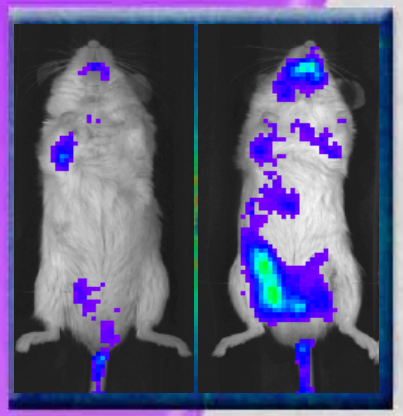
EDUCATION

DISCOVERY



TECHNOLOGY

Team Science

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UCDAVIS

Key Words in Team Science

"Technology knows no discipline. Technology knows a function. You have to drive that technology and *then* find the discipline to do it."

Lynn Preston - NSF

http://nextwave.sciencemag.org/cgi/content/full/2003/01/15/5

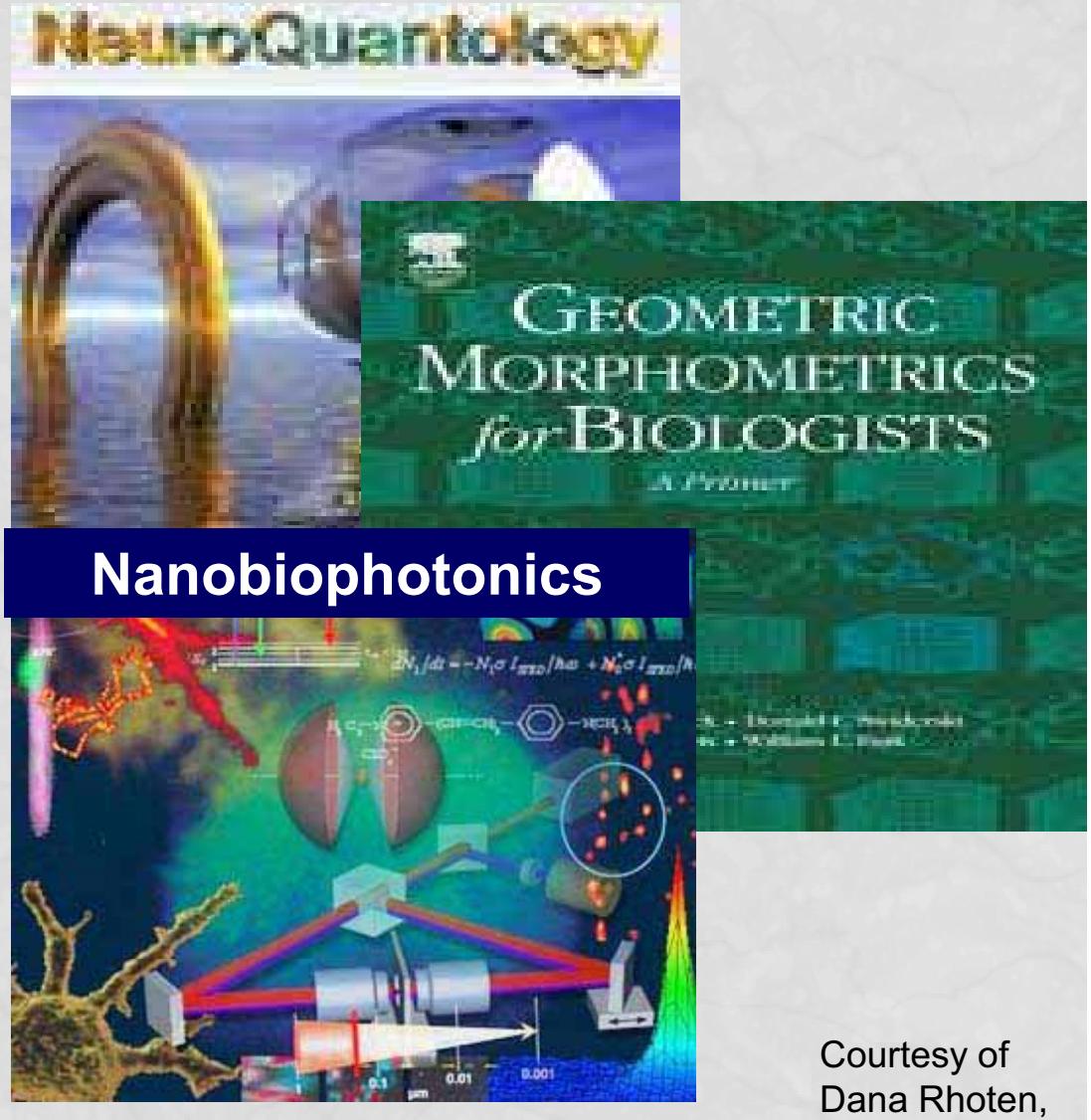
Interdisciplinary - *research and development based on new paradigms emerging from collective knowledge and expertise – participants not constrained by traditional disciplinary boundaries.*

