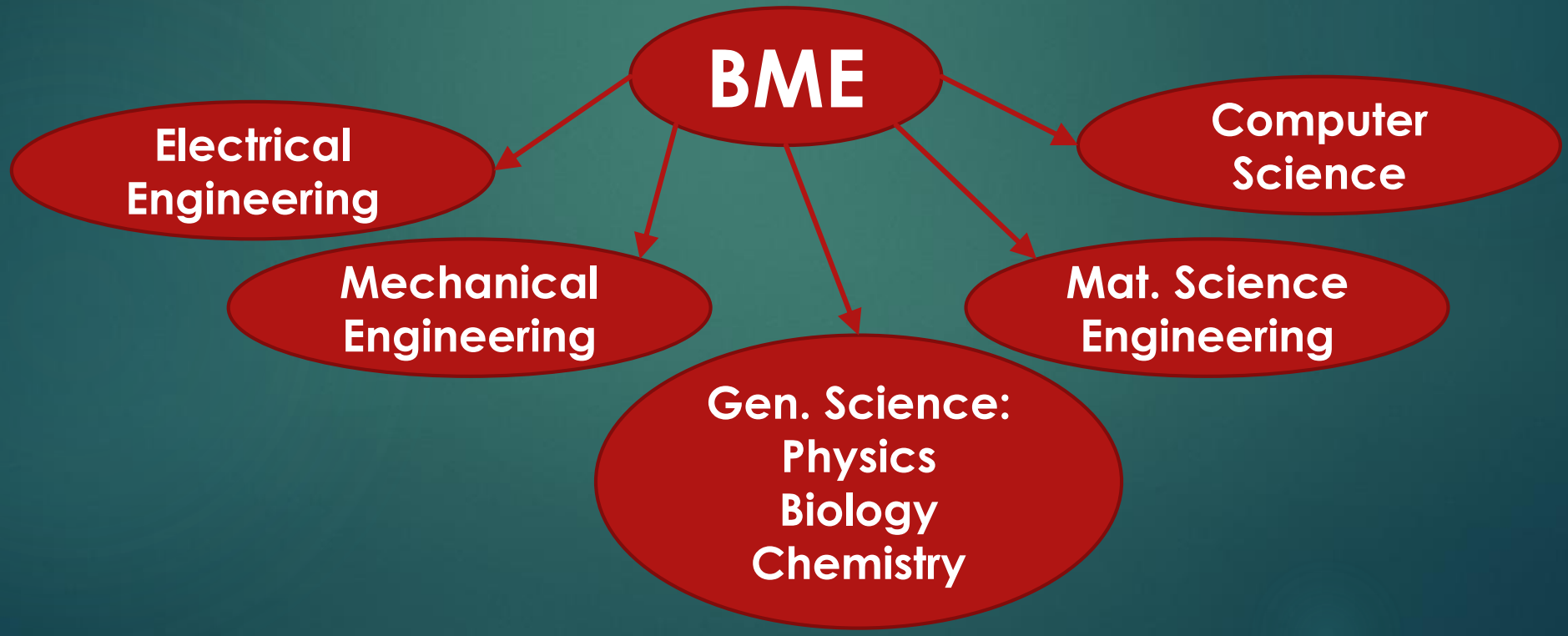
An Introduction to BME Track Majors

What is BME?

Application of science, computer science, and engineering principles to solve medical and healthcare problems



The tracks introduced

Our Dept. currently divides the discipline into 4 main tracks:

- Biomaterials & Tissue Engineering
- Biomechanics & Mechanobiology
- Systems, Imaging & Instrumentation (Bioinstrumentation)
- Computational & Systems Biology (Bioinformatics)

What are Biomaterials ?

- Constructs (materials) that interact with biological systems and used to replace a natural function.
- Biomaterials can be derived from nature or synthesized in the laboratory. Examples: Metals, ceramics, plastic, glass, and even living cells and tissue.

Biomaterial from pig's intestine used in healing wound

How are biomaterials used in current clinical practice?

