The Case for Enabling Distributed Innovation

Karim R. Lakhani (Harvard Business School)

Agenda

- Joy's Law and The Distributed Nature of Knowledge
- The Advantage of "Open"
- The Power of Collaboration
- Field Experiment in Collaboration
- Coordinating Interdisciplinary Collaboration
- Building an Infrastructure for Pre-Competitive Research

Most Organizations are Faced with Joy's Law

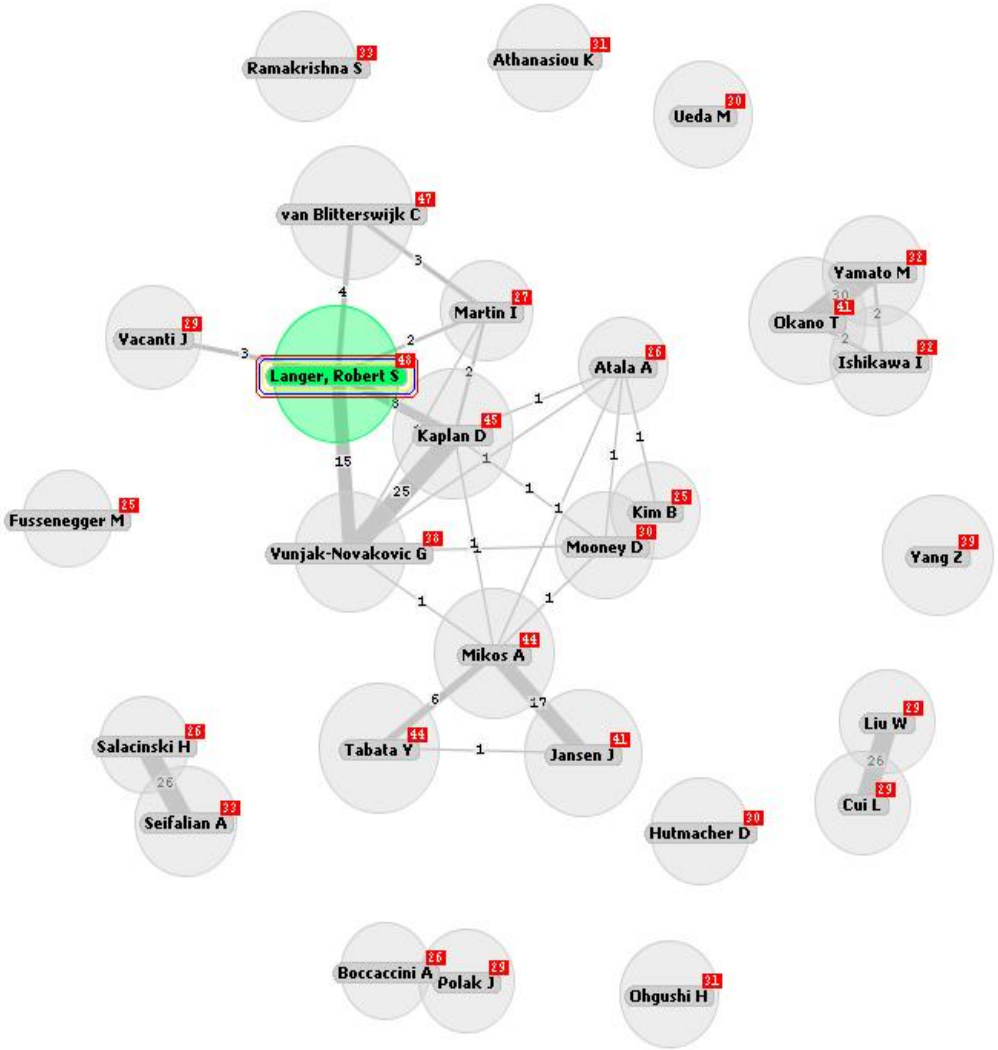
"No matter who you are, most of the smartest people work for someone else" –

Bill Joy

Co-founder, Sun Microsystems

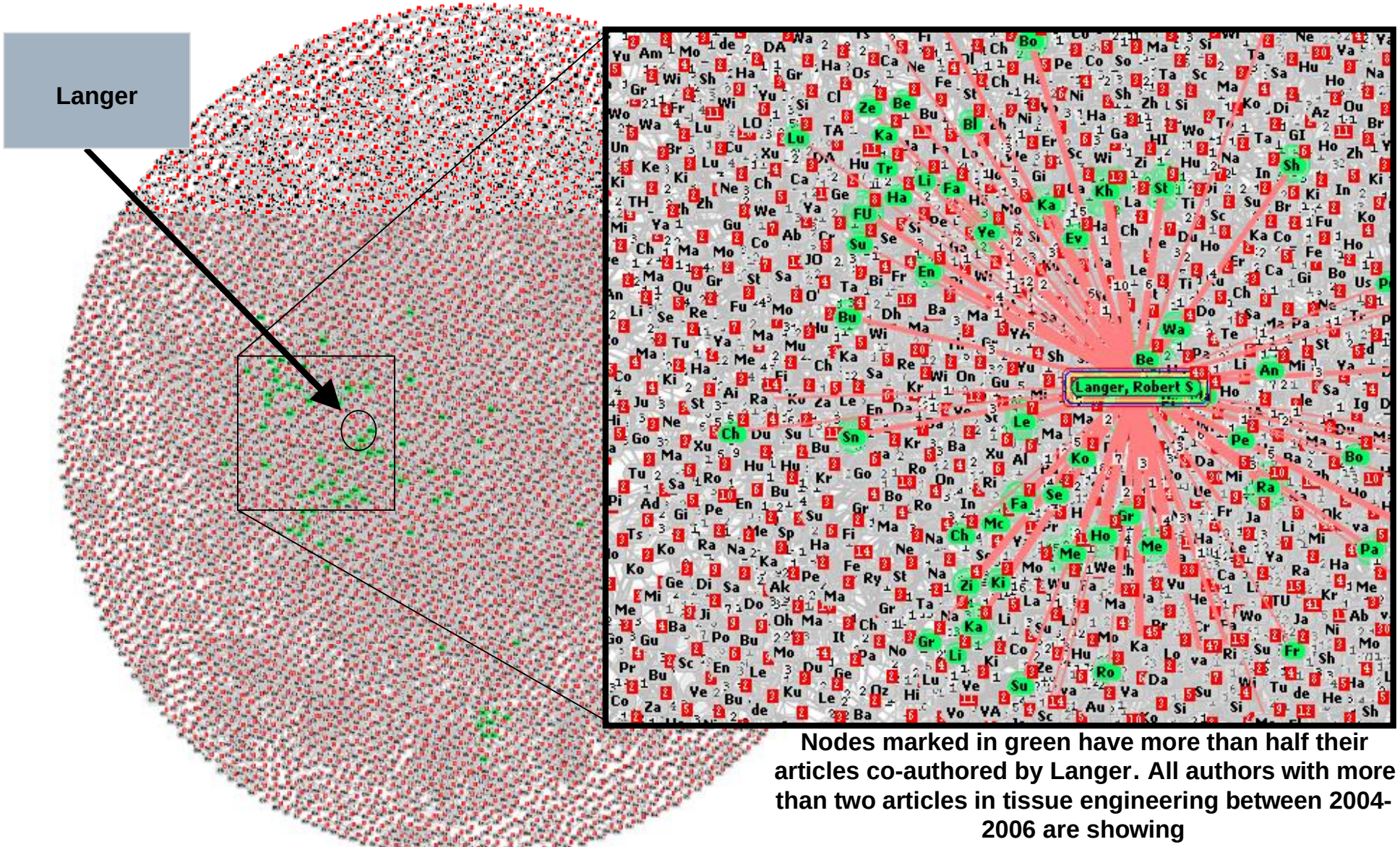
Lead technical contributor to TCP/IP, Berkeley Unix, Sparc, and Java

