

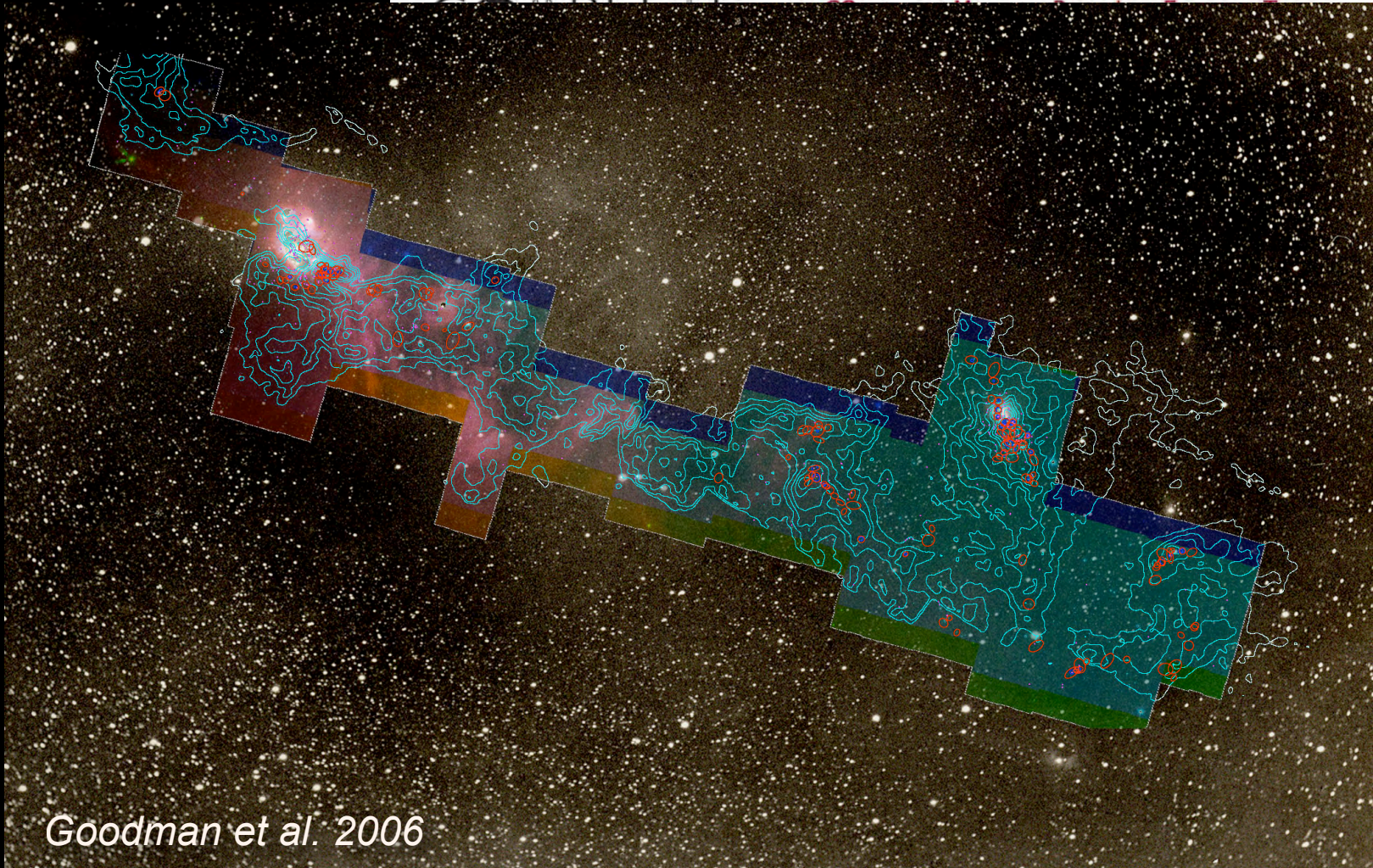
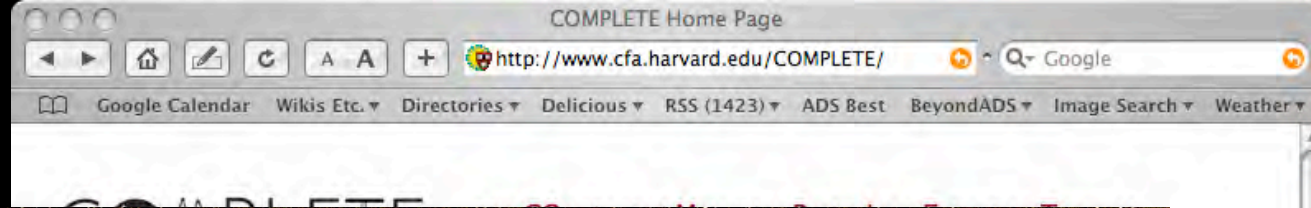
The Initiative in Innovative Computing @ Harvard

★ Visiting NSF Today (July 18, 2007)

- Alyssa A. **Goodman**, Director of IIC & Prof. of Astronomy (speaker)
- Felice **Frankel**, Senior Research Fellow/IIC Visual Computing Group
- Josh **Grindlay**, Prof. of Astronomy, PI of DASCH project
- Michael **Halle**, Senior Scientist @ IIC/PM of Astronomical Medicine
- Ros **Reid**, Editor, American Scientist & Visitor to IIC
- Rita **Tavilla**, Dir. of Administration & Operations @ IIC
- Louie **Weitzman**, Head of Internet Technologies Group @ IIC



Why me?



Goodman et al. 2006

[COMPLETE Postdoc, 2007](#) ^{NEW}

Referencing Data from the COMPLETE Survey

COMPLETE data are non-proprietary. Please reference
Ridge, N.A. et al., "The COMPLETE Survey of Star
Forming Regions: Phase 1 Data". 2006. *AJ*. 131. 2921 as



Goals for this Hour

Introductions (3 min)

What are we doing at IIC? (2 min)

Where did IIC come from? (2 min)

What is IIC for? ... The “GAP” (5 min)

How is IIC organized? (Branches x Projects, 5 min)

Example efforts:

Astronomical Medicine (6 min)

The Connectome (3 min)

Envisioning Science (5 min)

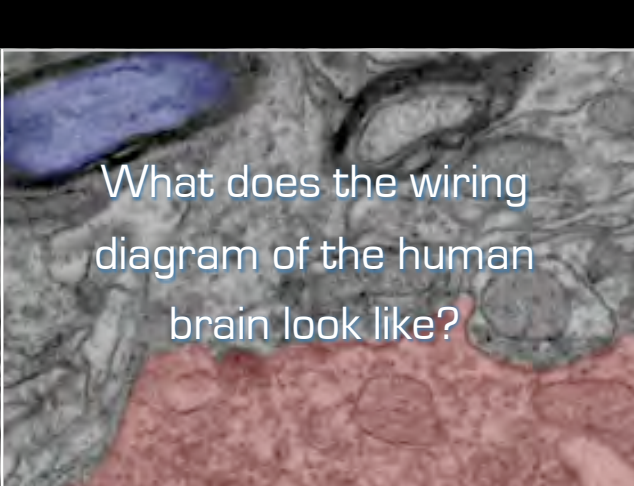
iSTEM (2 min)

The Space-Time Machine (5 min)


Going “Off-the-Desktop” (4 min)

Q&A (20 min)






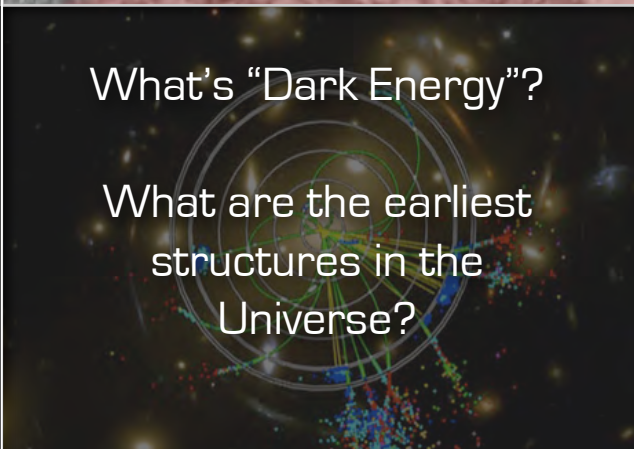
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How do stars form in our Galaxy today?

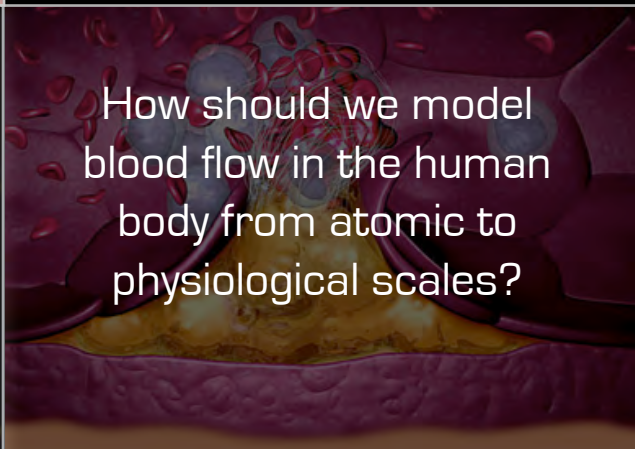


How do humans interact with "big data"?

