Advancing life sciences theory at the beginning of the century of biology when we have less money than we feel we need to fund all of the exciting research there is –

So what is an ambitious, talented, creative Directorate to do?

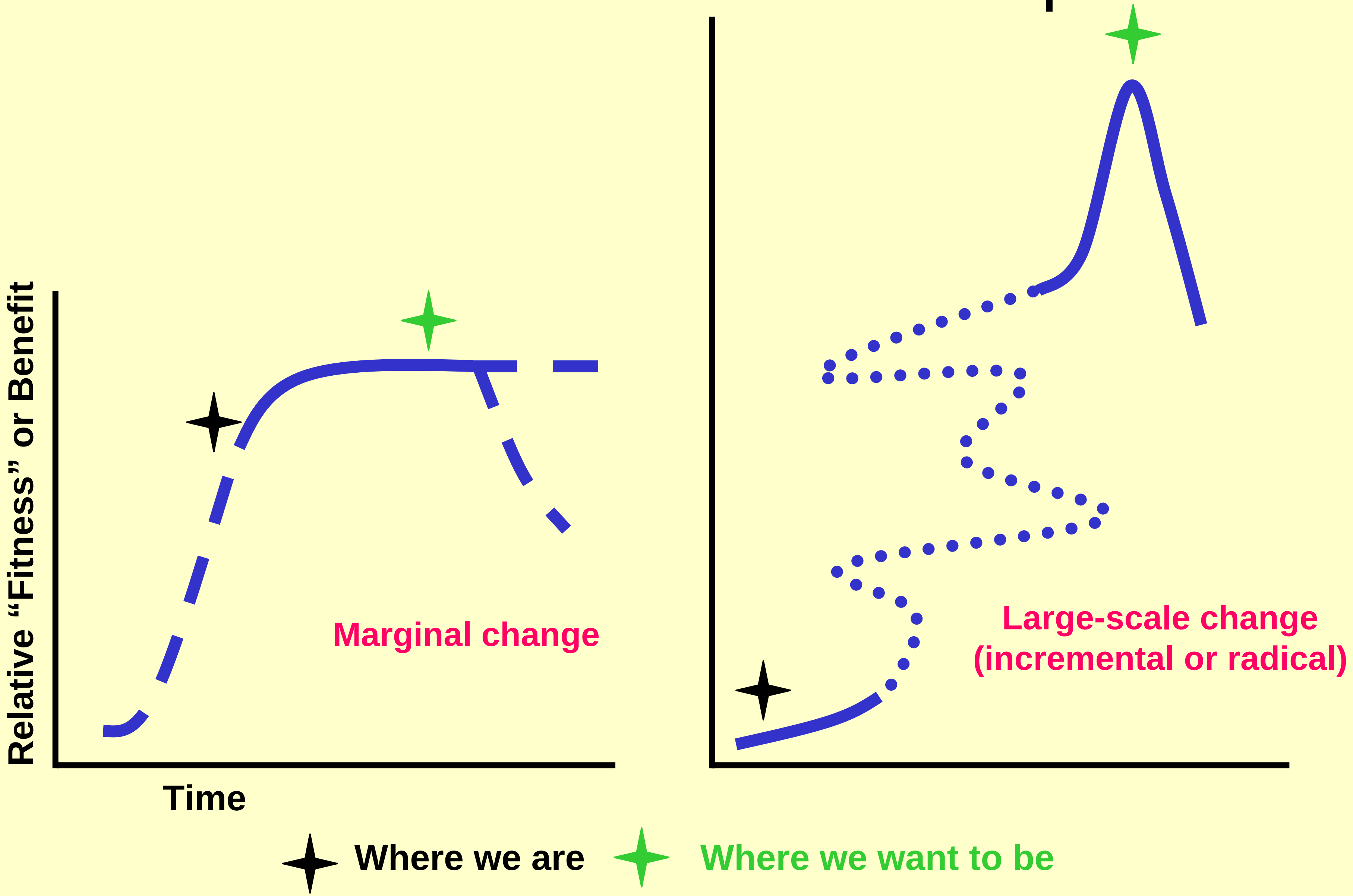
BIOAC

November 17 – 18, 2005

Outline

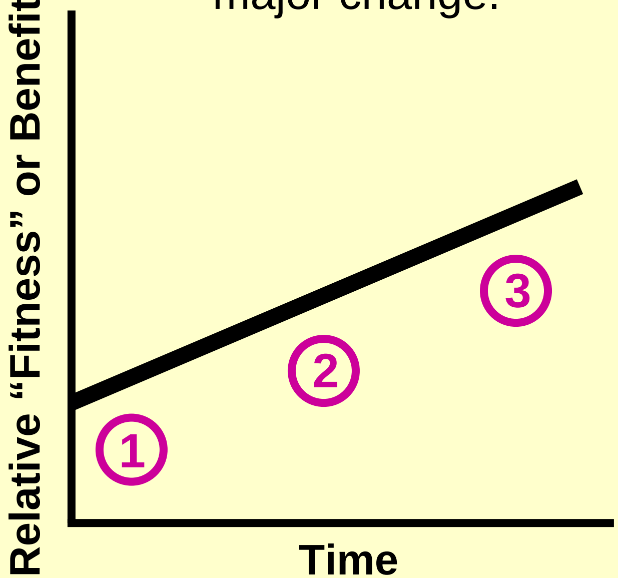
- **How do we change science programs?**
- **How can we transform biological research in the early 21st century?**
- **What are BIO’s core competencies?**
- **Are there some general lessons associated with transforming programs?**
- **Central challenge: How do we operate the BIO of today while becoming the BIO of tomorrow?**

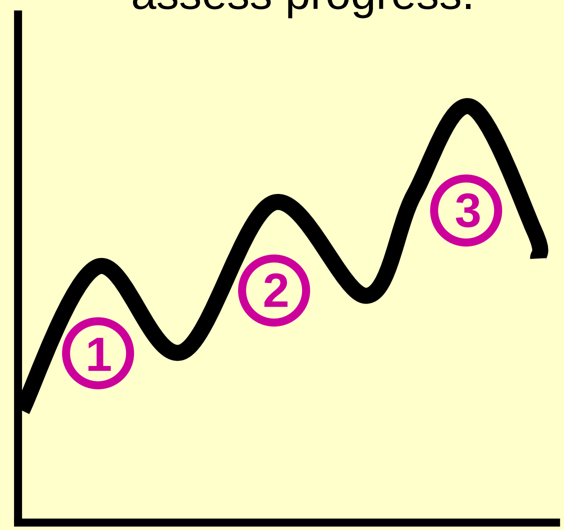
How do we change science programs?
Research “Fitness Landscapes”



A model of institutional change in which bottom-up, self-organized efforts can prevail. Progress is possible without significant costs, and achieving recognition for the merits of progress is relatively easy. Likely an unsuccessful model for major change.

A model of institutional change in which significant investments of leadership and resources need to be made to negotiate the "troughs." The ordinate can be any of a number of measures a research program might use to assess progress.



