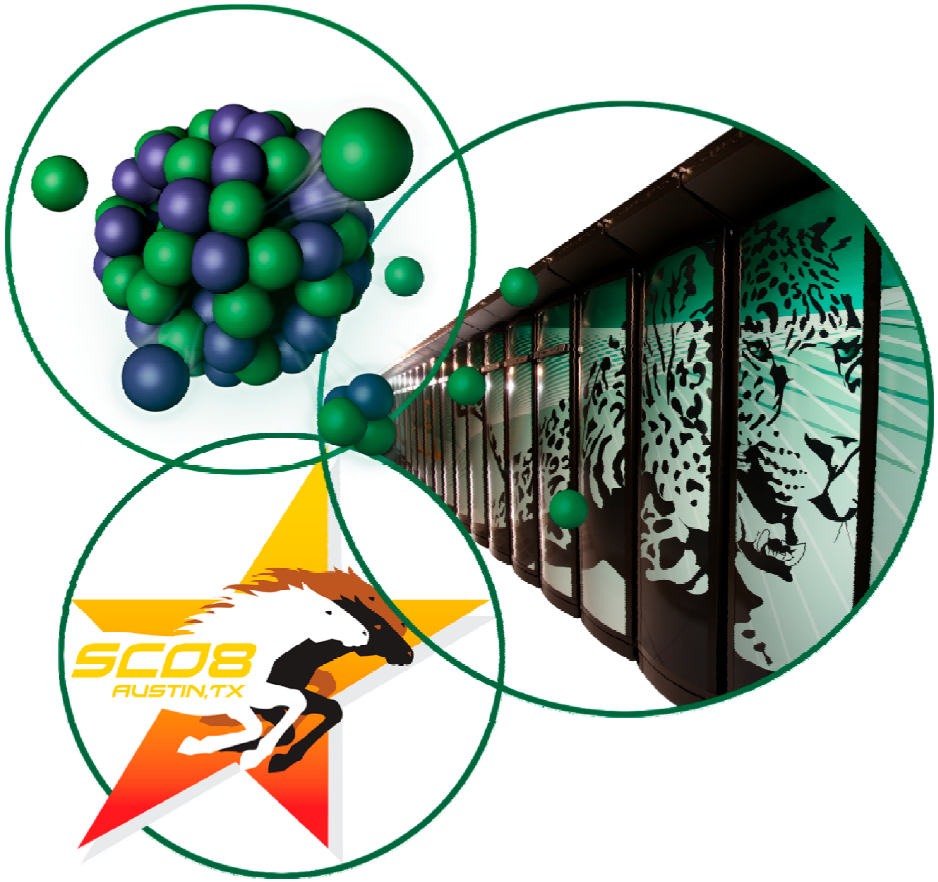
Biomedical Engineering and Biomedical Informatics



