Leadership Coalition Faculty Conference
2010

Biology (Science)
collaborative, connected, data dense, and dynamic

The inverse problem: setting up structures to support students in this new world

A famous philosopher: "you gotta skate to where the puck is gonna be" (Wayne Gretsky)

Tom Daniel
http://faculty.washington.edu/danielt

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collaborative, connected, data dense, and dynamic

Observations about science today
Quantitative pipeline and collaboration in a curriculum
Mentoring pipeline and collaboration in a laboratory
Is the culture changing? What are the drivers?

~yes

HHMI
NSF
Gates Foundation
Demography of faculty
UW promotion policy
Public Schools
Students

Observations:

- Biological sciences increasingly computational and quantitative (yet may attract students who have shied away from those nerdier parts of STEM domains)
- Biological sciences moving from *descriptive* to *predictive* disciplines, placing more demand for computational expertise -- analyzing highly connected systems.
- Exponential growth in data (a "scientific data tsunami")
- Exponential growth in collaboration and multi-disciplinary teams

simple physical systems....

Interchangeable components

Simple interactions

Regular or well-mixed structures

Image: Institute for Condensed Matter Physics of the National Academy of Sciences of Ukraine

but biology is highly ...

differentiated

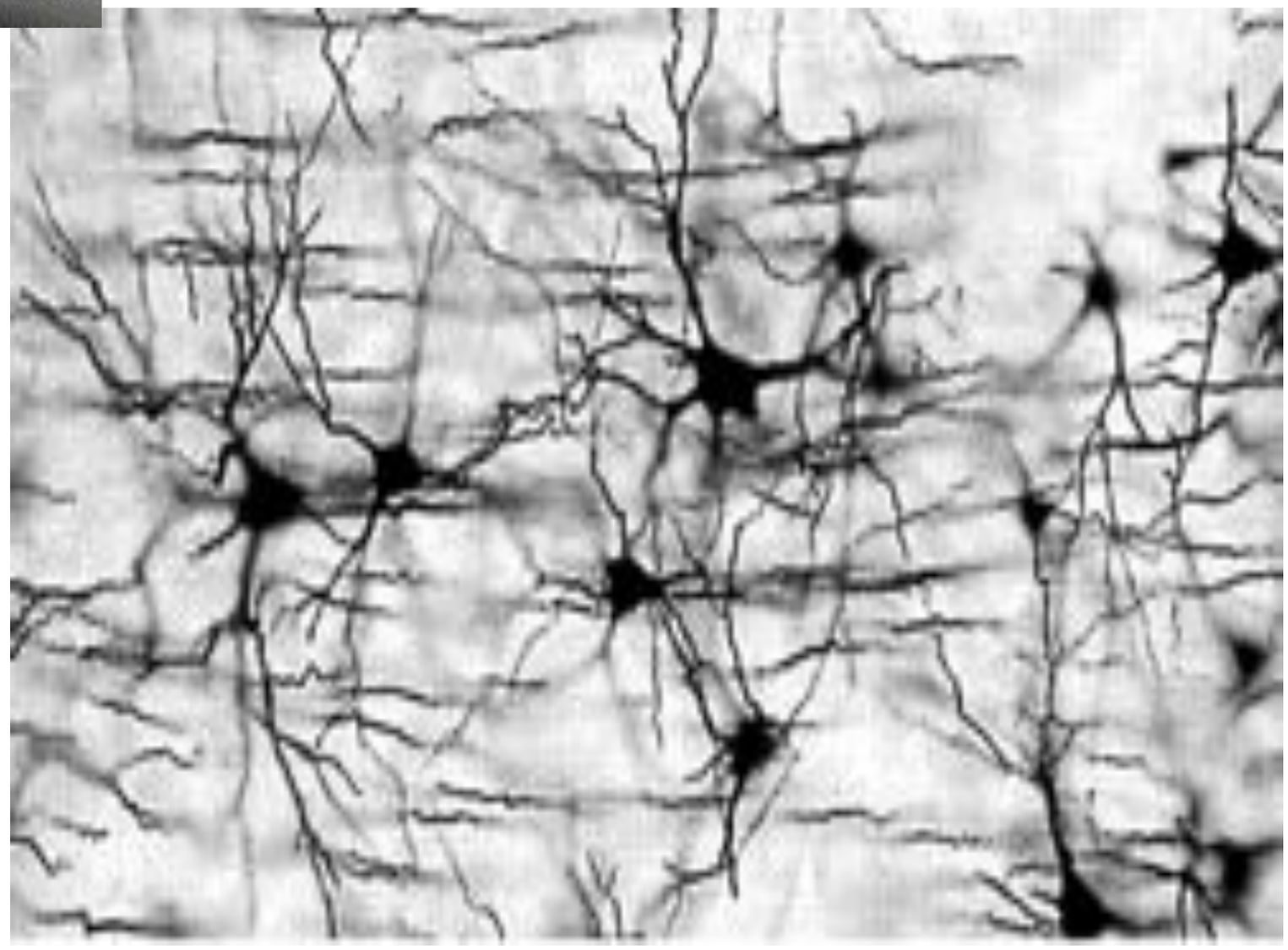
multipartite

integrated

dynamic

From C. Bergstrom

Networks.



How is information encoded and transmitted ?

