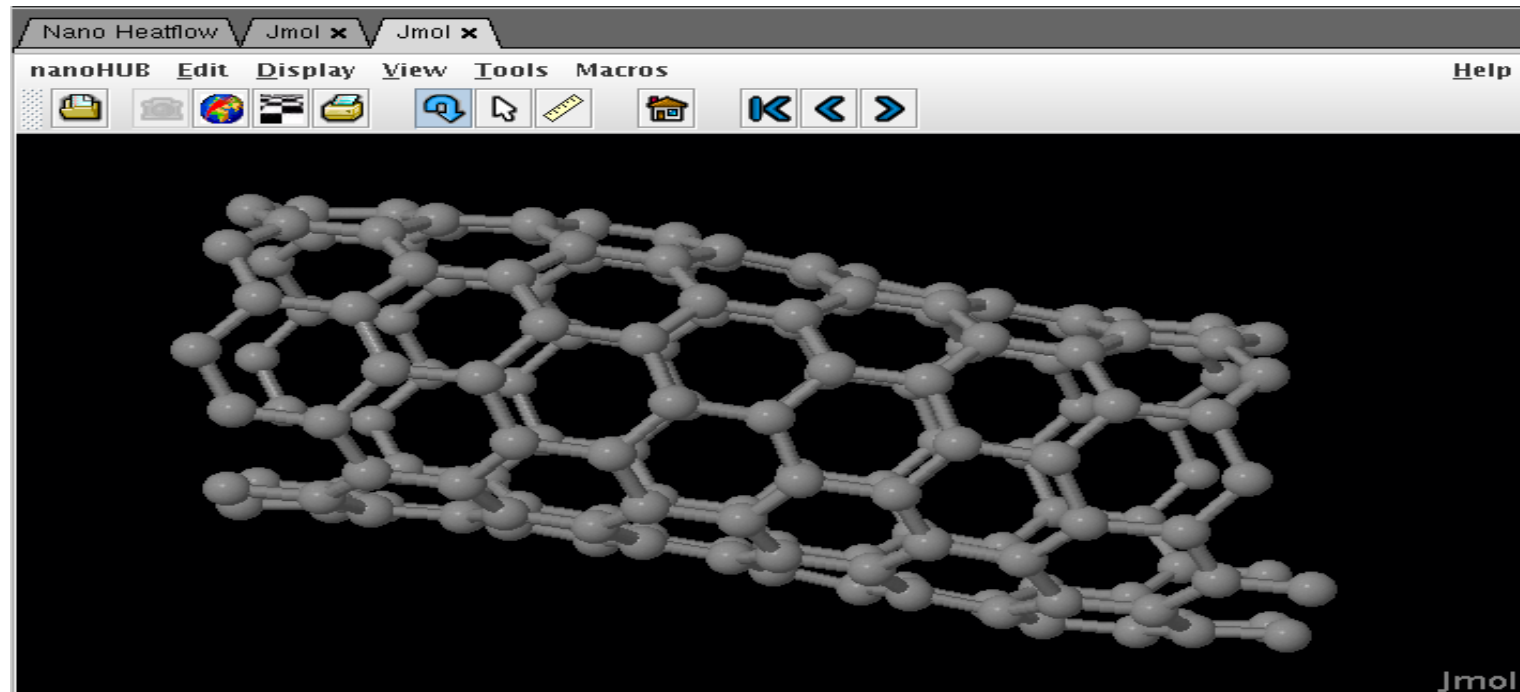
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Examples of Simulation Tools

[nanoMATERIALS nanoscale heat transport](#)

This tool will enable the users to calculate two heat transport properties: thermal conductivity and phonon relaxation time.





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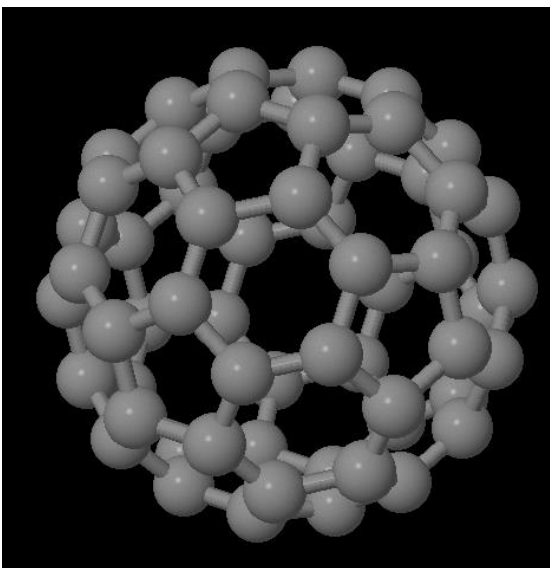
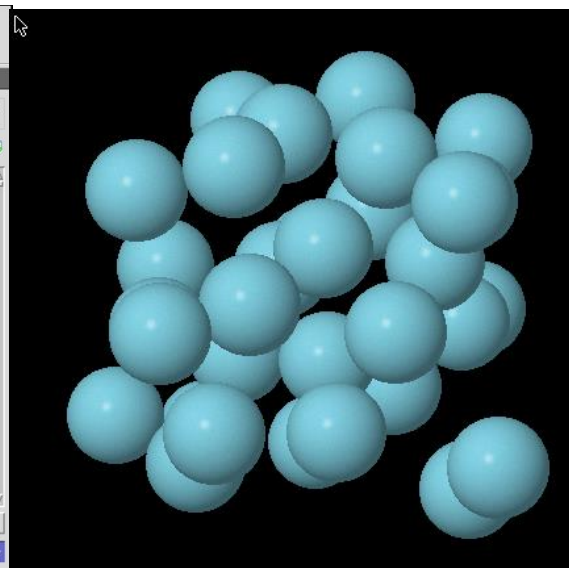
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Examples of Simulation Tools

MIT Atomic-Scale Modeling Toolkit

This tool is part of MIT Atomic-Scale Modeling Toolkit which serves Overview of Computational Nanoscience: a UC Berkeley Course



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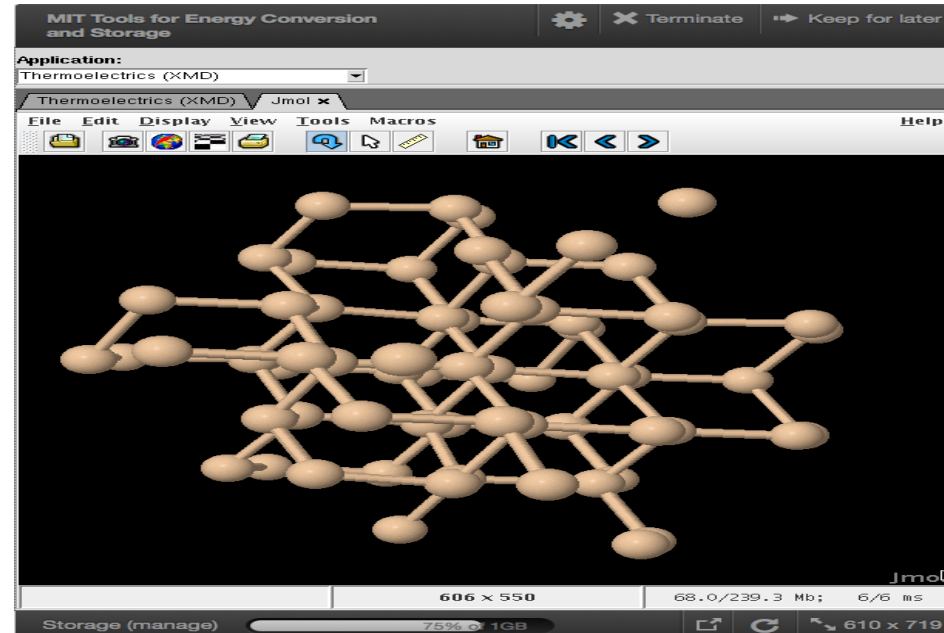
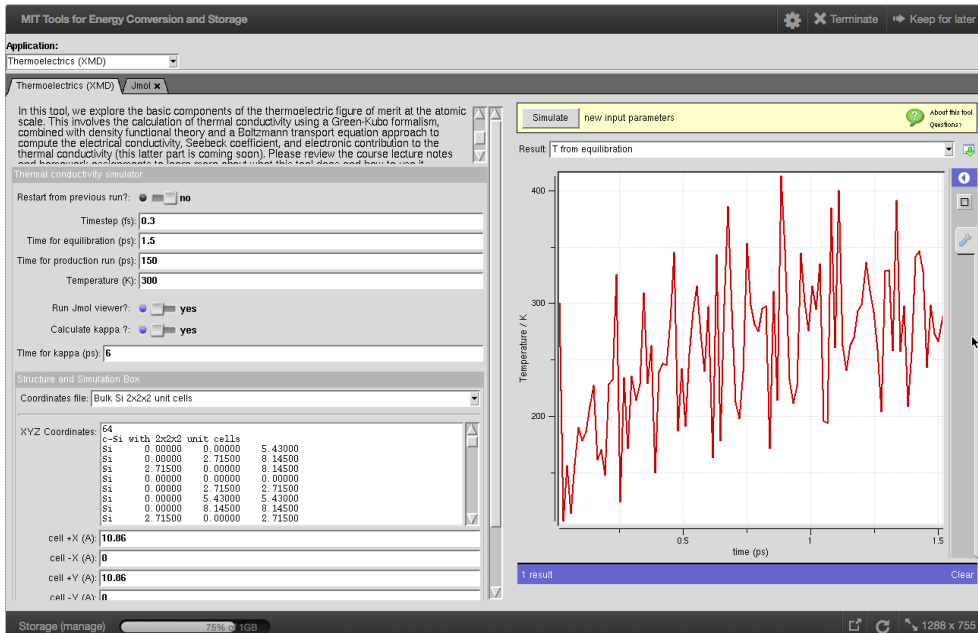
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MIT Tools for Energy Conversion and Storage

Examples of Simulation Tools

These tools allow students to focus on the atomic-scale physics and chemistry underlying four separate energy conversion and storage materials: thermoelectrics, solar fuels, solar photovoltaics, and hydrogen storage. Within each of these four different tools, the user can compute properties that are directly relevant to the key fundamental conversion and storage mechanisms.





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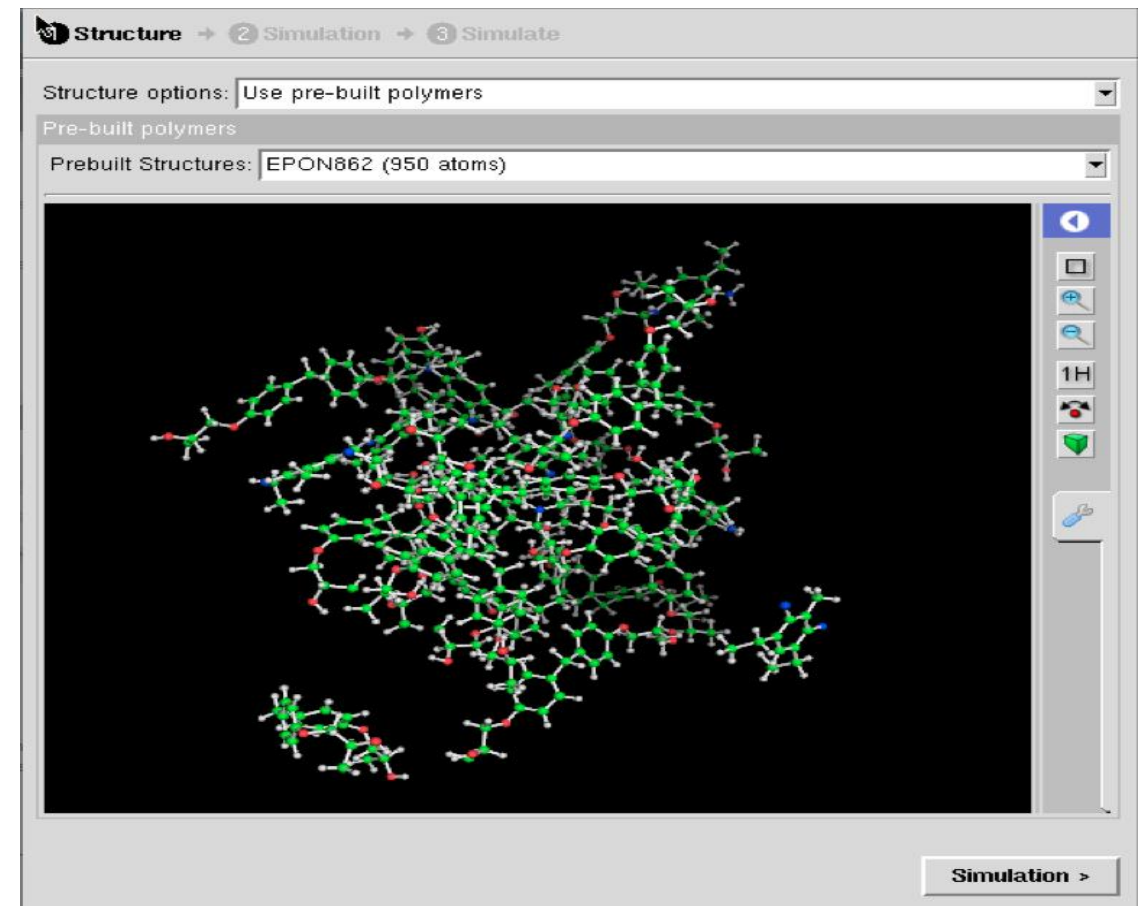
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Examples of Simulation Tools

Polymatic: A Simulated Polymerization Algorithm

Polymatic is a set of codes for structure generation of amorphous polymers by a simulated polymerization algorithm. The main task of Polymatic is to perform polymerization steps within a system based on a number of defined bonding criteria. It works in conjunction with a simulation package to perform energy minimization and molecular dynamics simulations during the polymerization.





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Amorphous Silicon Generator

Examples of Simulation Tools

This tool generates realistic random-network models of a-Si with periodic boundary conditions.

Amorphous Silicon (a-Si:H) Tool Jmol x

System Size

Number of Si Atoms: 64

Mode: Basic

Basic Mode

Bonds to replace with 2 Hydrogens: 3

Initial randomization steps to perform: 9

Max anneal temperature KT (eV): 0.9eV

Min anneal temperature KT (eV): 0.5eV

Step size in anneal (eV): 0.05eV

Software Tools for Academics and Researchers
Office of Educational Innovation and Technology

Massachusetts Institute of Technology

Generate New Structure

Result: Generated a-Si:H Structure

1 result Parameters... Clear



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Examples of Simulation Tools

Molecular Dynamics with Monte Carlo Simulations

RASPA tools, which include:

- Void Fraction Calculator
- Calculates the void fraction (pore volume) of nano-porous materials
- Gibbs Adsorption Simulator
 - Simulates the adsorption of gases using Gibbs ensemble
- Adsorption Energy Calculator
 - Calculate the total energy of adsorbates as they move around a metal organic framework
- Gas Adsorption Calculator
 - Simulates gas adsorption onto metal organic frameworks
- Henry Coefficient Simulator
 - Calculate Henry's constant of several sites on a nanoporous material
- Gas Diffusion Coefficient in Metal Organic Frameworks
 - Calculates gas self diffusion coefficient in metal organic frameworks



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NanoDDSCAT

Examples of Simulation Tools

Calculate scattering and absorption of light with arbitrary geometry and complex Refractive Index

1. Target

The screenshot displays the 'Target' configuration window in NanoDDSCAT. At the top, a navigation bar includes 'Target', 'Spectrum Calculation', 'Field', 'Process', and 'Simulate'. The main area features a 3D visualization of a yellow cylinder with a coordinate system (x, y, z) and labels for 'Cylinder Axis', 'SHPAR1' (length), and 'SHPAR2' (radius). A legend defines the cylinder axis orientation: SHPAR3 = 1 for x-axis, 2 for y-axis, and 3 for z-axis. Below the visualization, the 'Shape of Nanosystem' is set to '6. Cylinder'. The 'Shape Parameters (nm)' section lists SHPAR1: 16, SHPAR2: 16, SHPAR3: 1, SHPAR4: 0, SHPAR5: 0, and SHPAR6: 0. The 'Dipoles per (nm):' is set to 1. The 'Target Rotations' section is partially visible at the bottom.