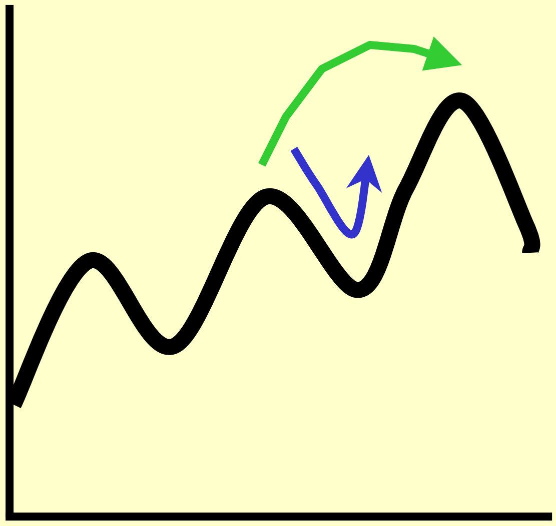


(1) = individual investigator (2) = 1 + collaborative (3) = 2+ interdisciplinary

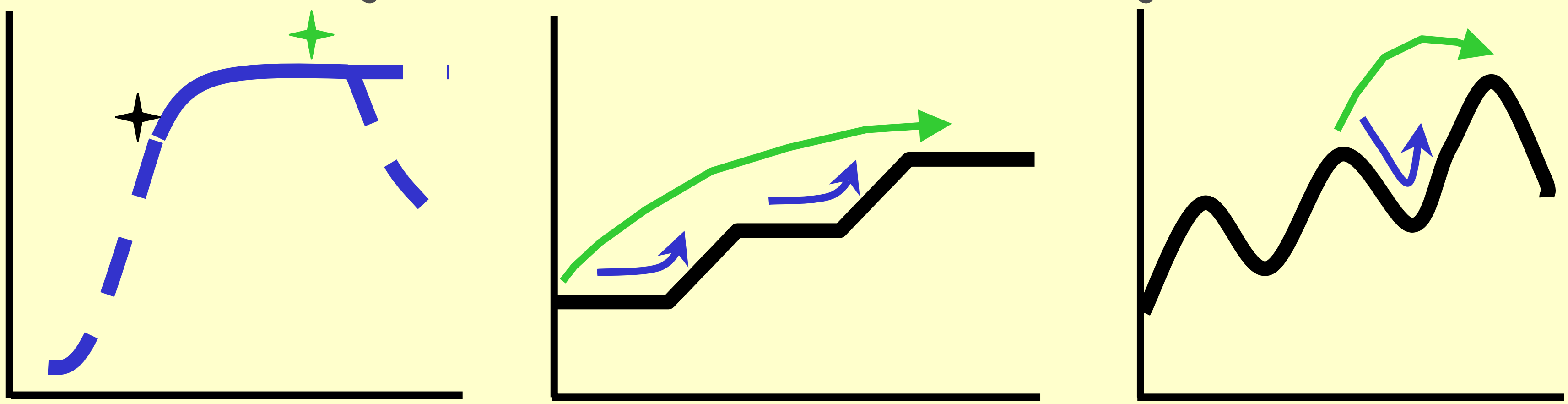
Developmental Stage

Peak Model

- Incremental change
  - Possible, but requires patience, leadership, and resources to offset temporary erosion in ‘fitness’.
  - Institutional pressure to avoid troughs is often high, and could prevent progress.
- Revolutionary change
  - May be difficult to achieve because of colleagues “left on a prior peak.”
  - What are the costs of sustaining both peaks? In business this type of change is characterized as the “Innovator’s Dilemma.”

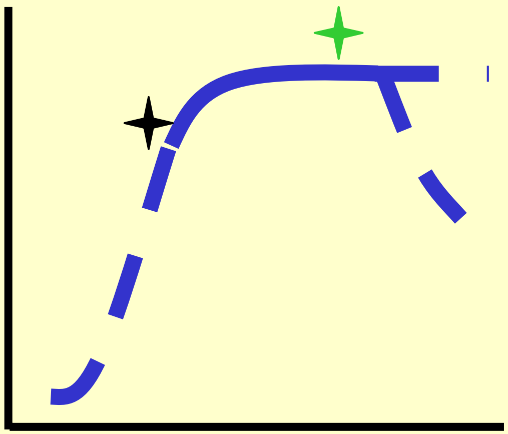
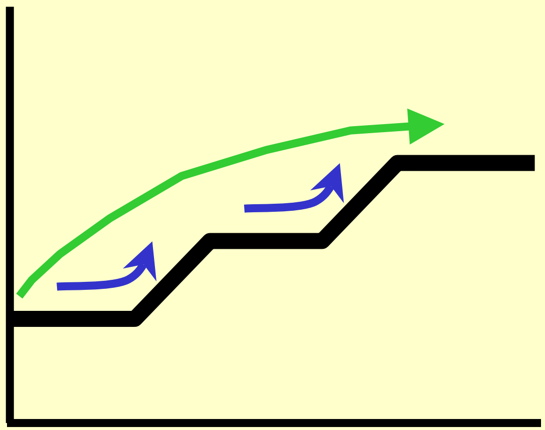
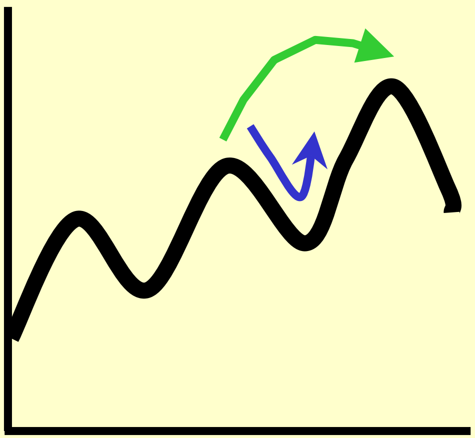


Challenges



- **Which model applies? Does it matter? Does the appropriate model differ for research, education, and outreach activities? For different types of research institutions?**
- **What does this mean for the steps we take in creating the NSF of the 21st Century? What are the biggest potential gains and the largest potential pitfalls?**

Some questions for consideration…

- If only marginal change is needed, why has fostering change in some areas, like improving access, been so slow?
- Will incremental change be fast enough to meet our responsibilities for improving the scientific capacity of the US?
- How do we foster radical change? How do we ensure we land on a peak? How do we know we're on a peak?