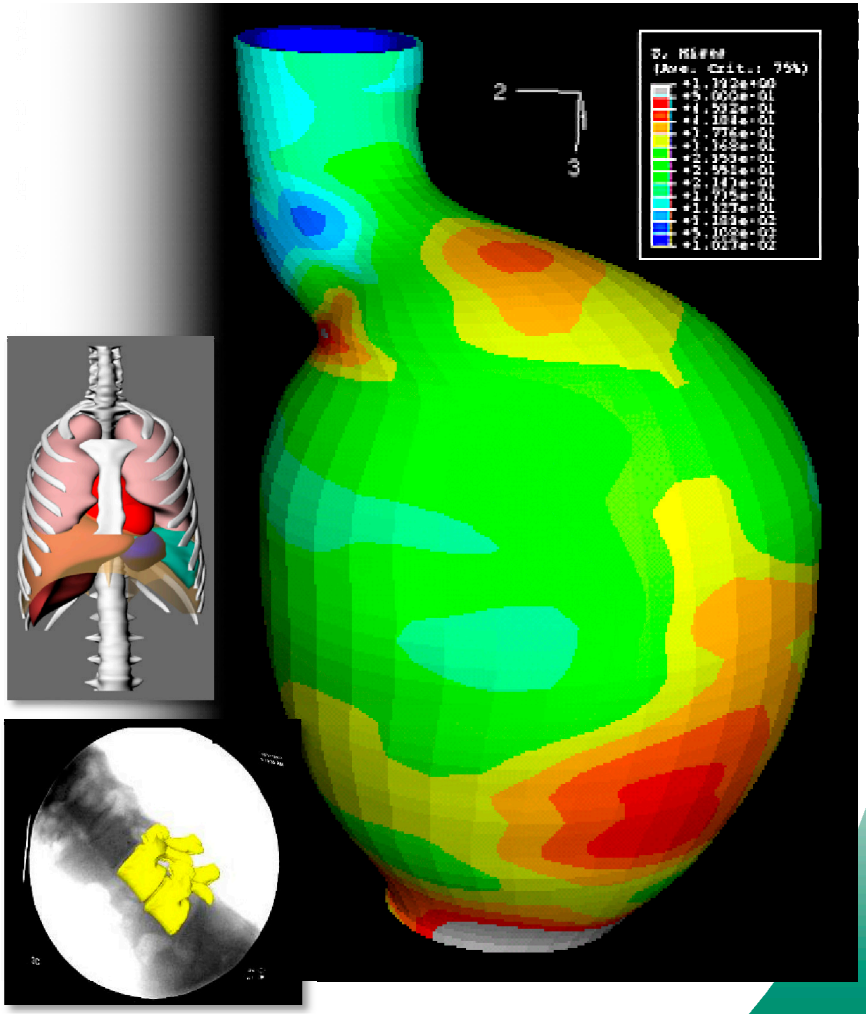
Presented by

Barbara Beckerman

Modeling and Simulation Group
Computational Sciences and Engineering

Biomedical engineering and biomedical informatics research at ORNL

- Biokinetic and biotransport modeling
- Three-dimensional organ and tissue modeling using CT or other imagery (pulmonary, arterial, musculoskeletal)
- Knowledge discovery, text and image processing, and intelligent agents for data mining and analysis
- Integration of models at multiple temporal and spatial scales
- Computer environments (data repositories, search tools, visualization, etc.) in support of biomedical and medical applications
- Biomedical informatics and telemedicine
- Predictive, inductive, mechanistic, and statistical models of vascular pathologies

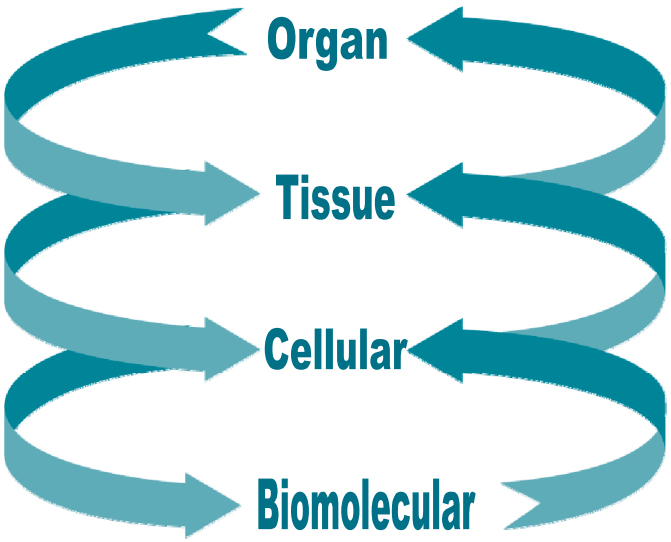


Predictive multiscale modeling

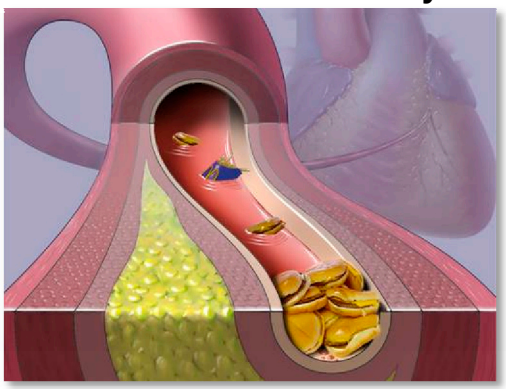
Goal: Predict migration of smooth muscle cells from media to intima due to inflammatory response after injury

Model for predicting vascular disease

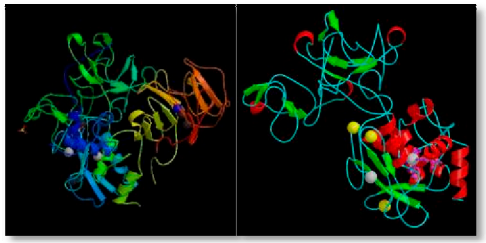
- Spatial modeling of cell migration
- Diffusive and kinetic modeling of biochemicals
- Result: a multi-cale hybrid continuous-discrete predictive model for tissue pathology



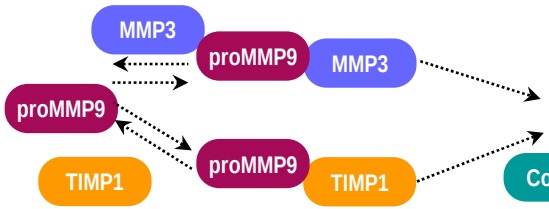
Atherosclerotic artery



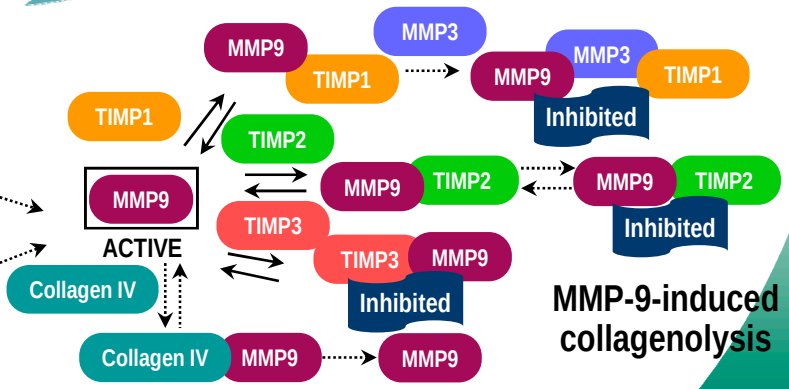
R. Conway 2005, zoologynews.blogfa.com/post-23.aspx