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Examples of Simulation Tools

NanoDDSCAT

Calculate scattering and absorption of light with arbitrary geometry and complex Refractive Index
 2. Spectrum Calculation

1 Target → 2 Spectrum Calculation → 3 Field → 4 Process → 5 Simulate

Define a Wavelength Window for Light Spectrum to be Observed

I.e. 400-700 nm window, 3 divisions

Window applies to every dipole

Acceptable Wavelength Ranges (in nm) Vary Depending on Dielectric Usage as Follows:

- Copper (Cu): 187.85 to 1937.25
- Gold (Au): 397.00 to 1650.00
- Palladium (Ag): 187.85 to 1937.25
- Platinum (Pt): 309.96 to 1239.84
- Silver (Ag): 187.85 to 1937.25

If you are providing your own Dielectric file(s), then you are responsible for accurately using your defined range.

Note: DDSCAT will still run outside of the appropriate ranges, but it will give incorrect and potentially misleading results!

First Wavelength (nm):

Last Wavelength (nm):

Wavelength Window Steps: + -

Division Separation Scale Type: ▾



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NanoDDSCAT

Examples of Simulation Tools

Calculate scattering and absorption of light with arbitrary geometry and complex Refractive Index

3. Field

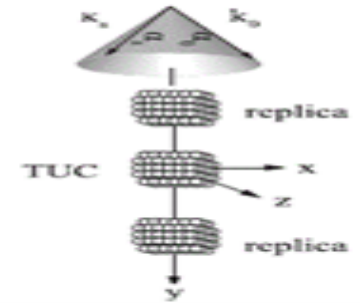
1 Target → 2 Spectrum Calculation → 3 Field → 4 Process → 5 Simulate



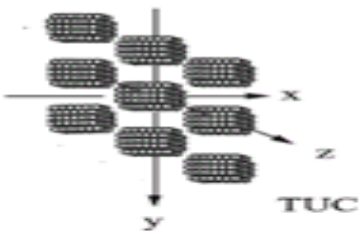
Wavelength with maximum light extinction intensity is considered.

Nearfield Calculation:

1-D Periodicity



2-D Periodicity



Note: Periodicity is currently only supported for custom files. A custom shape file must be input to access this menu.



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NanoDDSCAT

Examples of Simulation Tools

Calculate scattering and absorption of light with arbitrary geometry and complex Refractive Index

4. Process and Simulate

```

nanoDDSCAT
Target → Spectrum Calculation → Field → Process → Simulate

0 = NEFLD (-0 to skip nearfield calc., -1 to calculate nearfield E)
0.5 0.5 0.5 0.5 0.5 0.5 (fract. extens. of calc. vol. in -x,+x,-y,+y,-z,+z)
***** Error Tolerance *****
1e-5 = TOL = MAX ALLOWED (NORM OF |G>=AC|E>-ACA|X>)/(NORM OF AC|E>)

***** maximum number of iterations allowed *****
10000000 = MXITER
***** Interaction cutoff parameter for PBC calculations *****
1e-2 = GAMMA (1e-2 is normal, 3e-3 for greater accuracy)
***** Angular resolution for calculation of <cos>, etc. *****
0.5 = ETASCA (number of angles is proportional to [(3+x)/ETASCA]^2 )
***** Vacuum wavelengths (micron) *****
0.5 0.5 1 'TAB' = wavelengths (first, last, how many, how=LIN, INV, LOG)
***** Refractive index of ambient medium *****
1.0 = NAMBIENT
***** Effective Radii (micron) *****
0.00992560785439 0.00992560785439 1 'LIN' = seff (first, last, how many, how=LIN, INV, LOG)
***** Define Incident Polarizations *****
(0,0) (1,0) (0,0) = Polarization state e01 (k along x axis)
1 = IORTH (-1 to do only pol. state e01; -2 to also do orth. pol. state)
***** Specify which output files to write *****
0 = IWRKSC (=0 to suppress, -1 to write ".sca" file for each target orient.
***** Prescribe Target Rotations *****
-0.0 -0.0 1 = BETAMI, BETAMK, NBETA (beta-rotation around a1)
0.0 0.0 1 = THETMI, THETMK, NTHETA (theta-angle between a1 and k)
0.0 0.0 1 = PHIMIN, PHIMAX, NPHI (phi-rotation angle of a1 around k)
***** Specify first IWAV, IRAD, IORI (normally 0 0 0) *****
0 0 0 = first IWAV, first IRAD, first IORI (0 0 0 to begin fresh)
***** Select Elements of S_ij Matrix to Print *****
6 = NSHELTS = number of elements of S_ij to print (not more than 9)
11 12 21 22 31 41 = indices ij of elements to print
***** Specify Scattered Directions *****
LFRAME = CMDPRM (LFRAME, TFRAME for Lab Frame or Target Frame)
1 = NPLANES = number of scattering planes
0. 0. 180. 1 = phi, thetan_min, thetan_max (deg) for plane A

Export file transfer initiated. Thu Jul 18 15:45:57 2019
Export file transfer complete. Thu Jul 18 15:45:57 2019
Run 7334559 registered 1 job. Thu Jul 18 15:45:59 2019
    
```



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NanoDDSCAT Worldwide Usage

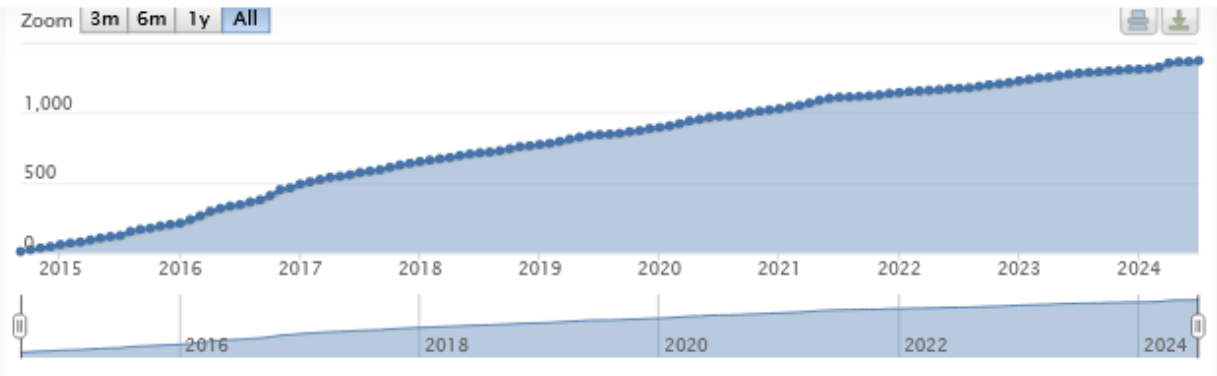
Examples of Simulation Tools



EXPLORE PUBLISH COMMUNITY ABOUT SUPPORT

Cumulative Simulation Users

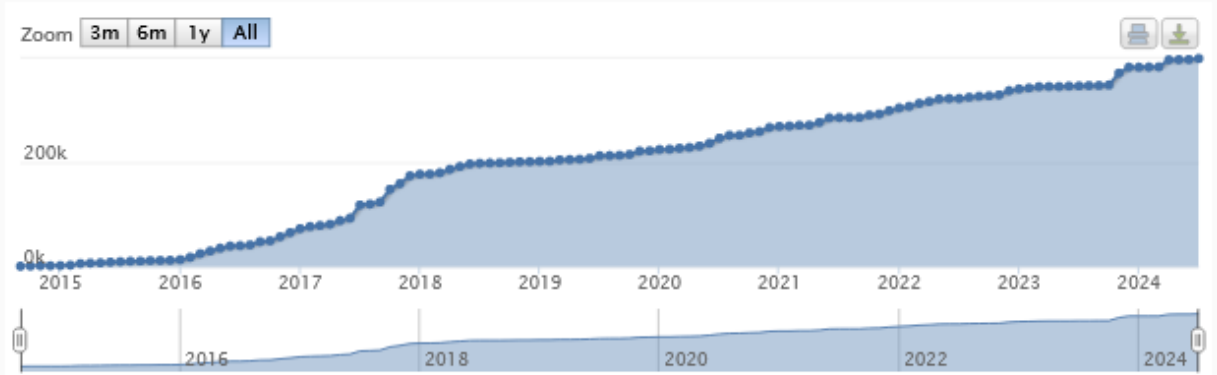
1,372



Simulation Runs

397,099

Jun 2024

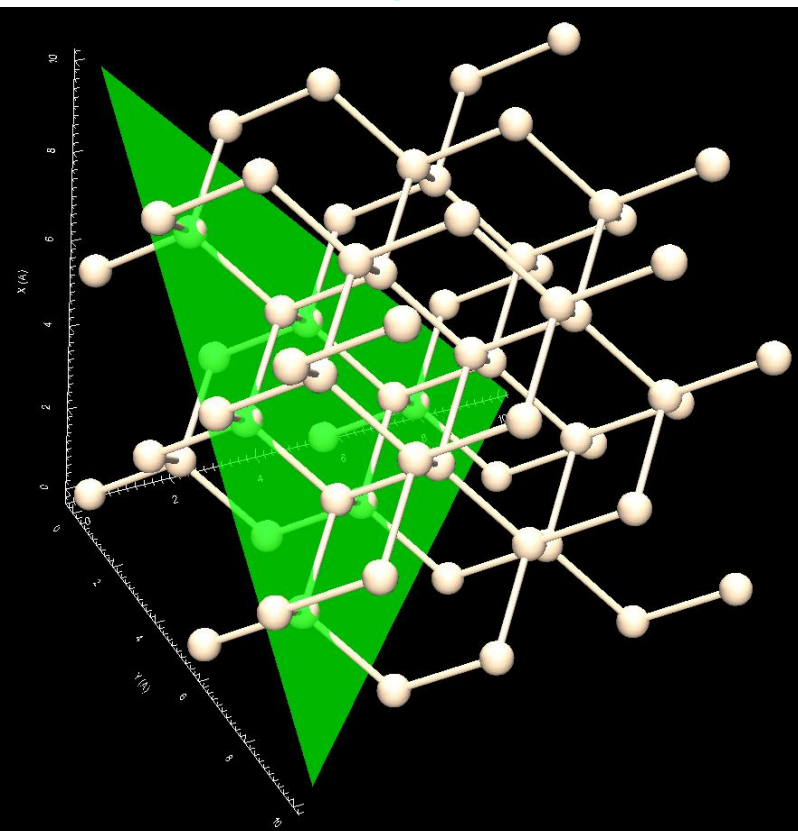




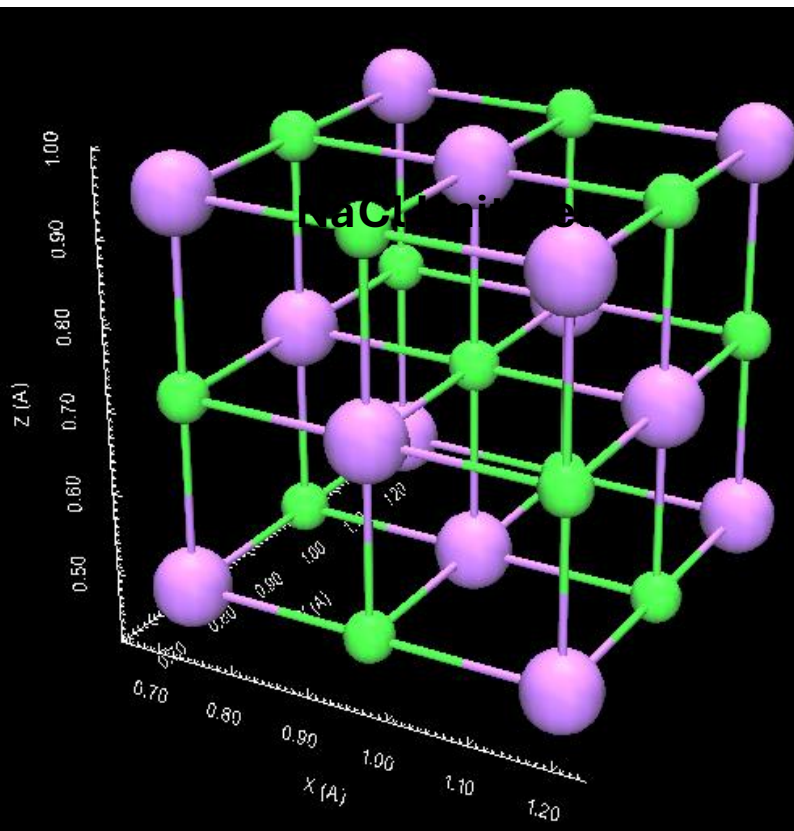
Examples of Simulation Tools

The Crystal Viewer simulation tool allows:

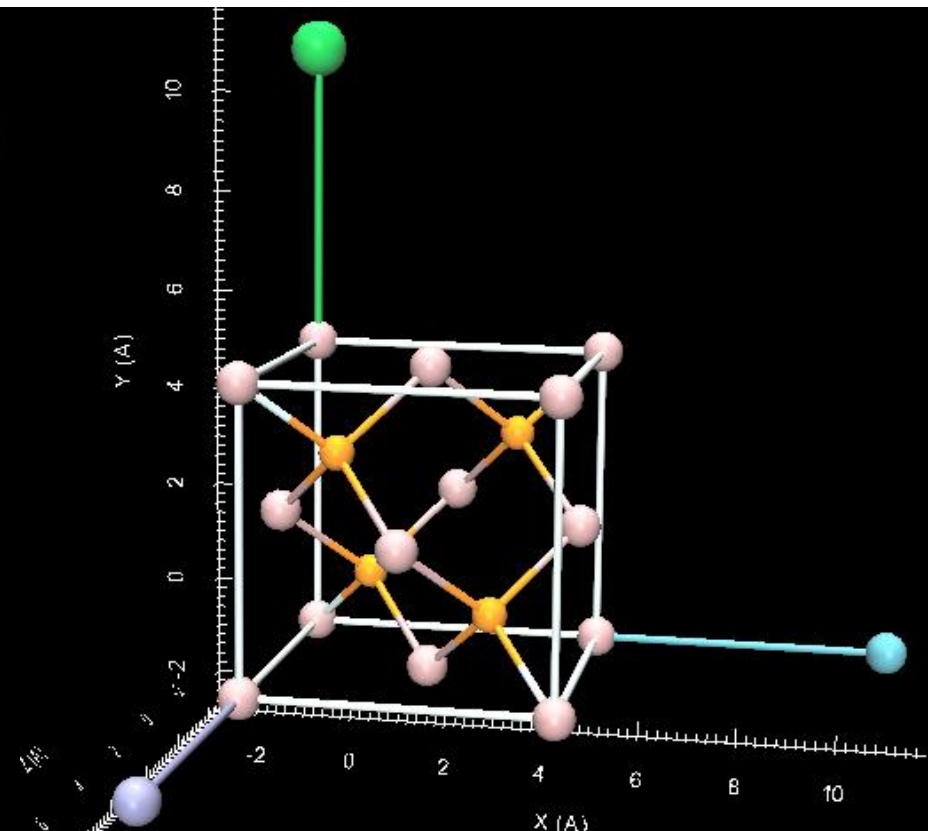
- (a) viewing all materials which have periodical structure
- (b) building crystal structure even not exists in nature