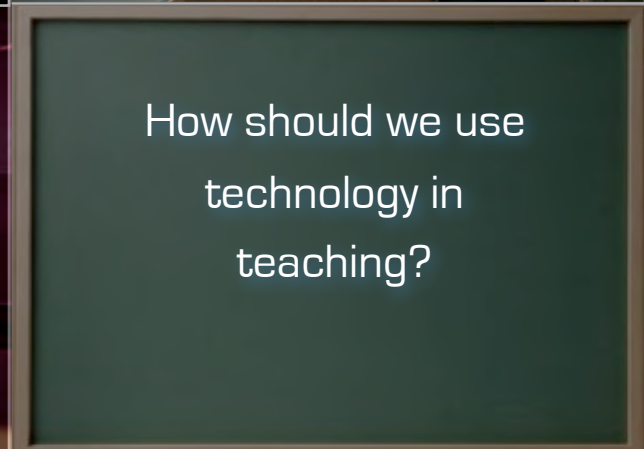


What's "Dark Energy"?

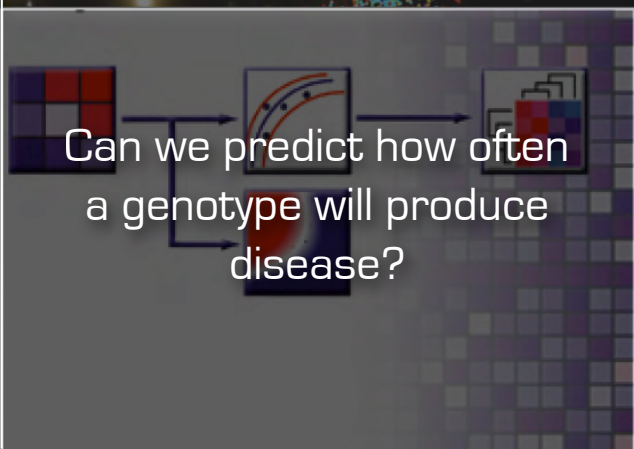
What are the earliest structures in the Universe?



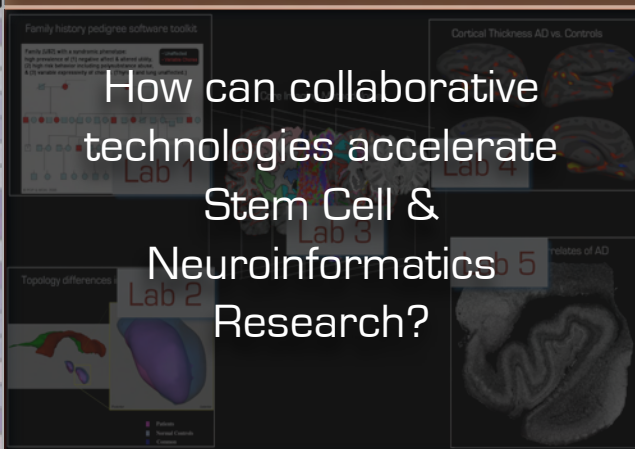
How should we model blood flow in the human body from atomic to physiological scales?



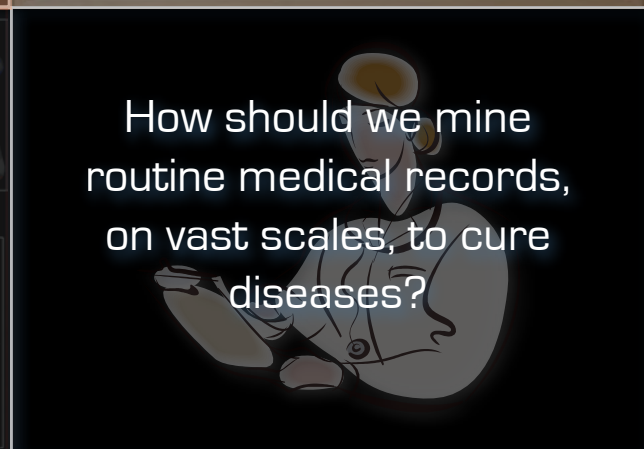
How should we use technology in teaching?



Can we predict how often a genotype will produce disease?



How can collaborative technologies accelerate Stem Cell & Neuroinformatics Research?

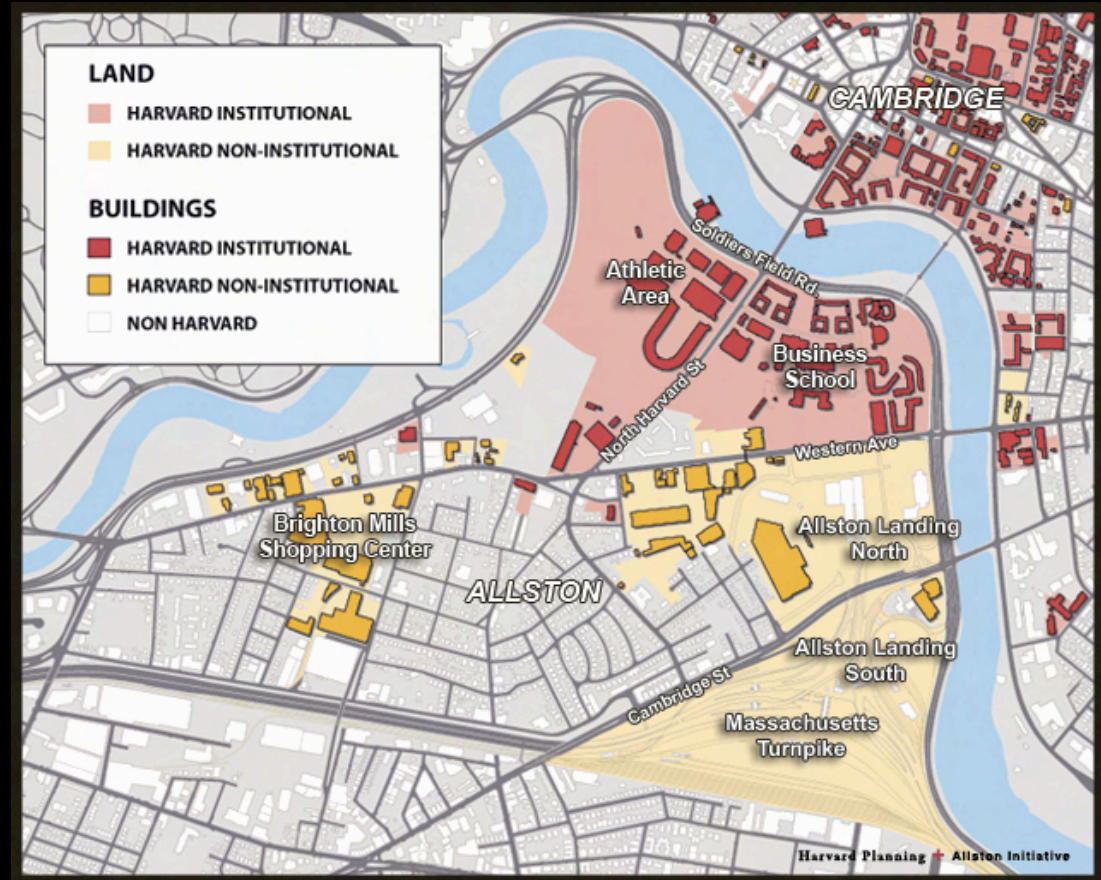


How should we mine routine medical records, on vast scales, to cure diseases?

How did IIC begin?

Response to Harvard's
“expansion” in Science,
and into Allston

See IIC [Whitepaper](#) (2004) &
Task Force on Science & Technology [report](#)
(2005) at iic.harvard.edu for more