Multidisciplinary - *research and development based on combined effort of specialists working within their respective fields.*

Science Engineering Medicine

From disciplinarity to interdisciplinarity

"I'M ON THE VERGE OF A MAJOR BREAKTHROUGH, BUT I'M ALSO AT THAT POINT WHERE CHEMISTRY LEAVES OFF AND PHYSICS BEGINS, SO I'LL HAVE TO DROP THE WHOLE THING."



Courtesy of Dana Rhoten, NSF

"Great discoveries and improvements invariably involve the cooperation of many minds."

-- Alexander Graham Bell

What is team science?

- ***What is it?*** - Mission-oriented research and development (R&D), based on the ***directed*** contributions, ***collective*** reasoning, discovery and actions of a ***group*** of individuals that may have different skills, knowledge and expertise

Attention to teamwork has secured wins for the New England Patriots.

Examples

- Multidisciplinary team focused on a common research problem or mission
- Multidisciplinary team focused on developing a product (new tools, new technology for clinical applications, etc.)
- Teams using shared facility/instrumentation/database
- Team carrying out clinical trials
- Team working at large-scale production facilities for development of research resources

Motivation for Team Science

- **Widespread need to address complex problems that cut across traditional disciplines**
  - Single investigator model limits scope of problems that can be addressed and rate of progress.
  - Many disciplines may be needed (i.e., biology, chemistry, physics, engineering, medicine, etc.)
  - Input/effort often required from scientific, technological, clinical, and/or commercial viewpoints
- **There is an emergence of new technologies that can transform existing disciplines and continuously generate new ones**

Motivation for Team Skills

- Note value of teamwork on the list of overall skills for entering the workforce

There's no "I" in Team

For new entrants with a four-year college diploma, applied skills are the top five "very important" skills in combined ranking with basic knowledge and skills.

Rank	*Skill*	
1	Oral Communications*	95.4%
2	Teamwork/Collaboration*	94.4
3	Professionalism/Work Ethic*	93.8
4	Written Communications*	93.1
5	Critical Thinking/ Problem Solving*	92.1
6	Writing in English	89.7
7	English Language	88.0
8	Reading Comprehension	87.0
9	Ethics/Social Responsibility*	85.6
10	Leadership*	81.8
11	Information Technology Application*	81.0
12	Creativity/Innovation*	81.0
13	Lifelong Learning/ Self Direction*	78.3
14	Diversity*	71.8
15	Mathematics	64.2
16	Science	33.4
17	Foreign Languages	21.0
18	Government/Economics	19.8
19	History/Geography	14.1
20	Humanities/Arts	13.2

Authors Jill Casner-Lotto, Linda Barrington

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The “Subtle” Motivation for Teams…

Stages of successful collaboration

	Stage One	Stage Two	Stage Three
Knowledge Engagement	**Expert**	**Coordinated**	**Collaborative**
Work Orientation	**Individual**	**Group**	**Team**
Leadership	**Top-Down Management**	**Facilitative Support**	**Web-like Empowerment**
Disciplinary Orientation	**Dominant**	**Parallel**	**Integrative**

Adapted from Amey, M. and D. Brown. 2002. Interdisciplinary Collaboration and Academic Work: A Case Study. Paper presented at annual meeting of the Association for Study of Higher Education.

