Benefiting Society through Information Technology: Why Changes in Education are Needed

Peter Arzberger
and many others
12 March 2009
MURPA Seminar: Year 2
Ask the Right Question

• With all of our technologies, how do we apply them to important problems?
  – Fang-Pang Lin, NCHC, April 2003
NCHC SARS Task Force 2003

Telescience/BIRN Portal was Quickly Adapted to a SARS Portal for Taiwan

Source: Fang-Pang Lin
Societal Needs, Technology Challenges, Community Needs

Place work in larger societal context:
How does my work fit into larger landscape of learning?
What are the social implications of my scholarship?

David Orr: Earth in Mind
Issues Facing Global Society

Living Beyond Our Means

Global Competence & National Needs

Can ICT help farmers and food crisis?

Seishi Ninomiya
National Agriculture and Food Research Organization, Japan

Science December 14, 2007

Dengue Fever
Prosperity Bug
A neglected tropical disease affects 1 billion people;
1% new drugs for NTD (1975-99)

WHO

Science

Reefs in Trouble

Lincoln Report 2005

WHO
Some Technology Trends

ENVIRONMENT
- Climate Change
- Lakes, Coral Reefs
- Fish stocks, ESS

HEALTH
- Infectious disease
- NTD
- Heart disease
- Cancer

ENERGY and RESOURCES
- Green Technology
- Water ...

CULTURAL HERITAGE PRESERVATION

IR Reflectography on Leonardo “Annunciation”, 1989
M. Seracini
Computational Translational Medical Science: Potential in the next 5 years

- Improving treatment planning for heart disease through individual patient modeling
- Understanding role of realistic subcellular structure on functions of cells via multiscale modeling at the mesoscale
- Speeding drug discovery by creating, improving the efficiency of, and enhancing computer aided drug discovery pipeline

Tools, Simulation Packages and Pipeline, CI
Trend: Data Richness Drives Biomedicine

Pipelines from acquisition to translational insights Optimize interventions, understanding, new drugs

NBCR: Linking tools, packages, and CI
GAMer: An FETK Library for Building Geometric Models from Light Microscopy Data

Bio-Rad RTS2000 Real-Time Confocal & Multi-Photon Microscope (NCMIR, UCSD)

Image courtesy: Masahiko Hoshijima (UCSD)

Personnel: Zeyun Yu (lead), Michael Holst.
Expected Outcomes: Improved algorithms/software for mesh generation

Membrane

T-tubules

1um

Image courtesy: Masahiko Hoshijima (UCSD)

Meshing

Feature Extraction

Skeletons of T-tubules (Yu et al, JSB 2008)

http://www.FETK.org
Sub-Cellular Modeling at the Micrometer Scale using FETK Platform

Idealized t-tubule geometry

Surface membrane

Cytoplasm

T-tubule

Realistic t-tubule geometric model extracted from EM imaging data

3-D Ca$^{2+}$ concentration distribution (~75 ms) in the presence of fluorescent dye. Membrane Ca$^{2+}$-transporting pathways homogeneously distributed. (Yuhui Cheng, Zeyun Yu et al., unpublished data)

3-D Ca$^{2+}$ concentration distributions at Ca$^{2+}$ peak (~68 ms) in the presence of fluorescent dye (left panel) or absence of fluorescent dye (right panel). Membrane Ca$^{2+}$-transporting pathways heterogeneously distributed. (Lu et al., IEEE EMB 2008)

Personnel: Anushka Michailova (lead), Yuhui Cheng, Zeyun Yu.
Expected Outcomes: State-of-the-art FETK-based simulator for sub-cellular modeling
Cultural Heritage
Center of Interdisciplinary Science for Art, Architecture, and Archaeology

Raphael "La Gravida" Galleria Palatina, Florence

Ultraviolet Fluorescence

Source: M Seracini
Center of Interdisciplinary Science for Art, Architecture, and Archaeology

Source: M Seracini
Center of Interdisciplinary Science for Art, Architecture, and Archaeology