Matrix metalloproteinases (MMPs)



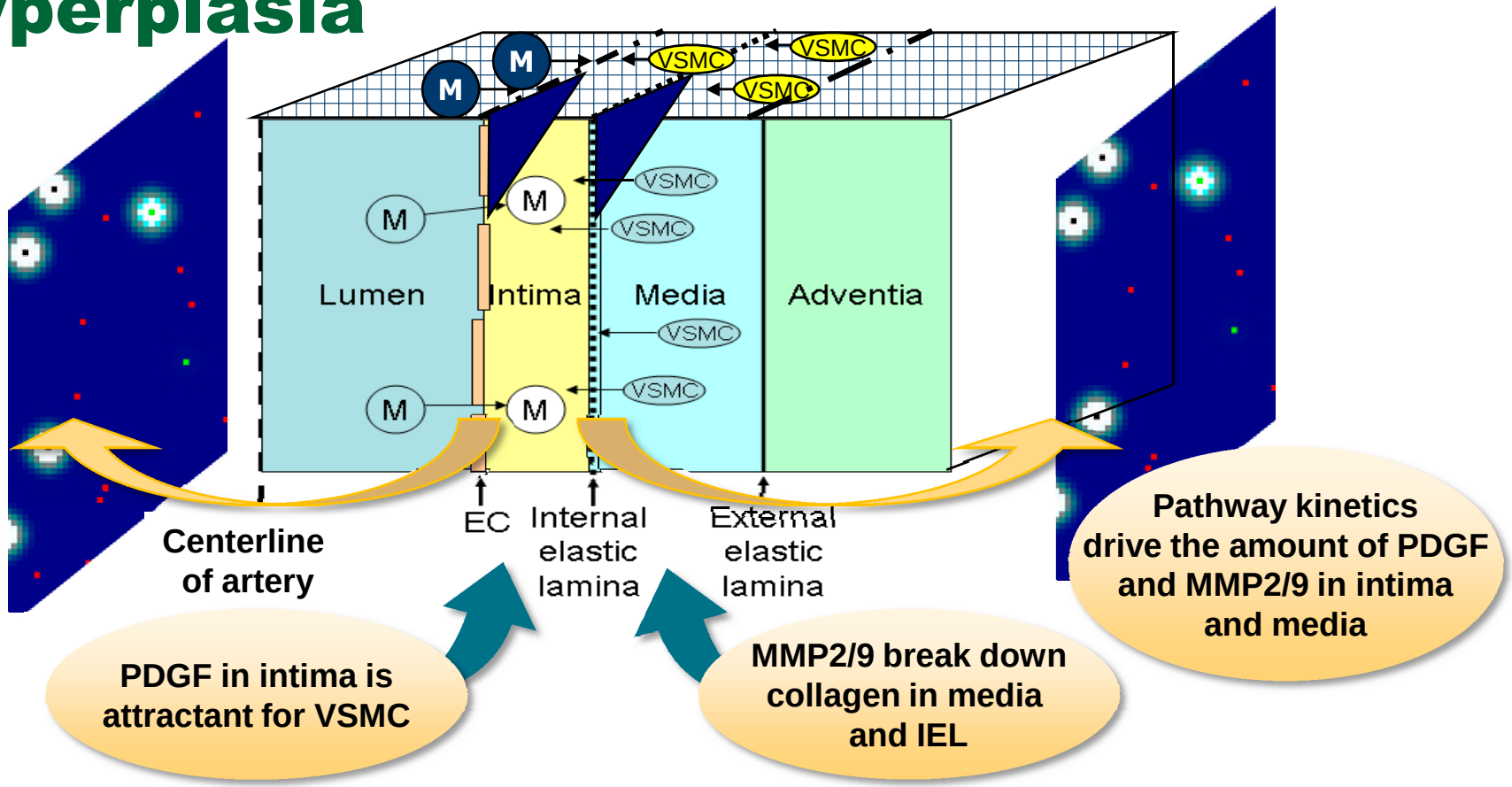
Activation of MMP-9



MMP-9-induced collagenolysis

Inhibition of MMP-9

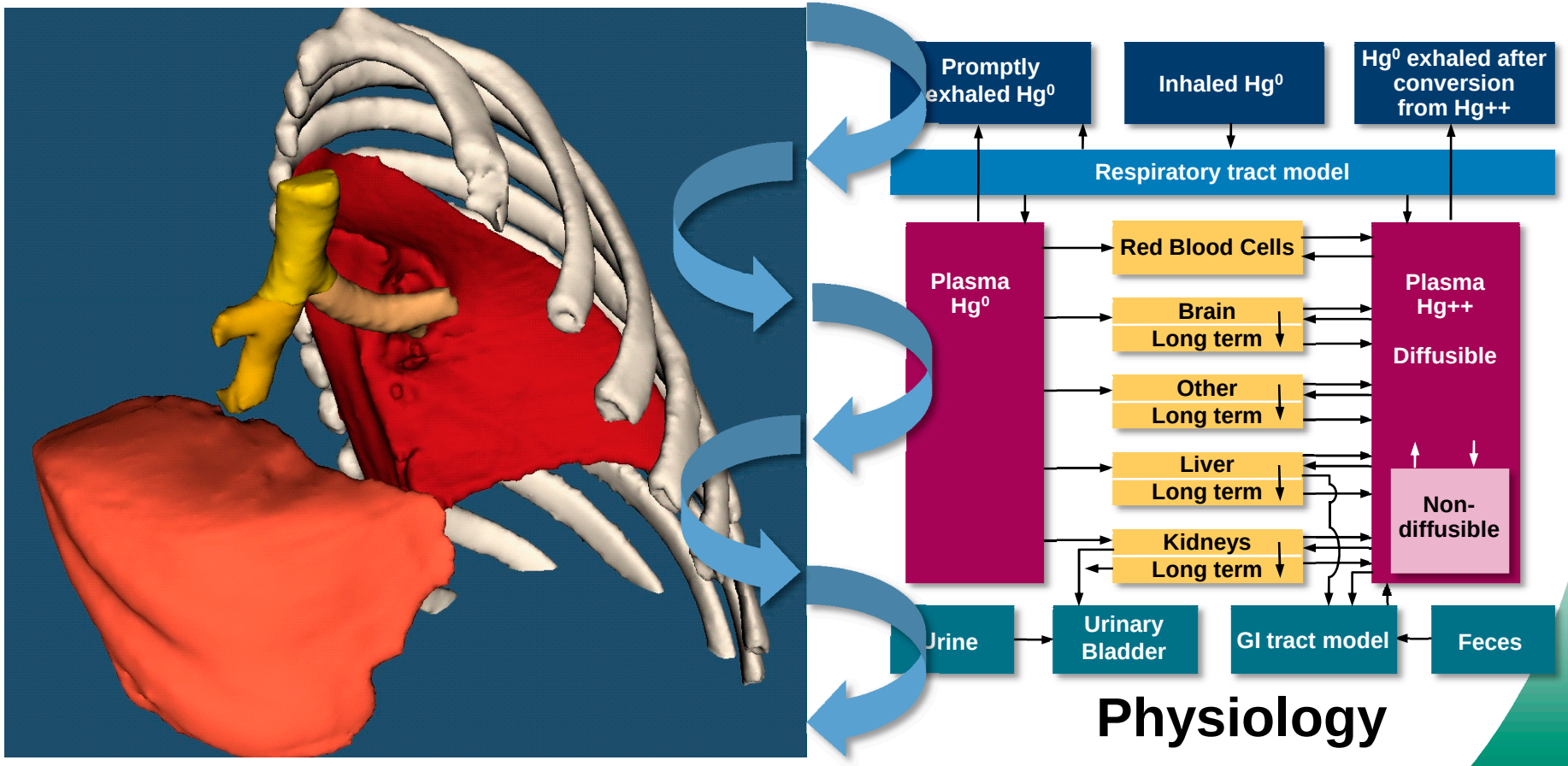
Schematic of hybrid model for intimal hyperplasia



- Build SMC proliferation/migration model