Courtesy of Dana Rhoten, NSF

Team Science at Different Levels

- **Project Level** (i.e., NIH R01): single mission, multi-investigator, common research goals.
- **Program Level** (i.e., NIH P01): multiple projects, multiple investigators, common themes or goals.
- **Center Level**: multi-institutional, massively multi-investigator, new organizational paradigm for addressing grand challenges.
- …….

The Center for Biophotonics Projects integrate Disciplines, Institutions, Education, Industry into TEAMS

- No single investigator projects – only multidisciplinary research team
- Multi-institutional strongly encouraged
- Education Components
  - UG/G research
  - Cross age teaching
  - Teacher-scientist-physician-student teams (e.g., CURE grant from NCI)
  - Career development education/opportunities at all levels of education
- Collaborations with Industry also encouraged
  - Multi-disciplinary researchers, multi-institutional with industry participation to expedite commercialization
  - Industry internships for both UG and G students
  - Team can also include MBAs, Venture Capitalists in addition to scientists and engineers and students- --- startup company model

Spotlight Surgical, Inc.

Sacramento Angels

Biosense Webster
a Johnson-Johnson company

OLYMPUS

BIO-RAD

AppliedPrecision®

Ingredients for Successful Team Science

- **Leadership:** vision, enthusiasm, commitment, true team spirit
- **Communication:** time, effort, technology, training
- **Management structure:** integrate leadership and communication
- **Team-friendly environment:** integrity, trust, respect, sharing
- **Institutional commitment:** space, administrative support, faculty investment