Source: M Seracini
**Flood Mitigation Grid:**

*Video-Camera Sensors for Flood Monitoring*

- **Real-time Monitoring**
  - River and Reservoir Stage
  - ~150 Sites

- **Remote Operation**

- **Data Recording and Searching**

Source: Fang-Pang Lin
3D Web-based GIS Taiwan Platform

Digital Map Layers & Bookmarks

Real-Time Video Stream

Sites List of real-time video

5m DTM data & Real-Time Video Display

DTM combined with space-borne or airborne images

Sources: T.L. Chung, R.Y. Chang
Real-time video stream of fei-cui Reservoir

Source: Fang-Pang Lin
Integration of Hydrological data and inundation simulation

Source: Fang-Pang Lin
The system used in real life flood emergency support by Water Resource Agency

Flood Monitoring System captured overflows of Dan-bao River ( ) and activated alarming system in Kaoshiung County


Source: Fang-Pang Lin
Colife

Group VTC
MP4 supported

User List
Texture chat root

Application sharing & whiteboard

Service Test Site for GLEON:
(1)Register in
(2)Login test portal
Contact: Mr Shih-Ching Lin (PI); b00lsc00@nchc.org.tw

Source: Fang-Pang Lin
## Societal Needs, Technology Challenges, Community Needs

### Societal Needs
- Environment
- Health
- Energy and Resources
- Cultural Heritage

### Technologies
- Instrumentation
- Information Technology: Networking, Data Storage, Computing

### Challenges/Opportunities
- Data: Acquisition to Synthesis Pipeline
- Collaboration: International Virtual Grass-Roots Communities

### Education: Societal Imperative
- Why
- Burden of Knowledge
- Possible Model
- Education for a Sustainable Planet
Future Discovery and Community Research

- High Performance Computing
- Data, Data Analysis, Visualization
- Learning & Workforce Development
- Virtual Organizations for Distributed Communities:
  - Cyberinfrastructure enables distributed knowledge communities that collaborate and communicate across disciplines, distances and cultures, …[to become] virtual organizations that transcend geographic and institutional boundaries (A.Bement)
Ask the Right Question

• Why don’t you take advantage of your location, on the Pacific Rim, and create deep collaborations by working with others in the this region?

– W.Y. Bill Chang

1998 1999 2000 2001
Strengthen Existing and Establish New Collaborations

Work with Science Teams to Advance Grid Technologies and Improve the Underlying Infrastructure

In the Pacific Rim and Globally

http://www.pragma-grid.net
PRAGMA Accomplishments 2008

- Streaming Underwater Video
- Bridging Grid Islands
- Integrating SCMSweb and Condor
- PRAGMA CA
- Monash University Research Program Abroad (MURPA)
- Expanding PRAGMA community

wwwPragma-grid.net
Working Groups: Organize Activities

Resources

Biosciences

- H5N1 related glycan conformation analysis using M*Grid and Glyco-M*Grid
- Relaxed Complex Method Molecular Dynamics Simulation Data Sets & Database
- Virtual Screening Data Sets & Database

Telescience

- PRAGMA Portal
- My WorkSphere
- CSF4 Server
- HPC Clusters, NBCR, TeraGrid, MHPCC

GEO

- NAMD
- AutoDock
- Zinc NCIDS
- Virtual Directory Tree
- H5N1 related glycan conformation analysis using M*Grid and Glyco-M*Grid
- Relaxed Complex Method Molecular Dynamics Simulation Data Sets & Database
- Virtual Screening Data Sets & Database
Savannah Burn:

How tightly linked are burning, vegetation, and rainfall?

- PRAGMA Testbed ran CSIRO climate model called CCAM in combination with Nimrod/G tool set.
- Executed on a maximum of 90 processors (out of a maximum 159) across 7 PRAGMA grid resources located in Australia, Japan, Korea, Taiwan, Thailand and the U.S.
- David Abramson, Amanda Lynch

Applications Using PRAGMA Resources

- PovRay Rendering using Ninf – G (AIST)
- Testing Datastreaming Middleware: DataTurbine (UCSD)
- Grid service debug architecture (Monash)
- Peer-to-peer middleware for grid monitoring (PIAX) (Osaka University)
- Parallel Job Migration (Jilin U)
- Brazilian Regional Atmospheric Modelling System (U Chile)
- Functional Magnetic Resonance Imaging (fMRI) data analysis application (U Melbourne)
Easing the Management of Resource

• VOMS Implementation Pilot Project
  – BeSTGrid, AIST, IHPC, UCSD
  – Sites are VOMS aware
    • Installed, setup and tested software - GUMS, AUTH tools, PRIMA, VOMS cient and GSISSh.
    – User can access all four resources once approved as member of PRAGMA VO
  – Documentation on web
    • Allowing others to implement VOMS