- Add monocyte migration and EC re-coverage
- Add detailed (low-level) enzyme kinetic models for degradation of collagen by MMPs in the media and IEL

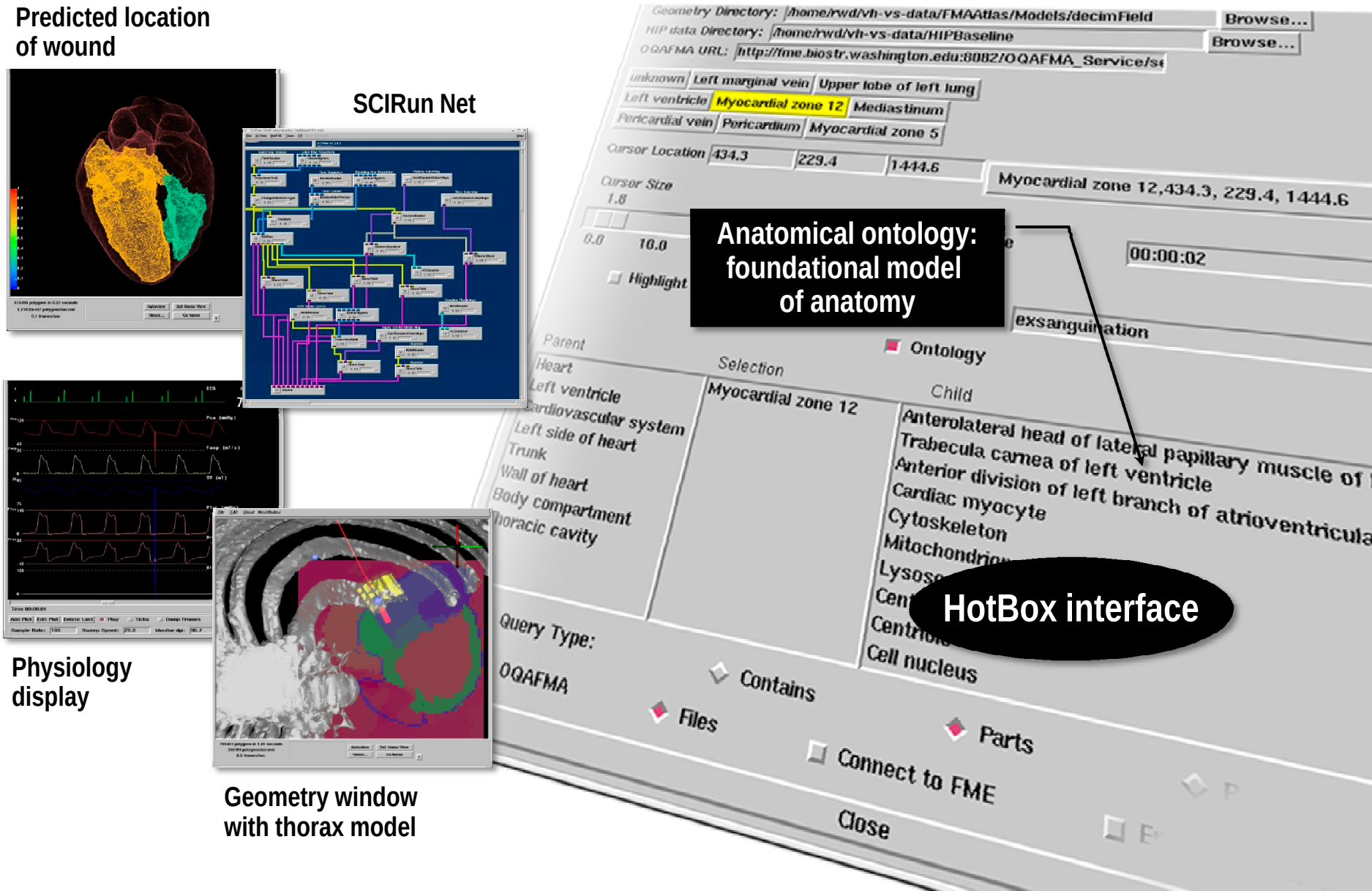
Virtual Human—bringing together anatomy and physiology