Silicon With Miller Plane



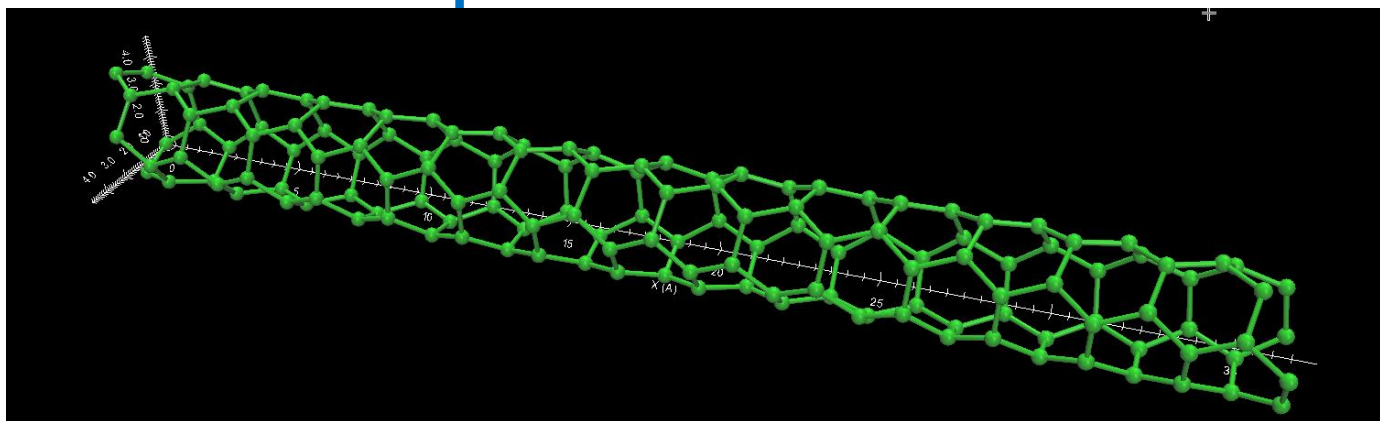
NaCl Unit Cell



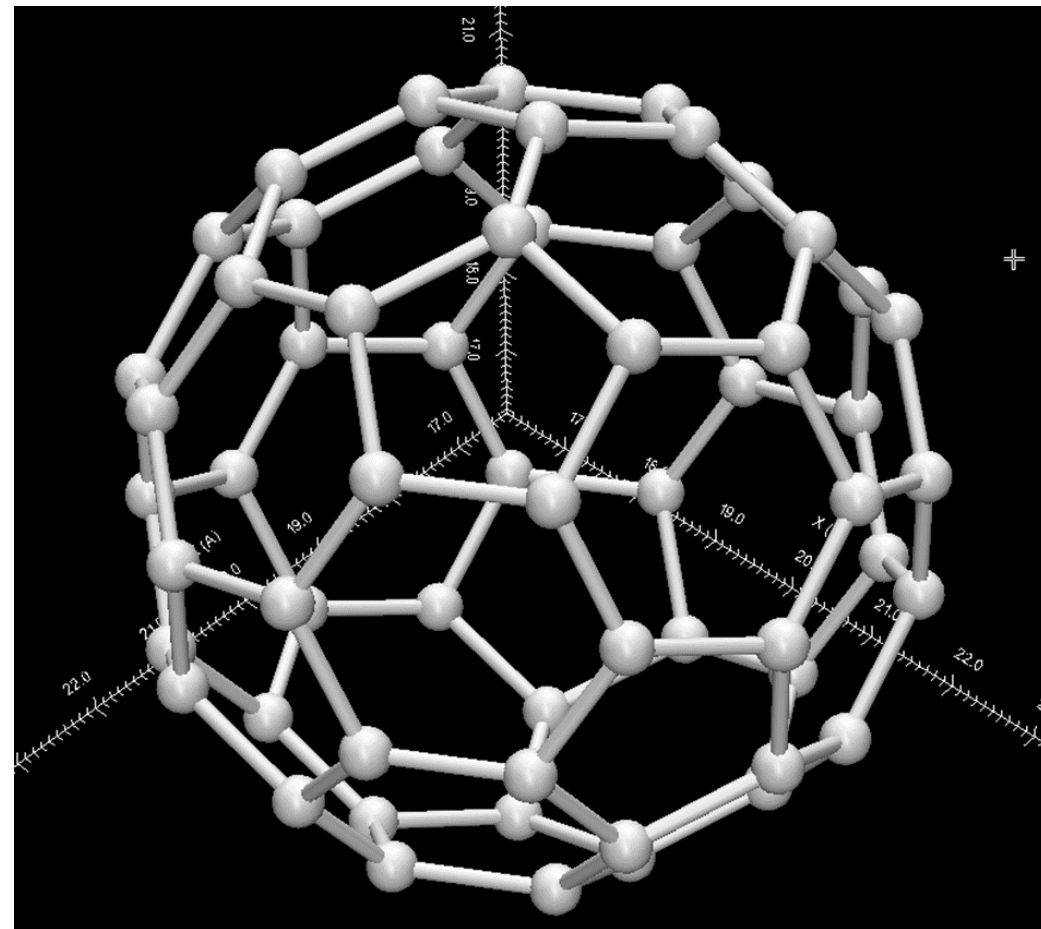
GaP Unit Cell



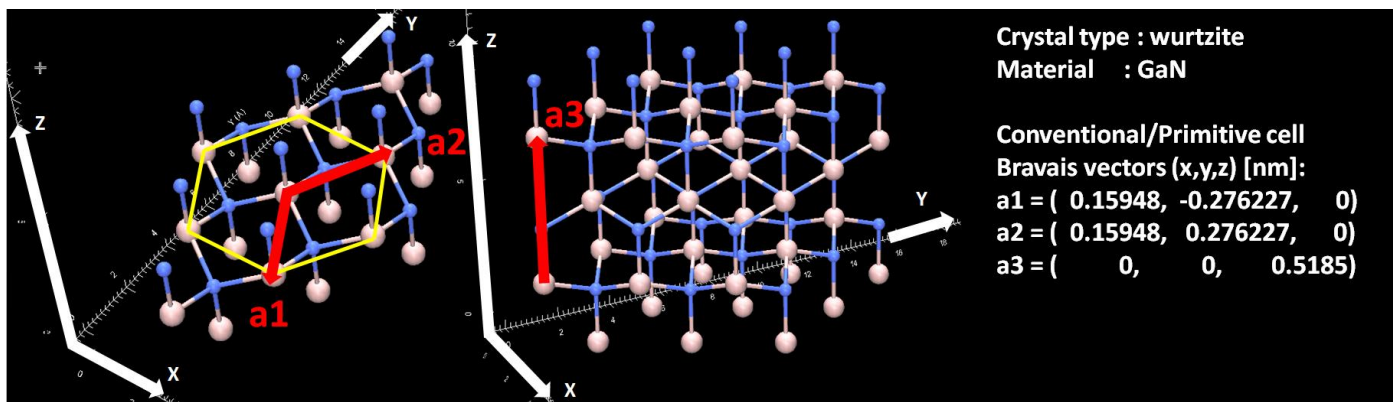
Examples of Nano Structure Visualization



Carbon nano tube



Buckey Ball



GaN Bravais Vectors



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Examples of Nano Structure Visualization

https://youtu.be/wm3VpgbM6_w



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Crystal Viewer

Worldwide Usage

Cumulative Simulation Users

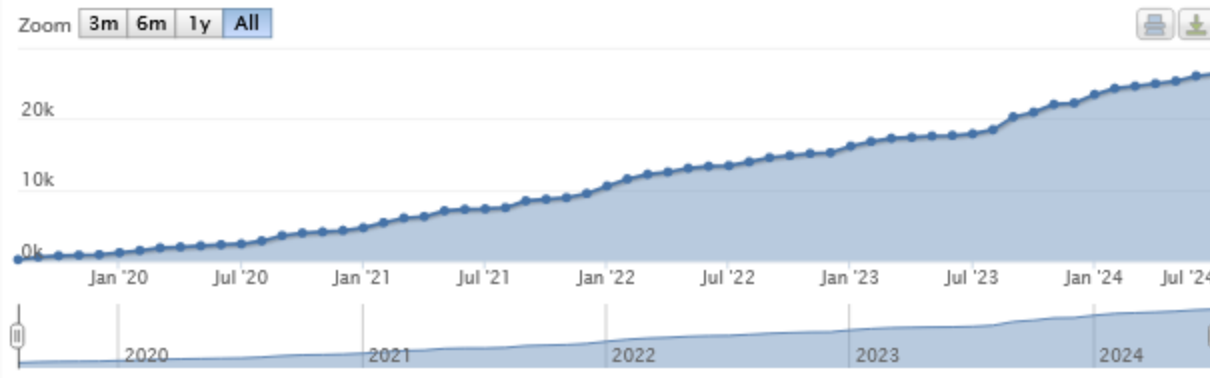
6,671



Simulation Runs

26,381

Jun 2024





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Nanosphere Optics Lab over NanoHub

Calculate absorption from metallic nanoparticles

Examples of Simulation Tools

The screenshot shows a web browser window with the nanoHUB.org website. The main content area displays the 'Nanosphere Optics Lab' interface. At the top, there are navigation links: RESOURCES, EXPLORE, NANOHUB-U, PARTNERS, COMMUNITY, ABOUT, SUPPORT, and DONATE. The interface includes a 'Simulate' button and a 'new input parameters' dropdown menu. Below this, there is a text block explaining the simulation: 'This module calculates the absorption, scattering, and extinction spectra of spherical nanoparticles using Mie theory. Results are given in terms of efficiency factors relative to the expected result from geometric optics. The choice of material (e.g. Gold) determines the wavelength dependent dielectric properties of the spheres. The particle size and refractive index of the material in which the spheres are embedded can be varied. The numerical solution of the scattering problem is achieved using the code of Bohren and Huffman as found in C. F. Bohren, D. R. Huffman, "Absorption and Scattering of Light by Small Particles" John Wiley and Sons, Inc. (1983). The optical constants of gold and silver are from P. B. Johnson and R. W. Christy, Phys. Rev. B, vol. 6, p. 4370 (1972).' To the left of this text is a small image of a test tube with a red liquid, captioned 'Solutions of gold nanoparticles ranging from 10 nm (left) to 80 nm (right). Courtesy of Matthew Hammond; JPEG image data, JFIF standard 1.01 3.8 kB'. Below the text is a form with the following fields: 'Particle Composition' (Au-Gold), 'Particle Refractive Index' (1.400), 'Surrounding Medium Refractive Index' (1.000), and 'Radius of particle' (20nm). At the bottom of the form, there are fields for 'Beginning wavelength' (300nm) and 'Ending wavelength' (1000nm). The bottom of the browser window shows a storage indicator (23% of 10GB) and a refresh button.



Nanosphere Optics Lab over NanoHub

Examples of Simulation Tools

Calculate absorption and scattering from single nanowires with or without shells

The screenshot shows a web browser window with the nanoHUB.org website. The main content area displays the 'Optical Properties of Single Coaxial Nanowires' simulation tool. The interface includes a 'Simulation Parameters' tab, a 'Nanowire Parameters' tab, and a 'Simulate' button. Below the tabs is a 'Nanowire Schematic' diagram showing a cylindrical nanowire with a core and shell, and two cases of illumination: Case I (H field perpendicular to the nanowire axis) and Case II (E field perpendicular to the nanowire axis). The diagram also shows the wave vector k and the electric field E and magnetic field H vectors for both Transverse Magnetic (TM) and Transverse Electric (TE) polarizations. Below the schematic are input fields for 'Initial Wavelength (nm): 300', 'Final Wavelength (nm): 1000', 'Angle of Incidence (degrees): 0', and 'Number of Multipoles: 20'. The 'Type of Calculation' is set to 'Option 1) Total Scattering, Absorption and Extinction'. On the right side of the interface, there is a text box containing the following information:

Optical Properties of Single Coaxial Nanowires

This program computes the following optical properties of a single nanowire with up to 2 shell layers using Mie-formalism:

- 1) Total scattering, absorption and extinction efficiency
- 2) Absorption efficiency of individual layers
- 3) The integrated photon flux absorbed and the ideal photocurrent density under AM 1.5 G illumination as a function of layer thickness
- 4) Electric and magnetic polarizability under TE polarization (E field perpendicular to nanowire axis)

Assumptions:

- 1) Nanowires are infinitely long which is valid as long as the nanowire length is $> 10 \times$ diameter.
- 2) Incident light is a plane-wave whose angle of incidence can be defined. Two polarizations are considered: Case I (H field is perpendicular to the nanowire axis) and Case II (E field is perpendicular to the nanowire axis). Unpolarized response is calculated as an average of Case I and Case II.

Note: When the illumination is incident normal to the nanowire axis, Case I corresponds to transverse magnetic (TM) and Case II corresponds to transverse electric (TE)

At the bottom of the browser window, the storage status is shown as 'Storage (manage) 23% of 10GB' and the page resolution is '1360 x 768'.



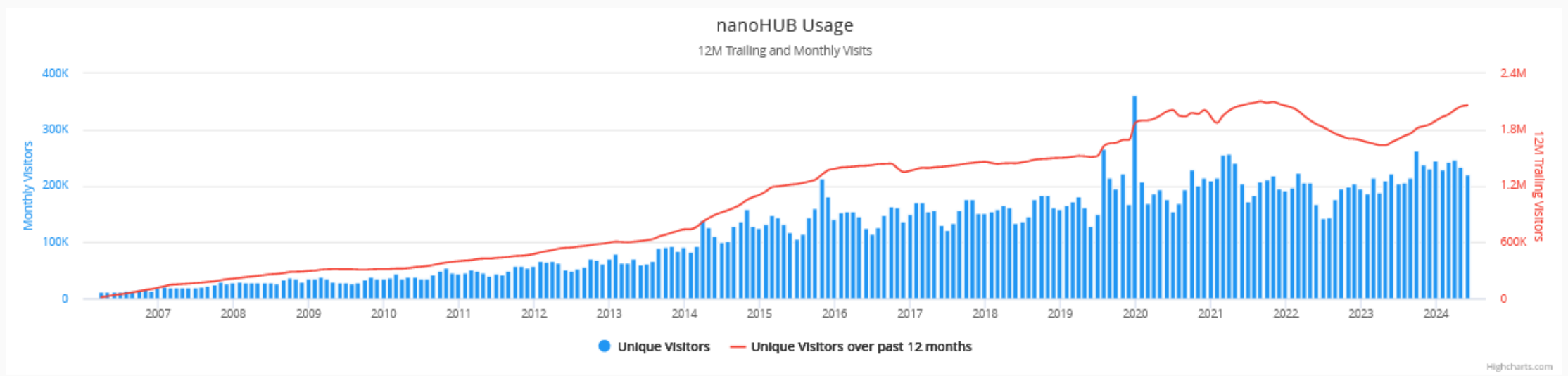
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NanoHub: Worldwide Usage



2,060,048
Unique Visitors

303,140
Registered Users

7,891
Resources

839
Published Tools

2,787
Citations

23,115
Simulation User Count



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Interactive Simulations for Science and Math

[EXPLORE OUR SIMS](#)

Over **1.5 billion** simulations delivered

PHYSICS



CHEMISTRY



MATH



EARTH
SCIENCE



BIOLOGY





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PhET Interactive Simulations

University of Colorado

For Physics, Chemistry, Math, Environmental Sciences
and Biological Sciences:

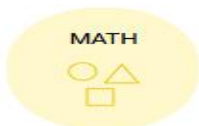
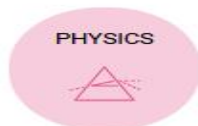
<https://phet.colorado.edu/>



Interactive Simulations
for Science and Math

[EXPLORE OUR SIMS](#)

Over **1.5 billion** simulations delivered





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PhET Interactive Simulations

University of Colorado

For Physics, Chemistry, Math, Environmental Sciences and Biological Sciences:

<https://phet.colorado.edu/>

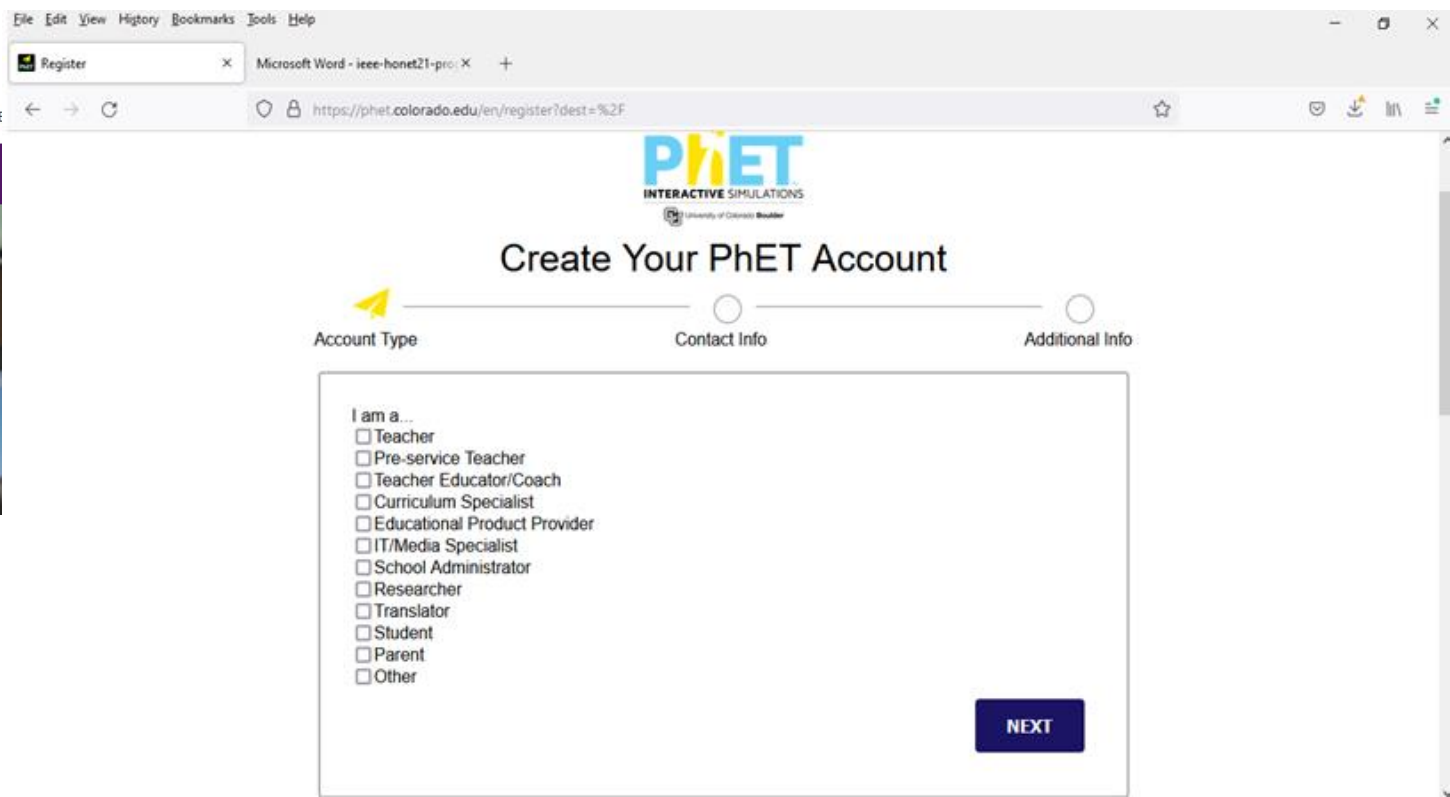


PhET's COVID-19 resources: [remote learning tips](#), [HTML5 prototype sims](#), and [browser-compatible Java sims](#).
Help us keep students learning. [Donate Now](#)



<https://www.youtube.com/watch?v=4Hj6GqBRpA0>

A0





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PhET Interactive Simulations

University of Colorado

For Physics, Chemistry, Math, Environmental Sciences and Biological Sciences:

<https://phet.colorado.edu/>

• PhET Simulations Help Students to:

- Engage in scientific exploration with multiple, positive learning
- Achieve conceptual learning
- Make connections to everyday life (e.g., science to the real world)
- Take and sense ownership of their learning

• PhET Simulations Help Educators to:

- Create a student-centered classroom
- Foster a supportive, goal-oriented learning environment
- Bring their experience, professionalism, and knowledge of their students to designing, implementing, and improving activities, implementation, and design.

Tips for Using PhET

PhET simulations are very flexible tools that can be used in many ways. Here, you will find videos and resources for learning about effective ways of integrating PhET simulations into your class.

A Brief Introduction to PhET:

An overview of the PhET Simulations





PhET Interactive Simulations: Accessibility Features

University of Colorado

For Physics, Chemistry, Math, Environmental Sciences and Biological Sciences:

<https://phet.colorado.edu/>

Teaching Resources, Activities, and Community

Teachers have access to simulation-specific tips and video primers, resources for teaching with simulations, and activities shared by our teacher community.

REGISTER NOW



INTERACT
DISCOVER
LEARN

Accessible Simulations

▼ Accessibility Features

- Alternative Input (e.g., keyboard navigation) ⓘ
- Sound and Sonification ⓘ
- Interactive Description ⓘ
- Interactive Description on Mobile Devices ⓘ
- Pan and Zoom ⓘ
- Voicing ⓘ

167
interactive
simulations



123
language
translations



3619
teacher-submitted
lessons



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PhET Interactive Simulations: Sample Simulations

For Physics, Chemistry, Math, Environmental Sciences and Biological Sciences:

<https://phet.colorado.edu/>

Balloons and Static Electricity

- Published Version: [Balloons and Static Electricity](#)
- Grab a balloon to explore concepts of static electricity such as charge transfer, attraction, repulsion, and induced charge.

Coulomb's Law

- Published Version: [Coulomb's Law](#)
- Observe changes to electrostatic force as you play with the distance between charges and charge amounts at both macro and atomic scales.

Faraday's Law

- Published Version: [Faraday's Law](#)
- Investigate Faraday's law and how a changing magnetic flux can produce a flow of electricity!

Friction

- Published Version: [Friction](#)

A complete list is available at: <https://phet.colorado.edu/en/accessibility/prototypes>



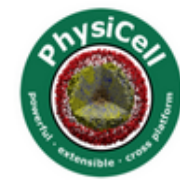
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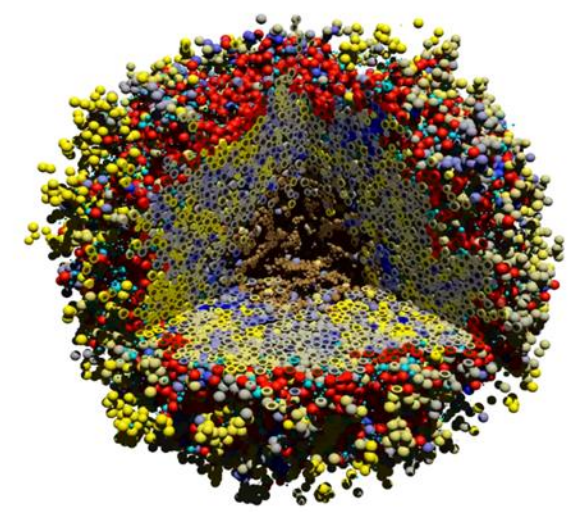
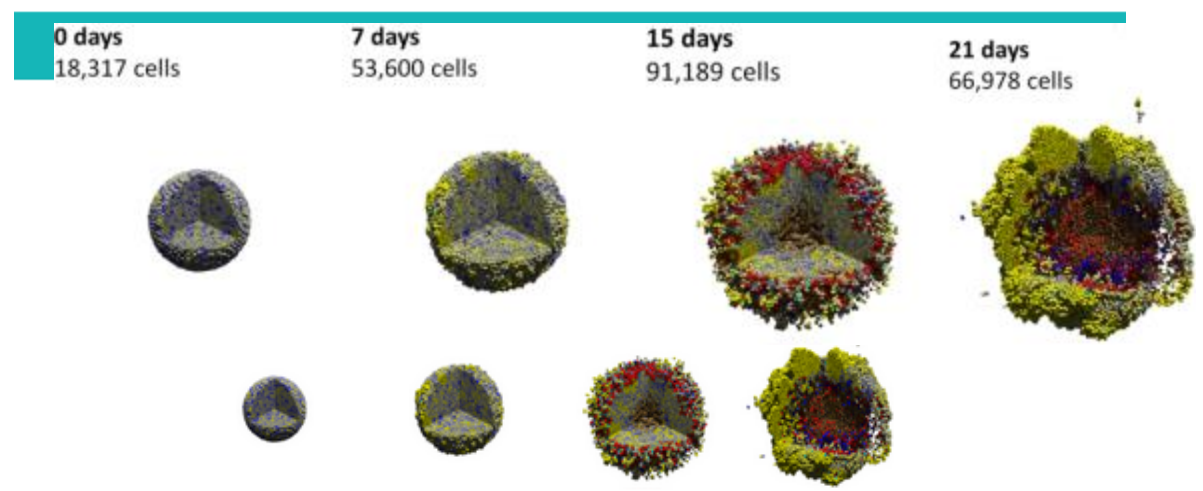
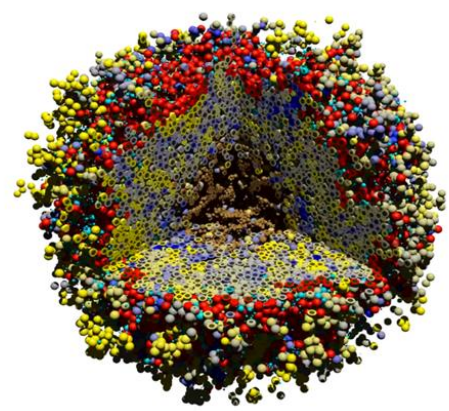
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PhysiCell provides a robust, scalable code for simulating large systems of cells in 3-D tissues on standard desktop computers: <http://physicell.org/>



PhysiCell



An open source physics-based cell simulator



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<http://physicell.org/>

Physicell can also be accessed via nanoHub.



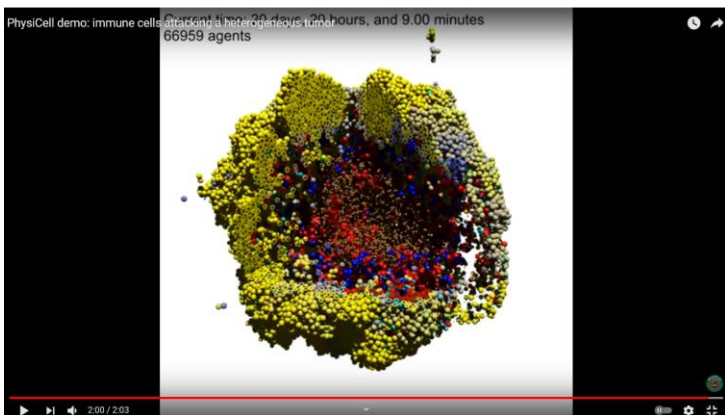
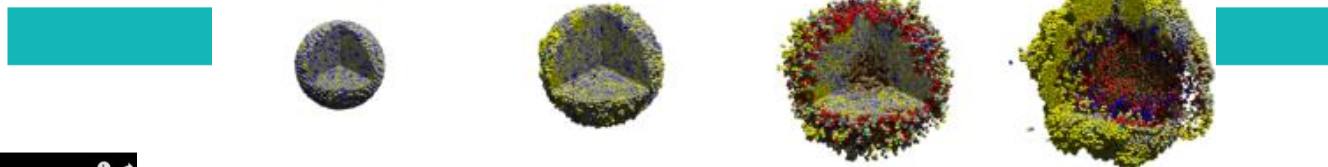
PhysiCell

0 days
18,317 cells

7 days
53,600 cells

15 days
91,189 cells

21 days
66,978 cells

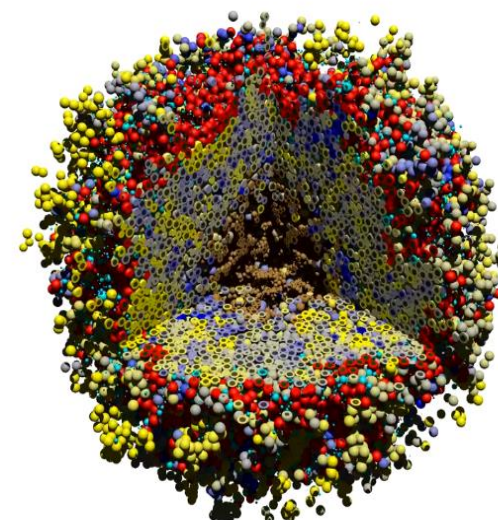
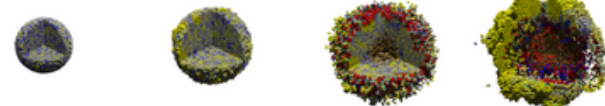


0 days
18,317 cells

7 days
53,600 cells

15 days
91,189 cells

21 days
66,978 cells



An open source physics-based cell simulator

[PhysiCell demo: immune cells attacking a heterogeneous tumor](https://youtu.be/nJ2urSm4iIU)

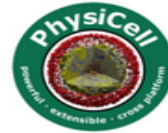
<https://youtu.be/nJ2urSm4iIU>



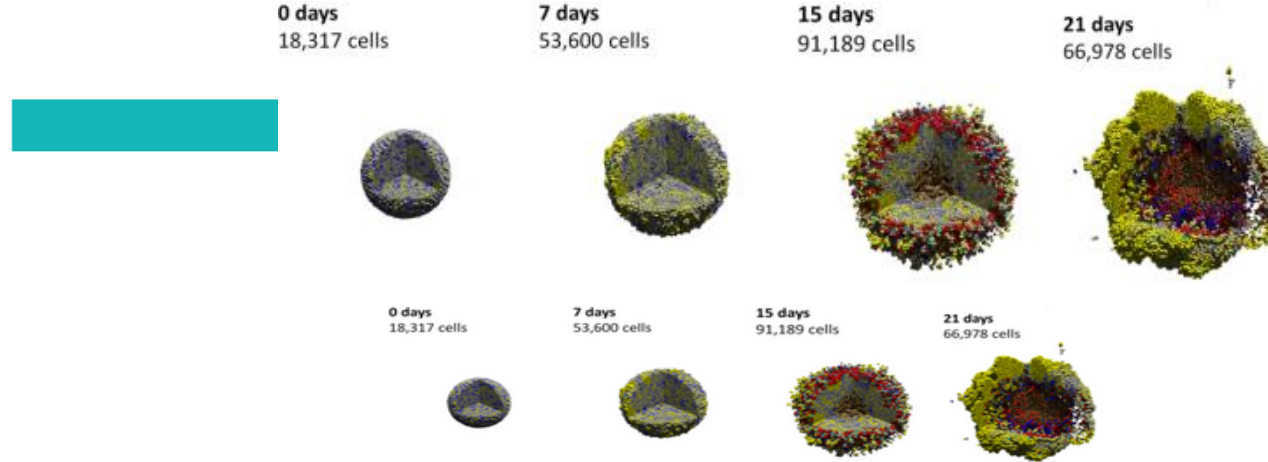
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PhysiCell



An open source physics-based cell simulator

<http://physicell.org/>

Physicell can also be accessed via nanoHub.

COVID19 tissue simulator

This model simulates viral dynamics of SARS-CoV-2 (coronavirus / COVID19) in a layer of epithelium and several submodels (such as single-cell response, pyroptosis death model, tissue-damage model, lymph node model and immune response).



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CompuCell3D: <https://compucell3d.org/>

CompuCell3D is a flexible scriptable modeling environment, which allows the rapid construction of sharable Virtual Tissue in-silico simulations of a wide variety of multi-scale, multi-cellular problems including angiogenesis, bacterial colonies, cancer, developmental biology, evolution, the immune system, tissue engineering, toxicology and even non-cellular soft materials. CompuCell3D models have been used to solve basic biological problems, to develop medical therapies, to assess modes of action of toxicants and to design engineered tissues. CompuCell3D intuitive and make Virtual Tissue modeling accessible to users without extensive software development or programming experience. It uses Cellular Potts Model to model cell behavior.

Home

- CC3D Home

Download

- Binaries
- Source Code
- Developer Zone

Help

- Manuals
- Problems?
- CC3D User Forum
- Tutorials
- Training Videos
- F.A.Q.

Demos

- Web Demos (no installation required)
- Model Repository
 - Covid19 on nanoHUB
- Visual Examples
- Simulation Movies
- Screenshots

Publications

- Publications
- Theses
- Talks and Posters

Welcome to CompuCell3D

NEW CC3D Version 4.6.0 (Jul 06 2024)

We are pleased to announce the new version 4.5.0 of our software CompuCell3D. This release includes many new features and several bug fixes. For more details please visit our Downloads page: [Downloads](#) page.