Langer's publication record in tissue engineering shows him collaborating with ~40% of prolific authors (> 25 publications) 2004 - 2006



Note: Co-authorship network of Robert Langer with most prolific authors on subject of tissue engineering between 1974 and 2003. Size of node reflects number of publications. Node is marked green if more than half their publications were with Langer. Only top 20 authors showing.
Source: Pubmed database, BCG analysis

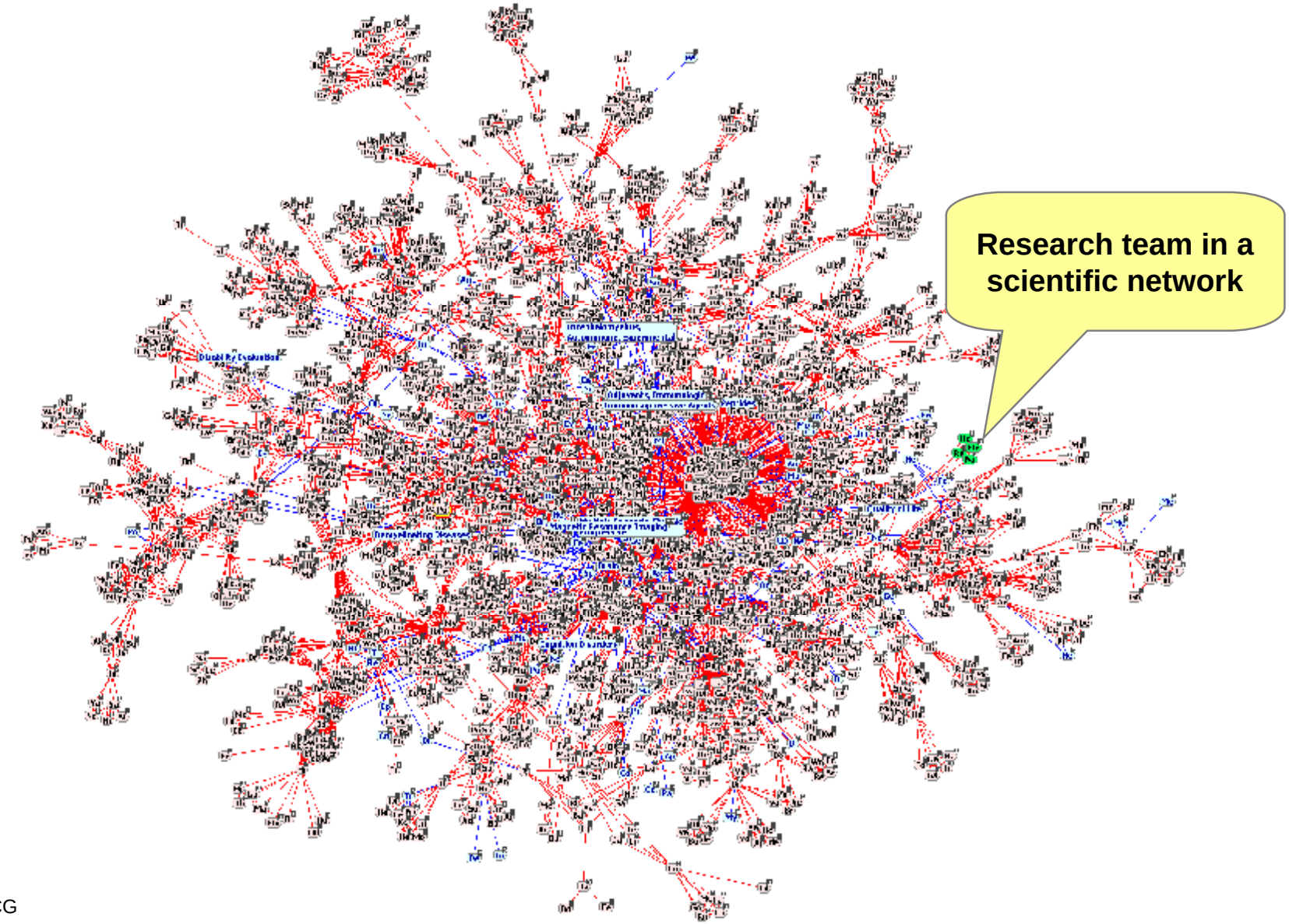
Joy's law in tissue engineering
6131 articles by 17044 authors (2004 - 2006)



Nodes marked in green have more than half their articles co-authored by Langer. All authors with more than two articles in tissue engineering between 2004-2006 are showing

Note: Network map of all authors that have published two or more articles on tissue engineering between 2004 and 2006. A total of 17044 authors published 6131 articles.
Source: Pubmed database, BCG analysis