Virtual Human



Oak Ridge National Laboratory

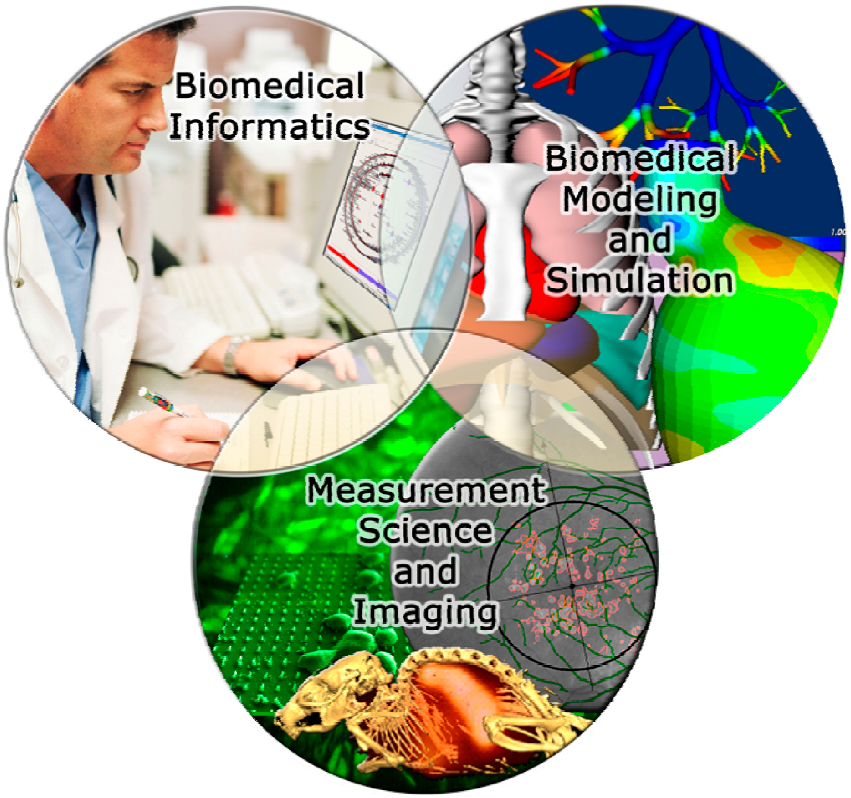
ORNL HotBox integrates all the DARPA Virtual Soldier windows



BSEC

Biomedical Science and Engineering Center

OAK RIDGE NATIONAL LABORATORY



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BSEC thrust areas

BSEC
Biomedical Science and Engineering Center
OAK RIDGE NATIONAL LABORATORY

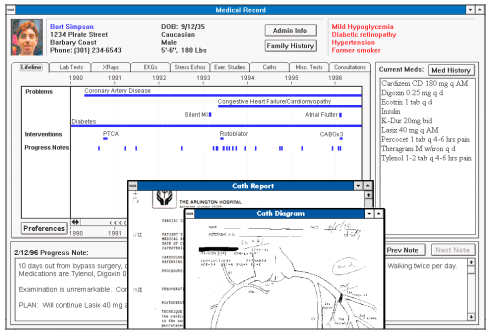
- ***Biomedical informatics*** **(knowledge discovery, fusion, data mining, visualization, analytics, image processing and analysis, geographic information systems, and decision support systems for research and clinical use)**
- ***Biomedical modeling and simulation*** **(predictive modeling, 3-D visualizations, organ models, and mathematical modeling tools)**
- ***Measurement sciences technologies*** **(diagnostic instrumentation, imaging instrumentation and measurement, prosthetics, fusion with other data sources, and biosensors/biomarkers for biodefense, cancer-detection technologies, and drug delivery)**