2024 CompuCell3D Workshop and Hackathon

NIH U24 EB028887,
NSF 2120200,
NSF 2000281,
NSF 1720625

2024 Multicell Virtual Tissue Modeling Online Summer School & Hackathon

Apply:

<p>Virtual Tissue Summer School Learn the basics of Virtual Tissue modeling with CompuCell3D Sun – Sun, July 28 – Aug 3</p>	<p>Virtual Tissue Modeling Hackathon Build the foundation of your model with expert guidance Fri – Sun, Aug 9 – 11</p>
---	--

Tutorials with live support (zoom) compucell3d.iu@gmail.com
& daily group discussions (zoom) compucell3d.org
ALL experience levels welcome! Apply: <https://tinyurl.com/CC3D2024>

Announcing the 2024 Multicell Virtual-Tissue Modeling Online Summer School and Hackathon! Come learn to model your problem of interest in CompuCell3D. All backgrounds and experience levels welcome.

- **Workshop:** July 28 – August 4, 2024
- **Hackathon:** August 9–11, 2024



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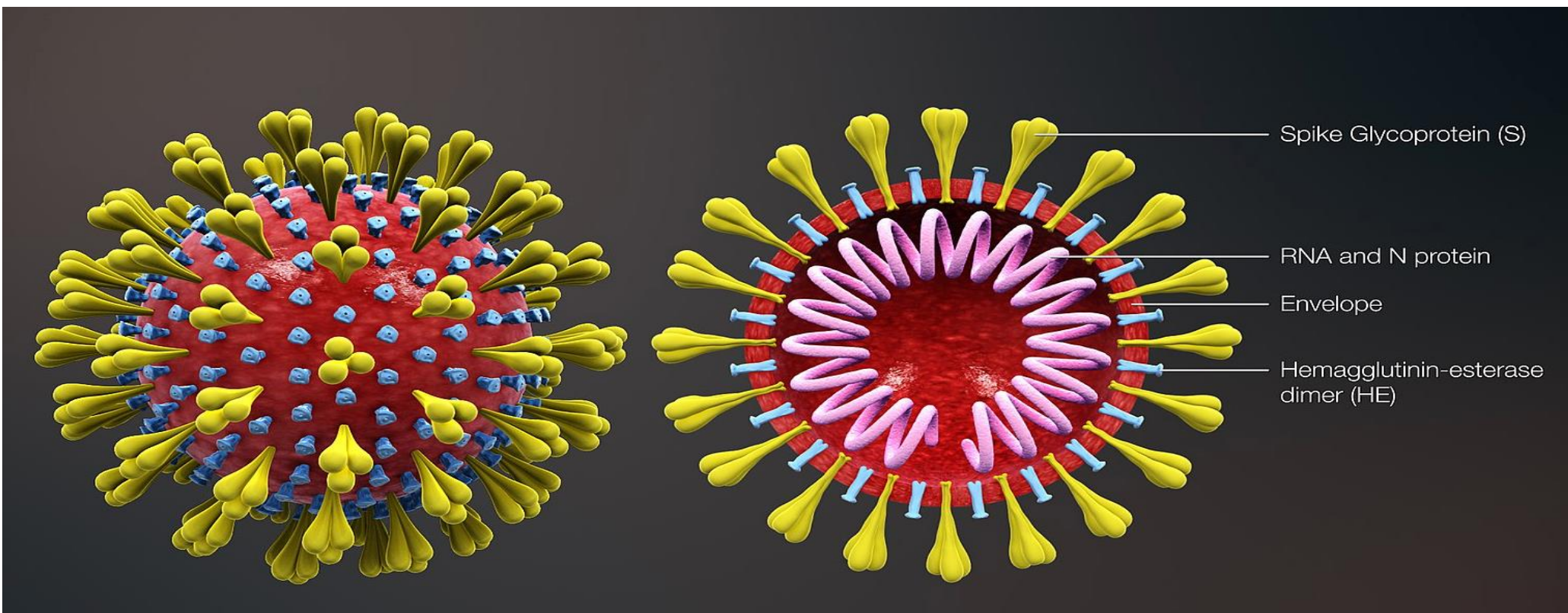


Example of the Application of CompuCell3D

A multiscale model of viral infection in epithelial tissues

COVID 19 Virtual Tissue Model - Tissue Infection and Immune Response Dynamics

By [Josua Oscar Aponte-Serrano](#), [T.J. Seago](#) Simulates tissue and immune system interactions during a viral lung infection





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CompuCell3D Multiscale, Virtual-Tissue Spatio-Temporal Modeling of Simulations of COVID-19 Infection, Viral Spread and Immune Response and Treatment Regimes

“Simulations of tissue-specific effects of primary acute viral infections like COVID-19 are essential for understanding differences in disease outcomes and optimizing therapeutic interventions. In this two-part mini-workshop we present an open-source Python and CC3DML-scripted multiscale model and simulation of an epithelial tissue infected by a virus, a simplified cellular immune response and viral and immune-induced tissue damage and show how you can use it to model basic patterns of infection dynamics and antiviral treatment. Part I presents the model and teaches how to run it and to change model parameters for generating new biologically meaningful simulations. Part II teaches how to extend the model with additional images, graphics and file outputs, additional cell types, diffusive fields, cell behaviors and interactions and improved subcellular and immune-system models.” [<https://compucell3d.org/>]

How to Run, Extend, Adapt and Improve the CompuCell3D COVID-19 Model

Part-I: Video

<https://www.youtube.com/watch?v=edL8yHE8cO8&feature=youtu.be>

Part-II: Video

https://www.youtube.com/watch?v=hDc0ttw_wqo&feature=youtu.be

CompuCell3D can be downloaded from <https://compucell3d.org/SrcBin> or it could be accessed via [NanoHub](#).



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A great characterization virtual experience: MYSCOPE



Train for advanced research

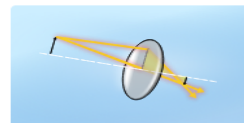
Welcome

MyScope was developed by Microscopy Australia to provide an online learning environment for those who want to learn about microscopy. The platform provides insights into the fundamental science behind different microscopes, explores what can and cannot be measured by different systems and provides a realistic operating experience on high end microscopes.

We sincerely hope you find the website an enjoyable environment where you can explore the microscopy space and leave ready to undertake your own exciting experiments.

[Please choose a topic to learn more](#)

TOPICS



Microscopy Basics



Scanning Electron Microscopy



Transmission Electron Microscopy

MyScope is standalone Australian website for training on characterization tools.

Examples of Simulation Tools...Use of SEM and TEM at GVSU

ACKNOWLEDGMENTS

Microscopy Australia Facilities



Partners



Educational Supporters





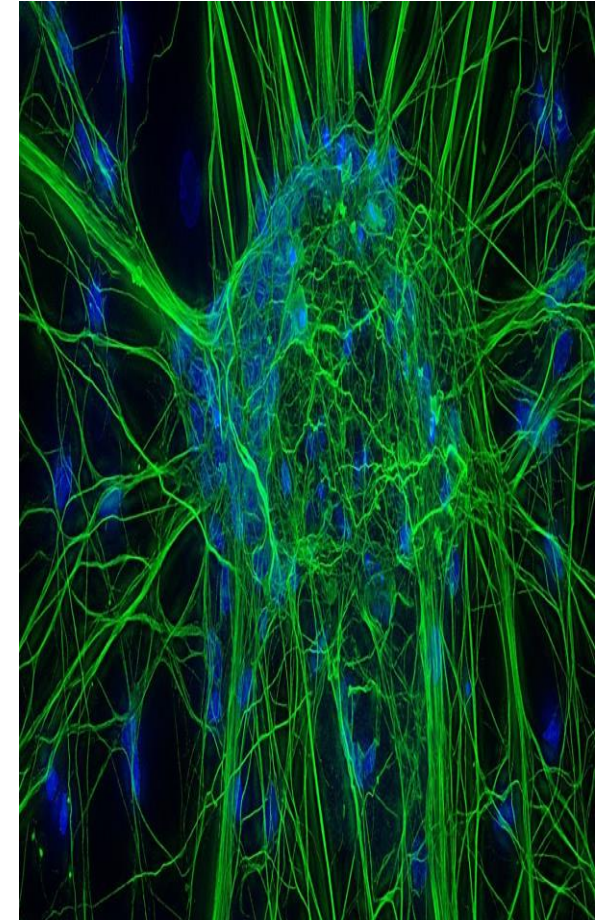
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Need For Visualization at the Nanoscale

- Visualization of physical phenomena can confirm hypothesis
- Observation provides opportunities for the sample study without damaging .
- Objects under study may be too small for our hands to handle or manipulate
- Our students are motivated by “seeing for themselves”!
- Measurement tools for nanotechnology applications is expected to create a multibillion-dollar market within the next decade
- Morphologic characterization of Viruses such as Covid-19
- Development of new products based on nanotechnology requires visualization coupled with interfacial interactions & measurement at the nanoscale.

THUNDER Imager 3D Live Cell & 3D Cell Culture - Decode 3D Biology in Real Time*





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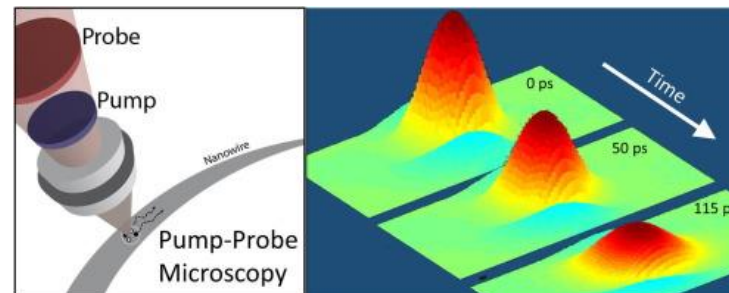
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Advantages of Visualization at the Nanoscale

- Enhance students understanding of the properties of matter at the nanoscale which differ from bulk material.
- Help instructors improve teaching of abstract concepts of nanoscale phenomena.
- Understand the benefits and application of visualization at the nanoscale.
- Increase knowledge in the field of nanotechnology and STEM education.
- Understand the use of remotely accessible instruments for visualization of nanoscale samples .





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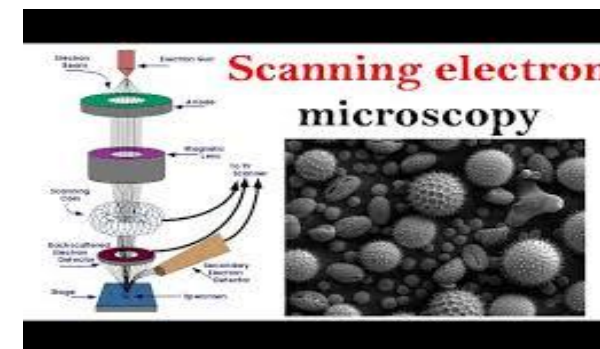
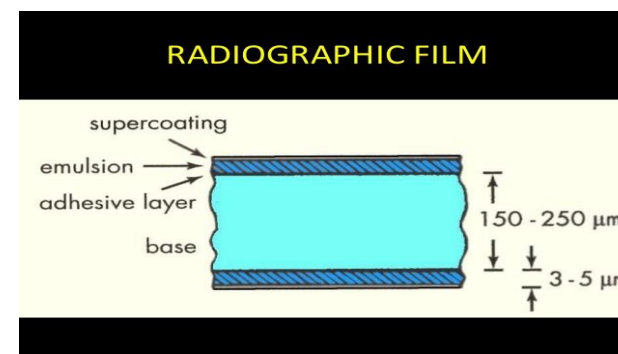
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Options in Visualization

- Observe the sample with shorter wavelengths of light or radiation
 - Need to convert the imaging result into something that we can visualize
 - X-Ray film
 - Scanning Electron Microscope
- Probe the sample physically
 - Need to be very, very careful
 - Mechanical feedback
 - Motion to vision conversion required





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Methods of Nanoscale Visualization

Optical Microscope

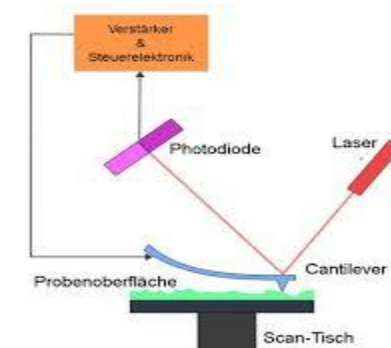
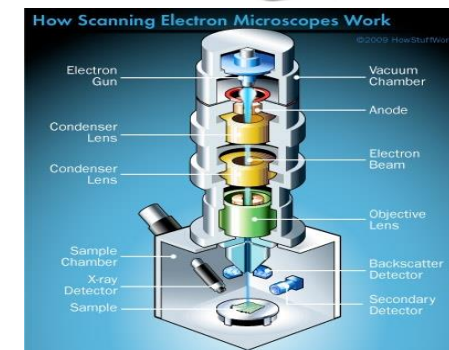
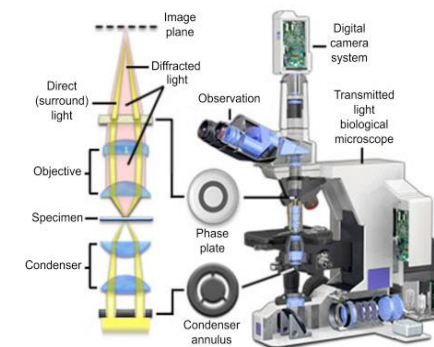
Suffers from diffraction effect on sample surfaces.
Limited resolution at nanoscale.

Scanning electron microscope (SEM)

Require the use of electron beams at high vacuum environment and cannot be used for biological non-conductive samples and samples under liquid.

Atomic Force Microscopy (AFM)

Uses sharp probe scanning over the sample while maintaining a very close spacing to the surface. A tool to measure both topography and force-related material properties at the nanoscale.