MIND THE GAP

SCIENTIFIC DISCIPLINES



COMPUTER SCIENCE

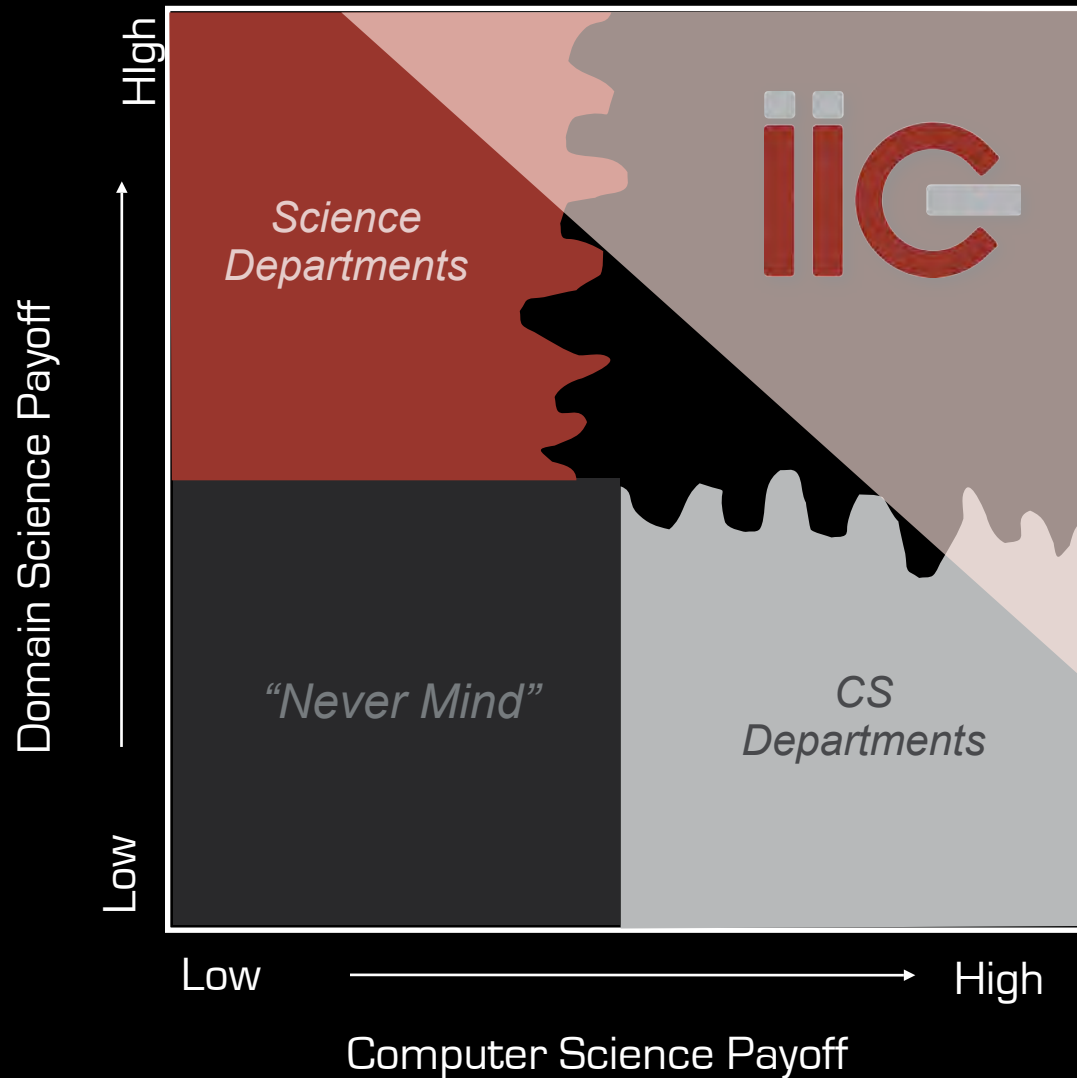
Increasingly, core problems in science require computational solution

Typically hire/“home grow” computationalists, but often lack the expertise or funding to go beyond the immediate pressing need

Academic researchers often focused on finding elegant solutions to basic computer science challenges

Often see specific, “applied” problems as outside their interests

IIC's Ideal "Space"



Original IIC “Branches”

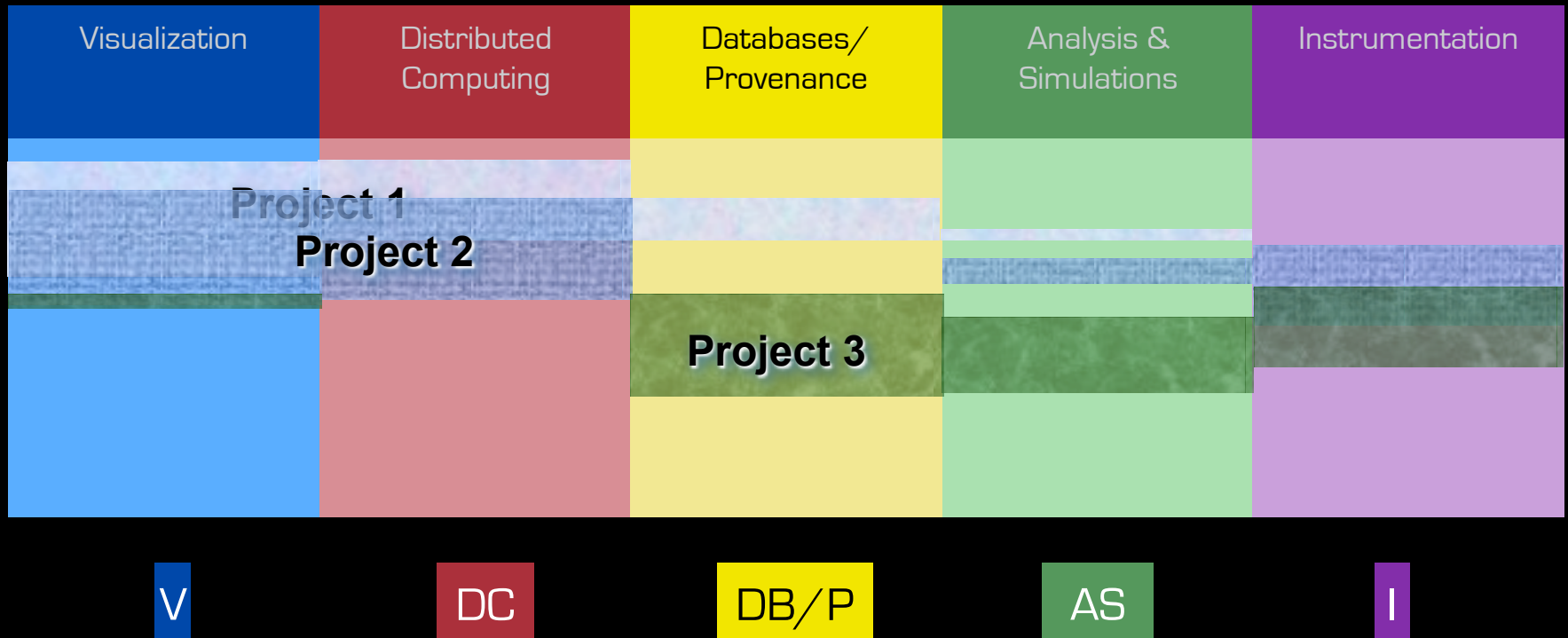
(and Projects Draw upon >1)

Visualization (Visual Computing)	Distributed Computing (Internet Technologies)	Databases/ Provenance (+HPC/Data)	Analysis & Simulations (+HPC/processing)	Instrumentation (Including “off-the desktop” computing)
Physically meaningful combination of diverse data types.	e-Science aspects of large collaborations. Sharing of data and computational resources and tools in real-time.	Management, and rapid retrieval, of data. “Research reproducibility” ... where did the data come from? How?	Development of efficient algorithms. Cross-disciplinary comparative tools (e.g. statistical).	Improved data acquisition. Novel hardware approaches (e.g. GPUs, sensors).
V	DC	DB/P	AS	I



Plus...Educational Programs that bring IIC Science to Harvard students, and to the public at large.

Building the Best (Startup) Program



Responses to March 2006 IIC Call for Ideas

Atomistic Modeling of Biomolecular Function	V	DC	DB/P	AS	
Multiscale Hemodynamics	V	DC	DB/P	AS	
Gene Pattern + The Virtual Data Center	V	DC	DB/P	AS	
Medical Treatment Outcomes Online		DC	DB/P		I
Enhanced Viz/Analysis Tools for Archaeo/Geo/Seismology	V	DC	DB/P	AS	I
Spatial Ontology Mapping (Community-based)	V	DC			
Knowledge Ecology of Science (Peer-to-Peer Collaboration Networks)	V	DC	DB/P		
Framework for Multimodal Studies in Genetics, Biology & the Mind	V	DC	DB/P	AS	I
Connectional Analysis of Synaptic Circuitry in the Mammalian Nervous System (The "Connectome")	V	DC	DB/P	AS	I
LHC/LSST/MWA Consortium for Data-Intensive Science	V	DC	DB/P	AS	I
A Portal for the National Virtual Observatory	V	DC			
Time-Series Research Collaborative	V	DC	DB/P	AS	

Education is central to IIC's mission

At Harvard:

Undergraduate & graduate **courses** focused on “data-intensive science”

New **graduate certificate program**, within existing Ph.D. programs

Research opportunities at undergraduate, graduate, and postdoctoral levels

Envisioning Science/**Picturing to Learn**

IIC Seminar Series

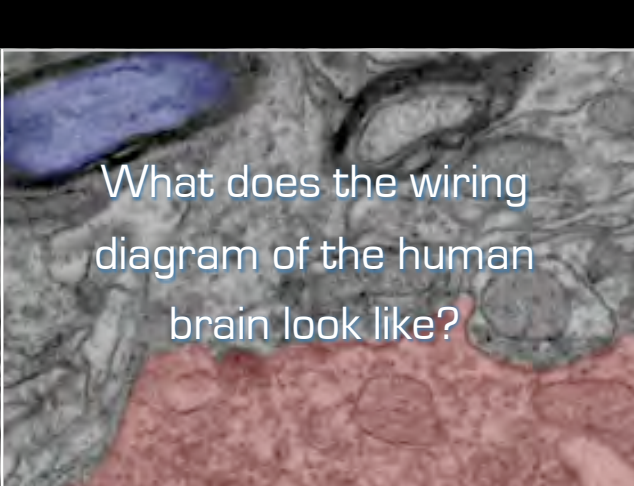
Faculty Hiring

Beyond Harvard:


Envisioning Science/**Image & Meaning** Program

New museum, highlighting the kind of science done at the IIC






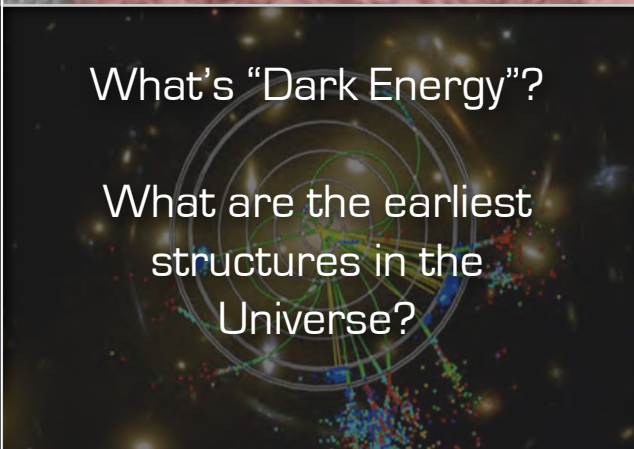
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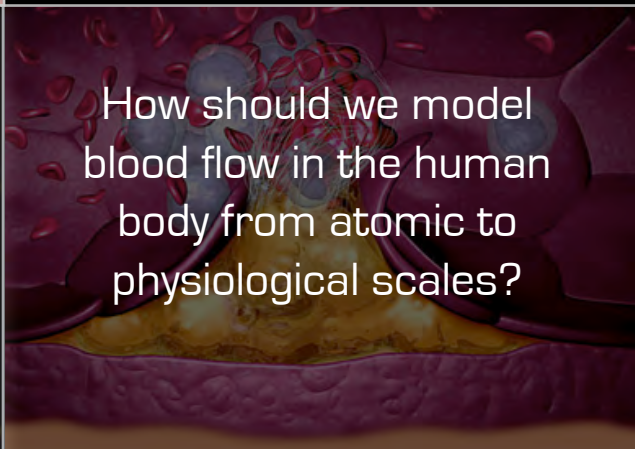


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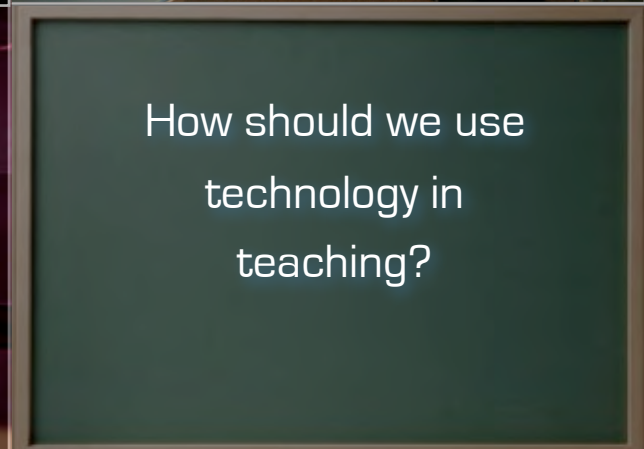


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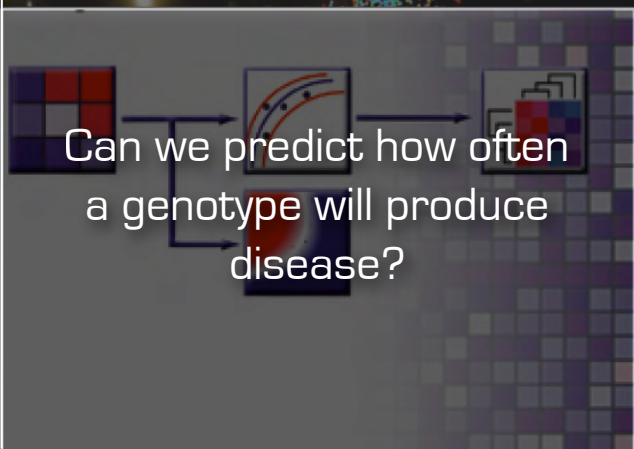
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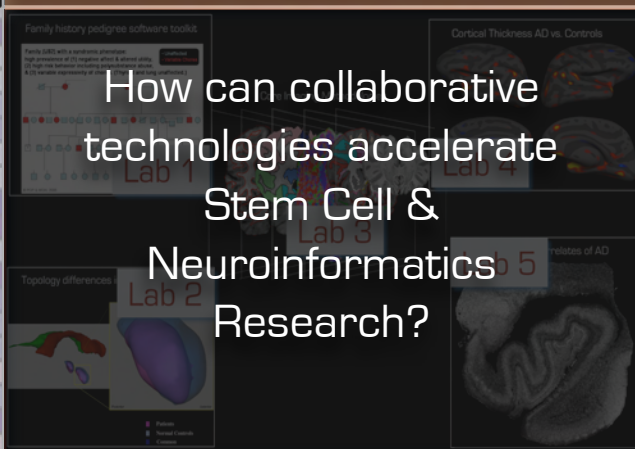
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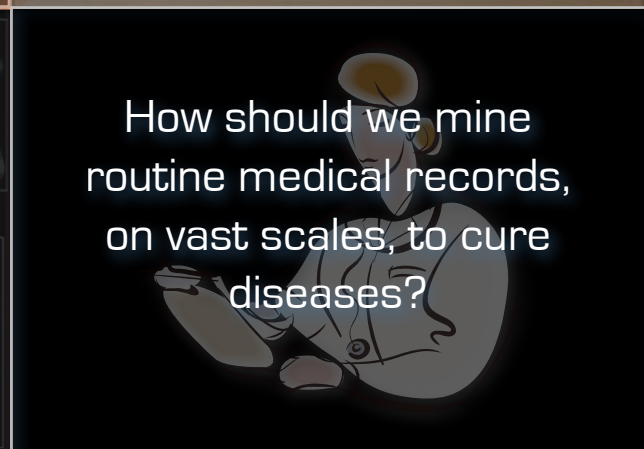
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The AstroMed Story