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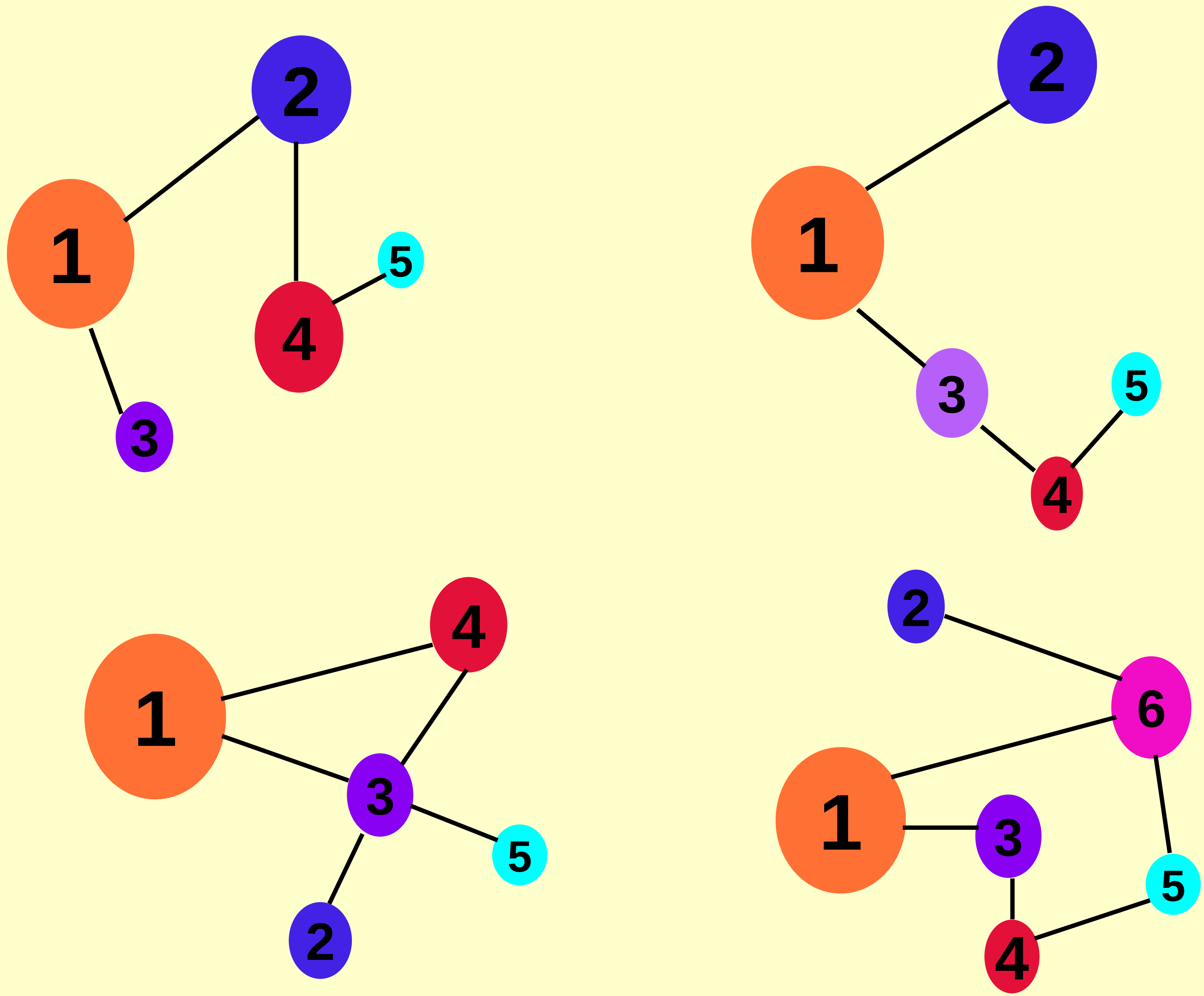
How can we transform biological research in the early 21st century?

Biology at the frontier: stimulating the development of research areas that the research community needs but has not yet imagined…

Transforming biological research by <u>integrating</u> research projects, programs, and networks…

Constellations of scholars



21^{st} Century Biology

- Multidisciplinary
- Multidimensional
- Information-driven
- Education-oriented
- Internationally engaged

21st Century Biology

“… the 21st century is going to see a cohesion of the sciences and disappearance of their borders.”

- David Baltimore

Technological Convergence and the Evolution of Life Sciences R&D

- big biology
- big rewards
- big dilemmas
- big shifts in science policy

The Rise of Big Biology

- individual investigator and laboratory → multi-disciplinary teams and networks
- low capital base → high cost platform technologies
- limited datasets → massive datasets
- analysis of isolated elements → integrative, systems biology

The Rise of Big Biology

• few competitors and slow academic commercialization	• rapid commercialization and genesis of new competitors
• low intensity IP climate	• intense “land grab” era and broad IP claims
• incremental change and easy “catch-up”	• discontinuous change • high cost penalty for delays and wrong choices
• harnessing innovation within a sector	• leveraging value from convergence between sectors…..

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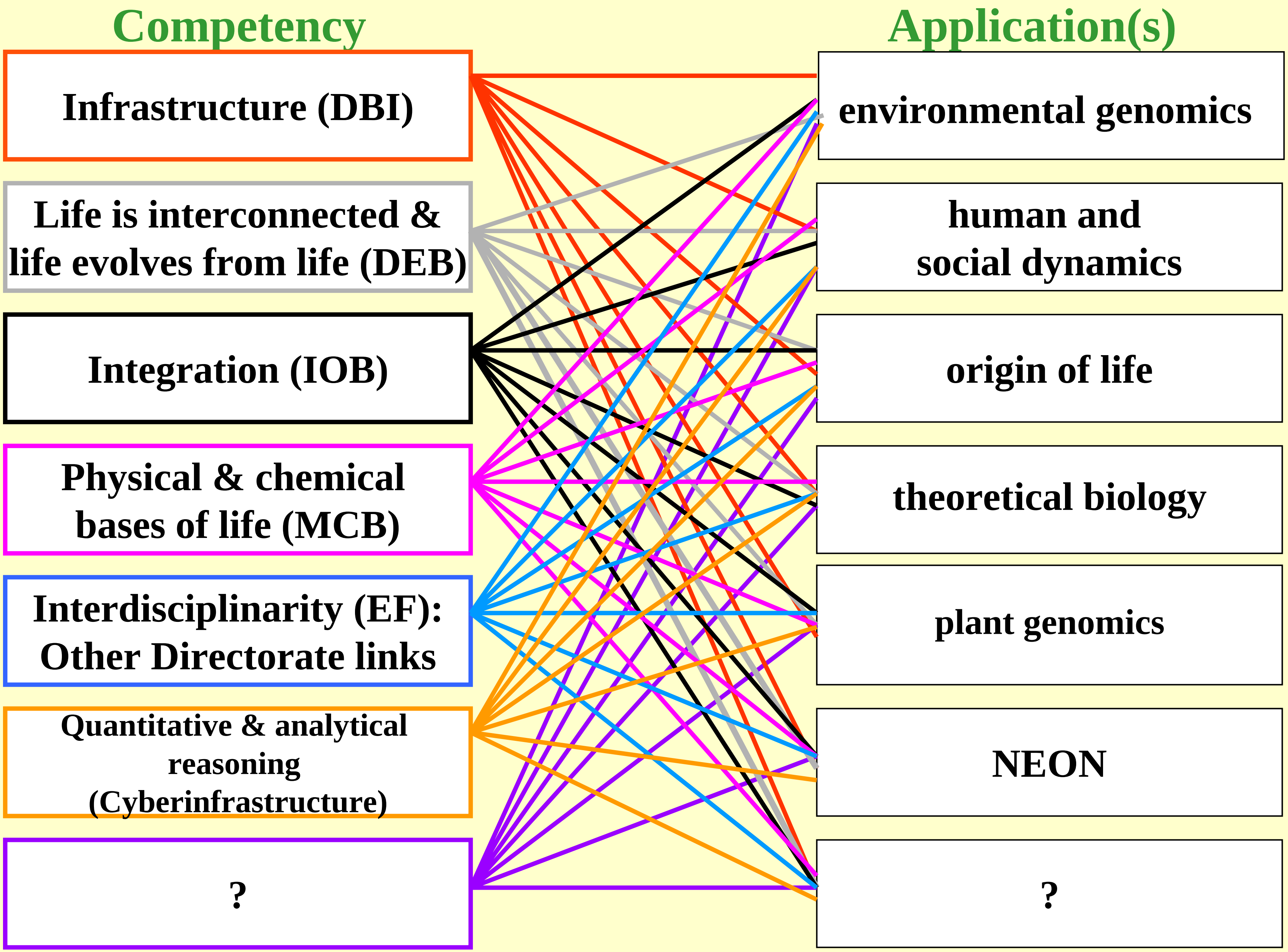
What are BIO's core competencies (not core programs)?