• Pilot project lead also to:
  – New experimental PRAMGA CA
  – Upgrade VOMS server for greater stability
Biosciences: Creating an Avian Flu Grid through sharing and integrating middleware

- H5N1 related glycan conformation analysis using M*Grid and Glyco-M*Grid
- Relaxed Complex Method Molecular Dynamics Simulation Data Sets & Database
- Virtual Screening Data Sets & Database
- HPC Clusters, NBCR, TeraGrid, MHPCC
- PRAGMA Portal My WorkSphere CSF4 Server
- Gfarm File System /gfs/$USER
- NAMD
- AutoDock
- Zinc NCIDS
- Virtual Directory Tree
- Relaxed Complex Method Molecular Dynamics Simulation
- Data Sets & Database
- PRAGMA Portal
- My WorkSphere
- CSF4 Server
- HPC Clusters, NBCR, TeraGrid, MHPCC
- Mr. Bayes
Ensemble-based Virtual Screening with Relaxed Complex Scheme

**Receptor Ensemble**
- Receptor crystal structure (or homology model), apo or holo complex
- MD, GB-MD, SMD, High T MD, TMD, Accl. MD
- Snapshot 10 ps
- Reduction of structures
  - clustering RMSD
  - QR
  - manual selection

**Ligand Ensemble**
- Available
- N/A
- ZINC, NCI, ACD, org. synth.
- ligand PDBs

**AutoDock4**
- AutoDock (full ligand flexibility)
- Docking Data: hundreds of MB

**Post-Processing**
- Set of docked complexes
- AD4, MM-PBSA, single step perturb.
- LIE, FEP, TI
- CPU cost, accuracy confidence level

**Simulation Data: hundreds of GB**
- Multiple targets: HA, NA subtypes
- Each target: 30~50 MD snapshots, 1~2 MB each

**Applied in HIV integrase inhibitor design – Isentress from Merck**
- Total data to date: ~5 TB in long term storage.
- Each experiment is about 1 Petaflops accumulative in computation cost.

**NCI Diversity Set:** 3.3 MB, 2000 compounds; Required at each site
- ZINC subset: 200,000. A few hundred MB

**Developed by J.H. Lin**
Using CSF4 in the Avian Flu Grid Project

Deployment

Biosciences: Grid Workflow and Data Aware Plug-ins for CSF4

NBCR Resource

Mirume Cluster
Yuki Cluster

Grid1 Cluster in JLU, China

PRAGMA

XSVC Cluster in AIST, Japan
Rocks-52 cluster in SDSC, U.S.

Portal User
Console User

The Job without Decision
The Job with Decisions
The Job with More Decisions
Data Aware Plug-in enhances Workflow Plug-in performance

Implement the Grid Workflow Scheduling for Data Intensive Applications with CSF4
Z. DING, X. WEI, Y. ZHU, Y YUAN, W. W. Li, O. Tatebe. IEEE conference on escience Dec08
New Drug Design Strategy using Active Fragments and the Relaxed Complex Scheme

- NA active site domain is intrinsically flexible and MD simulations may account for receptor flexibility and important configurations not seen in crystal or NMR studies
- D. Kim, Chonnam U has tested top compounds of virtual screening for neuraminidase
- MOU signed (10 sites)
- International Workshop on Infectious Disease Researches in Cyberinfrastructure (IDRiC International Workshop), 23 March 2009
Ecogrid: An Outgrowth of PRAGMA Telescience

![Graph showing water temperature and precipitation over a period of 6 days from 22-Aug to 28-Aug. The graph includes lines for different depths: Surface, 0.5 meters, 1 meter, 1.5 meters, 2 meters, 2.5 meters, and 3 meters, with corresponding water temperature values. Precipitation is also plotted with a scale from 0 to 20 mm per 5 minute interval.]
Ask the Right Question

- If we can connect two lakes, why can’t we connect more? And thereby change the type of research and the conduct of it for lake ecologist?
  – Tim Kratz, 2004
GLEON Sites
September 2008

Understand lake dynamics at local, regional, global scales through grassroots use of cyberinfrastructure