- Biomaterials are used as the building materials for medical implants such as
  - Heart valves
  - Hip replacements
  - Stents and grafts
  - Artificial joints, ligaments, and tendons
  - Hearing loss implants
  - Contact lenses
  - Dental implants

… In addition, biomaterials are used for making:

- Molecular probes and nanoparticles that break through biological barriers and aid in cancer imaging and therapy at the molecular level.
- Biosensors to detect the presence and amount of specific substances and to transmit that data. Examples are blood glucose monitoring devices and brain activity sensors.
- Drug-delivery systems that carry and/or apply drugs to a disease target. Examples include drug-coated vascular stents and implantable chemotherapy wafers for cancer patients.

Useful skills and knowledge to have to become a biomaterials engineer

- Biology
- Chemistry
- Material Science
- Cell Culturing
- Wet Lab Practices
- Use of Lab Animals
- Engineering
- Medicine

What is tissue engineering (also known as generative medicine)

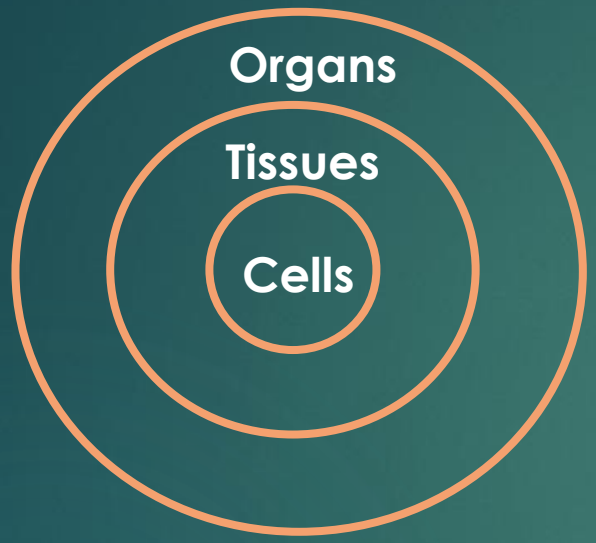
Tissue engineering is about regenerating or restoring the functions of organs and tissues.

- This branch of BME evolved from biomaterials engineering, making the two interrelated.

What is tissue engineering (also known as generative medicine)

Tissue engineering also includes self-healing: body uses its own systems to recreate cells and rebuild tissues and organs.

How does tissue engineering work?



- Cells are building blocks of tissues, which in turn are basic units of organs.
- Tissue engineering thus begins with the seeding of stem cells unto scaffolds, which provides the 3D structure.
- These cells will proliferate and grow into a tissue in the presence of growth factors and suitable environment.

Start with scaffold

Introduce stem cells and growth factors to scaffold

Put "cocktail" into an incubator or body to grow into tissue

What are some of the clinical/experimental applications of tissue engineering?

Clinical (Implanted in patients)

- Supplemental bladders
- Small arteries
- Skin grafts, cartilage,
- trachea

Experimental

- Heart
- Lung

What are some of the clinical/experimental applications of tissue engineering?

- Drug development
  - Using functioning human tissue to help screen medication candidates could speed up development and provide key tools for facilitating personalized medicine while saving money and reducing the number of animals used for research.

Click this link for short video on how human livers implanted in mice are aiding therapeutics

Useful skills and knowledge to have to become a biomedical tissue engineer

- Biology
- Chemistry
- Material Science
- Cell Culturing
- Wet Lab Practices
- Use of Lab Animals
- Engineering
- Medicine

What is biomechanics

Biomechanics is the study of the kinetics (movement and forces), structure, and related injury mechanisms of the human body. These include