Joy's Law in Pharmaceuticals



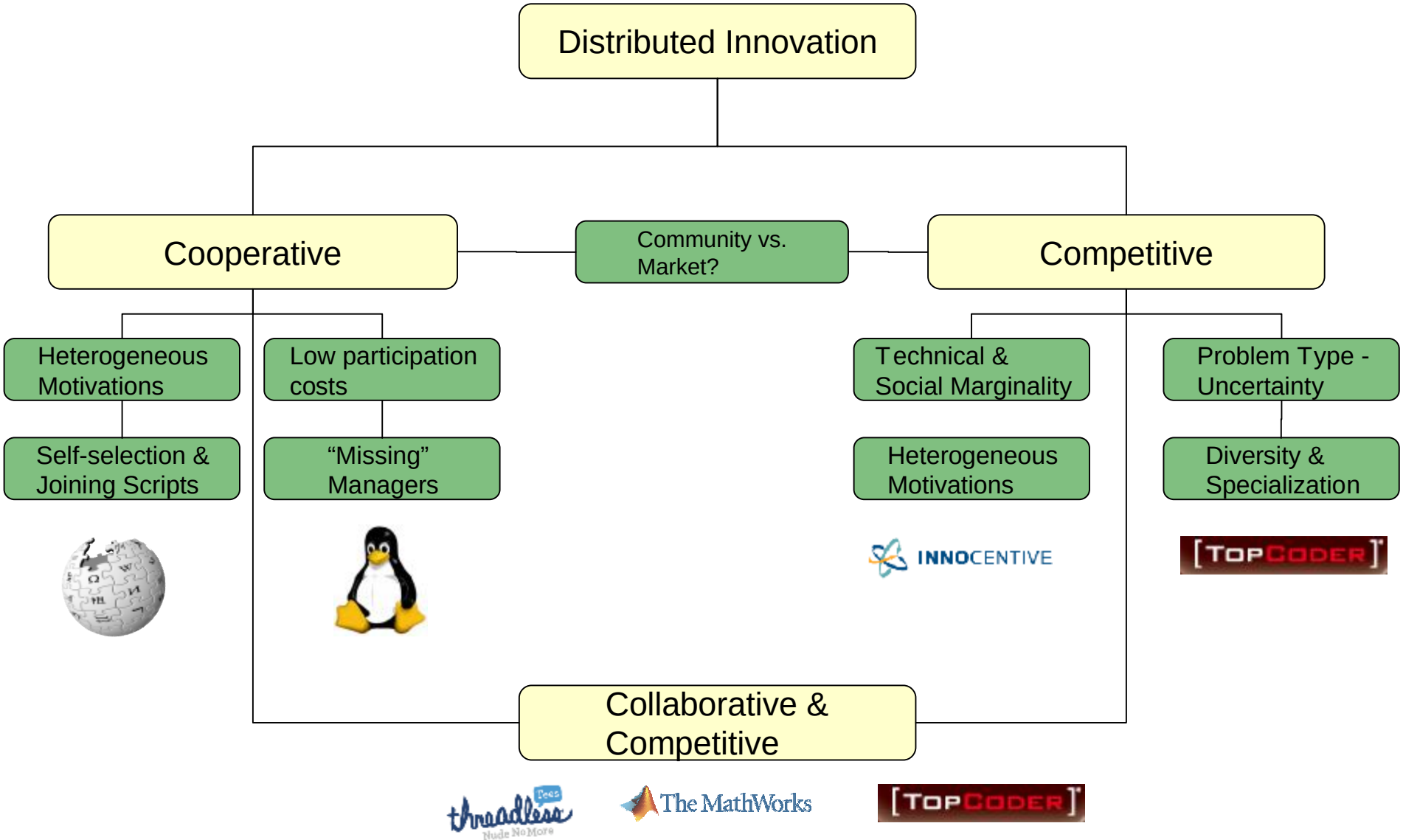
Source: BCG

The Causal Explanation for Joy's Law

- Knowledge is unevenly distributed – Hayek (1945)

- Knowledge is sticky – von Hippel (1994)

Distributed Innovation Can Help to Overcome Joy's Law



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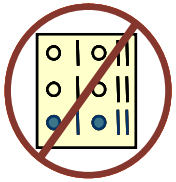
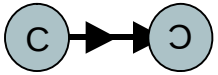
Open Source Principles

Intellectual property



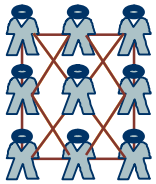
Code should always be open -
“Free speech, not free beer”

“Copyleft”



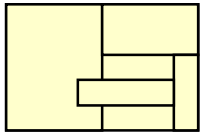
“Use copyright to
ensure copyleft”

Development paradigm



Extensive involvement of
user/developer community

“Release early, release often”

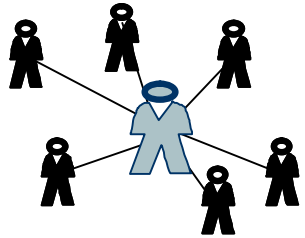


Modularize code

Resource model

Good ideas come from solving a
problem or scratching an itch

“The three obligations: to give,
to receive, to reciprocate”

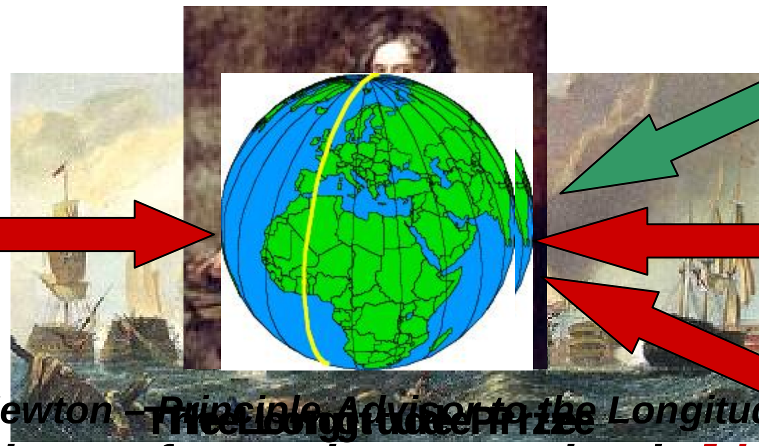


Peer leadership -
vision, engagement, code

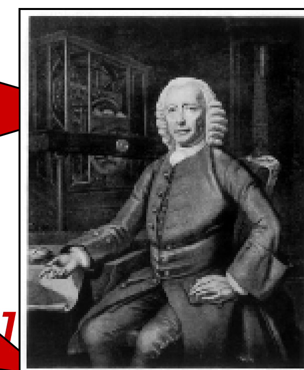
Solving the Toughest Scientific Problem from 300 Years Ago

Finding the Longitude at Sea
1300s to 1700s

Local Search to Longitude Problem



The Longitude Prize
1714 - Up to £20,000
British Fleet Sinks in 1707
Due to Bad Navigation
Anyone can enter.
Need a working solution