Lake Erken, GLEON 7
September 2008
T. Blenckner

Lake Observatory

IT Development

Launched by PRAGMA
Telescience WG

GLEON 8, Feb 09 NZ

Source: Tim Kratz
Observing Systems: Revolutionizing What We Understand

"You can imagine how much you'd miss if you only had your eyes open one day a month every year. That was the amount of data we were collecting. I see a very different vision now. I see a vision of having these sensors deployed so we are going to have our eyes open 24/7/365, and that will revolutionize what we understand ...." - Hilary Swain, Archbold Biological Station, 2008

GLEON 6, Feb08 Lake Annie
Linking Data from Lakes Globally

Typical Instrumentation

- Weather
- Thermistor chain
- Dissolved Oxygen sensor
- Chlorophyll fluorometer
- CDOM fluorometer
- Turbidity
- pH
- CO2
- PAR penetration
- ADCP
- etc

Source: Tim Kratz
Of 4665 samples from 1835 lakes worldwide, 87% were supersaturated.

Why?


Source: Tim Kratz
Communicating with the Public

http://www.uctv.tv/search-details.asp?showID=1586
Shown UCSDTV 19 February 2009, UCTV 2 March
GEO and Telescience: PRAGMA – GLEON Partnership
Integrate Remote and Land-based Measurements:
Joint effort of AIST-Japan & NSPO/ NARL-Taiwan

Lake Rotorua in New Zealand
Source: Deniz Özkundakci

Aster data, Source: R. Nakamura
Color is surface temp, centigrade

Formosat 2- Chl.Conc. Band Ratios
HDV@ Kenting
NCHC, NMMA, UCSD, TORI

NCHC, Hsinchu (4M, 1M)

NMMA, Kenting (10M)

http://140.110.31.130/SC/

Source: Fang-Pang Lin

PRAGMA 14 March 2008 Taiwan
CREON Integration Meeting Started
Ask the Right Question

• How do we structure partnerships to succeed?
  – Philip Papadopoulos
Lessons Learned in Building e-Communities

- **Repeated** semi-structured, high-quality, **face-to face interactions** (workshops) to build the community
- Group **focuses** on enabling science outcomes
- Technology builders give **tutorials** on capabilities
- Science + Technologists work **side-by-side**
- **Culture of openness and sharing** of know-how and software
- **Continue to experiment**: Applications, Technologies, Meetings (structure, types), People (and students)
- **Baby steps**: and more baby steps (**Learn by doing**)
- **Break bread together**
- Stay **PRAGMAtic**

But is there a conceptual framework to guide growth and to measure success?
Sense of Community

- A concept in social psychology that focuses on the experience of community rather than its structure, formation, setting, or other features.
  - Membership
  - Influence
  - Integration and fulfillment of needs
  - Share emotional connection

Source: Grace Hong, LSE MA Thesis
A Question for the Future of Virtual Teams and Community

- How can we model e-Science collaboration, programs and networks around social psychological values for developing communities of which members maximize both the intellectual and technological strengths?

Virtual Organizations as Sociotechnical Systems
NSF Program Announcement

Sense of Community

Systems: Networks Collaborations
Processes: Group formation Collaborations
People: Colleagues Sensibilities

Technology enables collaborations, people make it happen
Societal Needs
- Environment
- Health
- Energy and Resources
- Cultural Heritage

Technologies
- Instrumentation
- Information Technology: Networking, Data Storage, Computing

Challenges/Opportunities
- Data: Acquisition to Synthesis Pipeline
- Collaboration: International Virtual Grass-Roots Communities

Education: Societal Imperative
- Why
- Burden of Knowledge
- Possible Model
- Education for a Sustainable Planet
Ask the Right Question

• How can we prepare students for the new world of global research and societal challenges, synthesis, virtual communities, and a global interconnected economy?
  – Gabriele Wienhausen
Why Should We Care?