Immune signaling networks

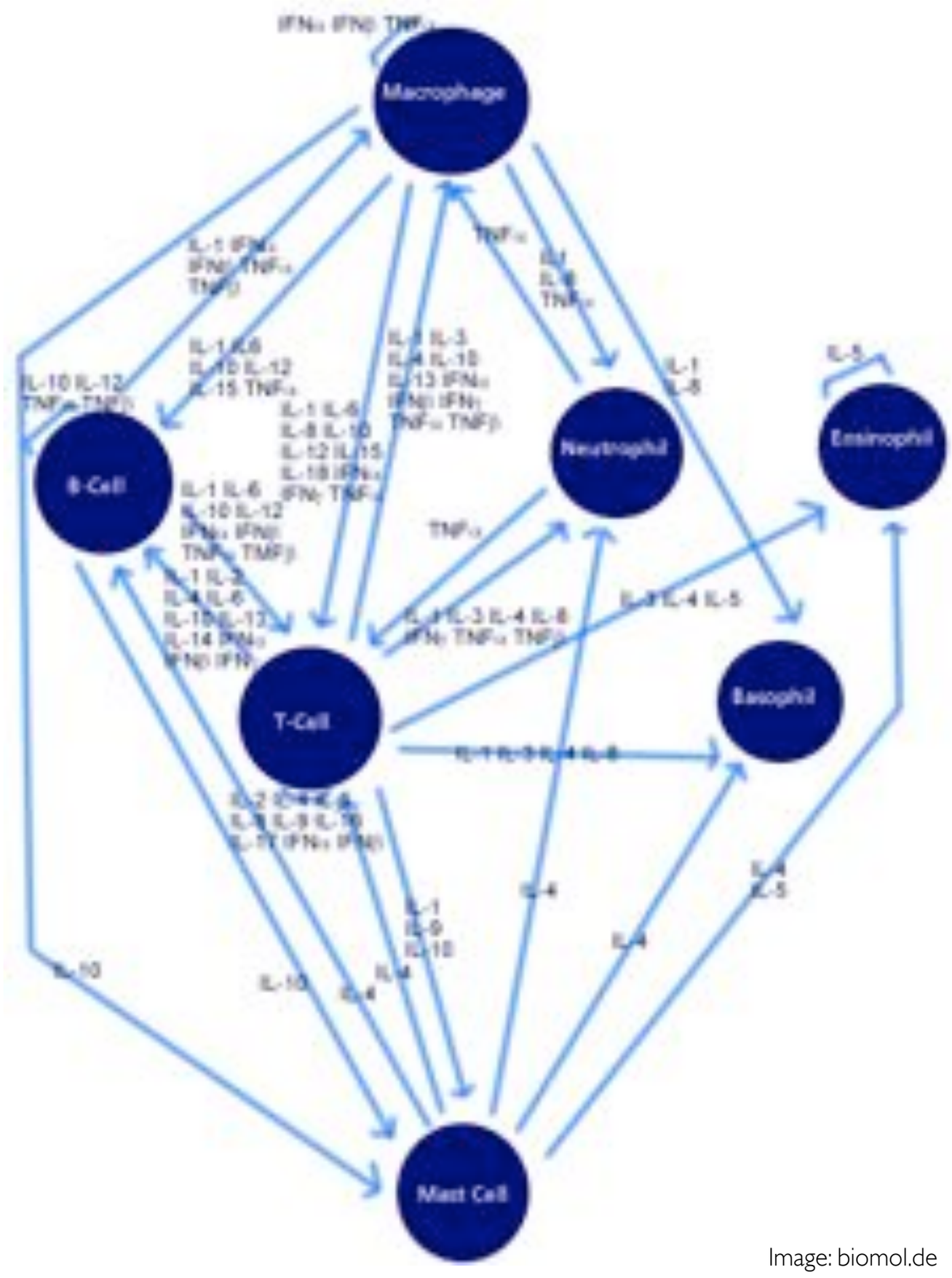