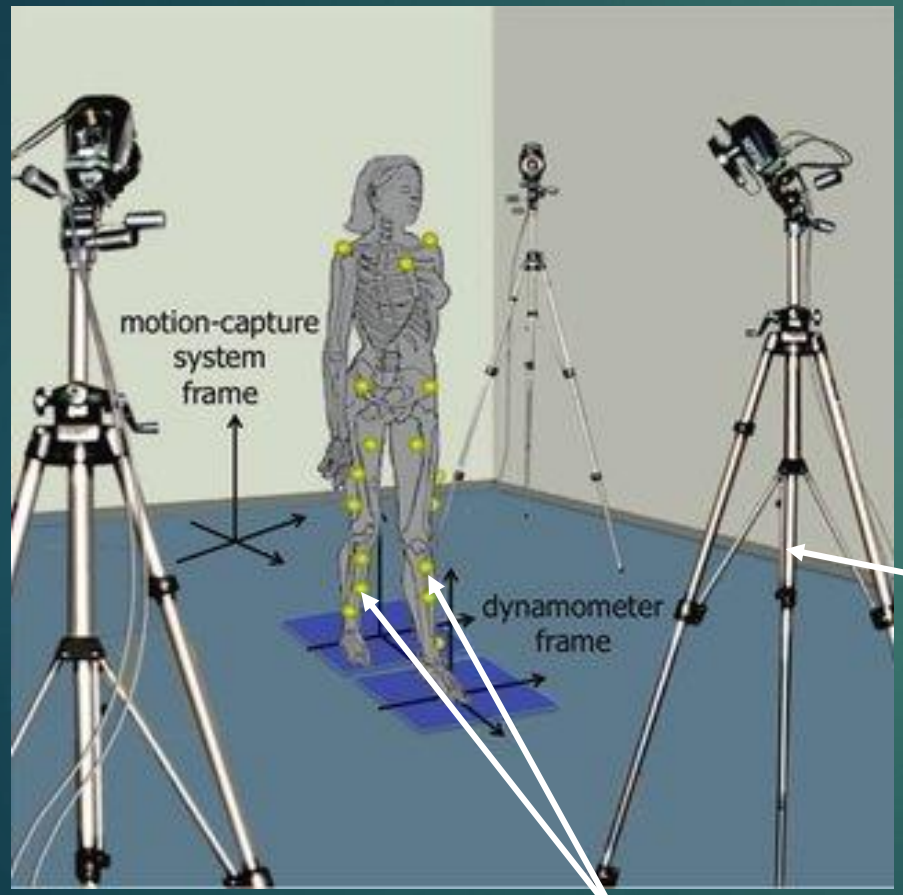
- forces affecting the interaction of molecules and cells such as DNA and proteins
- Biological fluid motion such as blood circulation

What tools are used to measure body motion?

- Biomechanics uses human motion analysis to understand the function of the musculoskeletal system.
- A combined experimental and computer modeling approach is used since the internal forces are difficult to measure non-invasively.
- Measurable quantities include motion of the musculoskeletal systems defined by skin markers and measured by motion capture systems and external forces applied to the system using force plates.
- EMG signals

What tools are used to measure body motion?