POC: beckermanbg@ornl.gov

Computer tools for medical analytics and visualization (combine M&S, KD, and Viz)

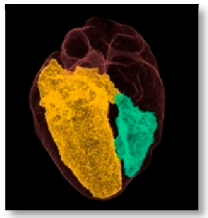
Patient-centered care

Patient medical record



Patient record

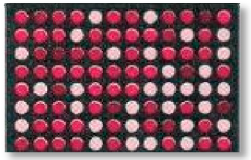
Data sources



Imagery

Tissue biopsy

Microarray data



Databases/system architecture

System architecture integrates databases

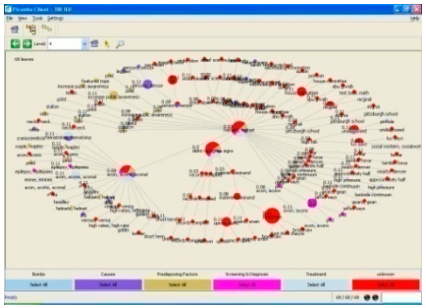
Advanced analysis and visualization

Image retrieval, processing and integration

Visualization

Knowledge discovery engine

Data analytics



KD output

DAMSEL: Data analytics for medicine using SEmi-supervised learning*

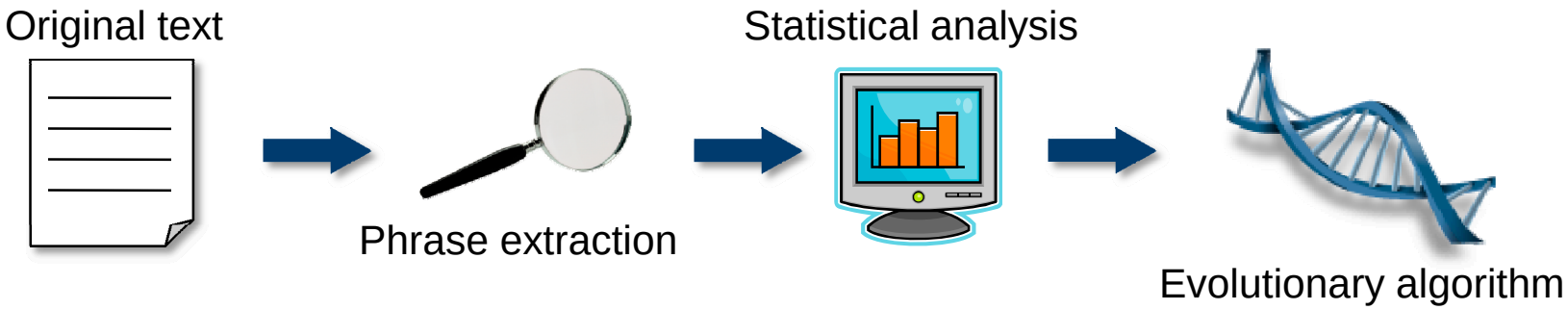
OBJECTIVE

Develop a comprehensive, flexible, and responsive computing framework that incorporates ability to analyze multimodality data using semiautomated learning environments

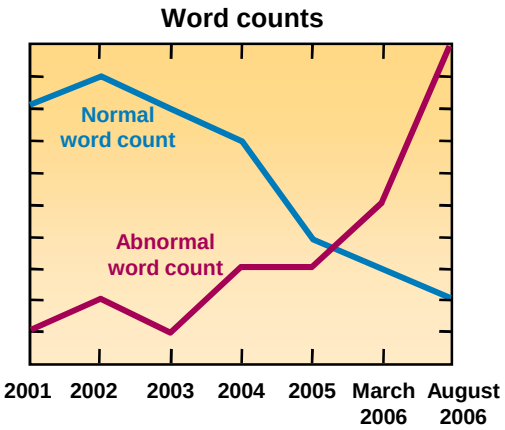
*Research proposed to be sponsored by the Laboratory Directed Research and Development Program of Oak Ridge National Laboratory (ORNL), managed by UT-Battelle, LLC for the U.S. Department of Energy