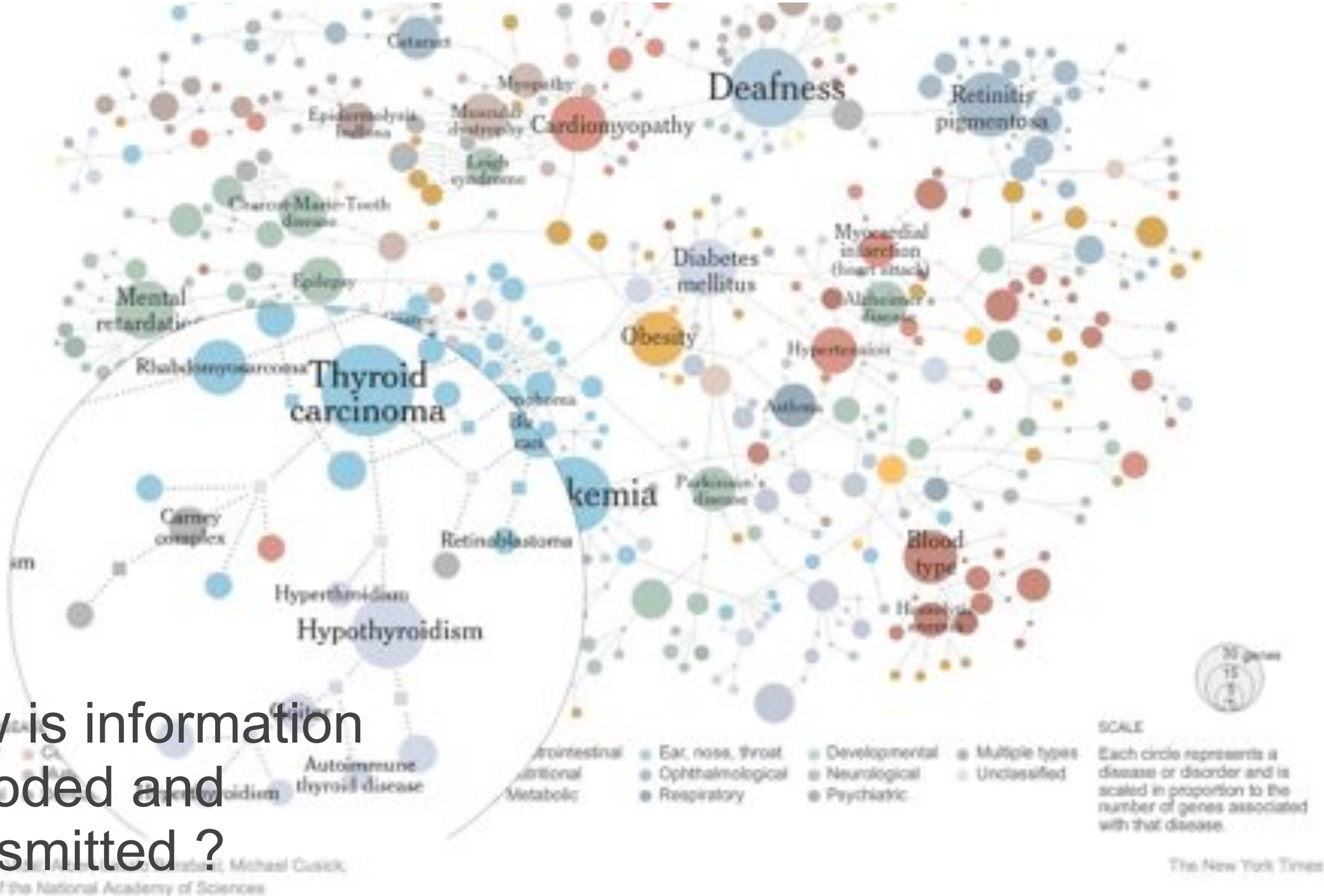


Image: biomol.de

How is information encoded and transmitted ?