Computer Scientist

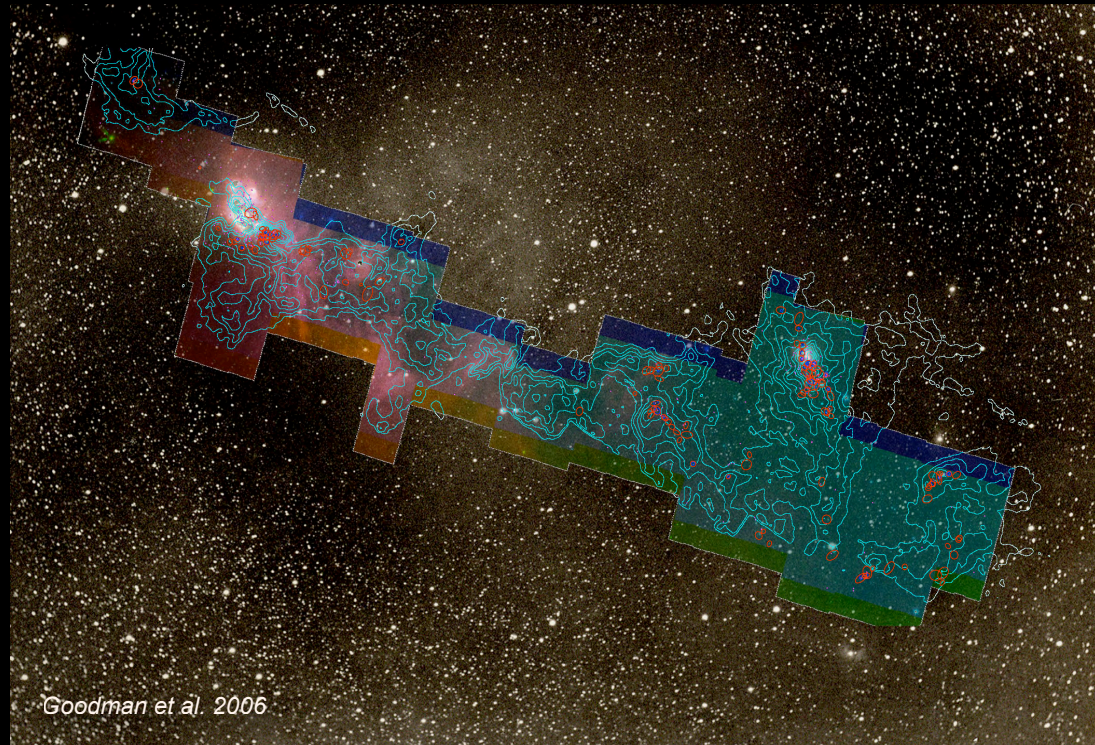


Computer Scientist



Astronomer

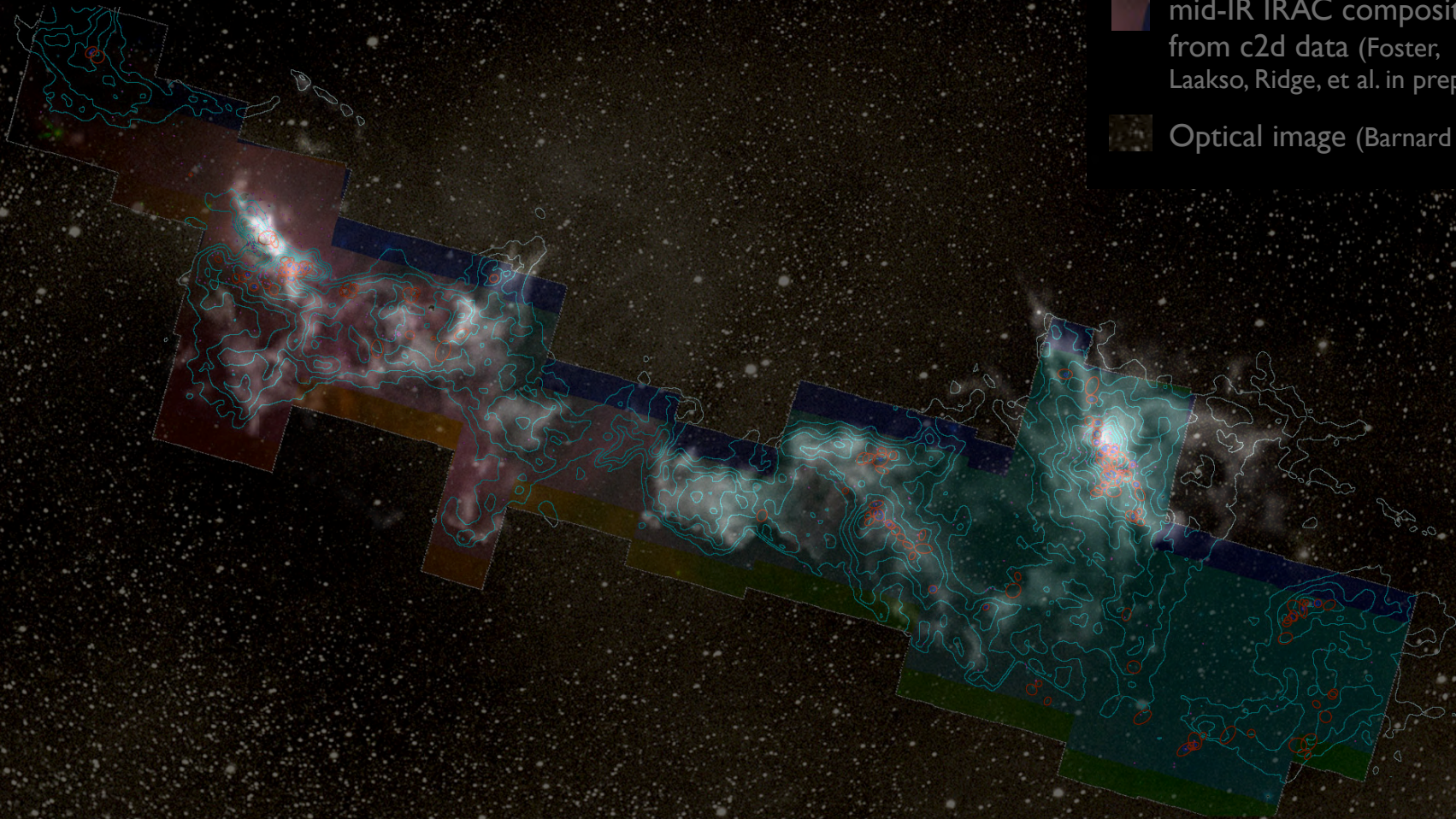
“Viz has failed the scientific community...”



COMPLETE = COordinated Molecular Probe Line Exinction Thermal Emission

image size: 520 x 274
view size: 1305 x 733
VL: 63 WW: 197

-  mm peak (Enoch et al. 2006)
-  sub-mm peak (Hatchell et al. 2005, Kirk et al. 2006)
-  ^{13}CO (Ridge et al. 2006)
-  mid-IR IRAC composite from c2d data (Foster, Laakso, Ridge, et al. in prep.)
-  Optical image (Barnard 1927)



m: 163/249
zoom: 227% Angle: 0

"Slices"

"KEITH"



"PERSEUS"



Real 3D space



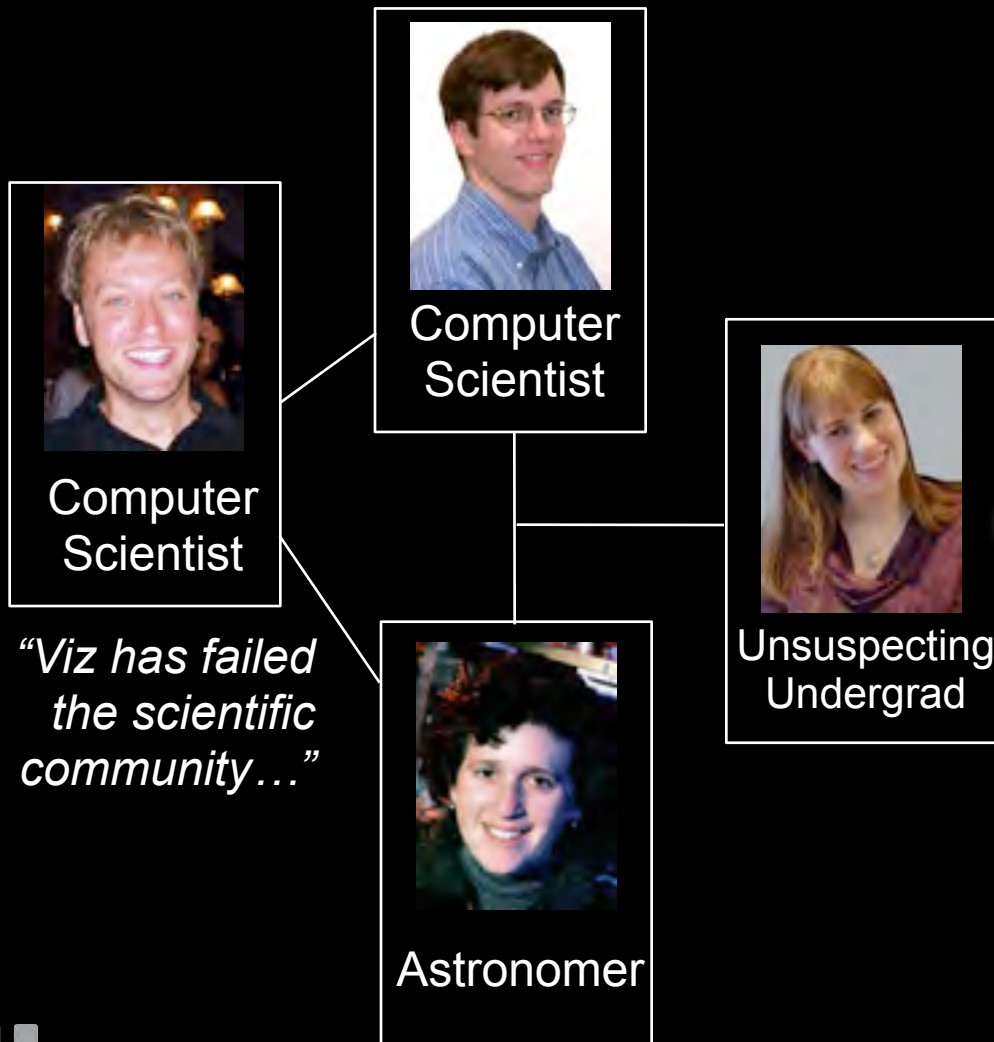
3D rendering: [GE Healthcare](#)

“Position-Position-Velocity” Space



3D rendering: AstroMed /N. Holliman (U. Durham), using VolView (ITK-based)