Text analysis approach

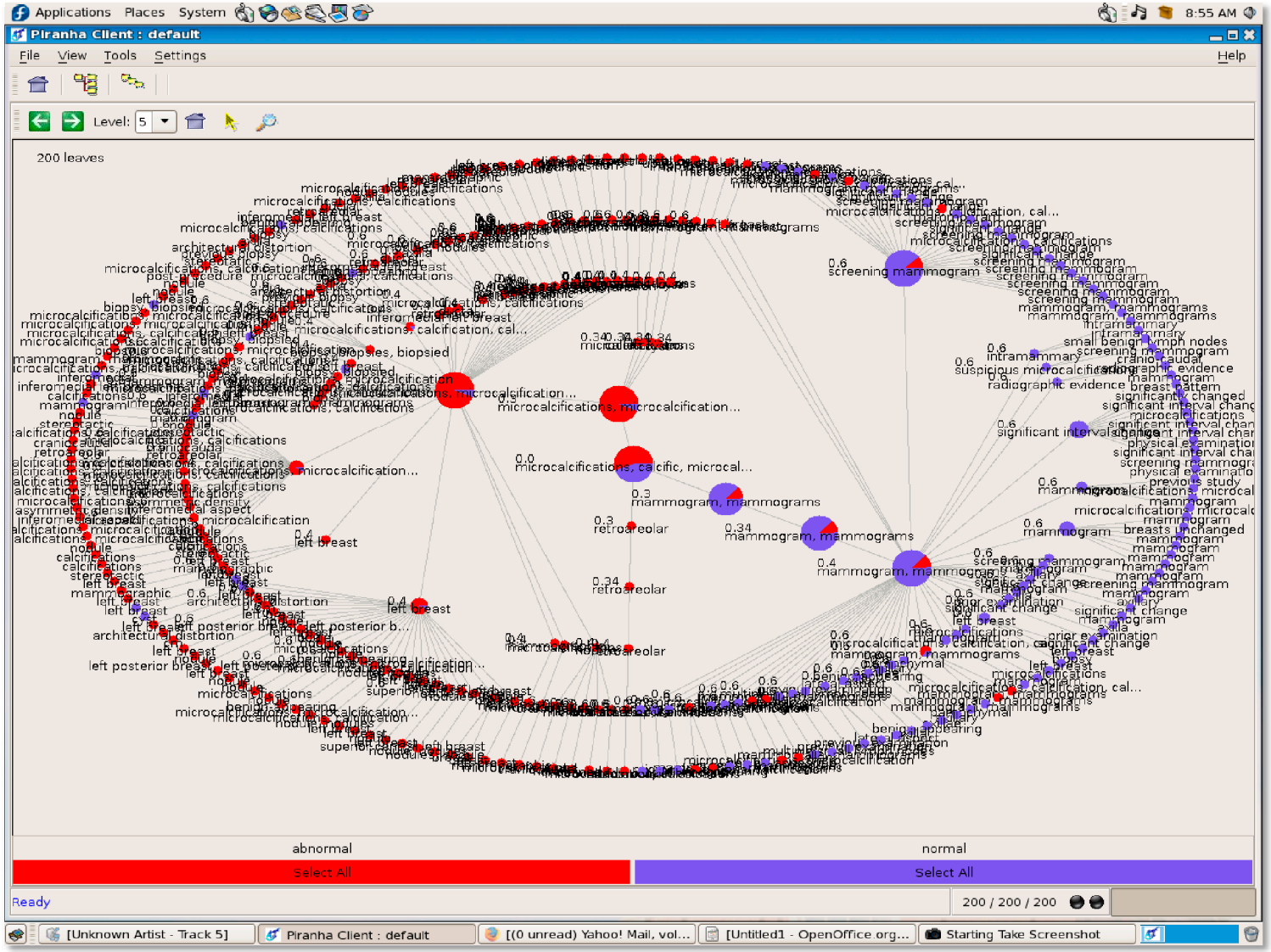
- Leverage *human expertise* to characterize the data
- Enhance *statistical analysis* with *evolutionary algorithms* to learn domain-specific, significant textual features



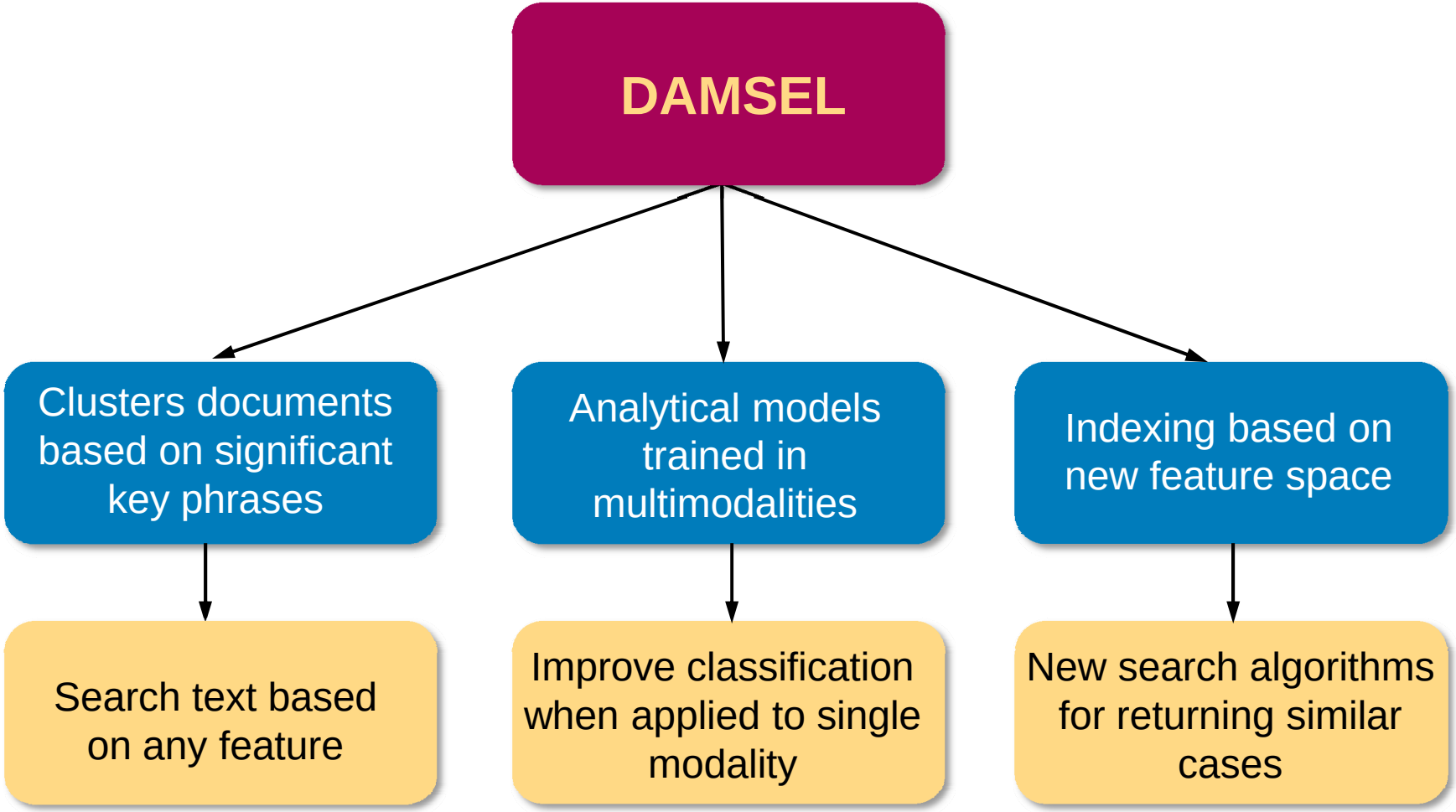
- Provide *textual feature space* in Learning Environment
- Characterize the *"language"* of the domain
- Perform *longitudinal analysis* for temporal spikes or trends