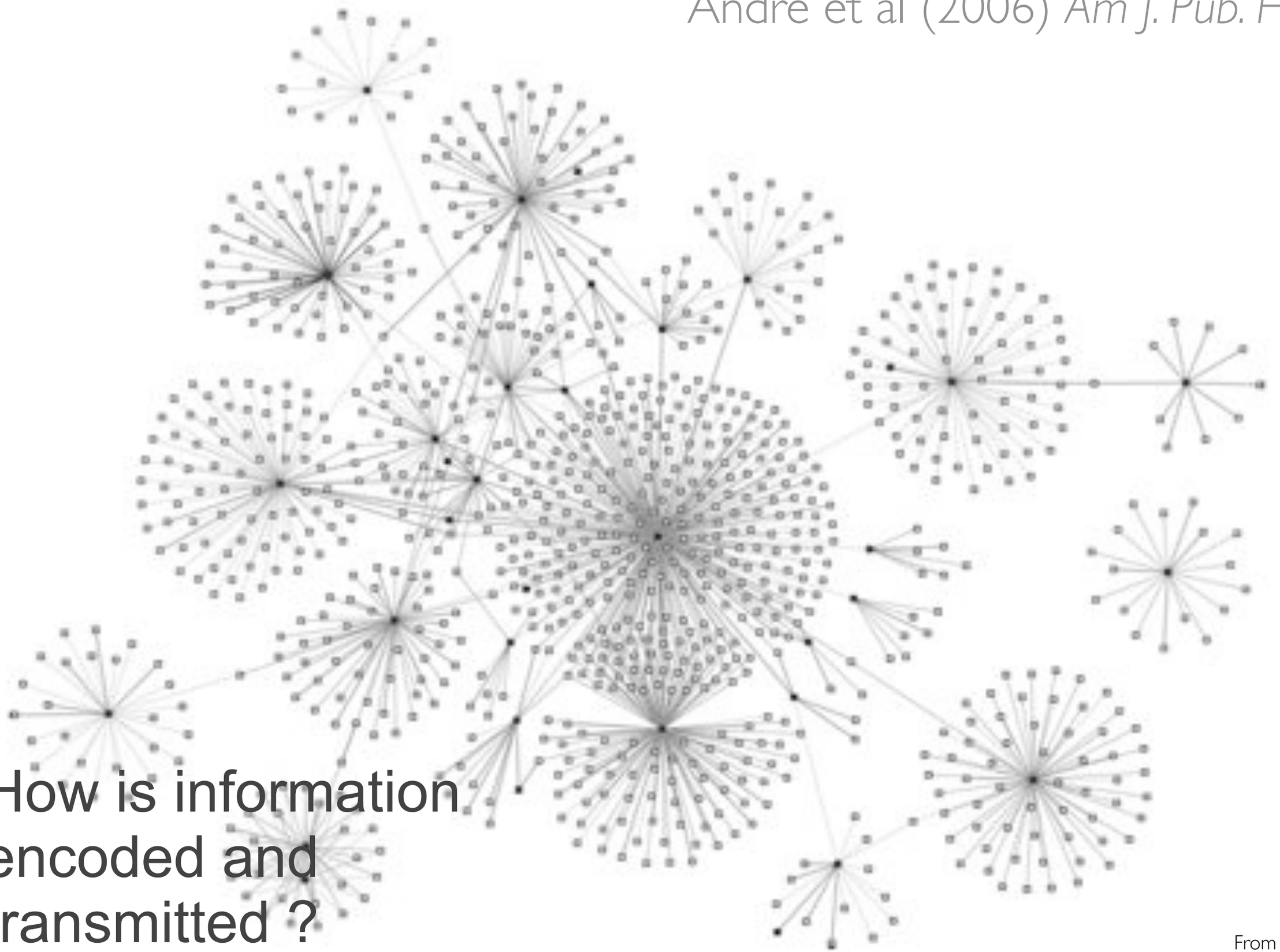
Disease association networks



How is information encoded and transmitted ?

TB contact network, SW Oklahoma

Andre et al (2006) *Am J. Pub. Health*



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The Changing World of Science?

Exponential growth of data in all domains of science.