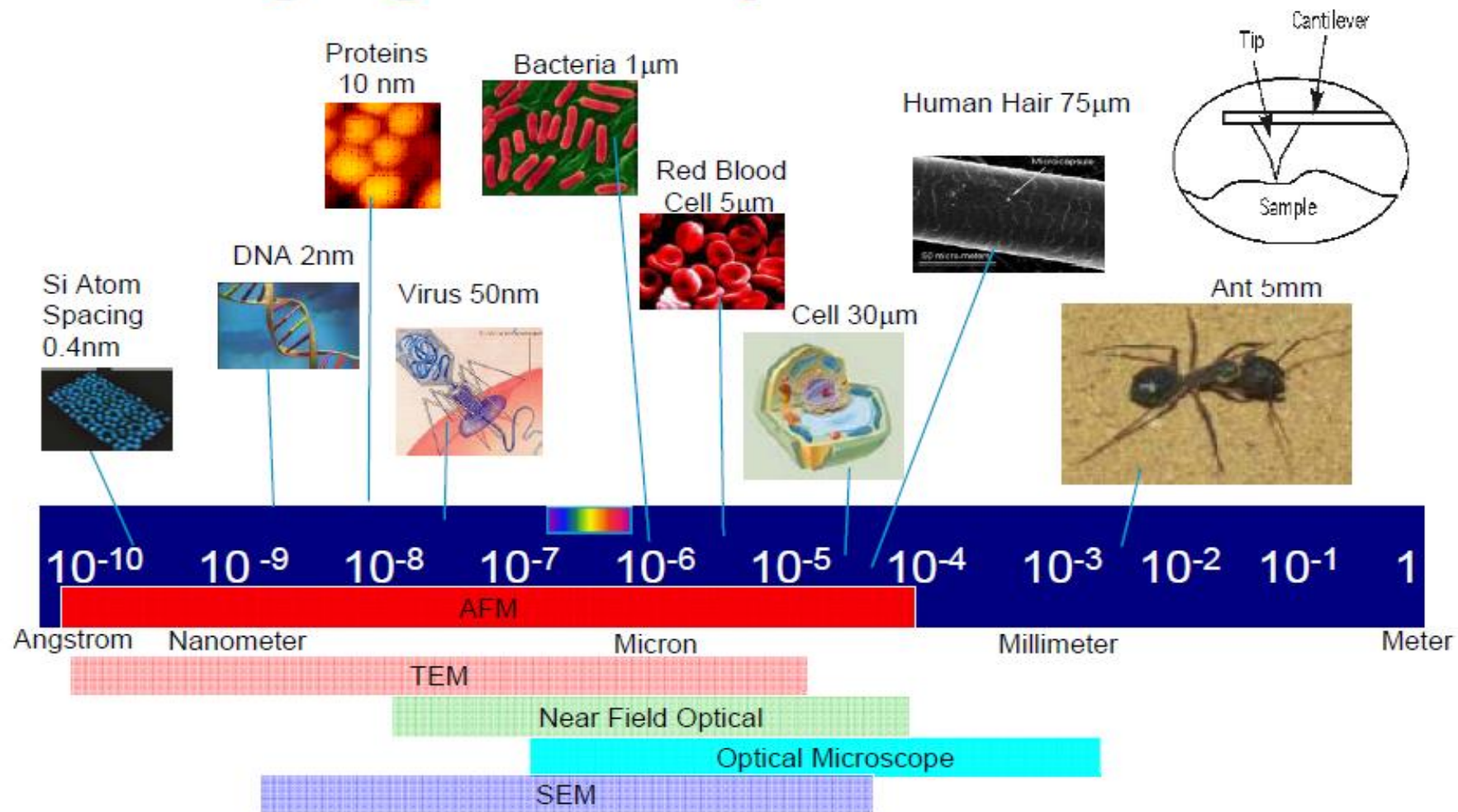


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Imaging Techniques: Scales





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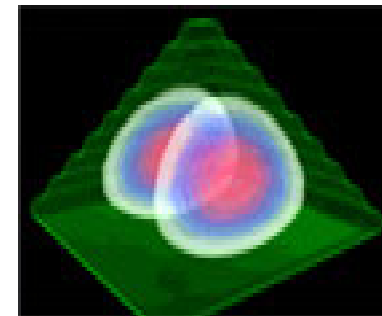
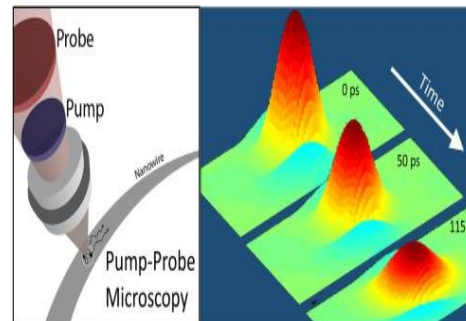
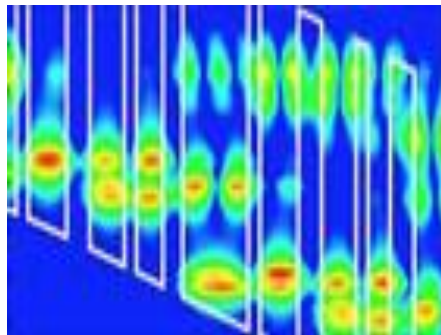
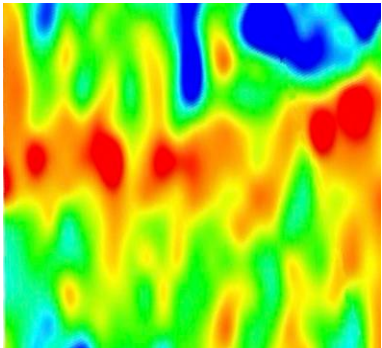
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Visualization at the Nanoscale

Visualization of processes can be achieved by using laboratory instruments, online simulation and remote access instruments.





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Online Tool/Methods For Visualizations

Remote Accessible Instruments for Nanotechnology (RAIN):

<https://www.nano4me.org/remotearchess>

Benefits

- Saving on buying an expensive equipment
- Helps to train students before buying the equipment
- Introduces students to the processes and phenomenon at nanoscale





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Nano4Me.org

Brought to you by the Nanotechnology Applications and Career Knowledge (NACK) Network

NANOTECHNOLOGY
Materials and Manufacturing for the 21st Century

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- ALUMNI
- EDUCATORS
- INDUSTRY
- ABOUT US
- PARTNERS

Home | Educators | Remote Access

- Getting Started
- Nano Tools
- Partners
- Gallery

Remote Access

Remotely Accessible Instruments for Nanotechnology (RAIN) allows students to access and control microscopes, like FESEM-field emission scanning electron microscopes, and analytical tools, like EDS-energy (X-ray) dispersive spectroscopy, to look at nano-sized materials from the ease of classrooms, or even home computers, all across the country. Students control the tools over the Internet in real-time and with the assistance of an experienced engineer at the microscope advising over video conferencing software.



[Mission Statement](#)

Remote Access: Establishing a Connection

<https://youtu.be/Tz1AvCUqoNo>

Click to Play Video



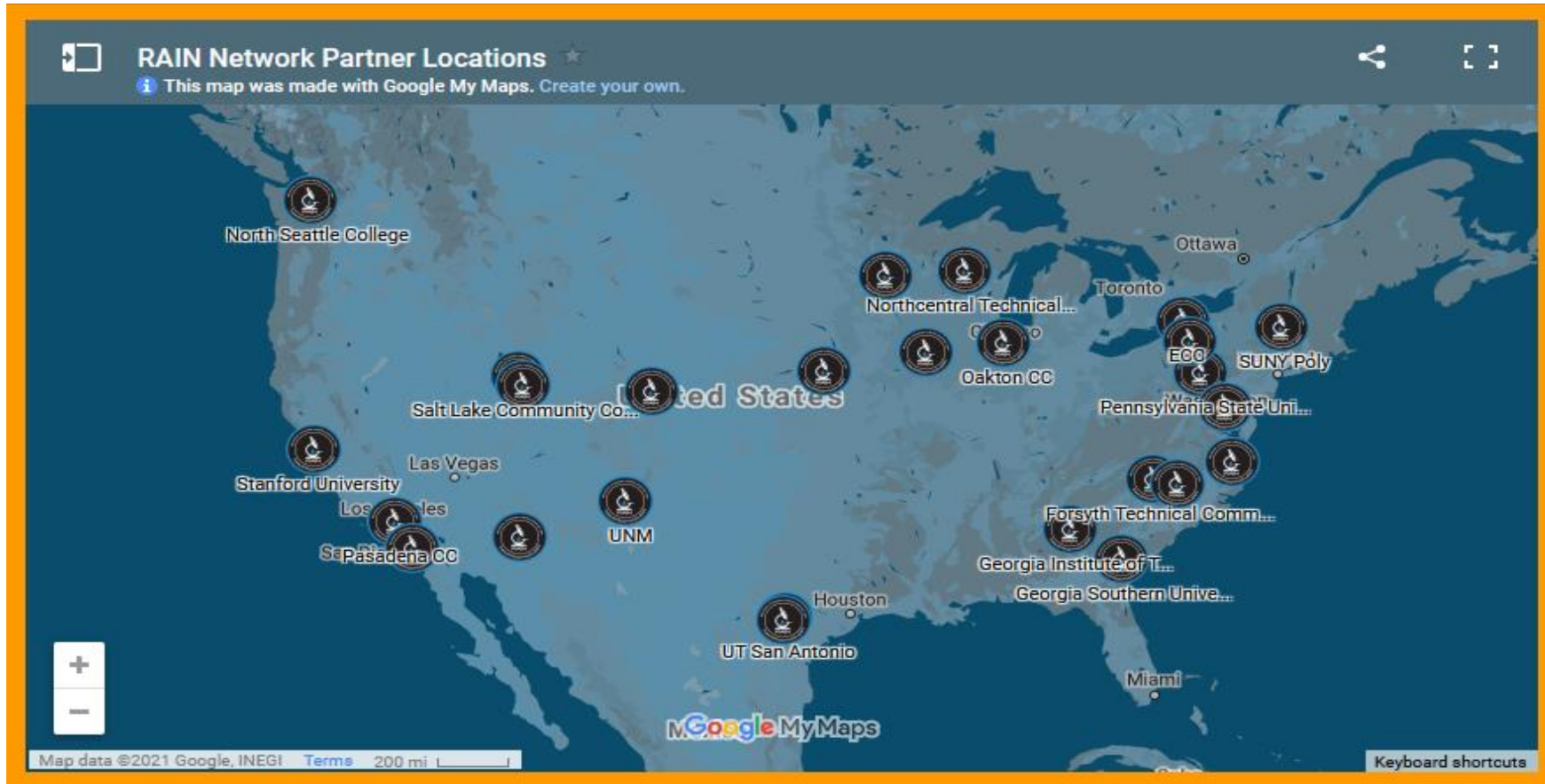
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RAIN Network Partner Locations





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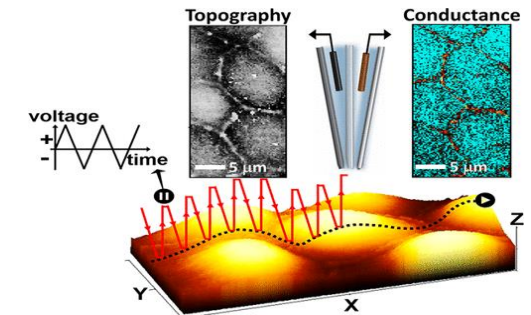
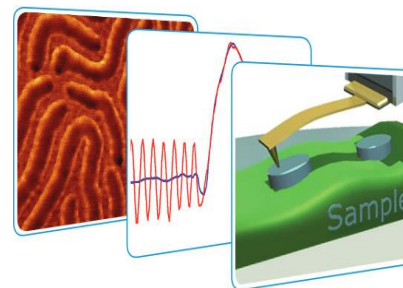
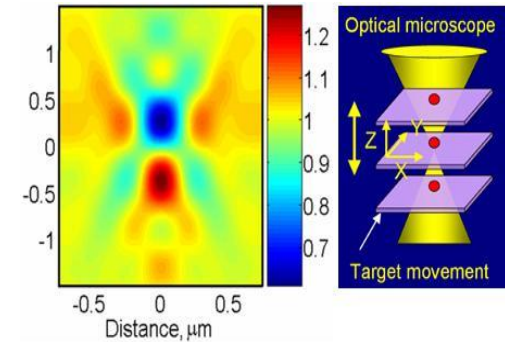
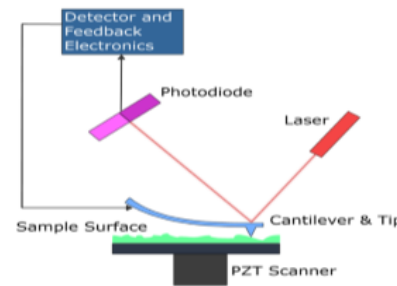


Learning through Visualization at the Nanoscale

Types of Tools at RAIN

- RAIN allows students to access and control microscopes and analytical tools, to look at nanosized materials from the ease of classrooms, or home computers, across the country.
- Students control the tools over the Internet from 26 centers in real-time.

- Atomic Force Microscope (AFM)
- Optical Microscope
- Confocal Microscope
- Scanning Electron Microscope (SEM)
- Energy Dispersive Spectroscopy (EDS)
- Profilometer
- Ultraviolet–visible Spectrophotometer
- Molecular Analyzer
- Fourier Transform Infrared Spectroscopy (FTIR)
- X-ray fluorescence (XRF)
- Fabrication Tools





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RAIN Network Instruments

nano4me.org/remoteaccess

RAIN Site	Remote Access Instruments
Arizona State University	SEM
Erie Community College	SEM/EDS
Forsythe Tech Community College	AFM
Northcentral Technical College	SEM, AFM, Flex AFM
North Seattle College	Confocal Microscope, AFM, Profilometer, SEM/EDS
Oakton Community College	SEM/EDS, Flex AFM, Profilometer
Pasadena City College	SEM/EDS
Pennsylvania State University	FESEM/EDS, SPM/AFM, Profilometer, UV-vis
Salt Lake Community College	SEM, AFM/SPM
University of Texas at San Antonio	SEM/EDS





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Atomic Force Microscope (AFM)

- [Forsyth Tech Community College](#) - ([Nanosurf Flex Scan head AFM](#))
- [Northcentral Technical College](#) - ([Nanosurf easyScan 2](#))
- [North Seattle College](#) - ([Nanosurf easyScan 2](#))
- [Oakton Community College](#) - ([Nanosurf easyScan 2 FlexAFM](#))
- [Pennsylvania State University](#) - ([Bruker Innova](#))
- [Salt Lake Community College](#) - ([Agilent 5400 AFM/SPM](#) & [Nanosurf easyScan 2](#))

Scanning Electron Microscope (SEM)

- [NCI-SW at Arizona State University](#) - ([Phenom Pro](#))
- [CABOCES](#) - ([Phenom ProX](#) & [JEOL-JSM-6010PLUS/LA](#))
- [Erie Community College](#) - ([JEOL JSM-6010LA](#))
- [Northcentral Technical College](#) - ([Hitachi TM 3030](#))
- [Oakton Community College](#) - ([Hitachi TM 3000](#))
- [North Seattle College](#) - ([Aspex EXplorer](#))
- [Pasadena City College](#) - ([Phenom ProX](#))
- [Pennsylvania State University](#) - ([ZEISS 55 Ultra FESEM](#))
- [Research Triangle Nanotechnology Network](#) - ([FEI Quanta 200 Field Emission Gun](#))
- [Salt Lake Community College](#) - ([Hitachi TM3000](#))
- [SUNY Polytechnic Institute](#) - ([Hitachi TM3000 w/ x-ray \(EDS\)](#))
- [University of Texas at San Antonio](#) - ([Hitachi S5500 STEM](#))
- [SCME at University of New Mexico](#) - ([Phenom ProX](#))

Optical Microscope

- [Pennsylvania State University](#) - ([Leitz Ergolux](#))



A complete list is available at:

<https://www.nano4me.org/remoteaccess#NanoTools>



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How to Incorporate RAIN into your courses

Accessing RAIN Network

nano4me.org/remoteaccess

Step 1

Watch Videos: To get the most out of your remote access session, we suggest that teachers and students learn about the technology used to view things at the nano-scale level. Our recommended videos can be viewed in the classroom or assigned as homework.

Step 2

Complete the Remote Access Request Form: This is where you request a **remote test session** (if this is your first time running remote access with us) and a **live session**; select the **instruments** and **topic areas** you'd like to focus on; and provide your lab instructor with other important information such as your **class' interests** and **knowledge level**.

Step 3

Run a remote test session

◦ This is used to check your audio, video, and Internet connections.

◦ Takes about 20 minutes.





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Before you start remote access, you'll need to:

1. Install Video Conferencing Software

Based on the instrument and partner site you requested, you will need either [Zoom](#) or [Team Viewer](#). Both are free to download and use.

2. Set up your computer. You need:

- Webcam
- Microphone
- Speakers
- A projector or large display is recommended, but not require

Step 3

Choose your samples: You can use in house samples or send your own to the remote access site you selected when scheduling your session. Based on your remote access request (step 2), a remote access manager will reach out to you regarding in house sample availability and to provide address information for any samples you wish to mail in.

Step 4

Run a live session

- This is where you will have live remote access to the lab equipment.
- This can take anywhere from 15 minutes to 2 hours.

Step 5: Give us feedback! Help us show the NSF that remote access is a valuable resource.