Chronometer Wins
John Harrison
Unknown
Cabinet Maker

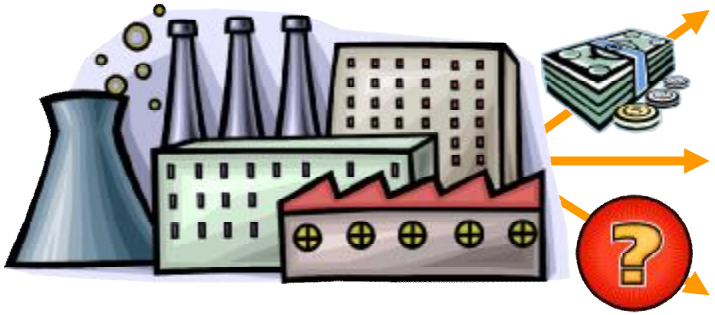
Over 100 Solutions Proposed

Sir Isaac Newton – Principle Advisor to the Longitude Board:

"And I have told you oftener then once that it [the longitude] is not to be found by Clockwork alone. Nothing but Astronomy is sufficient for this purpose (the only right method) and the method pointed at by the Act of Parliament). I am unwilling to meddle with any other methods then the right one.

Even Newton Could Be Wrong!
Solution Award Took 40 Years

InnoCentive as a Modern Implementation of Innovation Contests



R&D Labs

Knowledge Broker

110,000 independent scientists

Context:

1. R&D Labs inside of major multinationals are not able to solve certain scientific problems
   - Their own internal and external experts cannot obtain solutions
2. Hope to get solution by going to distributed scientists that they do not know who may have an answer

Example Problem from InnoCentive.com

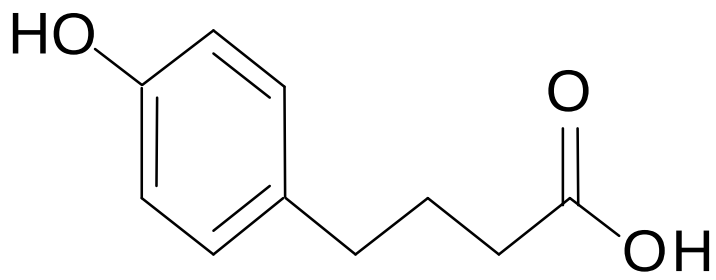
INNOCENTIVE 3109

R4-(4-HYDROXYPHENYL) BUTANOIC ACID

POSTED: June 26, 2001

DEADLINE: Nov 30, 2001

$25,000USD



Solution Criteria:

Synthesize following chemical:

- **2 steps or fewer**
- **>80% overall yield**
- **>95% purity**
- **<$100/Kg**
- **2.0g white to off-white solid**

Solution to Problem

- 221 individuals express interest in solving problem and create project rooms on InnoCentive.com site
- 10 individuals from 7 countries submit chemicals for analysis
- Retired scientist with wet lab in his backyard wins

InnoCentive Solver
Dr. Werner Mueller

Two Central Questions

1. What explains which problems get solved?

- Heterogeneity in the scientific interests of the pool of solvers competing to win
- Specialization in the solver pool

2. What explains who creates a winning solution?

- Technical Marginality: Increasing distance between solver's own field of expertise and the problem field
- Social Marginality: Women scientists, when they enter, more likely to win

Source: Jeppesen and Lakhani, ***Organization Science*** (forthcoming)

Table 3 Heckman Probit Model for Predicting Which Solver Submits a Winning Solution

	Model 1		Model 2		Model 3		Model 4	
Variables	Probit Coefficient	Robust Standard Errors	Probit Coefficient	Robust Standard Errors	Probit Coefficient	Robust Standard Errors	Probit Coefficient	Robust Standard Errors
Second stage: Solver winner								
Control Variables								
Problem Familiarity	0.029	0.052	0.075	0.057	0.038	0.051	0.086	0.055
Solver Interest & Problem Discipline Match	-0.069	0.174	-0.030	0.177	-0.067	0.172	-0.033	0.175
Scientific Interest Count	-0.009	0.008	-0.012	0.008	-0.011	0.007	-0.015	0.007*
Time Invested (Hours)	0.002	0.001***	0.002	0.001***	0.002	0.001***	0.002	0.001***
Constant	0.061	0.305	-0.339	0.371	0.031	0.316	-0.376	0.376
Independent Variables								
Expertise Distance			0.085	0.044*			0.087	0.045**
Gender (Female =1)					0.669	0.228***	0.671	0.231***
First stage: Submit a solution								
Gender (Female = 1)	-0.158	0.087*	-0.156	0.087*	-0.195	0.088**	-0.195	0.088**
Ethnicity (Anglo Saxon = 1)	-0.054	0.060	-0.051	0.060	-0.058	0.060	-0.055	0.060
Previous Problems Opened	0.078	0.008****	0.078	0.008****	0.078	0.008****	0.078	0.008****
Solver Interest & Problem Discipline Match	0.171	0.052***	0.171	0.052***	0.171	0.052***	0.171	0.052***
RTP Solution Requirement	-0.265	0.069***	-0.264	0.069***	-0.264	0.069***	-0.264	0.069****
Award Value (Log)	-0.158	0.032****	-0.158	0.032****	-0.158	0.032****	-0.158	0.032****
Constant	-0.653	0.294**	-0.658	0.294**	-0.648	0.294**	-0.656	0.293**
Selection Correction Term	-0.749	0.143****	-0.767	0.149****	-0.800	0.147****	-0.825	0.156****
Wald Chi Square for independent equations:	27.54****		26.41****		32.20****		28.17****	

Number of observations (Stage 1): 12786
Number of censored observations: 12466
Number of uncensored observations (Stage 2): 320

*p at 10%, **p at 5%, ***p at 1%, ****p at 0.1% significance level.
Standard errors are clustered by broadcast problems.