• “Most of the major problems facing our country in the 21st Century require every young person to learn more about the world’s regions, cultures, and languages.” [Colin Powell]

• Our (US) society is heterogeneous, multicultural

• Less than 1% of US undergraduates in US study abroad [IIE AnnRep05]

• Only about 22 percent of Americans have passports; many Western European countries the number is much higher—reaching 71 percent in the United Kingdom. [Newsweek]

• Students must be prepared to compete globally for jobs and opportunities
People and Teams

• I sit here and talk, talk, talk about innovation, but it’s people who turn ideas into positive and productive innovation. And in today’s knowledge-driven world, innovation will depend on people who are actually technologically sophisticated, have strong critical thinking skills, have expertise in math and science and engineering. (Steve Ballmer's Address to the Democratic Caucus - CEO, Microsoft, 6 Feb 09)

• "One of the things we look for in American applicants particularly is work-study abroad," said a representative from Google at UCLA International Center, NAFSA: Association of International Educators (28 Oct 08)
Burden of Knowledge
and "Death of the Renaissance Man": Is Innovation Getting Harder?
Benjamin F Jones
Review of Economic Studies Jan09

• If knowledge accumulates as technology advances, then successive generations of innovators may face an increasing educational burden.

• Two observations
  – First, innovators are not born at the frontier of knowledge but must initially undertake significant education.
  – Second, the distance to the frontier may vary across fields and over time.
Facts about Innovation Behavior

• Increasing in time substantially
  – (i) the age at first invention, serving as a proxy measure for educational attainment
  – (ii) a measure of specialization
  – (iii) team size

• In cross-section, using a measure of "knowledge depth" and show that
  – (iv) teamwork
  – (v) specialization

  are greater in fields with deeper knowledge.

• The final fact is then particularly surprising:
  – (vi) the average age at first invention is strikingly similar across fields, and does not vary with depth of knowledge
Burden of Knowledge: Implications

• Troubling data and model implications
  – Burden of knowledge growing (inevitable by-product of technological progress), but lack of “scale effect”
    • Increase in R&D has not increased rate of “innovation”
    • Potential negative implications for long-term economic growth

• Possible escapes
  – A technology that collapses knowledge to shorten distance to the frontier (easing inter-generation transmission of knowledge)
  – Education policy revisions to increase transfer of knowledge (human capital) to young
Pacific Rim Experiences for Undergraduate (PRIME)

Providing students international interdisciplinary Research Apprenticeships and Cultural Competency Learning Experiences

*Began in 2004 as*

a proof of concept for honing undergraduate research and cultural competency skills

an intensive international experiential learning experience
2004 – 2007: There are 5 host sites: Osaka, NCHC, Monash, CNIC; NCREE
New in 2008: USM, U Auckland, U Waikato, New 2009 U Hyderabad; National Institute for Information and Communication Technology; Doshisha University; Academia Sinica, NMMBA

Source
Cindy Zheng
PRIME at SC08 and IEEE eScience

- Identification of a Specific Inhibitor for the Dual-Specificity Enzyme SSH-2 via Docking Experiments on the Grid. Pham, Phil; Marshall Levesque (UCSD); Kohei Ichikawa, Susumu Date (Osaka), Jason Haga (UCSD).

- Virtual Screening for SHP-2 Specific Inhibitors Using Grid Computing. Han, Simon X; Marshall Levesque (UCSD); Kohei Ichikawa, Susumu Date (Osaka), Jason Haga (UCSD).

- Optimized Rendering for a Three-Dimensional Videoconferencing System. Chu, Rachel, Daniel Tenedorio, Jurgen Schulze (UCSD); Susumu Date, Seiki Kuwabara, Atsushi Nakazawa, Haruo Takemura (Osaka); Fang-Pang Lin (NCHC).
• PRIME students working with elementary and middle school age students in rural Malaysia, learning firsthand through their Universiti Sains Malaysia mentor the need for scientists to reach out to their communities and improve education, especially in the Science, Technology, Engineering, and Mathematics (STEM) area (July 2008).
PRIUS and MURPA: Based on PRIME
New Models for Building Research Capacity
and Cultural Awareness

PRIUS

Monash U

Osaka University

MURPA

Monash U

 PRIUS

PRE-INTERNSHIP PREPARATION
requires faculty mentoring/interaction to
articulate a proposed research project:
cultural counselling/mentoring
orientation session

12 Oct 05

31 Jul 08
MURPA: Monash University Research Program Abroad

• Research and cultural experience to develop and grow people to become innovators and leaders by being able to work in diverse teams
• First year of program – four students came to UCSD, January – February 200
Telesciences and Education

• MURPA students make “two point” HD VTC presentation: From UCSD to Monash and NiCT (23 February 2009)

Let’s use this technology
Welcome
From PRAGMA to CEPERC: An Opportunity from Success to Excellence