**How to Incorporate RAIN
into
your courses**

Accessing RAIN Network
[nano4me.org/remote access](http://nano4me.org/remote-access)





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Web-Based Simulation and Remote Access Visualization Tools for Engineering and Technology Curricula

July 31, 2024

Dr. Ahmed S. Khan

Fulbright Specialist Scholar

Ex. Dean of the College of Engineering & Information Sciences

DeVry University, Addison, IL

Dr.a.s.khan@ieee.org

Use of Online Simulation Tools (SEM & TEM) at GVSU

Dr. Atilla Ozgur Cakmak

Assistant Professor of Electrical Engineering

School of Engineering, Seymour and

Esther Padnos College of Engineering and Computing

Grand Valley State University

Allendale, MI

cakmaka@gvsu.edu

Dr. Sala Qazi

qazi@sunypoly.edu



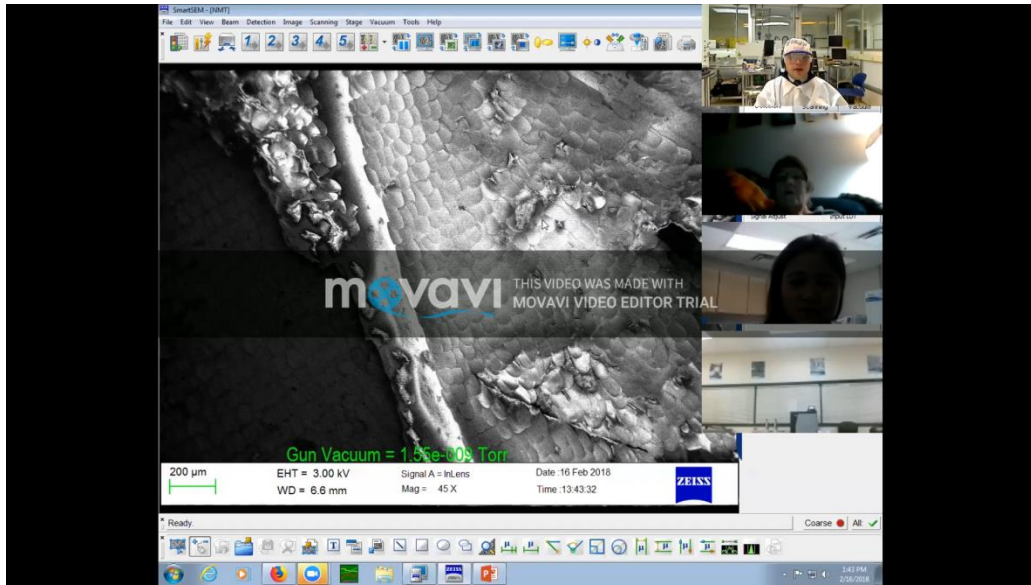
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- Scanning Electron Microscopy (SEM)
 - A very engaging tool for the students including K-12
 - Microscopy in general captivates general public interest since 1600s.
 - An expensive tool if Field Emission (FE)-SEM is desired





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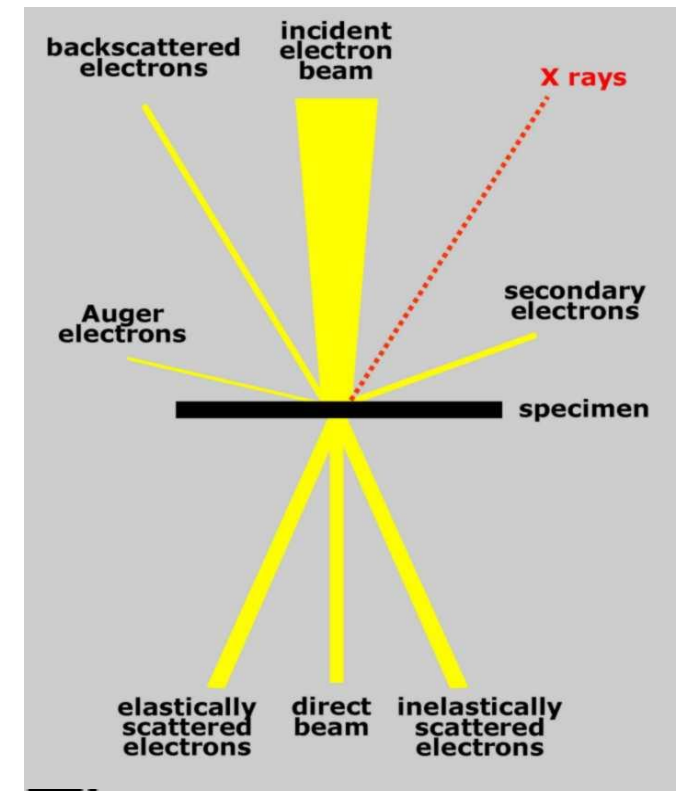
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• Scanning Electron Microscopy (SEM) fundamentals

- One way to see things at the nano-scale is to use **beams of electrons**. These beams can be used to let us see size, shape, structure and even composition.
- When a beam of electrons hits a material (specimen), a number of responses occur. Some of the electrons may go through the specimen (transmitted electrons). Some may bounce back (backscattered electrons) and new electrons may be knocked off the atoms of the specimen and come back (secondary electrons and Auger electrons). In addition, photons, including high energy photons (x-rays), generated by the relaxing of excited atoms may come back.
- Each one of these responses can be exploited to “see” the specimen
- Seeing by using the backscattered and secondary electrons is called **scanning electron microscopy (SEM)**. It is called **field emission scanning electron microscopy (FE-SEM)** when the impinging beam of electrons is produced by quantum mechanical tunneling.





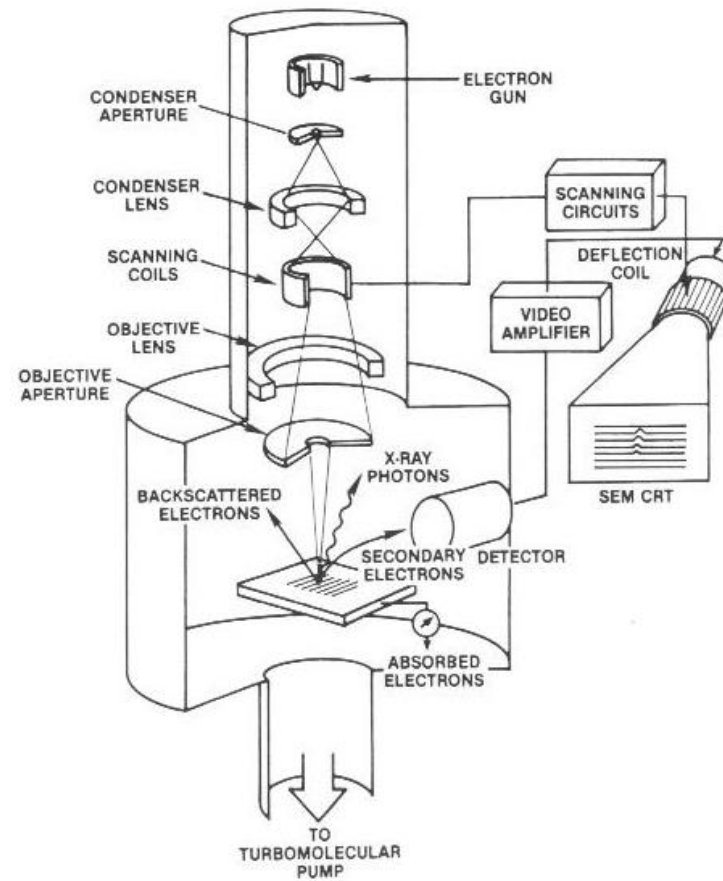
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- **Vacuum**- necessary for tool operation; column (high), chamber (low)
- **Electron gun**- source of the electron beam
- **Condenser Lenses** – focus and reduce/expand beam
- **Aperture**- series of micron-scale holes in metal film which block outer parts of beam
- **Gun valve**- pressure valve separating gun and sample chambers
- **Objective lens**- focuses electron beam on specimen surface
- **Deflector Coils**- create scan pattern and beam raster pattern
- **Specimen position**- x,y,z, tilt, and rotation on goniometric stage



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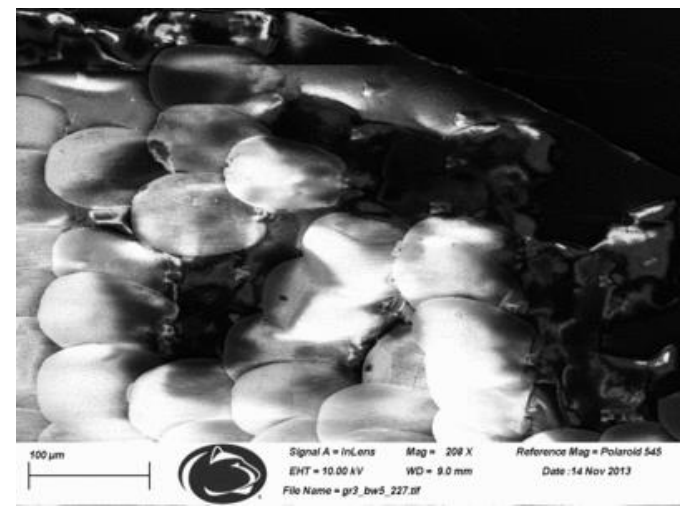
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X, Y Coordinate	Time (μSec.)
1, 10	0:01
2, 10	0:38
3, 10	1:15
4, 10	1:52
5, 10	2:29
6, 10	3:06
7, 10	3:43
8, 10	4:20
9, 10	4:57
10, 10	5:04
11, 10	5:11
12, 10	5:18

Time	Signal Intensity
0:01	█░░░░░░░░░
0:38	█░░░░░░░░░
1:15	███░░░░░░░
1:52	██████████░
2:29	█░░░░░░░░░
3:06	██████████░
3:43	██████████░
4:20	█░░░░░░░░░
4:57	██████████░
5:04	███░░░░░░░
5:11	█░░░░░░░░░
5:18	█░░░░░░░░░

It's me, Maria





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[MyScope Explore \(myscope-explore.org\)](https://myscope-explore.org)



MYSCOPE EXPLORE!

The world is full of things we can't see with our eyes. MyScope Explore takes us to the microscopic world.

Basics

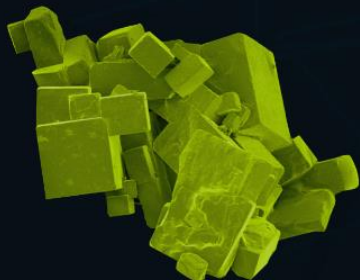
- > Magnification
- ✓ The Scanning Electron Microscope
 - > How does an SEM work?
 - > Parts of the SEM

Activities

- Let's zoom in
 - Learn to use an SEM
 - Explore with the SEM simulator
 - Challenge – What do you see?

More

- Glossary
- Extra Activities
- Lesson Plans
- Resources
- Connect with Us



More oriented for K-12



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**MYSCOPE
EXPLORE!**

Learn to use an SEM
Virtual SEM step by step simulator.

 MICROSCOPY AUSTRALIA
  ThermoFisher SCIENTIFIC

Evacuate

Accelerating Voltage

select one

Spot size

select one

Z height distance

select one

HV ON

Brightness

Contrast

Focus

Magnification

MUTE

START AGAIN

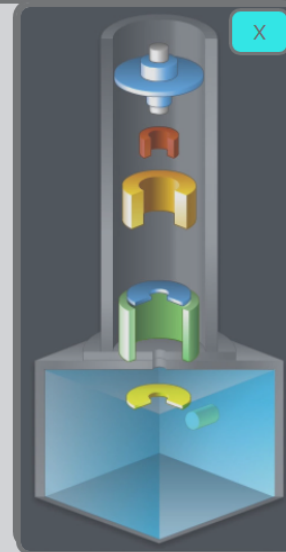
MENU

DIAGRAM

INSTRUCTIONS

Welcome to the Virtual SEM step by step simulator.

START



Load the sample

Evacuate

Choose Accelerating Voltage (Lower the better in general for organic samples)

Spot Size (Smaller => Better resolution)



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**MYSCOPE
EXPLORE!**

Learn to use an SEM
Virtual SEM step by step simulator.

MICROSCOPY AUSTRALIA ThermoFisher SCIENTIFIC

Evacuate i

Accelerating Voltage
5kv i

Spot size
5nm i

Z height distance
select one i

HV ON i

Brightness

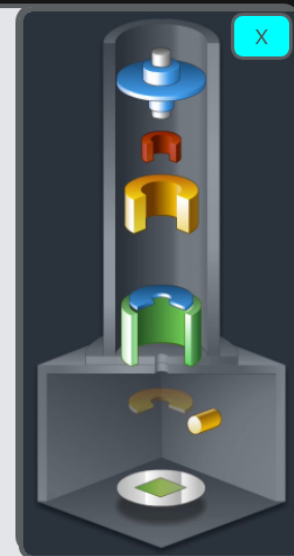
Contrast

Focus

Magnification

MUTE START AGAIN MENU DIAGRAM INSTRUCTIONS

Move the sample higher in the chamber by selecting a height from the drop-down menu. We suggest selecting 10mm. X



Choose a Working Distance (Z-height: Lower the better for fine resolution, if too close can bump into the lens)

Turn HV on

Adjusting Brightness, Contrast, Focus and Magnification => Capture the image!



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Evacuate i

Accelerating Voltage
5kv i

Spot size
5nm i

Z height distance
8mm i

HV ON i

Brightness

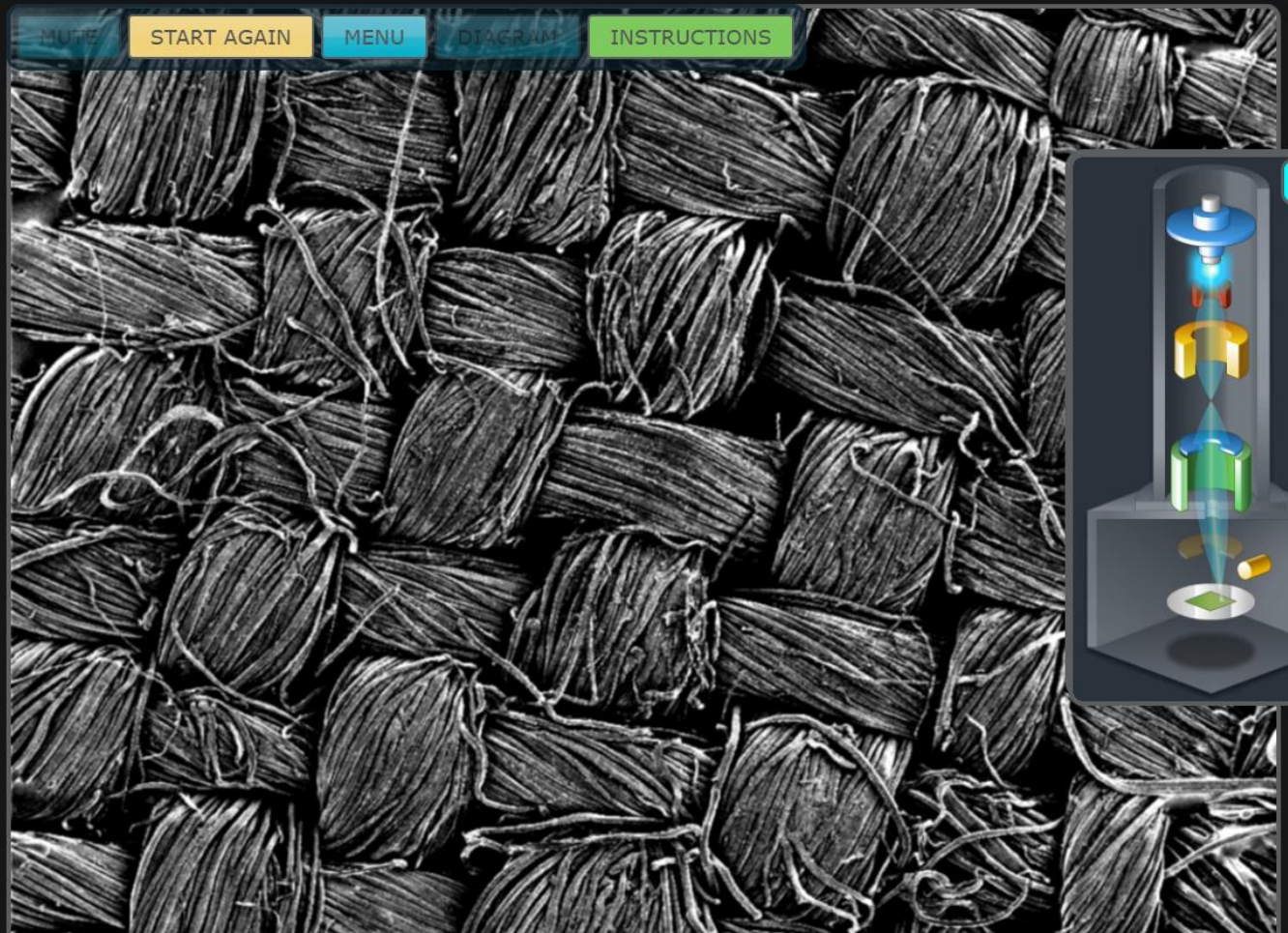
Contrast

Focus

Magnification

SAVE PRINT

MUTE START AGAIN MENU DIAGRAM INSTRUCTIONS



ACKNOWLEDGMENTS

Microscopy Australia Facilities



Partners



Educational Supporters



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Welcome

MyScope was developed by Microscopy Australia to provide an online learning environment for those who want to learn about microscopy. The platform provides insights into the fundamental science behind different microscopes, explores what can and cannot be measured by different systems and provides realistic operating experiences on the microscope simulators. We hope you find MyScope an enjoyable environment where you can explore the microscopy space and leave ready to undertake your own exciting experiments. Select one of the topics below to get started.