The AstroMed Story



iic
Initiative in Innovative Computing at Harvard

projects

Astronomical Medicine

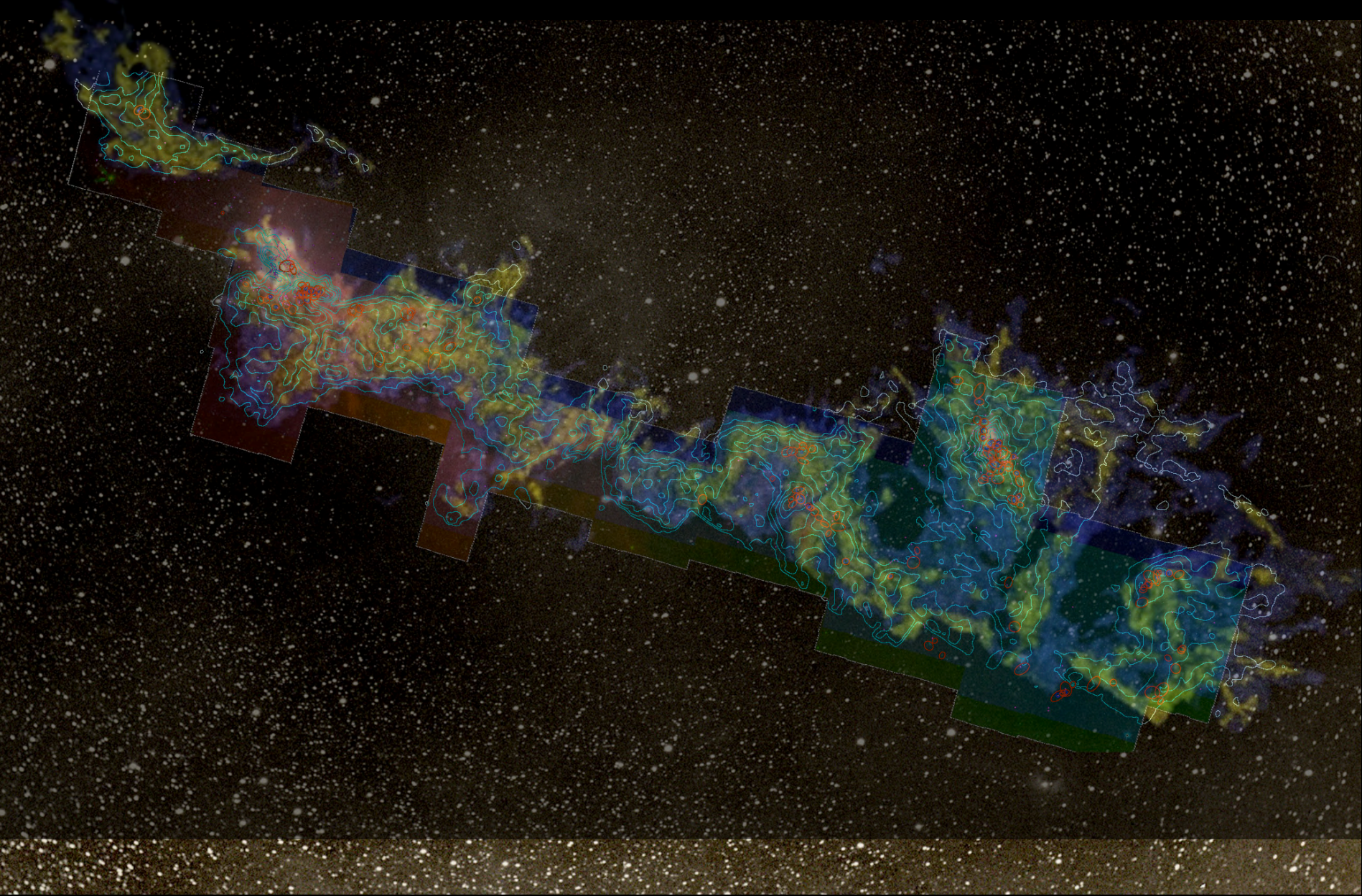


Lead Investigators
Alyssa Goodman (FAS/Astronomy, IIC), Mike Halle (HMS/SPL of BWH, IIC), Ron Kikinis (HMS/SPL of BWH), David Kennedy (HMS/Martinos Center of Harvard, MIT and MGH)

Project Staff
Doug Alan, IIC-Sr. Software Engineer
Michelle Borkin, IIC-Research Associate
Jens Kauffmann - IIC-Post Doc

Description
The goal of the "AstroMed" project is to extend the state of the art of complex data understanding in two very different fields, astronomy and medical imaging, using a broad-based approach to data exploration and analysis.





Generalizing & Sharing

Open-Source code released, and explained, as it is developed.

Changing the future of scientific publishing.

The screenshot shows the homepage of the IIC AstroMed Project. The header features the IIC logo and the text "The Astronomical Medicine Project" and "Initiative in Innovative Computing at Harvard". The main content area is titled "IIC AstroMed Project Home" and contains several sections: "AstroMed overview about us contact us", "Research papers images movies", "Software Slicer: getting started fits2tik", "Links IIC Home Center for Astrophysics COMPLETE Survey Surgical Planning Lab 3D Slicer", "User Login", "Search", and "Our approach". A central image shows a 3D visualization of a star formation region. The text describes the project's goal: "The goal of the Harvard IIC's 'AstroMed' project is to extend the state of the art of complex data understanding in two very different fields, astronomy and medical imaging, using a broad-based approach to data exploration and analysis." It also mentions "The best of two disciplines" and "The AstroMed project brings together researchers from the Harvard Medical School and the Harvard-Smithsonian Center for Astrophysics, along with both national and international collaborators, to combine their knowledge and advance the state-of-the-art in both medical imaging and astronomy."

The screenshot shows a scientific paper viewer displaying a paper titled "astromed_3d_paper.pdf". The interface includes a toolbar with options like "Create PDF", "Combine Files", "Export", "Secure", "Sign", "Forms", and "Review & Comment". A "Model Tree" panel on the left shows a hierarchy of objects: "node #-1", "Group", "outer contour", "Drawings", and "Vectorized Layer". The main content area shows a section of the paper with a dendrogram visualization. The text discusses "energy to gravitational binding energy (without external pressure or a magnetic field) for every branch in the dendrogram. We highlight in red every branch that corresponds, in our simplified model, to a self-gravitating object. The standard feature identification algorithms may find the objects at the top branches of the dendrogram tree, since these correspond to the peaks of 'clumps' - but would be unable to identify objects at the base of the dendrogram 'tree'." A figure shows a dendrogram with a red branch highlighted. The caption reads: "Figure 2 | Substantially uniform results of L1444 in ^{13}CO . The median star in $p-p$ space, where the front of the case is the plane of the sky. The intensity threshold shows a choice using the 'robustness' procedure described."



The Connectome:

Wiring Diagram for a Complete Brain Circuit

(Connectional Analysis of Synaptic Circuitry in the Mammalian Nervous System)

3D images from electron-microscope images of serial sections (slices)

- Large volumes studies: up to 500 mm cubes
- High resolution: $\sim 5\text{nm}$ x-y; 50 nm in z ($10^5 \times 10^5 \times 10^4 = 10^{14}$ voxels)
- Large datasets: 10-100 TB

Potentially intractable computationally w/o a hierarchical approach

Start with the large, dominant pathways:

The biggest wires and the biggest excitatory connections.

Use this as scaffolding to then solve other pathways:
inhibition, lateral connections, feedback.

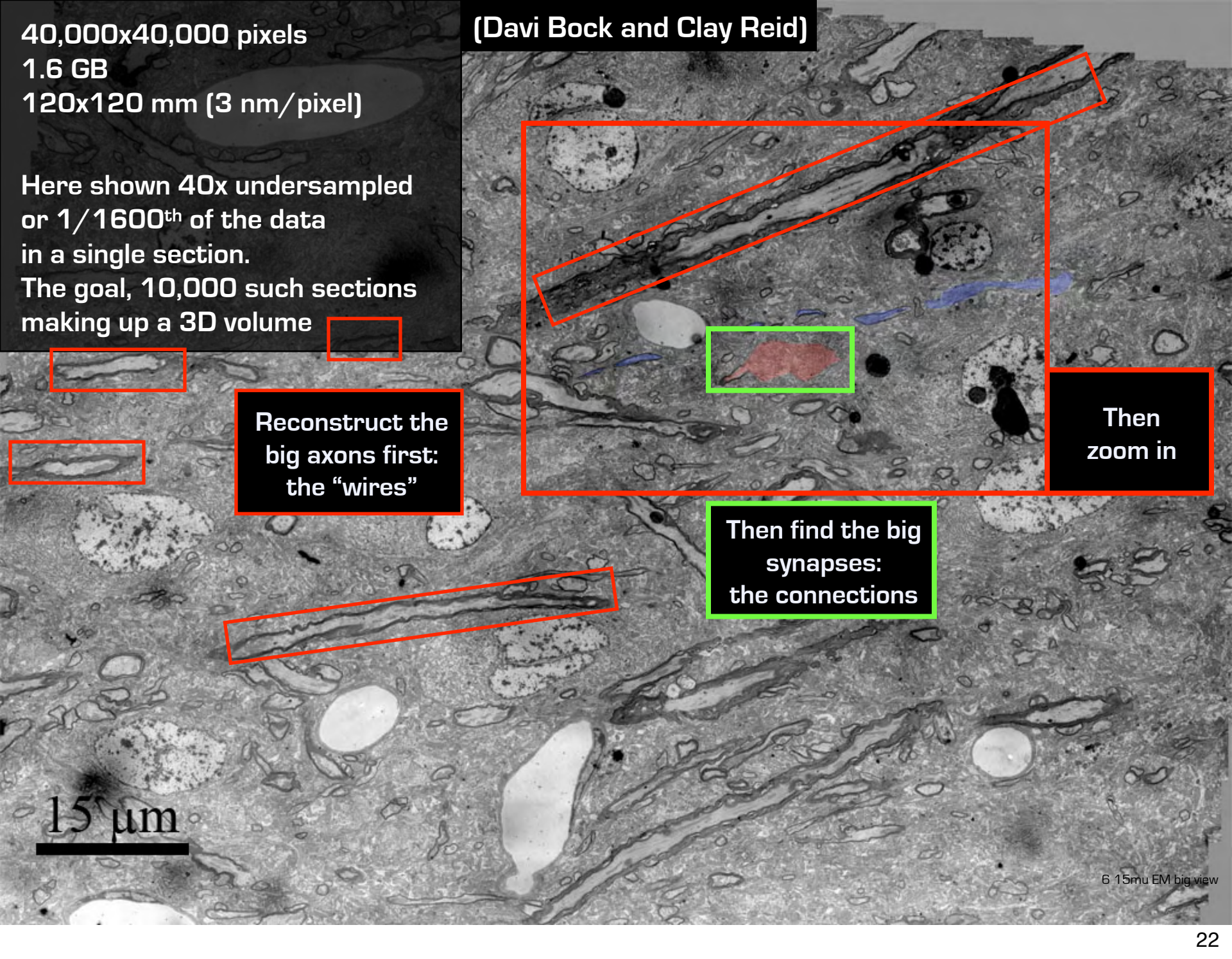
“PetaScale Computing” most certainly...