- *In biology that means learning to manage the flow of massive data sets (e.g. high throughput genomic, neural, population, environmental data)*
- *a "Data Tsunami" (medical images, genome searches..)*
- *multi-disciplinary collaborations dominate*

New social technologies + generational shift

- *lowered barriers to entry for computer-mediated communication*
- *citizen science (a citizen research machine? e.g. protein folding, social analyses ...)*
- *a new generation with "ubiquitous computing"*

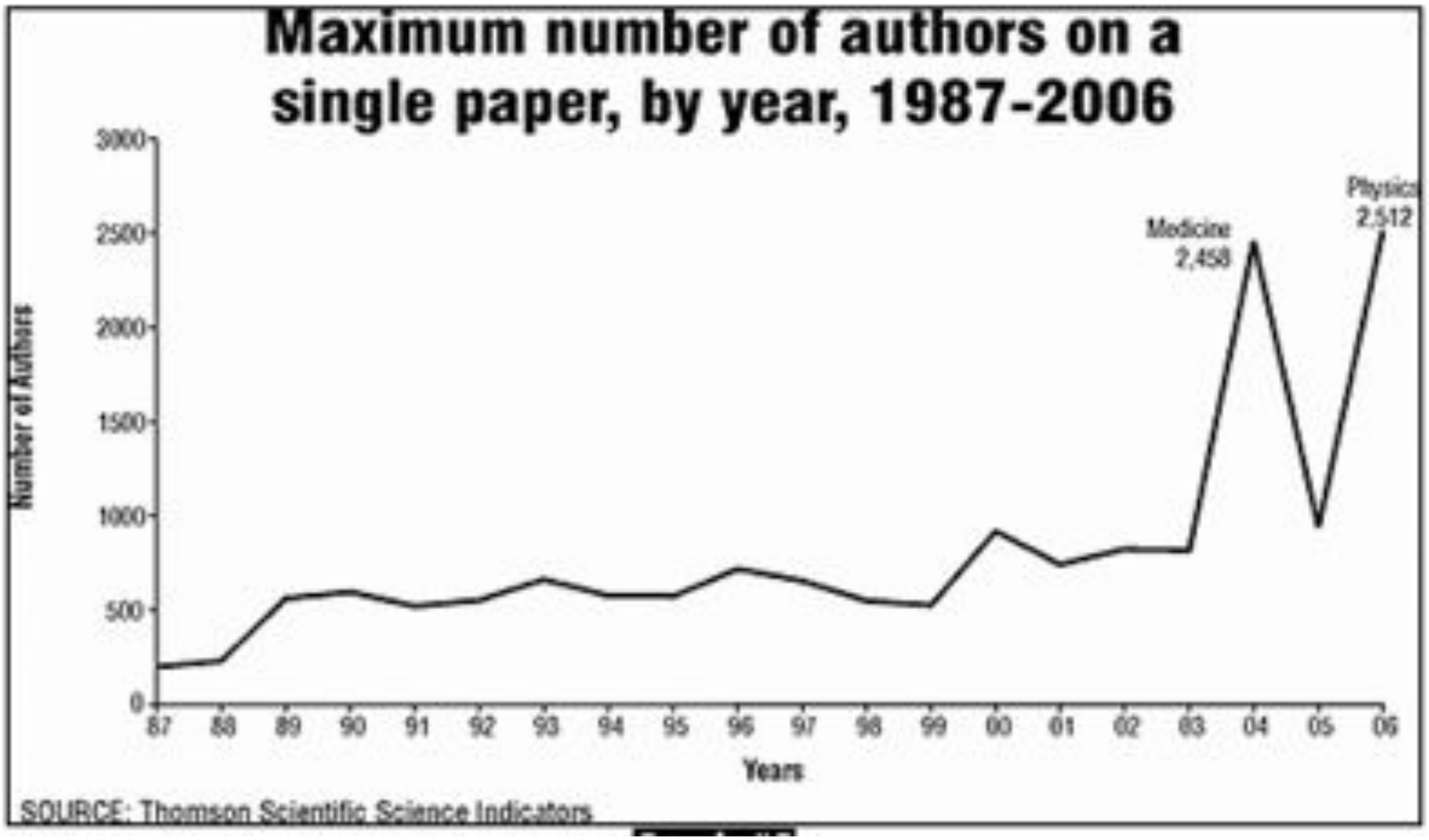
What makes collaboration important?

The flow of ideas through the sciences

Rosvall and Bergstrom, 2009

What makes collaboration important?