Motion Capture System



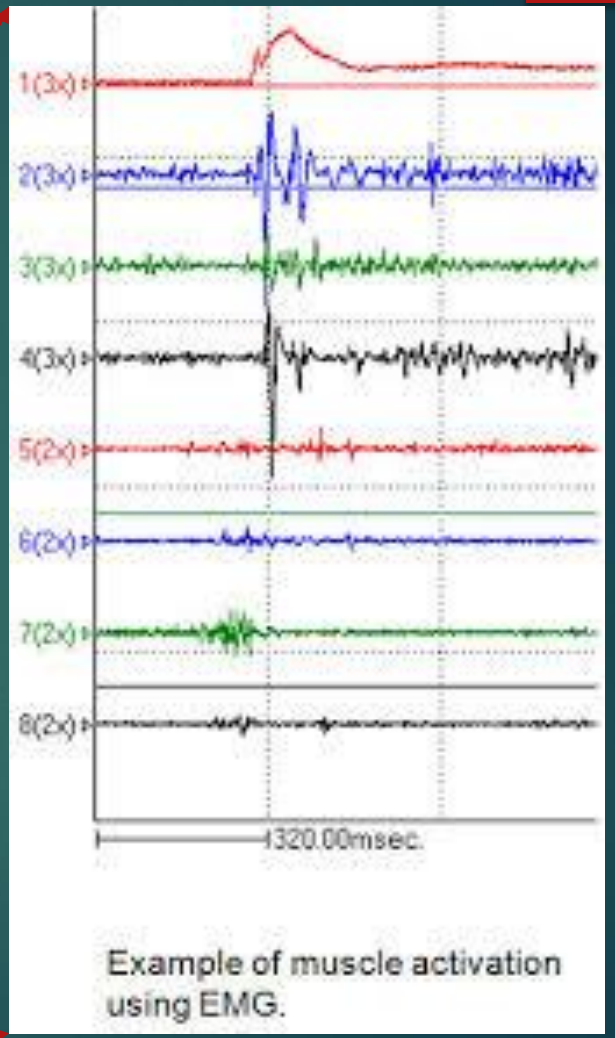
IR Camera

Skin markers

Computer modeling

Force platform

EMG recording systems



Example of muscle activation using EMG.

Applications of biomechanics

- Orthosis and Prosthesis
- Rehabilitation Medicine
- Sports Science and Medicine
- Ergonomics
- Forensics

What subject areas are needed to study biomechanics?

- Physics
- Math
- Biology
- Anatomy & Physiology
- Mechanical Engineering
- Computer modeling and simulation

What is bioinstrumentation?

Defined broadly, bioinstrumentation is the study of medical devices-implements used for diagnosing, curing, treating, preventing diseases or correcting the structure or function of the body for some health purpose.

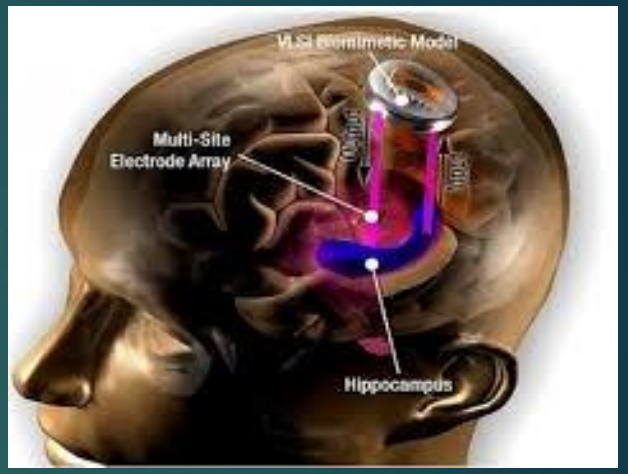
Under this broad definition, this area includes:

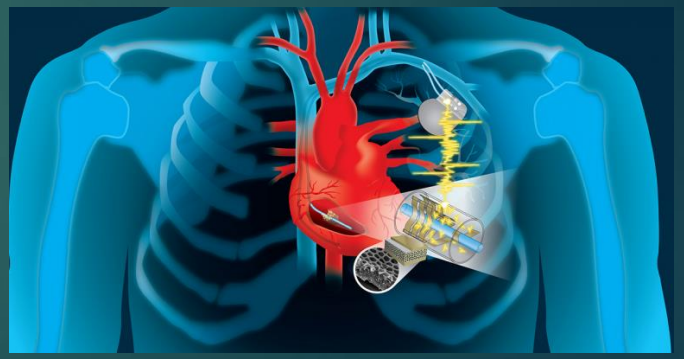
- Dental equipment
- Orthopedic instruments
- Surgical tools
- Stents and catheters
- Syringes and hypodermic needles etc.

Bioinstrumentation usually connotes medical devices with electrical or electronic components

Medical Implants:

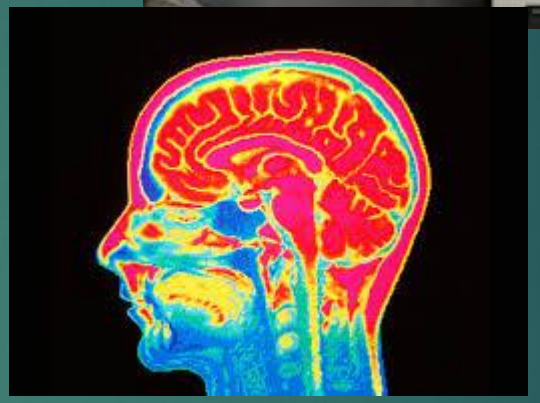
- Pacemakers
- Brain implants
- cardioverter-defibrillator
- Cochlear implants