40,000x40,000 pixels
1.6 GB
120x120 mm (3 nm/pixel)

(Davi Bock and Clay Reid)

Here shown 40x undersampled
or 1/1600th of the data
in a single section.
The goal, 10,000 such sections
making up a 3D volume



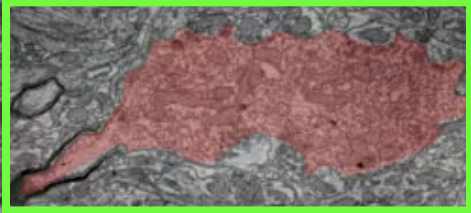
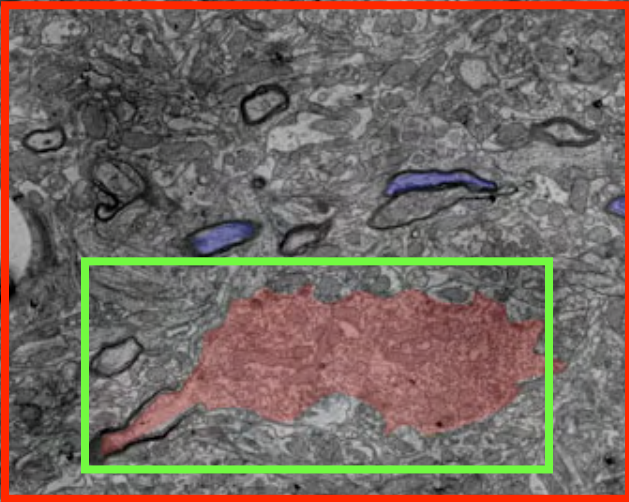
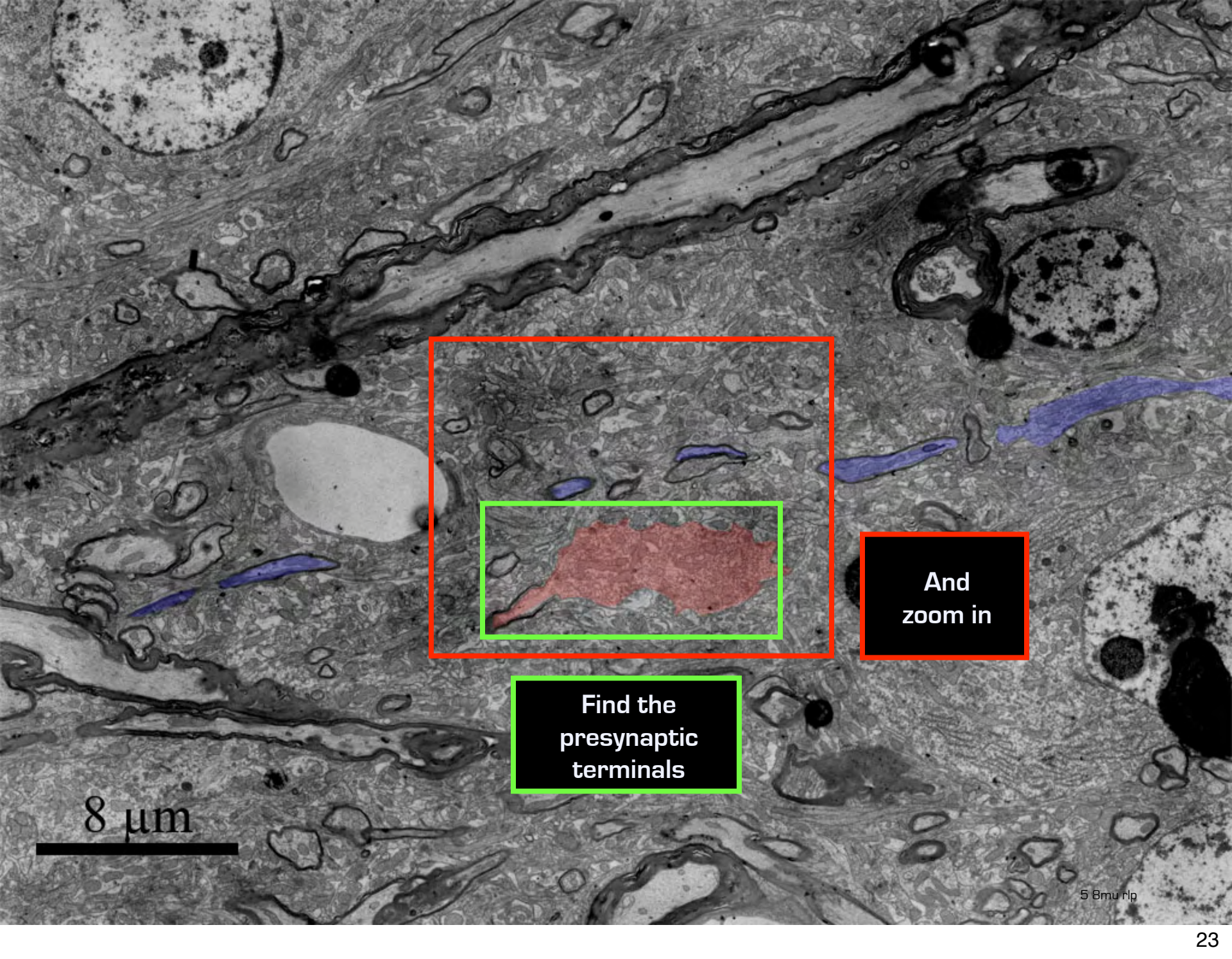
Reconstruct the
big axons first:
the "wires"