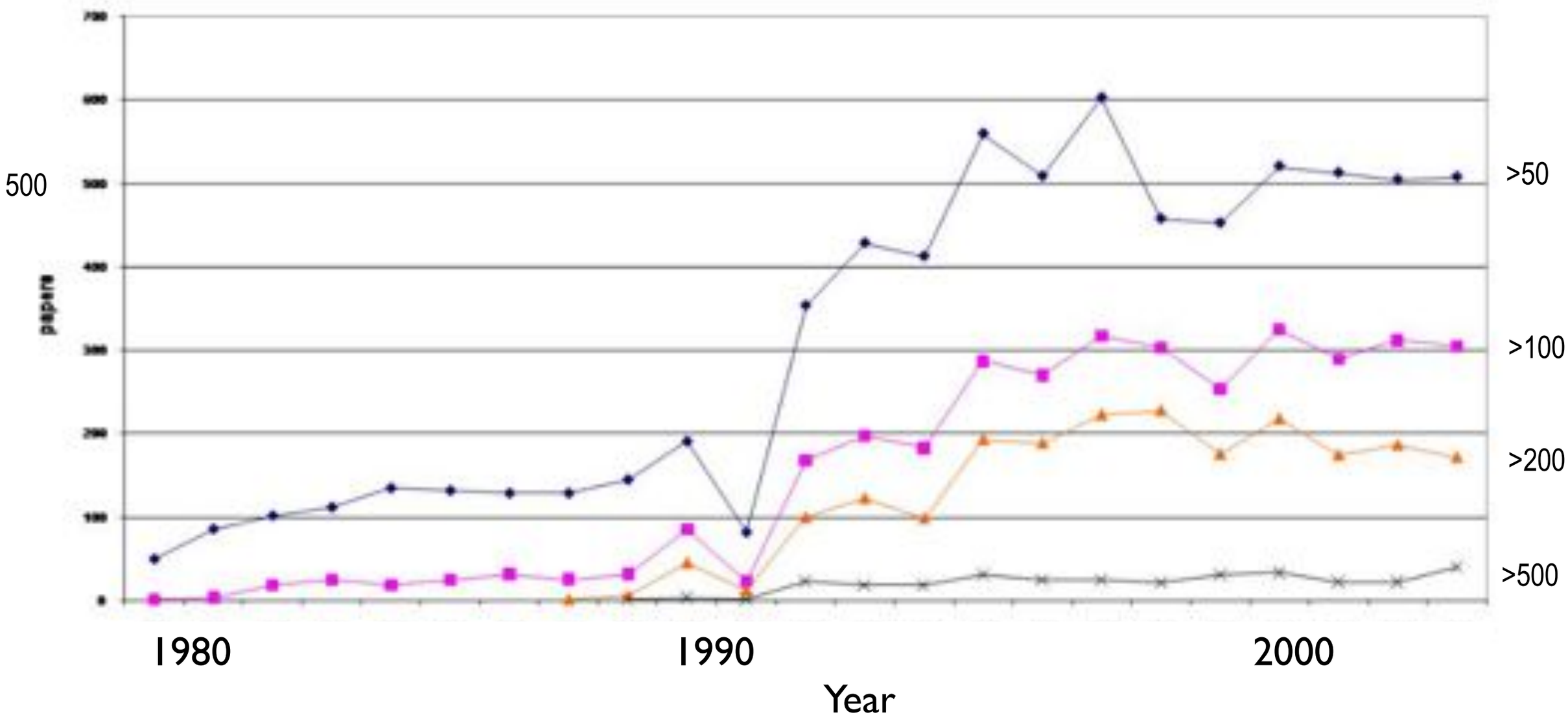
Growth in Scientific Collaboration: multi-author papers



http://sciencewatch.com/nov-dec2007/sw_nov-ded2007_page1.htm

What makes collaboration important?

Growth in Scientific Collaboration: Multi-author papers (1981-2003)



Blaise Kronin http://ekarine/org/2009/03/citations/

Barriers to scientific collaboration may be social rather than technical

Cummings and Kiesler study (2007) of 491 scientific collaborations, "Coordination costs and project outcomes in multi-university collaborations." ***Research Policy*****, 36(10), 138-152.**

C. Lee, "Barriers to Adoption of Collaboration Technologies," CHI 09 workshop "The Changing Face of Digital Science."

- **too little is known about dynamics of complex work teams**
- **collaboration across disciplines is difficult (different languages, methods)**
- **distributed work is difficult (different organizational structures and processes)**
- **need to study how to foster productive collaborations**
- **"The human infrastructure of cyberinfrastructure," Lee, Dourish, Mark, CSCW 2006**