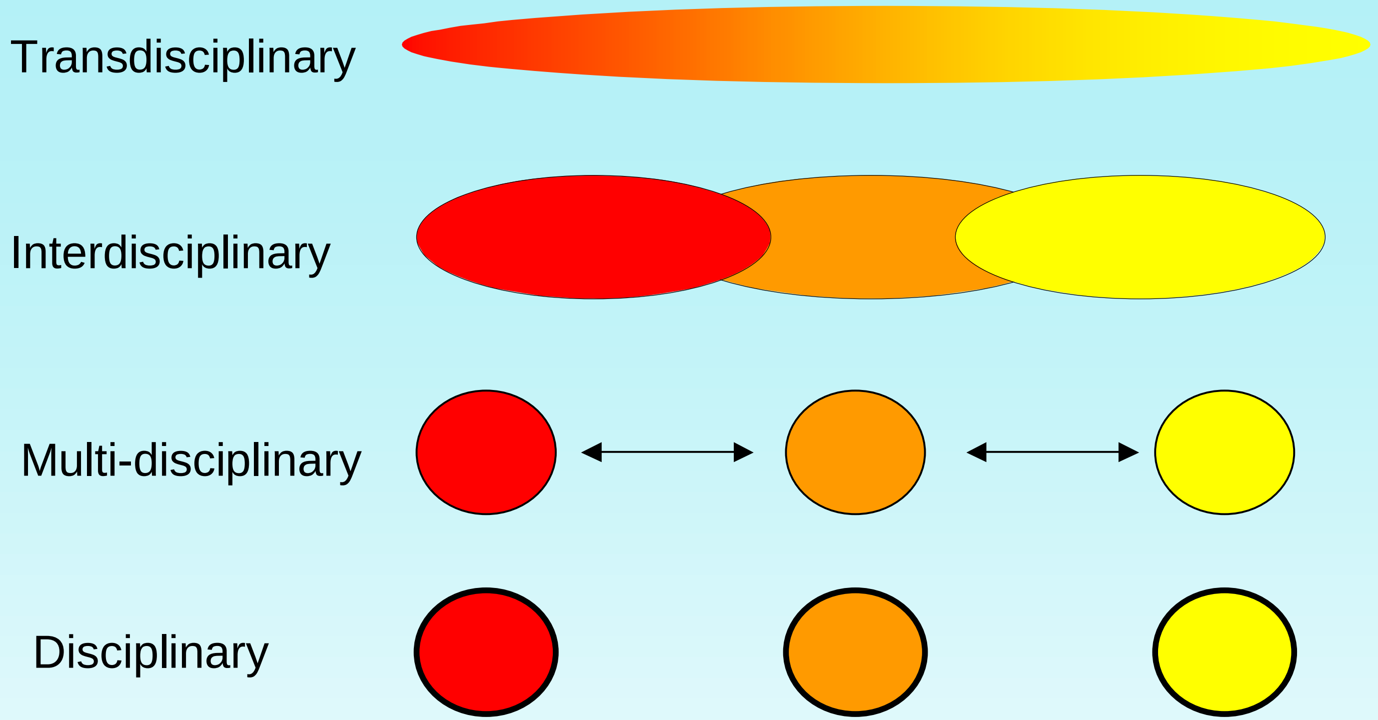
Core competencies are the collective learning in the organization, especially how to coordinate diverse skills and integrate multiple streams of information and technology. Core competence is based on communication, involvement, and a deep commitment to working across organizational boundaries.

What is BIO really good at? What do you value most? What do we need to keep this edge?

What competencies are required to make BIO the best research institute in the world?

BIO's competencies and principal applications





What do we mean by transformative research?

Two examples from BIO: Plant Genome Research and NEON

Plant Genome Research and NEON presentations:

Machi Dilworth

Elizabeth Blood

Central challenge:

How do we <u>operate</u> the BIO of today while <u>becoming</u> the BIO of tomorrow?

Current Issues in BIO

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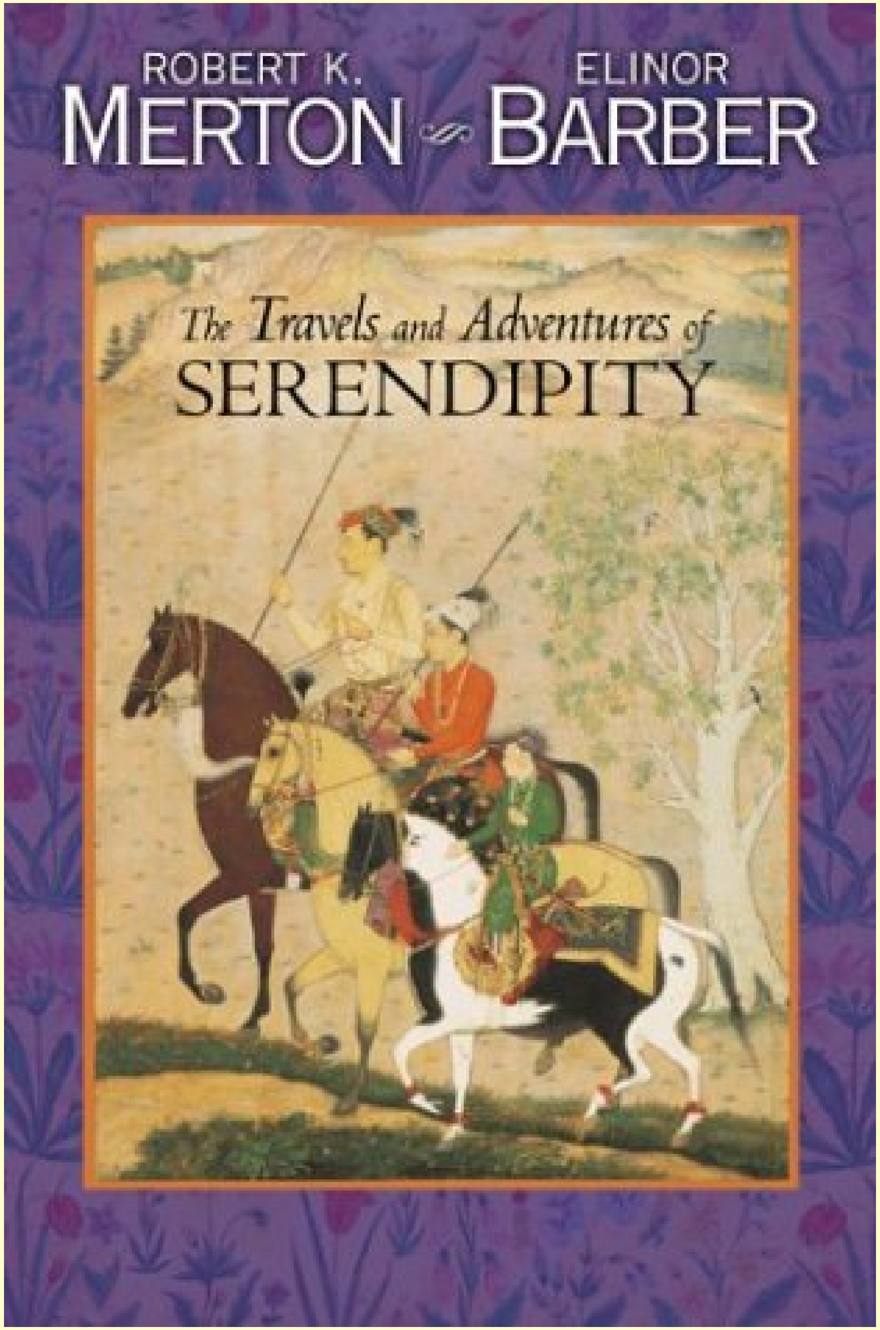
How is BIO today a distinctive model?