"Reuse" of Existing Information Makes Solving "Cheap" for Solvers

Source of Solution Information	
Did not use previously developed solution	27.5 %
Used previously developed solution	72.5%

n=40 winning solvers

Source: Jeppesen and Lakhani, ***Organization Science*** (forthcoming)

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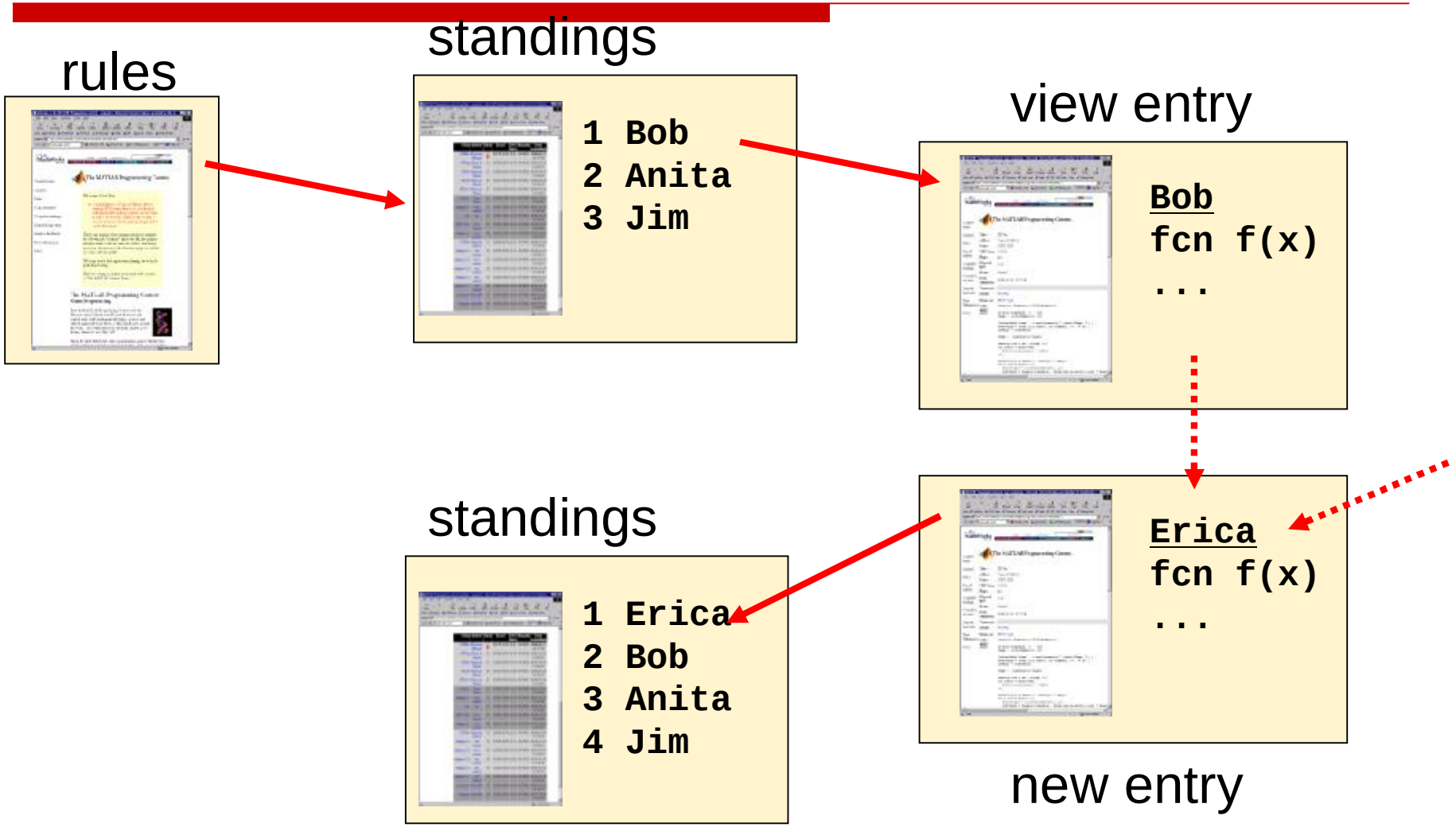
MATLAB Programming Contest Extends InnoCentive Model to Collaboration

A One Week "Wiki-like" Programming Contest



Contest Consists of Solving "NP-Complete" Problems : Need to Optimize Algorithm and CPU Time

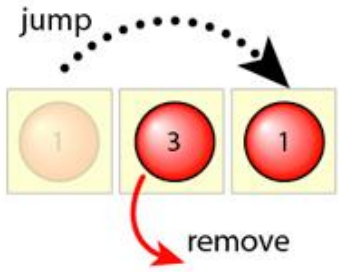
- **Example Problem: Peg Jumping**

The Problem

This contest is based on a simple peg jumping game, sometimes called Peg Solitaire. In a typical game of Peg Solitaire, the board contains pegs (sometimes marbles) and at least one empty space. You try to remove as many pegs with an artful combination of jumping moves.

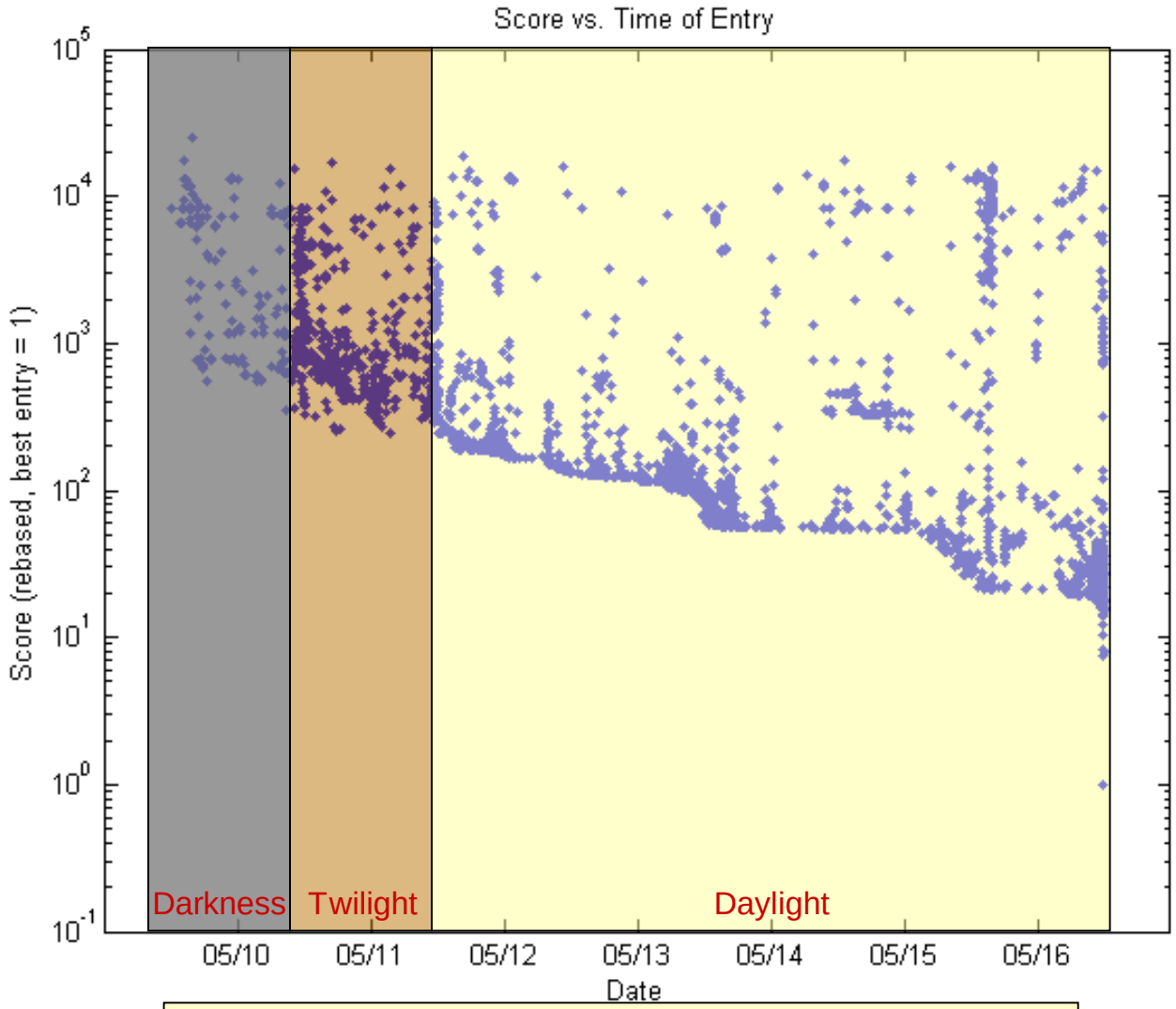
Naturally our version is a little more complicated. In this contest, your goal is to jump pegs in such a way that you make your score as low as possible. This may not mean removing all the pegs.