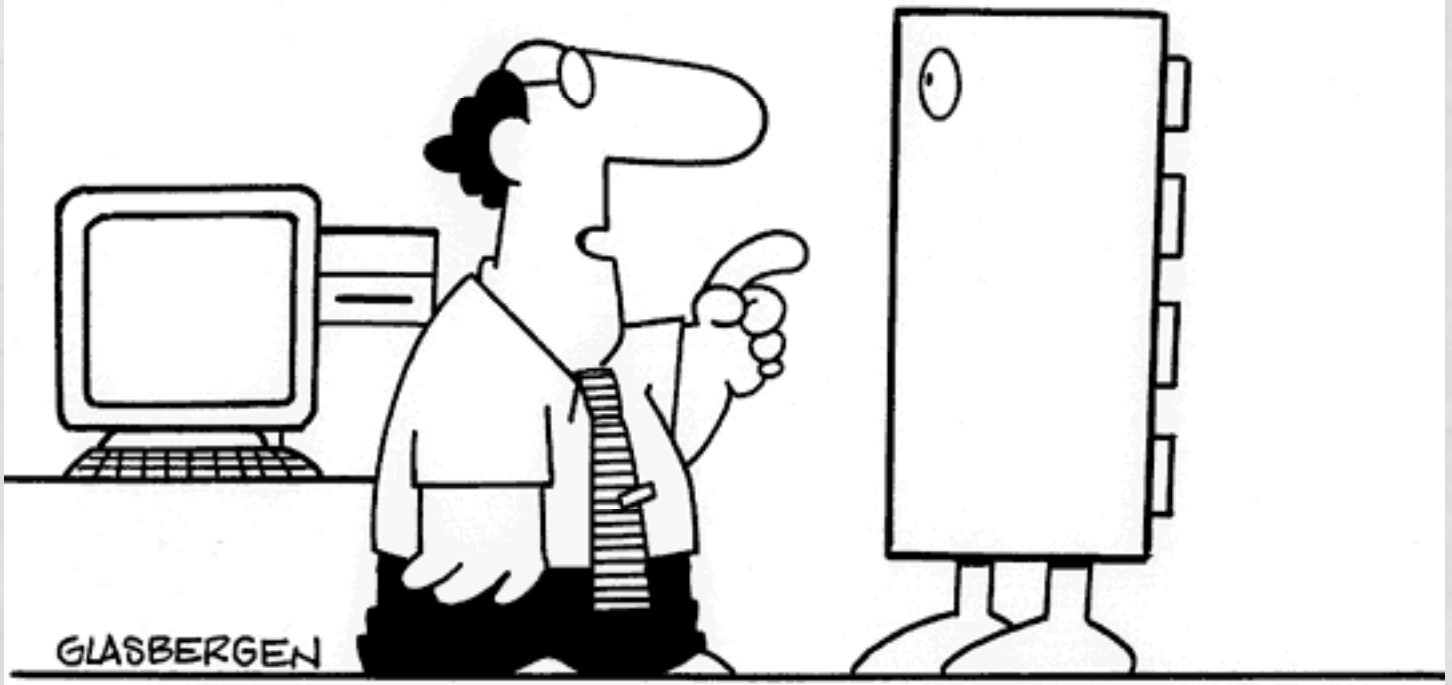
Common to all models

Adapted from BECON 2003 Symposium

Common needs

- **Administrative support**
  - Small teams: may be provided by external organizational unit administrative staff
  - Larger teams: need full-time, dedicated, and skilled staff; PhD-level staff can be highly effective but future career path for such staff is uncertain
- **Support structure for junior faculty, graduate students and post-doctoral fellows**
  - Mechanism for individual publication
  - Seed funds
  - Access to special resources
  - Mentoring
- **Administrative plan**: to take care of problems, to manage crises
- **Evaluation/assessment plan**: to set goals, measure success
- **IP management plan**
- **Phase-in and phase-out mechanisms**: ramp-up period; finite lifetime and sustainability options
- **Continued funding**, after initial grant expires

Adapted from BECON 2003 Symposium



"I want everyone at the meeting to dress up like Lego blocks. Then we can see exactly how each team member interlocks with the other team members in the project."

"We've got 57 team managers, 36 project coordinators, and 63 concept implementors— not bad for a company with only 18 employees!"

Advantages/Disadvantages of team-based science

Disadvantages	Advantages
Increase time to completion	**Reduce duplication of effort**
Increase individual interaction costs	**Maximize total available resources**
Introduce process "bottlenecks"	**Enhance research impact**
Suffer from "turf" wars	**Benefit from collective creativity and diversity of perpective**
Create short-term conflicts	**Engender long-term collegiality**
Dilute specializations	**Distribute knowledge**
Challenge individual notions of research success	**Discover holistic solutions to research problems**

Courtesy of Dana Rhoten, NSF

Obstacles to Team Science

- Society rewards the “hero”
- Lack of willing participants
- Fragmented infrastructure
- Cultural differences
- Lack of qualified investigators
- Merit package typically does not recognize or emphasize!
- Practical limitations
- High research costs
- Lack of funding

Communication and Cultural Barriers

Laboratory peer pressure

- Distinct professional languages and organizational cultures
- Varied definitions of success
- Different methods of research
  - Docs do research on weekends
- Different driving forces for technology development
- Different research end-points and metrics for success

Institutional Constraints

- Host institution organizational units may pose barrier to multi-investigator collaboration (Depts vs. Centers/Institutes)
- Partner institutions may introduce new constraints
- Physical separation (geographic distance) between lab and facilities and colleagues
- Negotiation of intellectual property, patent rights, etc.

Funding Limitations

- Grant awards too small to divert core funding towards establishing or maintaining interdisciplinary activities.
- Significant increase in indirect costs
- Lack of seed funding for high-risk, potentially high-benefit collaboration
- Academic “credit” for research is proportional to amount of indirect costs retained by the institution (normally awarded only to the PI)

Other issues of concern

- Young investigators and career development
- Intellectual property management, royalty distribution
- Authorship of papers – who is the lead?
- Metrics for success/failure
- Value of “team-centric” versus “PI-centric” science
- Longer lead times to build team and become productive
- Project phase-out and/or sustainability logistics
- ….