Scientifically, leading areas for BIO/NSF include:

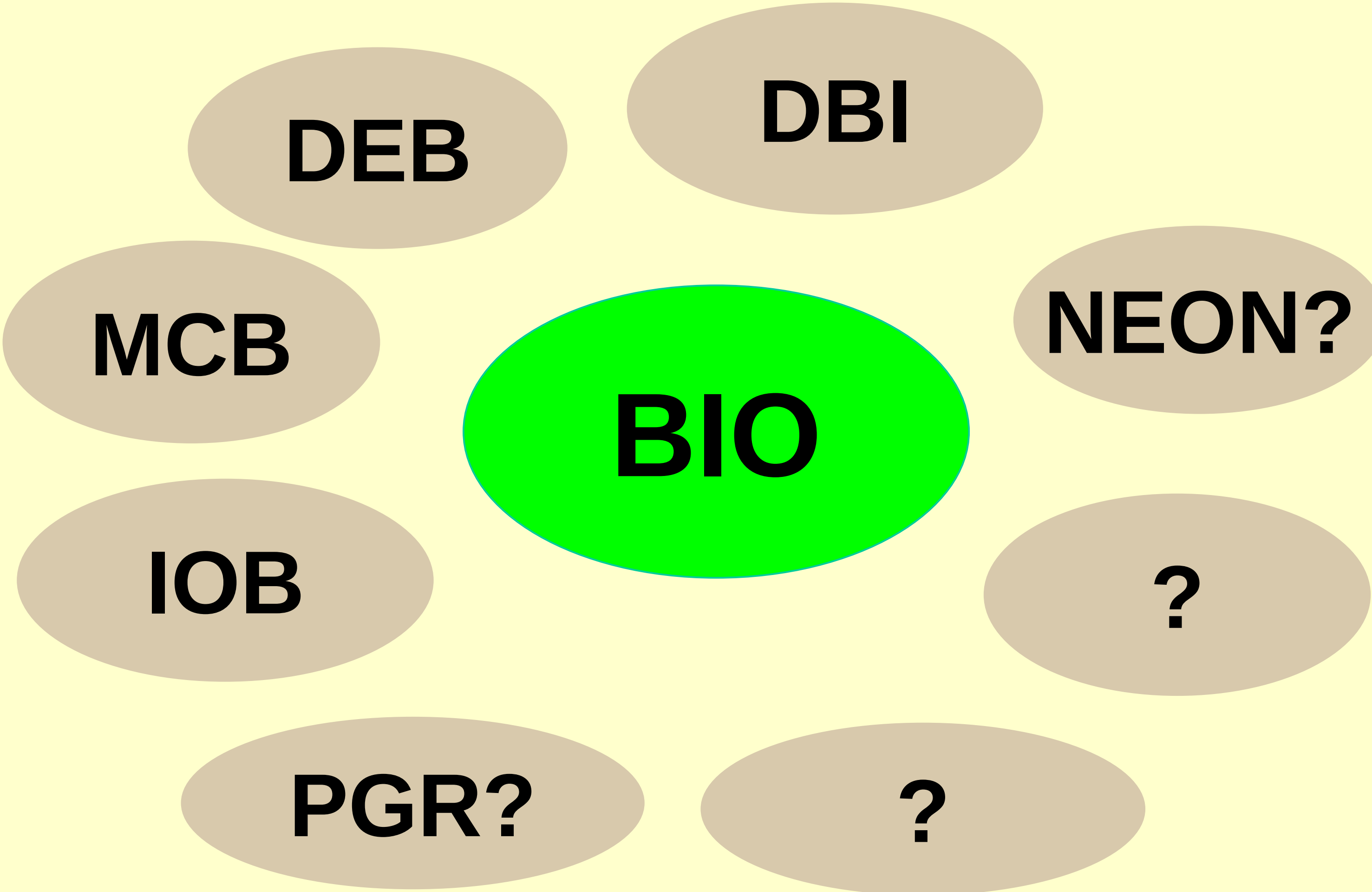
1) Environmental biology
2) Microbial biology
3) Plant biology
4) Integrative biology, including especially the study of "non-model" organisms

How do we ensure that BIO tomorrow remains a distinctive model?