Here's how it works. Each peg has a value, or weight. A move consists of one peg jumping over and thereby removing another peg. A "jump" is a horizontal or vertical move in which one peg passes over exactly one other peg and comes to rest on an empty space. Diagonal jumps are not permitted. You are rewarded for every peg that you remove from the board according to its weight, BUT you pay for each jump according to the weight of the jumping peg. Thus you want to harvest the high value pegs by jumping over them with low value pegs. The bigger the difference between the value of the two pegs, the better your score. If, however, you jump over a low value peg with a high value peg, the situation is reversed: your score will get worse.



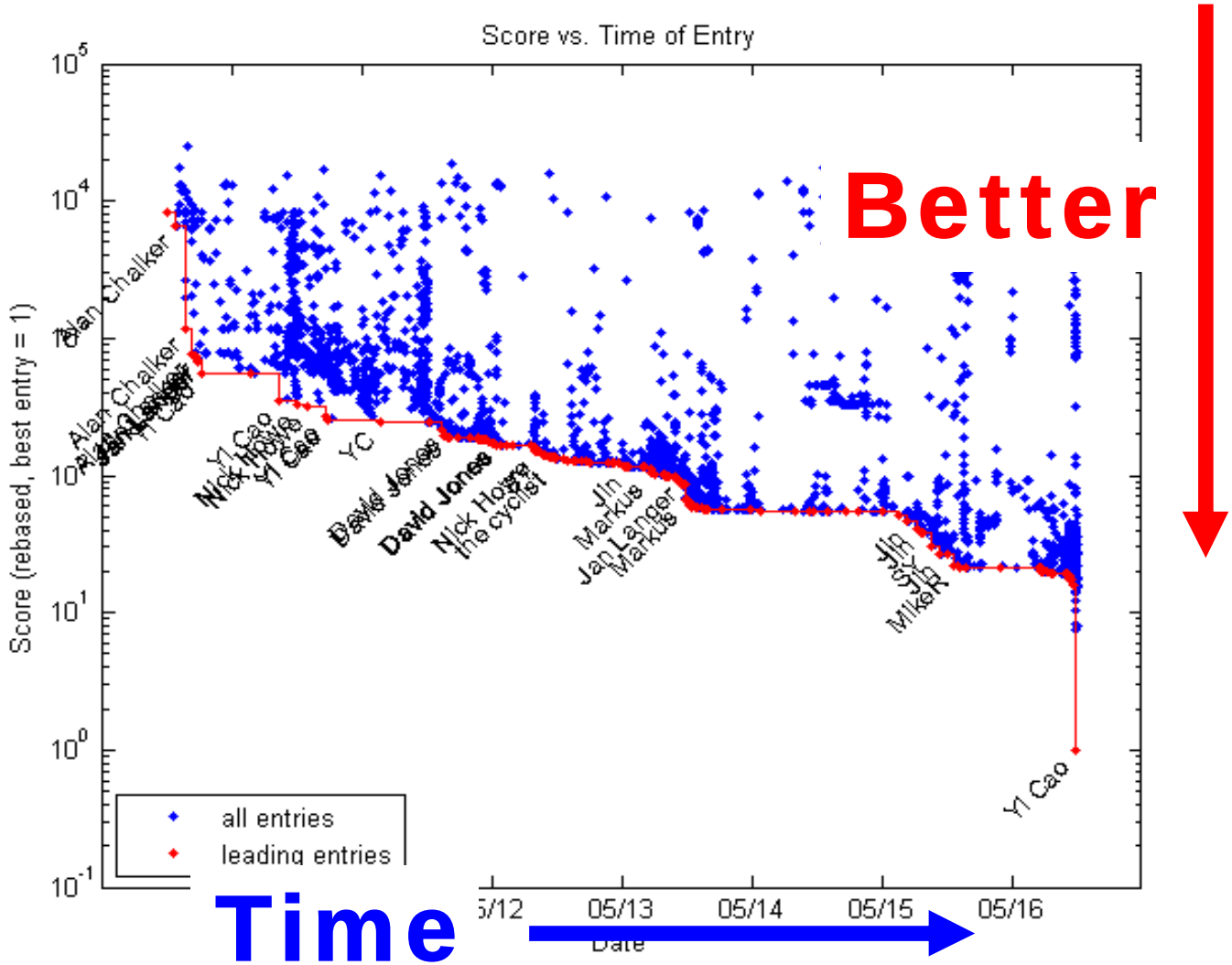
- **Programs are subjected to an extensive test suite**
- **Score = k1*(tour length) + k2*(cpu time)**
- **Competing for fame and glory + T-shirt**

Typical Contest Consists of Three Phases: Darkness, Twilight and Daylight



111 Authors - 3914 Entries

Dramatic Improvement in Performance



This is Yi Cao.

He is is a Senior Lecturer in the Department of Process and Systems Engineering at Cranfield University in the UK.

At 11:56 AM on May 16, 2007, he submitted a 545 line file to the online MATLAB programming contest.