Adapted from BECON 2003 Symposium

Lessons Learned and Challenges in Teaching Team Science

- **Lessons learned**
  - **Teach by example -**
  - **Use examples and m**
    audience (i.e, physic
  - **Ensure problems ch**
  - **Advancing science b**
    educators, business
- **Challenges**
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    - Need merit package to include score for team participation

Lessons Learned and Challenges in Teaching Team Science

- **Lessons learned**
  - **Teach by example - engage in team *"learning"* from the start**
  - **Use examples and models which are relevant to the target audience (i.e, physics or biology or engineering or medicine)**
  - **Ensure problems chosen by teams really need teams**
  - **Advancing science beyond research - think about engaging educators, business management, industrial liaisons, etc.**
- **Challenges**
  - **The norm is Secondary School and University courses focused on specific disciplines**
    - Need curriculum/programs/centers/institutes for interdisciplinary research – especially in graduate school
  - **Non supportive system of rewards - too focused on development of "principal investigators"**
    - Need merit package to include score for team participation

Closing Points

- Team Science is amazingly productive and a natural cultural behaviour
- Today, new discoveries and technologies mostly lie at the nexus of disciplines, not within.
- Grad school tends to sterilize teamwork out of young minds – medieval principal of the lone scholar
- Universities don't encourage it because of the way they are governed (discipline departments) – must fix
- We need to reinforce the value of the research team in awards/recognitions, like in sports
- We are forming a new team-based biophotonics institute – University R&D, Science Ed Academy, Technology/NewCO Foundry – a return to Edison's skunk works but modernized to include team invention & teaching at the MS, HS, &Teacher level in addition to University

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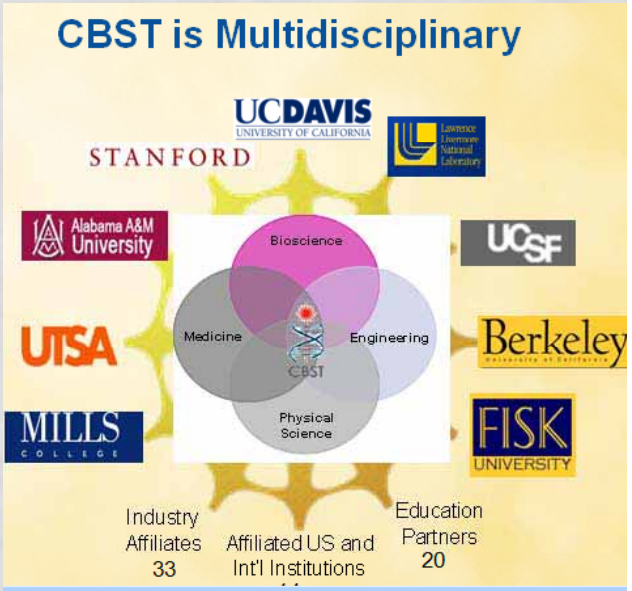

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ASU New College of Interdisciplinary Arts & Sciences
ARIZONA STATE UNIVERSITY

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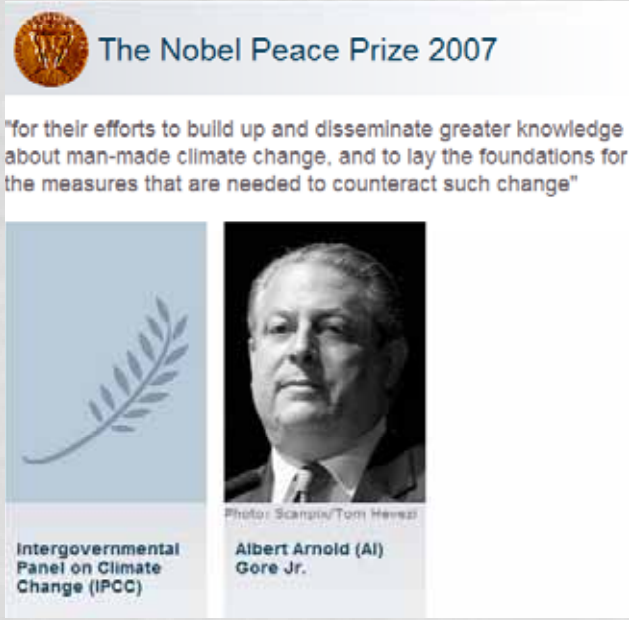

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