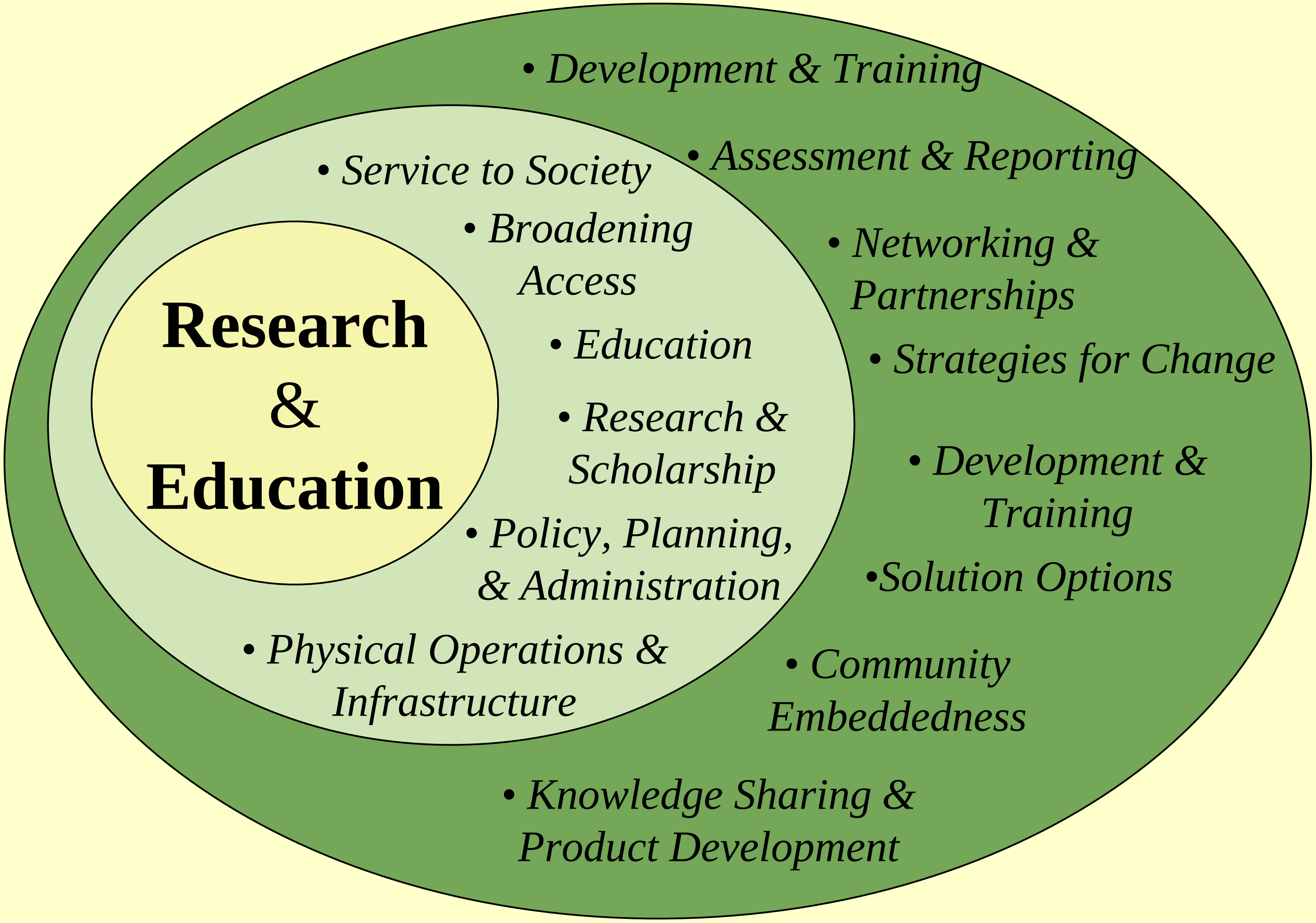
The two faces of “chance”….



A “federation” of competencies (divisions)



BIO as exemplar of an integrated NSF Directorate



How is BIO today an organizational leader?

1) Working across "boundaries" (Clusters, Divisions, Directorates [disciplines], agencies)

2) One biology - ALL of biology within a single organizational unit with extensive cooperation and coordination

3) Large proportion of rotators - working scientists who help identify scientific frontiers and serve to connect us to the wider research community

4) "Bottom-up" heavy: ~$475 of the $575 M in BIO used for "unsolicited" proposals

How can we ensure that BIO tomorrow remains an organizational leader?

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Are there some general lessons associated with transforming programs?

Developing transformative research, training, and administrative programs is easier said than done.

Step one is deciding exactly what it means to have such a program;
Step two is making it happen;
Step three is creating, sustaining/renewing, or disassembling the organization.

Some general lessons:
What makes for successful innovation?

Ability to Self-educate	Build around a question using value proposition Build to foster serendipity (depth v. breadth tradeoff)
Understanding Intellectual depth	Align with central administrators Reshape central administrators Assume the task will be harder than you think
Communication	Build around people who get the message Reward participants Communicate the message consistently

Some general lessons:
What makes for successful innovation?

Problem definition	Imagine institutionalizing your program Create a vision Recruit like-minded colleagues to foster cultural change
Ability to handle criticism	Expect some things to fail
Willingness to take risks	Find resources; be entrepreneurial Keep student welfare at the forefront Protect junior colleagues
Perseverance	

Issues for further discussion

Values/priorities

Fund the best, most creative scientific research and training activities.

a) Wait for the science/training proposals to emerge from the community.
b) Stimulate submission/creation of that research/training.

Broadening access of underrepresented groups

How do we best broaden access of underrepresented groups:

a) support K-12 programs?
b) support undergrad programs?
c) support grad programs?
d) support postdoc programs?
e) support young PIs?
f) support senior PIs?

Epistemology

What is the role of Emerging Frontier's in BIO's portfolio?

a) Should we recess all multiple investigator, interdisciplinary proposals within an activity like Emerging Frontiers, and create no new programs, especially centers?

b) Should we continuing using Emerging Frontiers as a strategic portfolio element for large, multiple investigator, interdisciplinary proposals?

Budget/management

Proposal numbers are increasing and the budget is decreasing – what should we do?

How low can success rates go before we need a new model?

What do we value about a success rate of a particular quantity?

FY 2006 Request for R&RA Activities by Directorate

($ in Millions) FY 2006 R&RA Request by Directorate	FY 2004 Actual	FY 2005 Estimate	FY 2006 Request	FY 2006 Request: Change over FY 2005 Estimate $	FY 2006 Request: Change over FY 2005 Estimate %
BIO	587.05	576.61	581.79	5.18	0.9%
CISE	605.35	613.72	620.56	6.84	1.1%
ENG *(less SBIR/STTR)*	461.99	458.54	475.35	16.81	3.7%
SBIR/STTR	*103.58*	*102.76*	*105.33*	*2.57*	*2.5%*
GEO	713.41	694.16	709.10	14.94	2.2%
MPS	1,091.59	1,069.86	1,086.23	16.37	1.5%
SBE	184.30	196.90	198.79	1.89	1.0%
OISE	*40.83*	*33.73*	*34.51*	*0.78*	*2.3%*
OPP	341.72	344.36	386.93	42.57	12.4%
IA	163.52	129.91	134.90	4.99	3.8%
Research & Related Activities Total	**$4,293.34**	**$4,220.55**	**$4,333.49**	**$112.94**	**2.7%**

Note: Totals may not add due to rounding

BIO Budget Request by Priority Area

($ in Millions)

Priority Area	FY 2005 Estimate	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Biocomplexity in the Environment	39.86	30.43	-9.43	-23.7%
Nanoscale Science and Engineer	5.85	3.85	-2.00	-34.2%
Mathematical Sciences	2.21	2.21	0.00	0.0%
Human and Social Dynamics	0.50	0.50	0.00	0.0%