It was called “Buy a ticket”, and it went on to win the contest.

Contributors to Yi Cao's Enty

These are all the authors (as they identified themselves)

Alan Chalker
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eigenvector
firefox
matlabboy
nathan q
petey torrione
srach
tgs
the cyclist

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Field Experiment to Test Value and Investigate Dynamics of Collaborative Innovation using TopCoder

- 2-sided marketplace:
  - Community of elite software coders (>200,000 members)
  - Global IT firms: BT, Microsoft, UBS, Google, Verisign, etc

- "Virtual" Competitions:
  - Attract, reward, assess and record skill
  - Prizes up to $25,000
  - Points for creativity, correctness and speed of solution
  - Full range of software problems
  - Ex-post learning and community building

TopCoder Global Footprint

Winning Contributors to a Sample Financial Services Application

HMS-HBS-TopCoder Collaboration to Solve "Tough" Computational Problems

- Objective: Test performance characteristics of various competitive and collaborative distributed innovation regimes
- Team: Ramy Arnaout, Carliss Baldwin, Kevin Boudreau, Eva Guinan, Karim Lakhani, Alan MacCormack
- Source "hard" scientific programming challenges:
  - Genomics/computational biology: heterogeneous spliced transcripts (e.g. mammalian immune system)
  - Setup – Two week long programming competition
- Treatments:
  - Fully Competitive – head to head competition
  - Fully Collaborative – full information sharing – individual submission
  - Hybrid – competition for one week, collaboration for one week

Preliminary Results

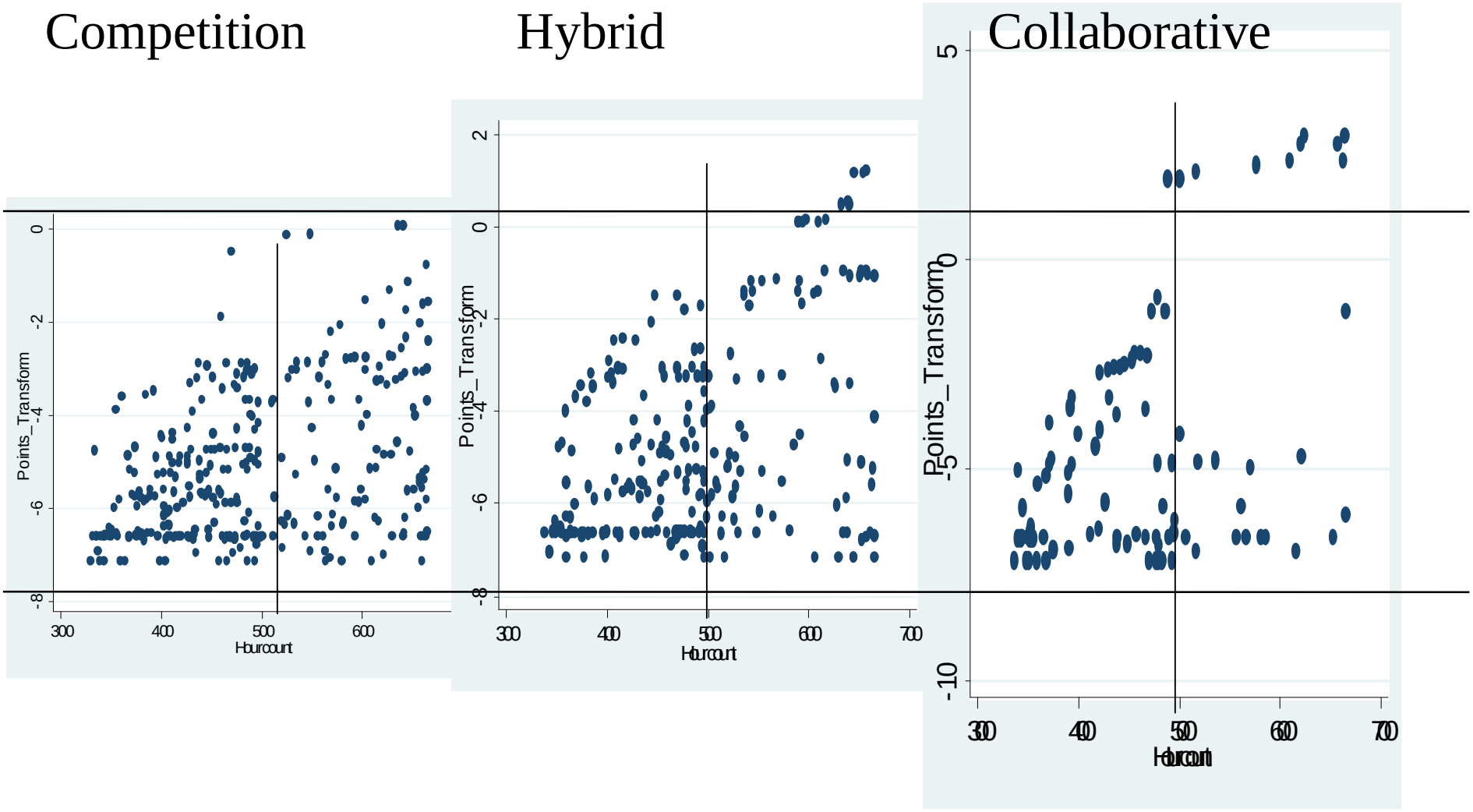
- 733 coders registered and were assigned to one of the three treatments
- 122 coders made 654 submissions
- $6000 prize pool
- Top 34 coders exceed state of the art in computational biology for same problem by factor of 100 to 100,000
- Winners from Russia, France, Egypt, Belgium and US
- 10 different approaches to solve problem identified

Preliminary Analyses Shows Collaborative Treatment to be Higher Performing and More Efficient

Competition

Hybrid

Collaborative



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Myelin Repair Foundation Created Infrastructure for Collaborative Science Research