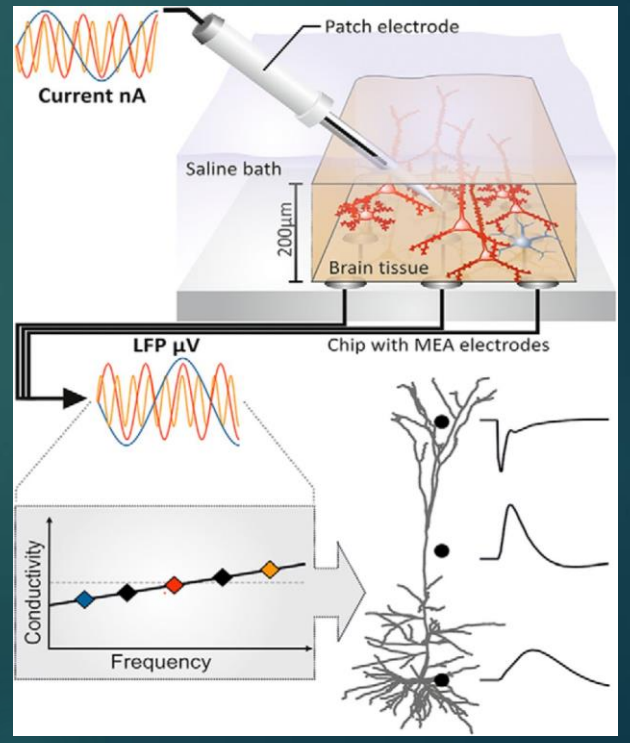




Diagnostic Devices:

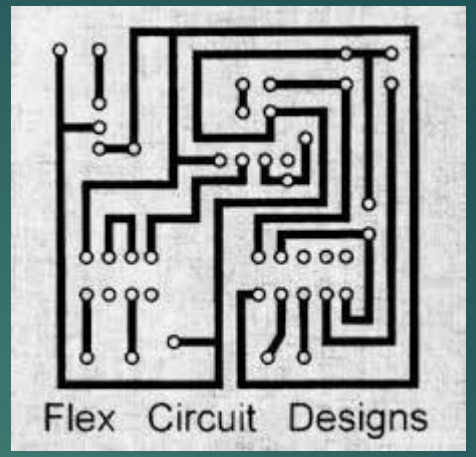
- Imaging systems
  - Microscopy
  - CT Scanner
  - Ultrasound
  - MRI
  - Optical-based systems
- Physiological recording systems

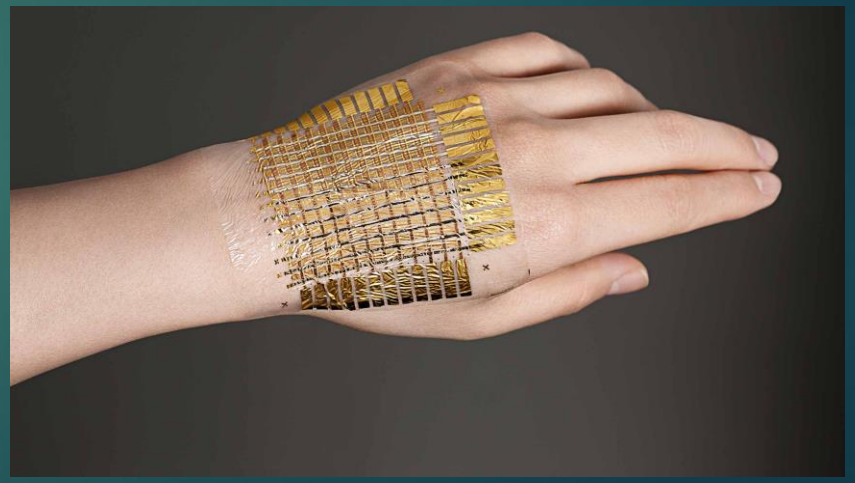




Wearable Devices:

- Smart textiles
- Nanotechnology
- Physiological monitoring sensors
- Drug delivery systems