The inverse problem: setting up structures to support students in this new world of collaboration, connected systems, dynamic systems, and data tsunamis

- Quantitative pipeline and collaboration in a curriculum
- Mentoring pipeline and collaboration in a laboratory

Quantitative pipeline and collaboration
Introductory Biology (~300, physiology with *Excel*)
Biomechanics (~75 undergrads with *Mathematica*)
Biophysics (~ 20 grads and undergrads with *Matlab*)

Introductory Biology @UW 4+ lectures/ 3 hr lab

- 180 Ecology & Evolution: are traits in populations different? t-test of plant characters
- 200 Cell & Development: rates of cell division and temperature? t-test...
- 220 Physiology & Systems: what factors determine normal arhythmias? gender differences in the cardiac axis? t-test on EKGs in teams...

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300 level primary literature-based courses:
(interpreting graphs, writing reviews)

400 level -- Example: Biomechanics
physics/mathematics/computing for biologists.
teams collaborate to solve problems (novel to them)
goal: create a computational model of a biophysical process

Goal 1: Reduce the expression of math antibodies by biology students
Goal 2: Develop modeling teams that tackle biological problems using math they have learned elsewhere in their careers...

A Mathematica Demo

Quantitative pipeline....
Introductory Biology (~350, physiology with *Excel*)
Biomechanics (~75 undergrads with *Mathematica*)
Biophysics (~ 20 grads and undergrads with *Matlab*)
A collaborative Matlab based course -- using Google Sites and some cloud computing

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If the wireless permit
a demon

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Research
Biomechanics and neural-computer interfaces --
"Neural Engineering"

R-eaching?
Network of students (all levels) and faculty solving problems together .. the culture of collaboration.

Some background

Research
Biomechanics and neural-computer interfaces --
"Neural Engineering"

Engineering *of* Neural Systems

What computing do they do? What information is acquired, processed, stored and retrieved?

Engineering *for* Neural Systems

Computational methods, MEMS devices, materials, recording, ...

Engineering *in* Neural Systems

Implanting computing and interfacing neural and synthetic systems.

A network of mentoring

Biomechanics of
Animal
Locomotion and
Design

Postdocs

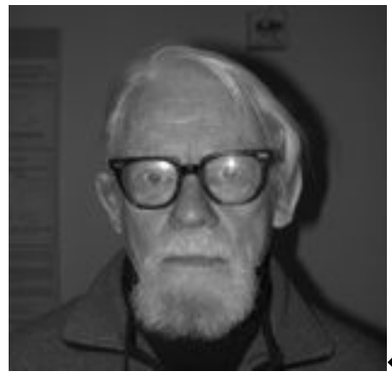
Grads

U.Grads

HS's


Zane Aldworth


Simon Sponberg


John Edwards

Emeritus faculty can (and do) participate in the mentoring ladder!


Armin Hinterwirth


Jessica Fox


Andrew Mountcastle


Dave Williams


Nicole George


Darren Howell


James Tse


Katie Miller


Mikael Daranciang


Stephanie Sundier


Saima Haq


*Cam Myhrvold


*Molly Geiger


Christina Tull


Peter Jeong

A network of mentoring

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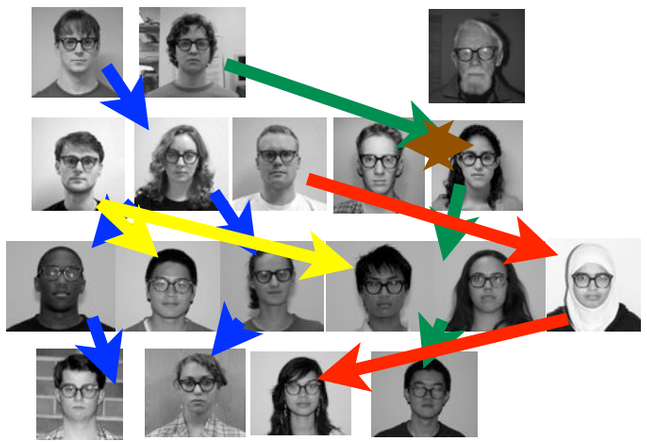

Goal 3: Learn new technical skills (data management, EE, ME, VLSI programming) while tackling fun problems in neural engineering

Comfort in teams
Language exchange (EE, Bio)
Mentoring skills
Stress reduction

Matlab shared expertise
Highly active wiki
National and international meetings

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