Clustering text data to visualize relationships

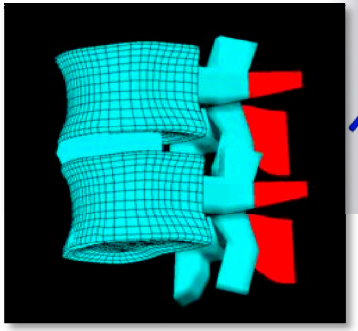


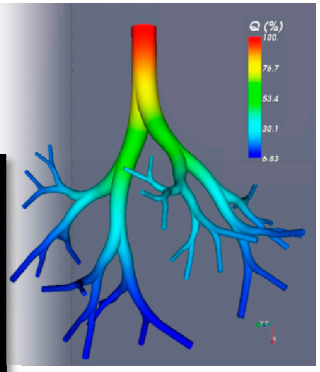
DAMSEL innovations

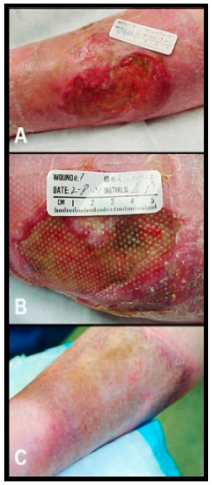


Examples of biomedical problem solving

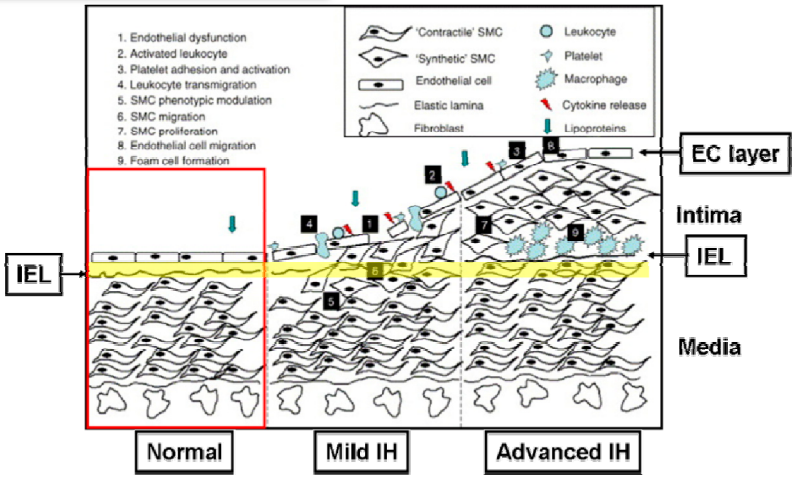
- Intimal hyperplasia
- Abdominal aneurysms
- Prediction of wounds, wound healing, vascular pathologies
- Traumatic brain injury/PTSD (knowledge discovery, data fusion, data analytics, M&S, imaging)
- Biomedical imaging (cellular and systems biology, 3-D microscopy, in vivo imaging to support computational model development, imaging modalities)
- Ontologies and informatics
- Systems medicine







www.erc.montana.edu/biofilmbook/MODULE_07/Mod07_S04-4_Blue.htm



Adapted from B. E. Rolfe, N. F. Worth, C. J. World, J. H. Campbell, G. R. Campbell, "Rho and Vascular Disease," *Atherosclerosis* **183** (1): 1−16 November 2005

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