Useful skills and knowledge to have to become a bioinstrumentation engineer

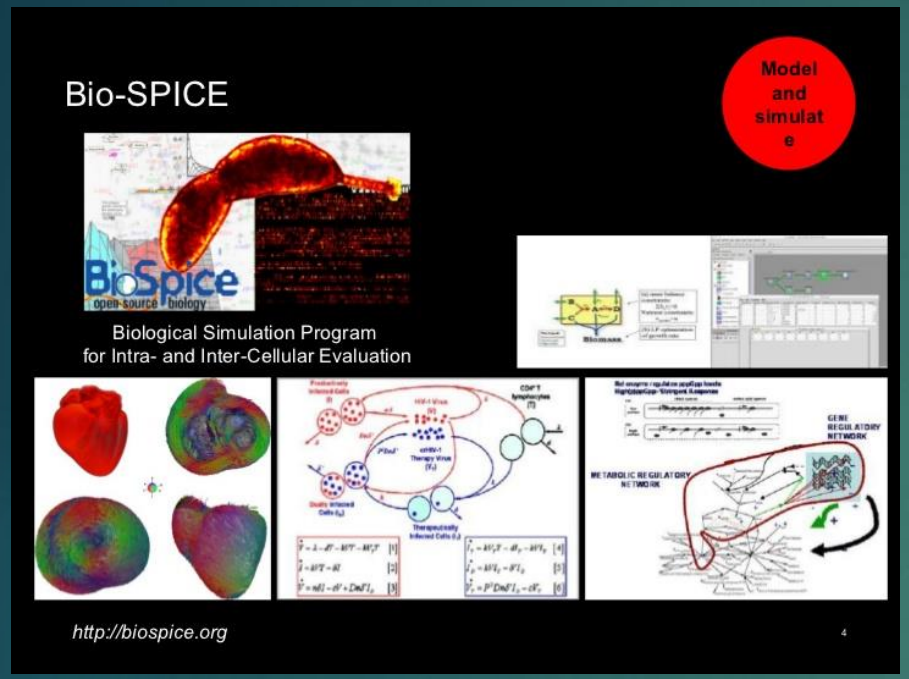
- Physics
- Math
- Electrical Engineering
- Optics
- Computational Modeling and Simulation
- Microcontrollers
- Signal Processing
- Electrical & Electronic Circuits
- Soldering and building PCBs