Microscopy Australia provides researchers and industry with access to microscopes and microanalysis tools and expertise at University-based facilities around Australia. If you are in Australia and would like to use an actual microscope in your work, please see our access guide.

TOPICS

Microscopy Concepts	Scanning Electron Microscopy	Transmission electron Microscopy
Light & Fluorescence Microscopy	Cryo-Electron Microscopy	X-ray Diffraction
Energy Dispersive Spectroscopy	Atom Probe Tomography	Focused Ion Beam
Scanning Probe & Atomic Force Microscopy	Secondary Ion Mass Spectrometry	Research Data Management



MyScope - Train for advanced research

There are several excellent simulators for TC and CC students as well as higher level training for instructors.

Going to quickly show some snapshots from SEM, EDS, TEM, FIB and SPM

Scanning Electron Microscopy

THEORY PRACTICAL ASSESSMENTS GLOSSARY EXPLORE

SEM Basics

A Scanning Electron Microscope (SEM) uses a focused beam of electrons to create a magnified image of a sample. The electron beam is scanned in a regular pattern across the surface of the sample and the electrons that come out of the sample are used to create the image.



Essentially, the way the scanning electron microscope 'looks' at the surface of a sample can be compared to a person alone in a dark room using a fine beamed torch to scan for objects on a wall. By scanning the torch systematically side-to-side and gradually moving down the wall, the person can build up an image of the objects in their memory. The SEM uses an electron beam instead of a torch, an electron detector instead of eyes, and a viewing screen and camera as memory.



Module Contents

- What is SEM?
- Background information
 - SEM Basics**
 - Applications and uses of SEM
 - What can it do differently to a light microscope?
 - What can't it do?
- How does an SEM work?
- How do I get a good image?
- Specialised SEM techniques
- SEM module Credits

MODULE PDF

TAILOR THIS MODULE

SEM SIMULATOR

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MYSCOPE SEM SIMULATOR

First, you need to let air into the sample chamber by clicking the VENT button.

VENT OPEN EVACUATE

HT SE BSE

ACCELERATING VOLTAGE

0kv 3kv 10kv 15kv 20kv 30kv

SPOT SIZE

2nm 5nm 10nm 15nm 20nm

WORKING DISTANCE

25mm 20mm 15mm 10mm 5mm 0mm

BRIGHTNESS

CONTRAST

MAGNIFICATION

COARSE FOCUS

FINE FOCUS

X STIGMATOR

Y STIGMATOR

SAMPLE

SCAN SPEED

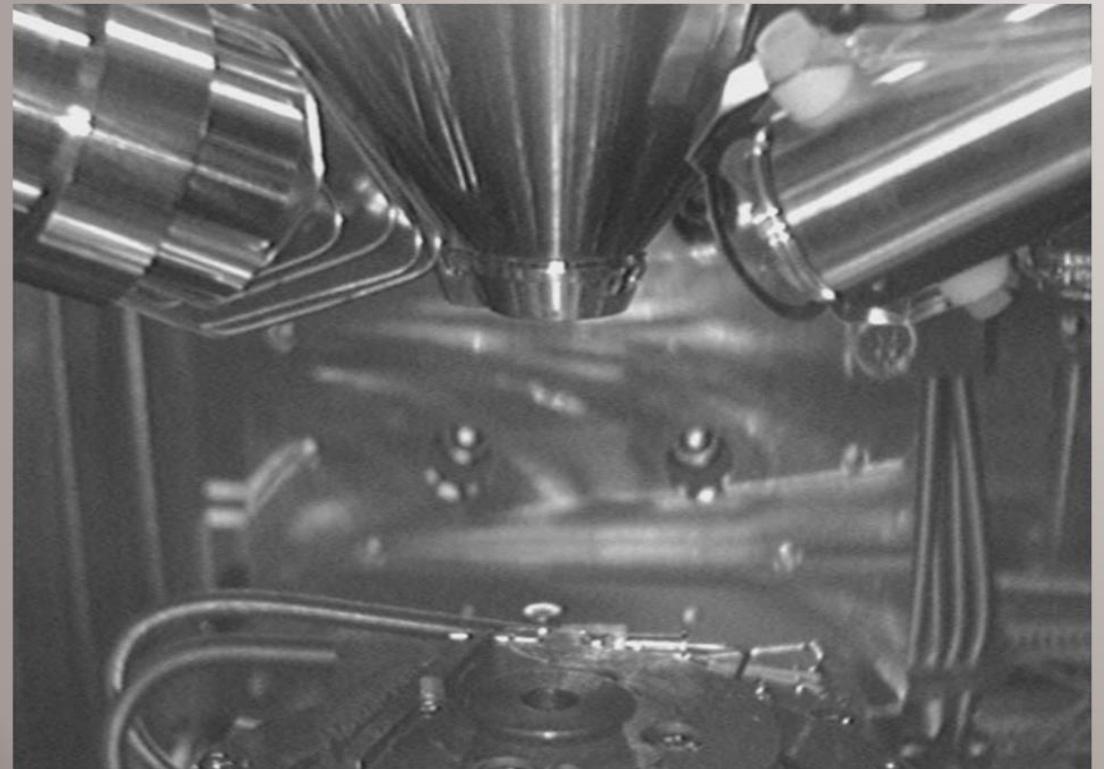
TV RATE

SLOW SCAN 1

SLOW SCAN 2

SAVE IMAGE

OPTIMAL IMAGE





Transmission Electron Microscopy

Module Contents

- ▼ What is TEM?
 - Introduction to TEM
 - Key advantages
 - What the TEM can do
 - What the TEM can't do
 - ▶ How does a TEM work?
 - ▶ How do I get a good image?
 - ▶ Specialised TEM techniques
 - TEM module Credits

MODULE PDF

TAILOR THIS MODULE

TEM SIMULATOR

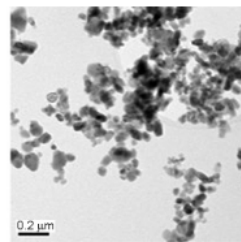
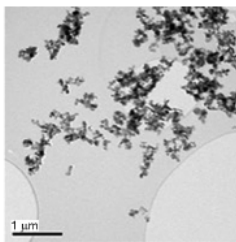
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THEORY PRACTICAL ASSESSMENTS GLOSSARY EXPLORE

Introduction to TEM

Transmission electron microscopy (TEM) is used to produce images from a sample by illuminating it with an electron beam in a high vacuum. The electrons that are transmitted through the sample are detected to form an image. Ultimately, by using a TEM we can see the columns of atoms present in crystalline samples and the molecular machinery inside cells. It allows visualisation and analysis of specimens in the realms of microspace (1 micrometre = $1\mu\text{m} = 10^{-6}\text{m}$) to nanospace (1 nanometre = $1\text{nm} = 10^{-9}\text{m}$). It is worth noting that microscopists often use the word 'micron', which means the same as micrometre.

The TEM reveals levels of detail and complexity inaccessible by light microscopy because it uses a focused beam of high energy electrons. It allows detailed micro-structural examination through high resolution and high magnification imaging. It enables the investigation of tissues, cells, sub-cellular structures, proteins, crystalline and composite materials. It is also able to provide information on the orientations of crystalline phases and elemental compositions of samples containing all but the lightest elements.



MYSCOPE TEM SIMULATOR

DIAGRAM STD FOCUS

AIRLOCK PUMP SPECIMEN INSERT

BEAM ON MAGNIFICATION

BEAM CURRENT

APERTURE

APERTURE SIZE

SPECIMEN STAGE POSITION

SPECIMEN TILT

IMAGING MODE

TEM STEM

IMAGING DIFFRACTION

STEM IMAGING STEM

BRIGHTNESS

OBJECTIVE LENS FOCUS

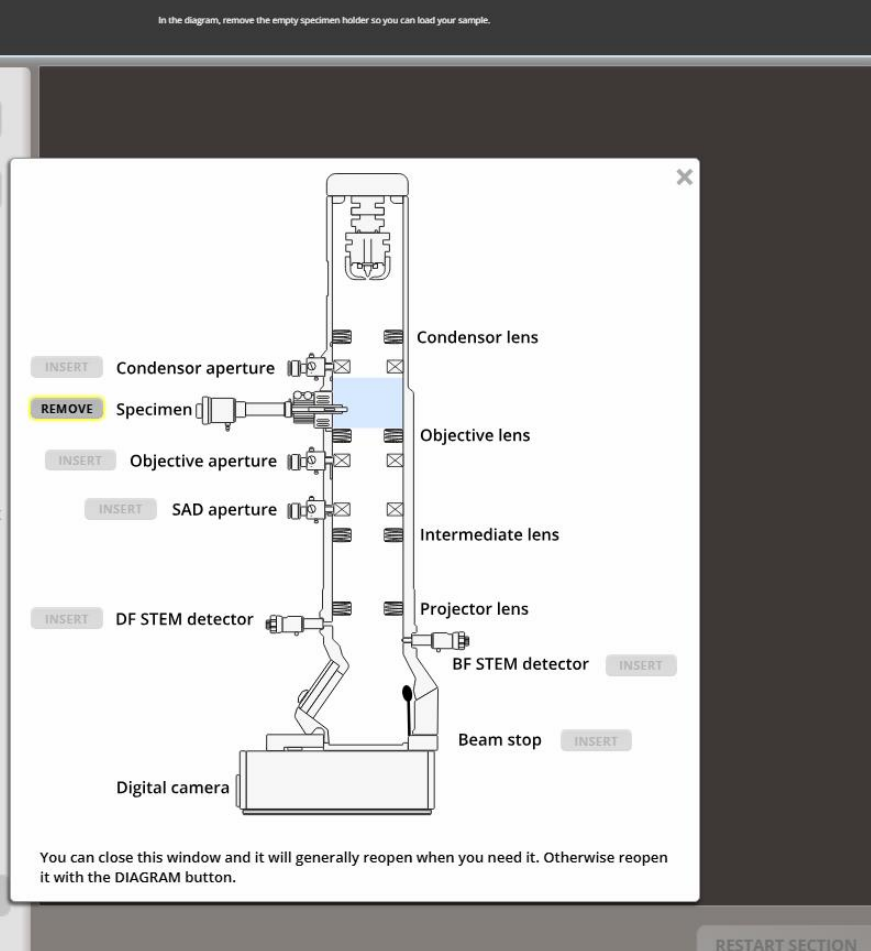
BEAM SHIFT STIGMATOR

PROJECTOR LENS ALIGNMENT FFT ON

LENS

WOBBLER

CAMERA INSERT ACQUIRE

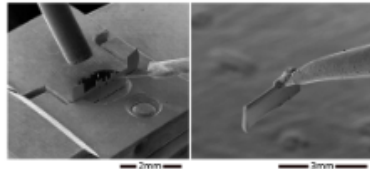


THEORY PRACTICAL ASSESSMENTS GLOSSARY EXPLORE

FIB overview

As the name suggests, a focused ion beam (FIB) is a stream of energetic ions that are focused into a fine beam. The FIB instrument is based on scanning this highly energetic ion beam onto a target material. The interactions of the ions with the specimen can lead to sample atom removal with nanometre precision, making it into a nanoscale machining device. The fully controlled ion beam, combined with a high precision sample navigation system, along with advanced signal detectors in the FIB, creates a multifunctional analytical platform for imaging, sputtering and micro-fabrication.

Mass production of microelectronics in the 1970s required a specialised analytical tool to precisely locate invisible faults on the top surfaces of Si wafer semiconducting devices. This has provided the driving force for commercialising the FIB and laid the foundation for the design and manufacture of this type of instrument. Regardless of the application, the FIB is simply removing material to a high depth and spatial accuracy. In addition to the ion beam, most FIB instruments have an electron beam just like in an SEM, thus we refer to them here as FIB-SEM instruments.



Next >>

TOPICS



Microscopy Concepts



Scanning Electron Microscopy



Transmission Electron Microscopy



MYSCOPE FIB SIMULATOR

VENT PUMP

SAMPLE

E BEAM CONTROLS

HT LIVE VIEW

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ACC VOLTAGE

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SURFACE CROSS SECTION

DYNAMIC FOCUS TILT CORRECTION

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Module Contents

- ▼ What is FIB?
 - [FIB overview](#)
 - Common applications of FIB
 - Ion sources
- Ion-Solid Interactions
- How does a FIB-SEM work?
- Applications
- FIB module Credits

MODULE PDF

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FIB SIMULATOR

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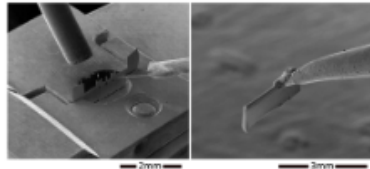


THEORY PRACTICAL ASSESSMENTS GLOSSARY EXPLORE

FIB overview

As the name suggests, a focused ion beam (FIB) is a stream of energetic ions that are focused into a fine beam. The FIB instrument is based on scanning this highly energetic ion beam onto a target material. The interactions of the ions with the specimen can lead to sample atom removal with nanometre precision, making it into a nanoscale machining device. The fully controlled ion beam, combined with a high precision sample navigation system, along with advanced signal detectors in the FIB, creates a multifunctional analytical platform for imaging, sputtering and micro-fabrication.

Mass production of microelectronics in the 1970s required a specialised analytical tool to precisely locate invisible faults on the top surfaces of Si wafer semiconducting devices. This has provided the driving force for commercialising the FIB and laid the foundation for the design and manufacture of this type of instrument. Regardless of the application, the FIB is simply removing material to a high depth and spatial accuracy. In addition to the ion beam, most FIB instruments have an electron beam just like in an SEM, thus we refer to them here as FIB-SEM instruments.



Next >>

TOPICS



Microscopy Concepts



Scanning Electron Microscopy



Transmission Electron Microscopy



MYSCOPE FIB SIMULATOR

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Conclusion

1. Online visualization and simulation tools help to enhance teaching/learning of nanoscale phenomena in Physics, Chemistry, Engineering, Engineering Technology, Material Science, Environmental Sciences, and Biological sciences.
2. Use of Visualization and Simulation promote students' interest in STEM education.
3. Increased interest in STEM education is expected to enable the students to join a rapidly growing workforce in the field of nanotechnology.
4. Free online RAIN facility is an excellent resource for introducing nanotechnology to the students at a small institution with limited funds.
5. RAIN allows to learn about nanotechnology instruments before acquiring them.
6. nanoHUB, based at Purdue University, is an excellent simulation platform for introducing and analyzing nanotechnology phenomena at all educational levels at no cost to the institutions.
7. Phet Interactive Simulations, based at University of Colorado, is an excellent resource for teaching Physics, Chemistry, Environmental Sciences, Material Science and Biological sciences in undergraduate programs.
8. Physicell is a robust, scalable code for simulating viral dynamics of SARS-CoV-2 (coronavirus/COVID-19) in a layer of epithelium and several submodels (such as single-cell response, pyroptosis death model, tissue-damage model, lymph node model and immune response).
9. CompuCell3D is flexible modeling platform that allows rapid simulations for cancer, developmental biology, evolution, immune system, tissue engineering, toxicology, non-cellular soft material and viruses such as Covid-19.



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Thanks for attending this presentation....Any Comments...Questions...Feedback? Please contact us via e-mail:

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To know what you know and what you do not know, that is true knowledge.

--- Confucius

The art of knowing is knowing what to ignore.

--- Rumi



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10. MYSCOPE is an excellent online tool for incorporating topics like SEM, EDS, TEM, FIB and SPM into curricula.



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