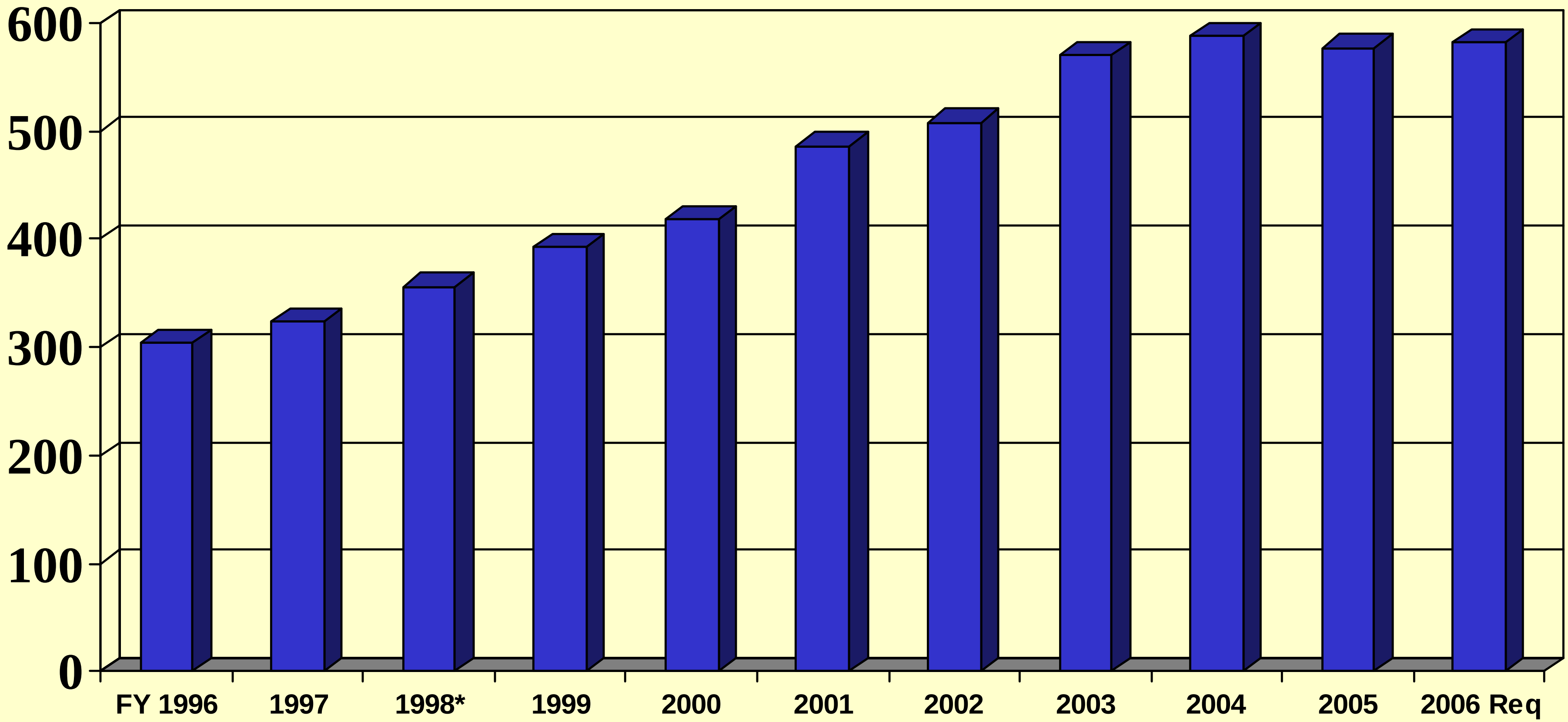
BIO Budget Request by Division

($ in Millions)	FY 2005 Estimate	FY 2006 Request	Change Amount	Change Percent
Molecular and Cellular Biosciences	118.16	109.75	-8.41	-7.1%
Integrative Organismal Biology	103.5	101.76	-1.74	-1.7%
Environmental Biology	106.04	107.18	1.14	1.1%
Biological Infrastructure	80.62	82.93	2.31	2.9%
Emerging Frontiers	74.05	85.93	11.88	16.0%
Plant Genome Research	94.24	94.24	0.00	0.0%
Total, BIO	**$576.61**	**$581.79**	**$5.18**	**0.9%**

Note: Totals may not add due to rounding

Growth in BIO Budget FY 1996-2006

(millions)



* 1998 – First year of Plant Genome funding

FY 2006 NSF Funding by Appropriation

Dollars in Millions	FY 2005 Estimate	FY 2006 Request	House Mark	Senate Mark	Conference
Research and Related Activities	**$4,221**	**$4,333**	**$4,378**	**$4,345***	**$4,388***
Education and Human Resources	**$841**	**$737**	**$807**	**$747**	**$807**
Major Research Equipment and Facilities Construction	**$174**	**$250**	**$193**	**$193**	**$193**
Salaries and Expenses	**$223**	**$269**	**$250**	**$230**	**$250**
National Science Board	**$4**	**$4**	**$4**	**$4**	**$4**
Office of Inspector General	**$10**	**$12**	**$11.5**	**$11.5**	**$11.5**
Total, NSF	**$5,473**	**$5,605**	**$5,643**	**$5,531**	**$5,653**

*** Includes Plant Genome +$6 million (Total = $100 million)**

Highlights from Conference Report

- Plant Genome Research +$6M (Total = $100M)
  - The conference report includes, by reference, language in the Senate report on the Plant Genome Research Program:

    "The Committee recommends $100,000,000 for the Plant Genome Research Program. The Committee remains a strong supporter of this important program due to its potential impact on improving economically significant crops. The Committee also recognizes its vast potential in combating hunger in poor countries. Accordingly, the Committee directs the NSF to accelerate funding for this program…"

Highlights from Conference Report

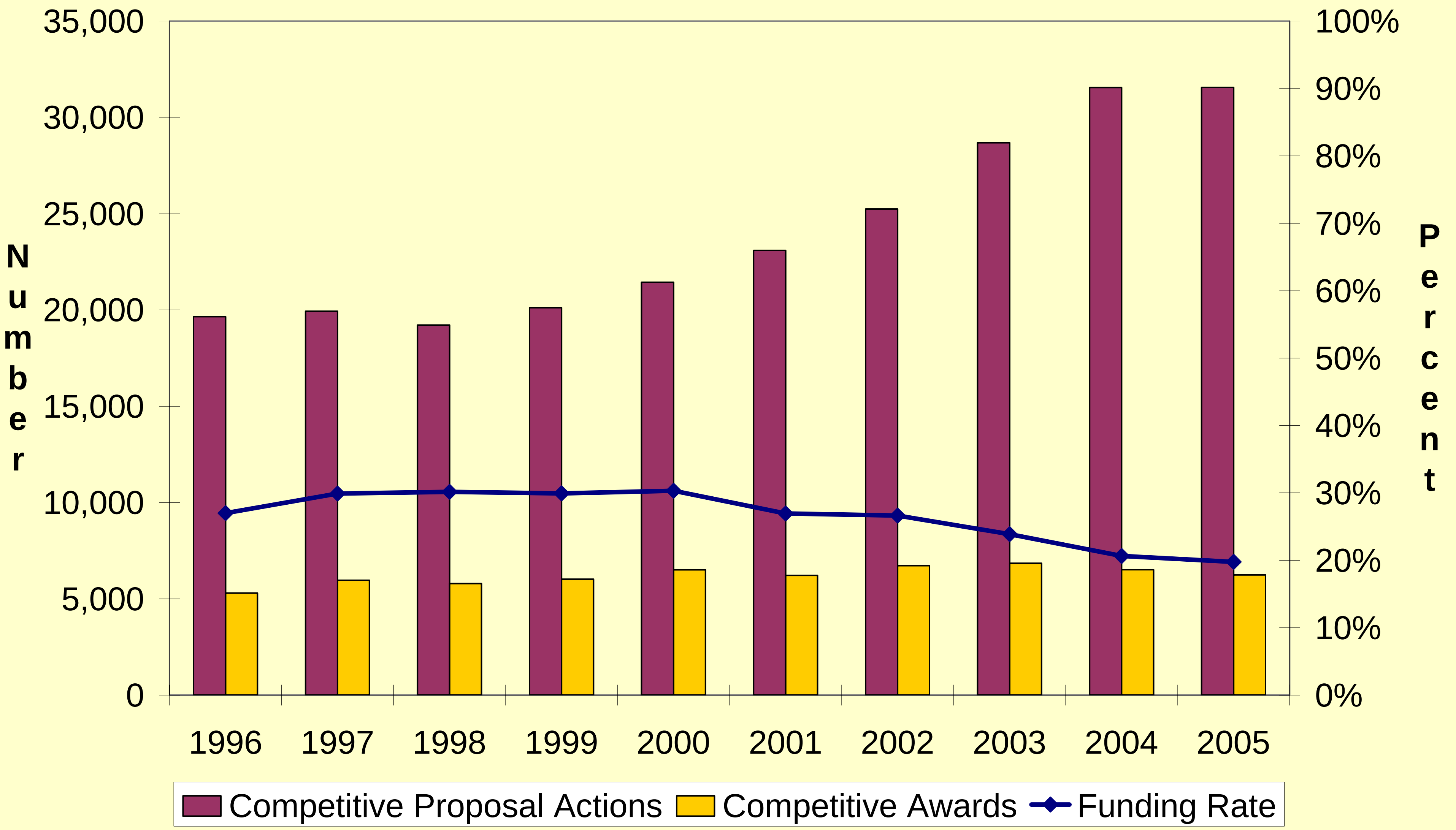
- Major Research Equipment and Facilities Construction
  - The conferees agree to the following distribution of available resources, which fully funds all requested MREFC projects for fiscal year 2006:

Atacama Large Millimeter Array	$ 49.24 Million
EarthScope	$ 50.62
IceCube Neutrino Observatory	$ 50.45
Scientific Ocean Drilling Vessel	$ 57.92
Total, MREFC	**$208.23**

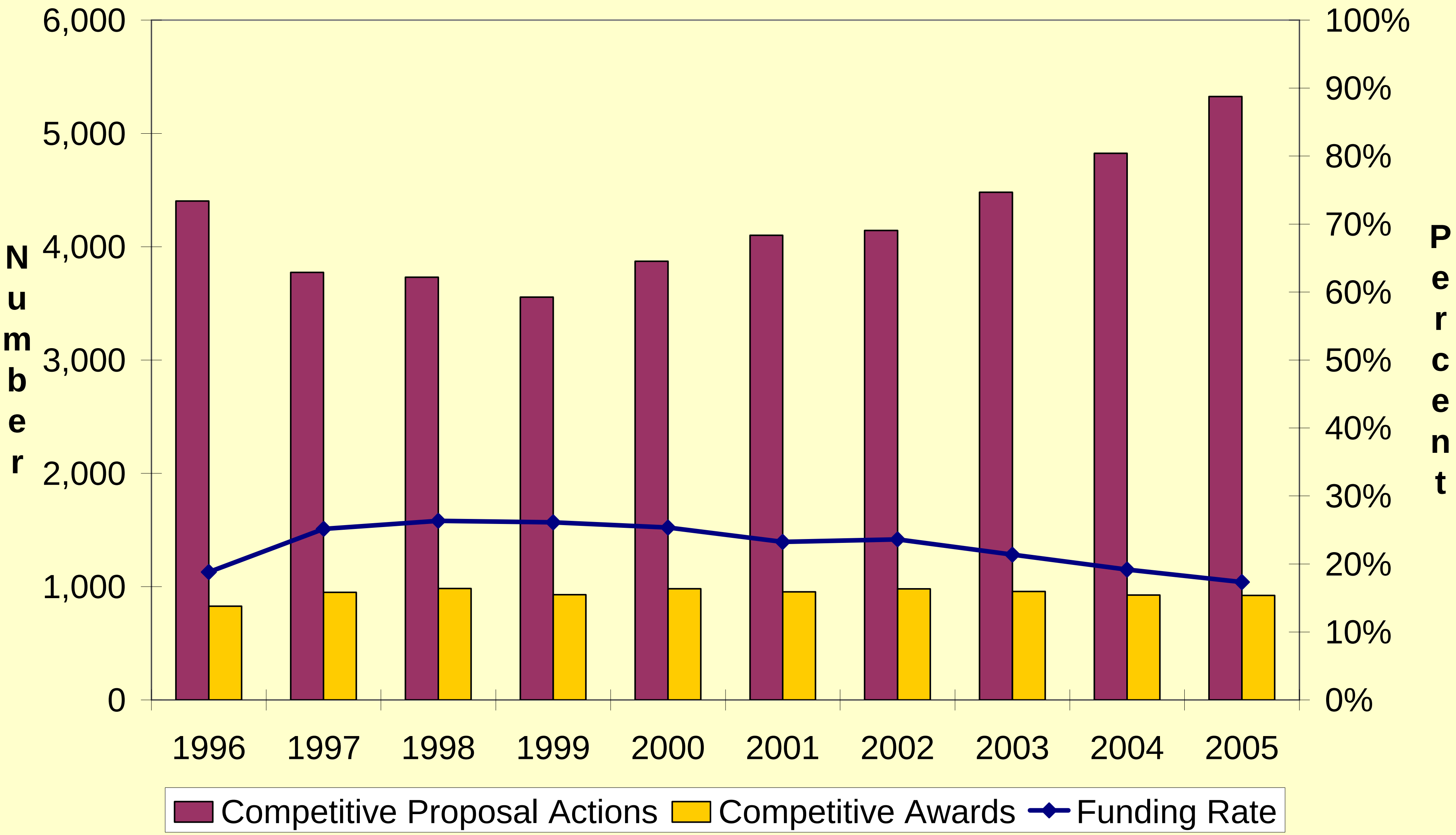
FY 2005 Funding Rate for Research Proposals by Directorate

	Proposal Actions	Awards	Funding Rate
BIO	5,326	923	17%
CISE	4,936	851	17%
EHR	433	51	12%
ENG	6,606	840	13%
GEO	4,024	1,002	25%
MPS	5,800	1,591	27%
OCI	67	26	39%
OISE	542	71	13%
OPP	759	231	30%
SBE	3,056	649	21%

NSF Funding Rate for Competitive Research Proposals



BIO Funding Rate for Competitive Research Proposals



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Central challenge: How do we <u>operate</u> the BIO of today while b<u>ecoming</u> the BIO of tomorrow?

- How do we change science programs?

By first understanding the nature of change.

- How can we transform biological research in the early 21st century?

By supporting the creativity needed to integrate research projects, programs, and networks inside and outside of NSF.

- What are BIO's core competencies?

By supporting in the short and long term research and training across all of Biology while sustaining the world class skills and infrastructure needed to identify the very best research.

- Are there some general lessons associated with transforming programs?

By keeping in mind the lessons of program transformation, the most important of which is that it's always harder than it looks.