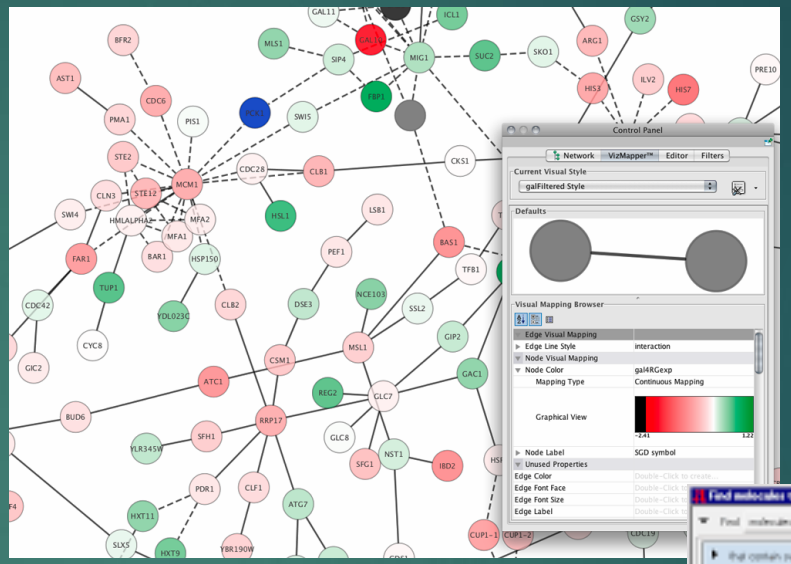
Computational & Systems Biology

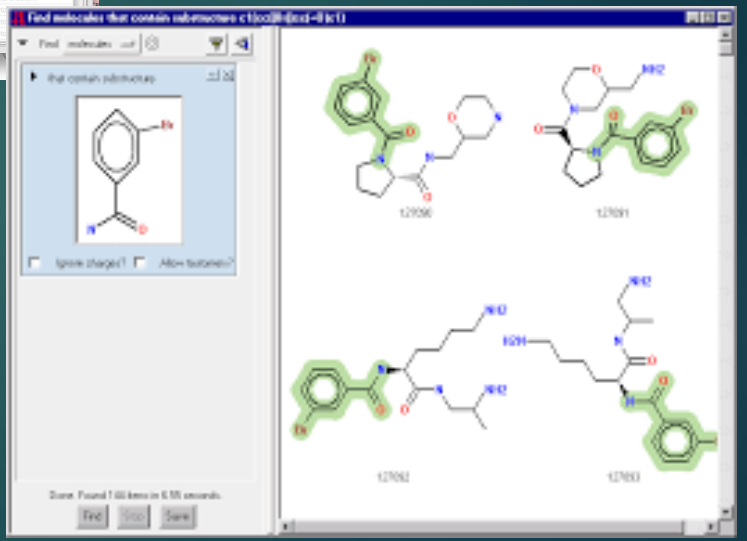
The use of computer models and simulations to study biological systems and processes such as

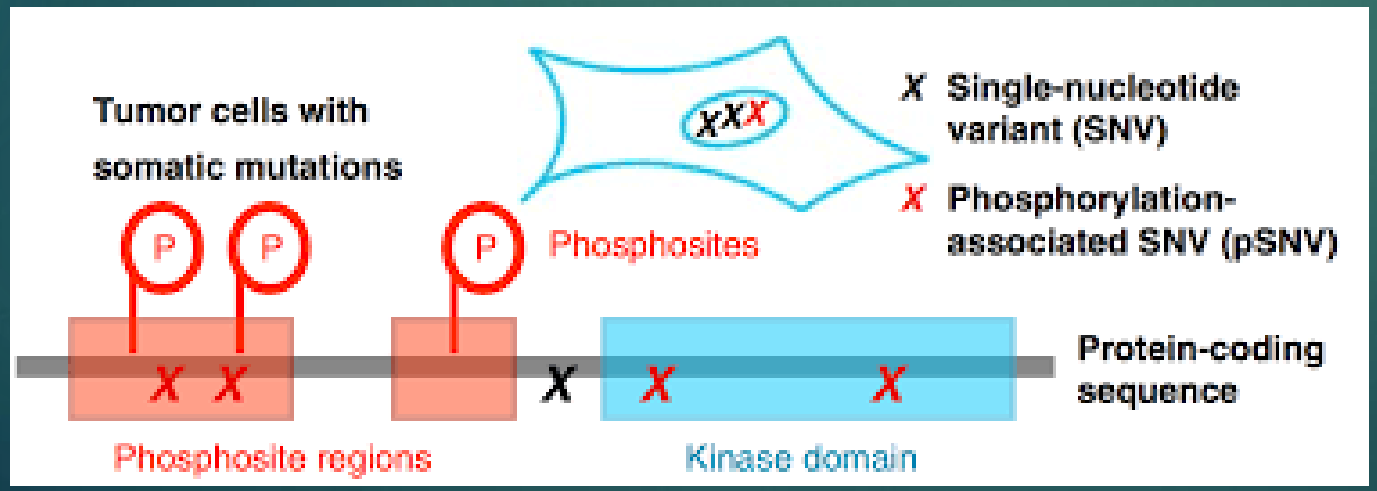
- Analysis of protein and nucleic acid structure and function.
- Gene and protein sequencing
- Evolutionary genomics and proteomics
- Population genomics, regulatory and metabolic networks
- Biomedical image analysis and modeling
- Gene-disease associations, and development and spread of disease

This is how the modeling look like…









This area has applications in…

- Pharmacodynamics
- Cellular Modeling
- Computational Genomics
- Proteomics
- Pharmacogenomics
- Pharmacokinetics
- Human Simulation Software, Drug Discovery & Development

Useful skills and knowledge to have to become involved in this endeavor

- Biology (especially molecular and neuro-biology)
- Biochemistry
- Math (especially statistics)
- Genomics
- Computer science (computational modeling and simulation and its development)