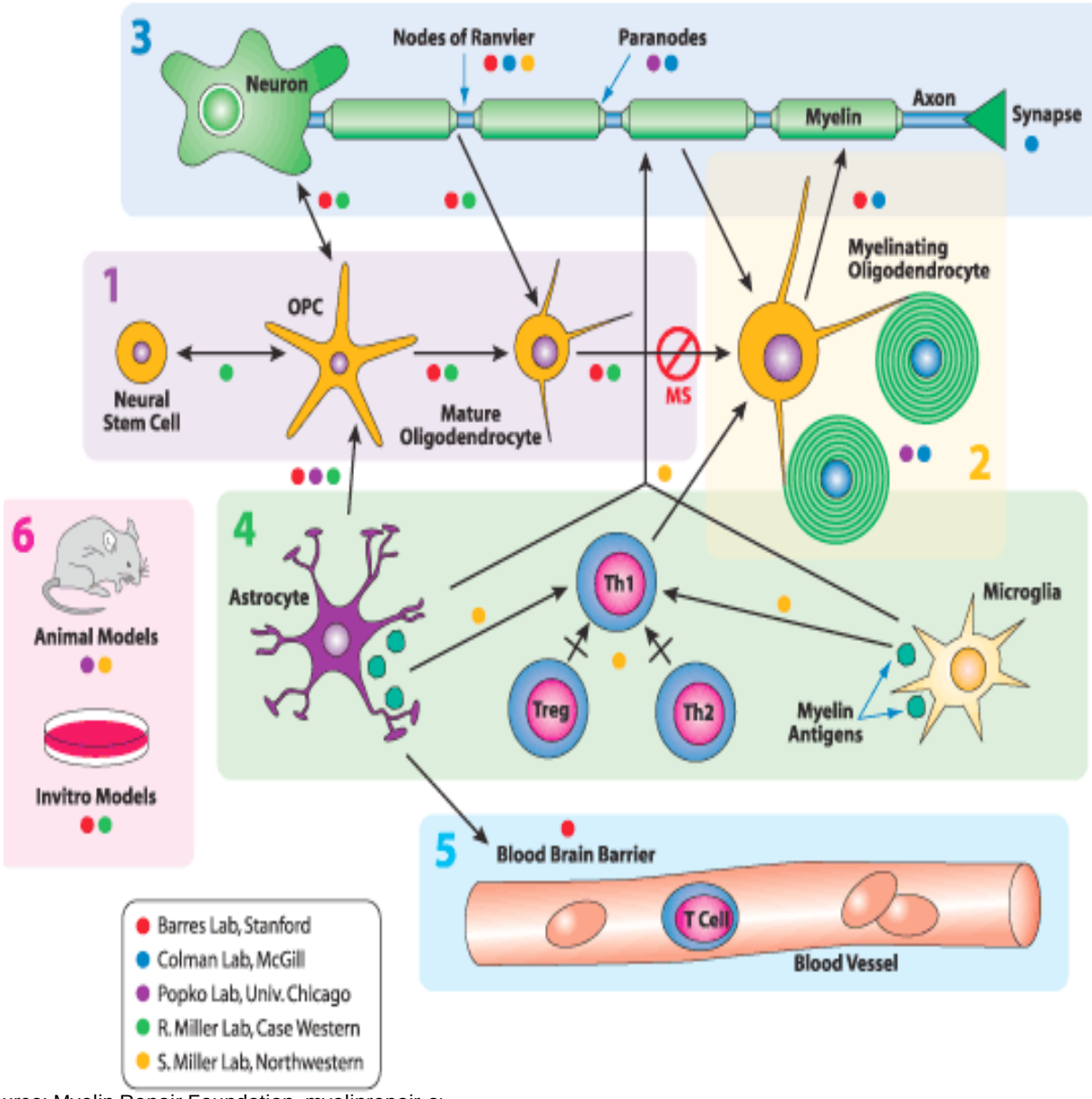
History

- Scott Johnson – Founder Diagnosed with MS 30 Years
- Frustrated with lack of progress in MS research
- Realized most problems are multi-causal and multi-disciplinary but R&D is organized sequentially (at best) results in a Science Gap and Commercial Gap
- In 2005, organize a team based research consortium of 5 labs in 5 institutions to *find treatment* for MS
- Labs represent expertise in: neurobiology, genetics, cellular models, animal models, proteomics and immunology
- Collectively generate 100 questions that need to be answered to develop joint research program

Results in three years

- 18 novel targets identified – 8 moving forward for further development
- >25 papers in peer reviewed journals
- 10 new tools for accelerating research (Databases, animal models, testing platforms)
- 7 patents

A Team-based Organization of Research



urce: Myelin Repair Foundation, myelinrepair.o

1. Understanding how oligodendrocytes are normally generated from neural stem cells and how multiple sclerosis perturbs this process.
2. Understanding the underlying mechanism of myelination and how it is perturbed in multiple sclerosis.
3. Understanding how nodes of Ranvier and paranodes are normally formed and how they are perturbed in multiple sclerosis.
4. Understanding the immune response in multiple sclerosis and how inflammation affects myelin repair .
5. Understanding how the Blood-Brain Barrier is effected in multiple sclerosis and its role in the disease.
6. Development of better animal models for study of multiple sclerosis and remyelination

Lessons on Barriers to Collaboration as Experienced by MRF

- Accepting R&D problems as given instead of designing problems that can be shared across disciplines and functions
- Allowing competitive and closed views of knowledge sharing to persist instead of actively developing new norms for transparency and intellectual property sharing that enable collaboration
- Creating projects that modularize work and experts instead of designing projects that create interdependencies amongst experts and require joint problem-solving
- Managing knowledge workers bureaucratically or hoping for self-organization instead of creating an infrastructure for collaboration that extends the capabilities of experts

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Two Traditional Innovation Models

Private Innovation Model (Most Firms)

- Firms' make private investments to solve technical problems – is often risky
- Expect monopoly rents for their successful innovations
- Innovation outcomes are rival and excludable
- Sharing of knowledge only happens through "accidental" spillovers

Collective Innovation Model

- Individuals get external subsidies to solve technical problems
- Knowledge is given to a common pool for reuse and creative recombination
- Parties self-regulate through norms like reciprocity, recognition and peer esteem
- Free riding becomes a central concern

Private-Collective Innovation Model Is a Hybrid of Both Systems

- Firms/Individuals exert private effort – but disclose work to others in a common pool
- Innovators get "selective benefits" through participation that outweigh the cost of investment
  - Access to novel knowledge
  - Access to new materials
  - Access to people
  - Shared risk
- Participants can combine knowledge from common pool with own specific and proprietary assets to create value
- Free riders cannot share in the selective benefits

Semiconductor Industry has Pioneered Approach: SRC/Sematech & IBM Radical Collaboration

Key Issues for Pharmaceutical Pre-Competitive Collaboration

- IP sharing
  - Culture change for most firms used to secrecy
  - Appropriate vehicles (e.g.: non-profits) for holding IP
  - Academic partner IP issues (publications)
- Coordination role
  - How will the work be coordinated?
- Determining joint objectives for participation
- Resource sharing agreements
  - People
  - Materials
  - Approaches
- Conditions for entry, exit and ending

Thanks!

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