Continued Evolution of Community Building

Pacific Rim 32 Institute members
Resource, Telescience, BIO, GEO Working Groups

PRAGMA

CollabTech Lab
Advanced Geo-Lab
Science Park
CyberInfrastructure
Knowledge Center

Domain Communities

NSF-NSC
Research
LTRER
GEOSS
TERN
WATERS
Visitng
New project

Education & Training
PRIME
EAPSI
SEAP
High School
Postdoctor
Master Course

NARL
ITRC
NSPO
NCDR
NCHC
TTFRI
NCREE
TORI

Synergy of NARL Environmental & Disaster Prevention Strength
Developing Leaders and Innovators: Through hands on experience and mentoring

Components

• Development
  – Team Building
  – Cultural Awareness
  – Communications
  – Policy Implications

• Mentoring

• Team Research

• Immersive International Experience/Activity

• Dissemination

• Assessment/Tracking

- Personal Goal
- Requires many partners
- Create program to improve education

Four principles follow
Wisconsin Idea: Benefit Society

• The boundaries of the university should be the boundaries of the state, and that research conducted at the University of Wisconsin System should be applied to solve problems and improve health, quality of life, the environment and agriculture for all citizens of the state.
  – UW President Charles Van Hise in 1904.

• Van Hise declared that he would "never be content until the beneficent influence of the university reaches every family in the state."
“What nations don’t know can hurt them. The stakes involved in study abroad are that simple, that straightforward, and that important. … college graduates today must be internationally competent.” [Lincoln Report 2005]
Communicate with the Public

• Future government funding will be based on citizens and policy makers understanding the value of science.
• What are we doing to train students to communicate with the public?
  – Does Grandma understand what you are doing?
  – Grandma does vote (and so do policy makers)
Earth in Mind
On Education, Environment, and the Human Prospect
David W. Orr

• Where does your field of knowledge fit in the larger landscape of learning?
• Why is your particular expertise important? For what and for whom is it important?
• What are its wider ecological implications and how do these affect the long-term human prospect?
• Explain the ethical, social, and political implications of your scholarship.
Societal Needs, Technology Challenges, Community Needs

**Societal Needs**
- Cardiovascular diseases 30%
- Cancer + Chronic respiratory diseases + Diabetes 30%
- Communicable diseases, maternal and perinatal conditions + nutrition disorders 10%
- Injuries 5%

**Technologies**
- Optical Networks Are Becoming the 21st Century Cyberinfrastructure Driver

**Challenges/Opportunities**
- Data: Synthesis
- Collaboration:
  - **A** Models
  - **B** Observations
  - Sensor networks
  - Questions
  - Random selection from Ecology 2003

**Education: Societal Imperative**
- Annual
- Monthly
- Weekly
- Daily
- Hourly
- Min.
- Sec.

Place work in larger societal context

David Orr: Earth in Mind
Acknowledgements

- Questioners: Fang-Pang Lin, Bill Chang, Phil Papadopoulos, Gabriele Wienhausen, Tim Kratz
- All PRAGMA members
- G. Wienhausen, D. Abramson, Kai Nan, FP Lin, Shinji Shimojo, S.Date- PRIME
- Susumu Date and Shinji Shimojo, Osaka University – PRIUS
- David Abramson, Ron Pose, Monash University - MURPA
- Tim Kratz, U Wisconsin; Fang-Pang Lin, NCHC, David Hamilton, U Waikato and many more – GLEON
- Larry Smarr – OptIPuter
- Wilfred Li – National Biomedical Computation Resource
- Tony Fountain, Tim Kratz, Ken Chiu, Rick McMullen, Sameer Tilak - Autoscaling
- Bill Chang, NSF for planting the seed and ongoing encouragement
- NSF, Gordon and Betty Moore Foundation, TATRC, NIH
- PRAGMA is supported by the NSF (Grant No. INT-0216895, INT-0314015, OCI-0627026), the San Diego Supercomputer Center, and the California Institute of Telecommunications and Information Technology, The University of California, San Diego and member institutions
- PRIME is Supported by the National Science Foundation under NSF INT 04007508
- AutoScaling, NEON 0446802
- GLEON, CREON: Funding in part by Gordon and Betty Moore Foundation
- TATRC – for funding of avian flu international collaboration
- NBCR – for biomedical infrastructure, funded by NIH