Then find the big
synapses:
the connections

Then
zoom in

15 μm

6 15mu EM big view

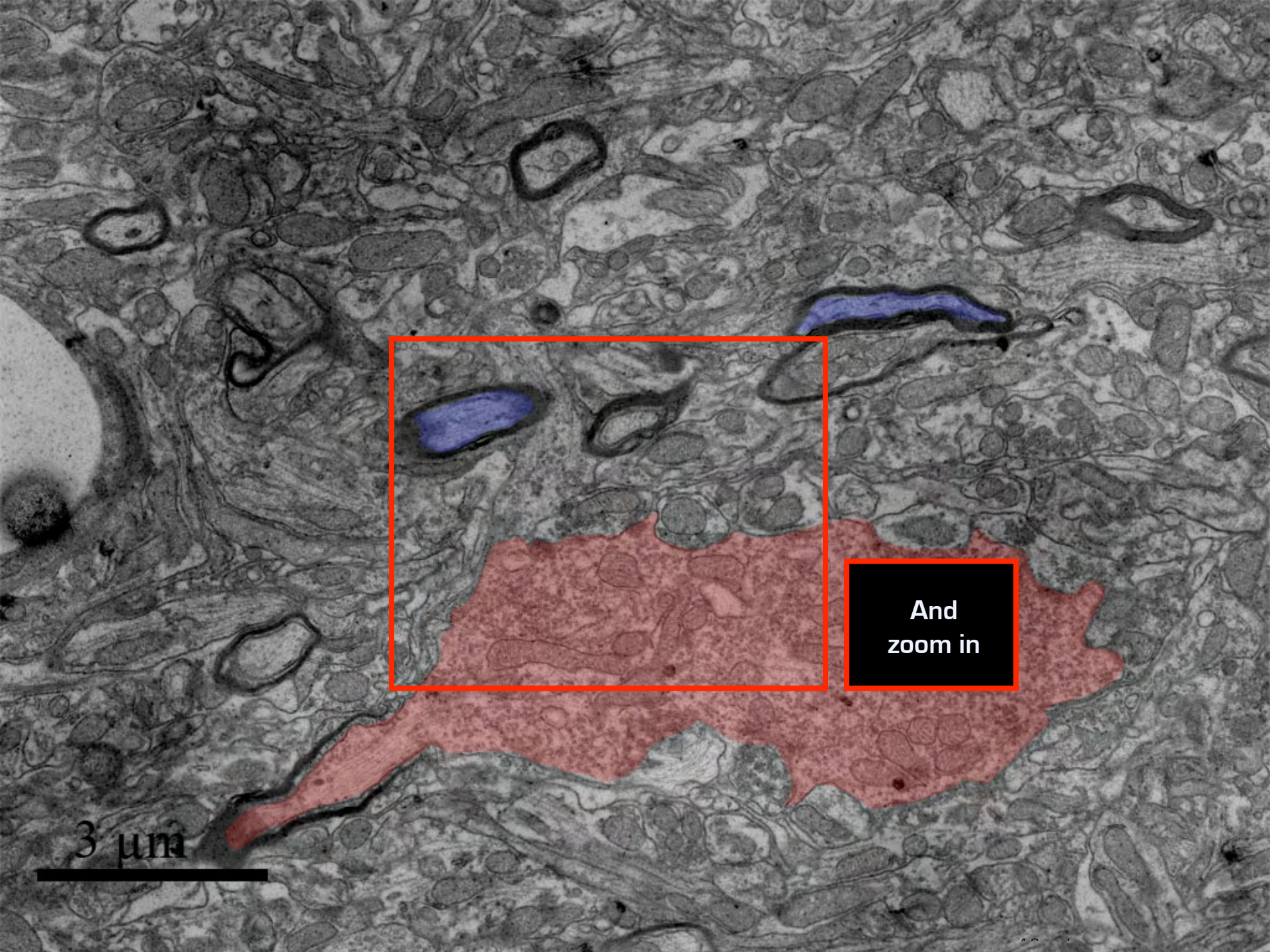


And
zoom in

Find the
presynaptic
terminals

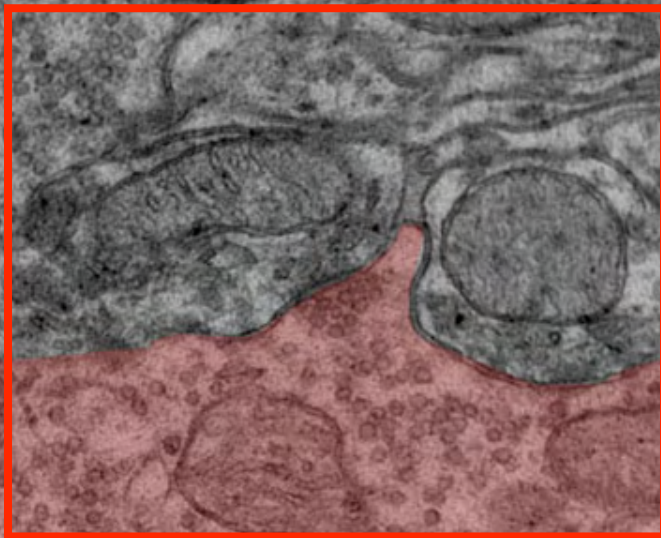
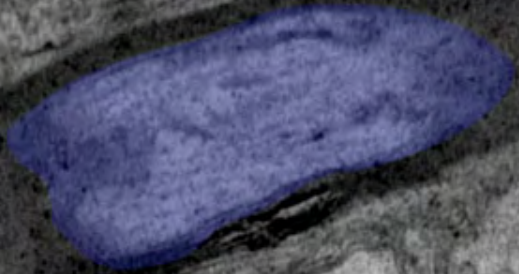
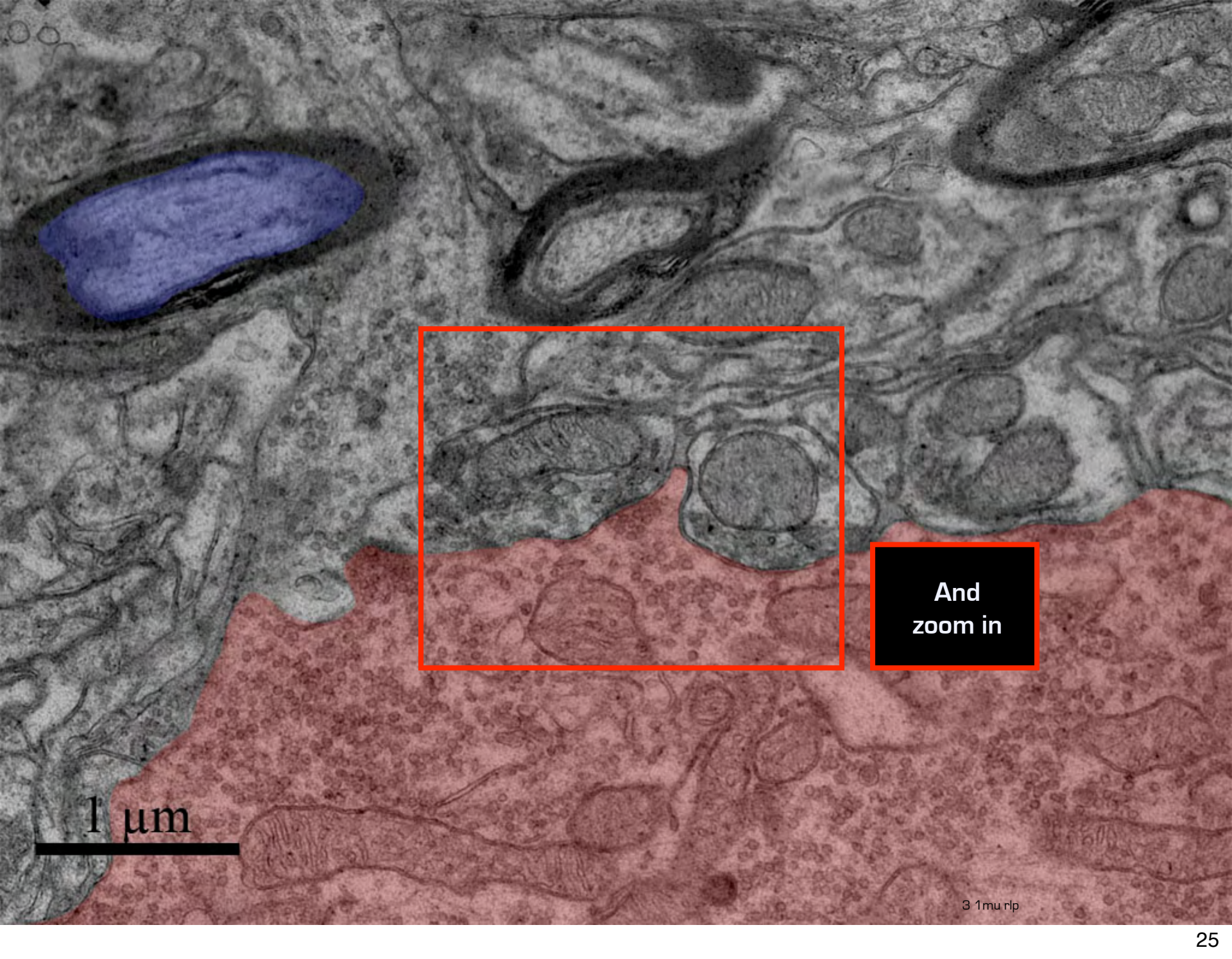
8 μm

5 8mu rlp



And
zoom in

3 μm

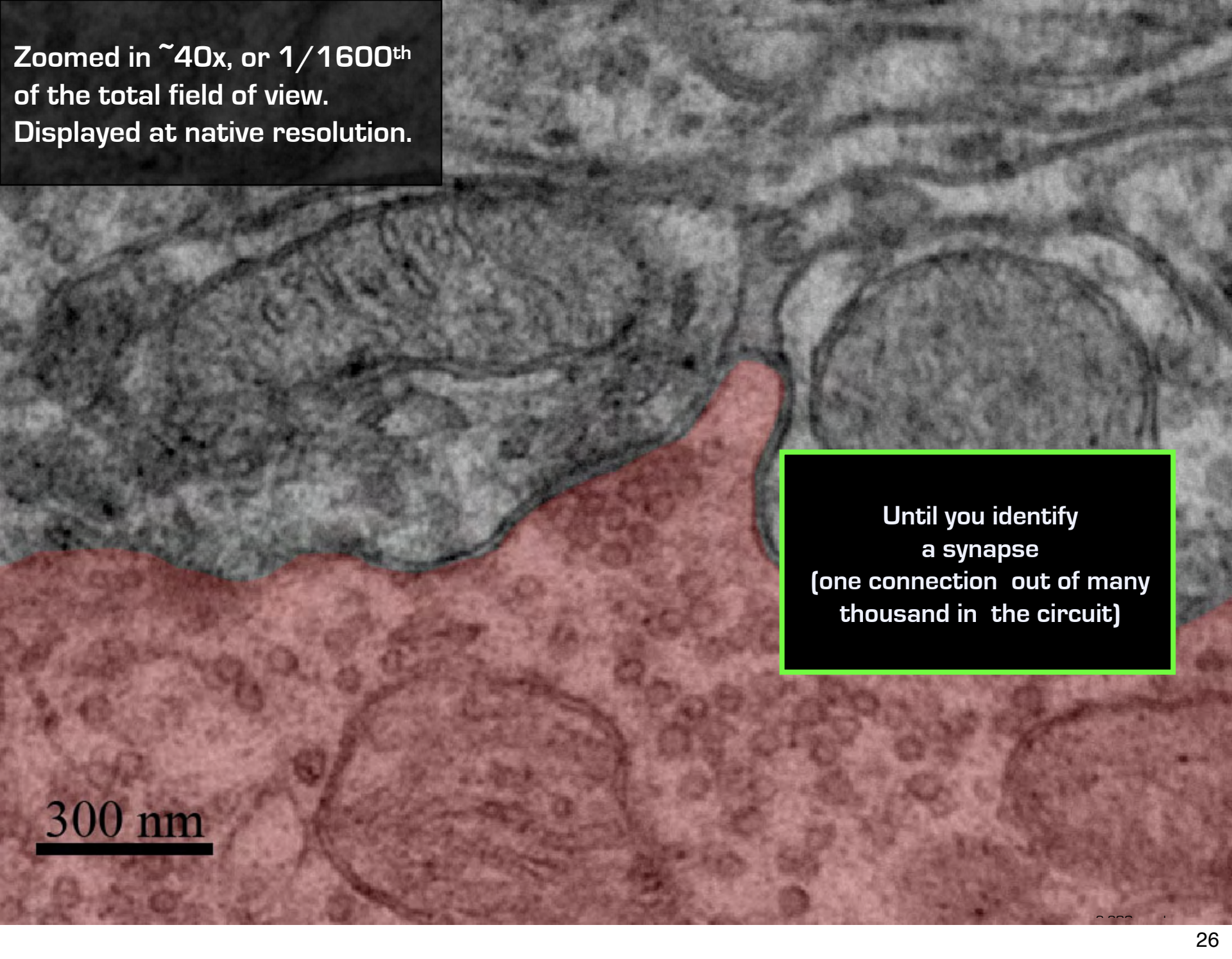


And
zoom in

1 μm

3 1mu rlp

Zoomed in $\sim 40\times$, or $1/1600^{\text{th}}$
of the total field of view.
Displayed at native resolution.

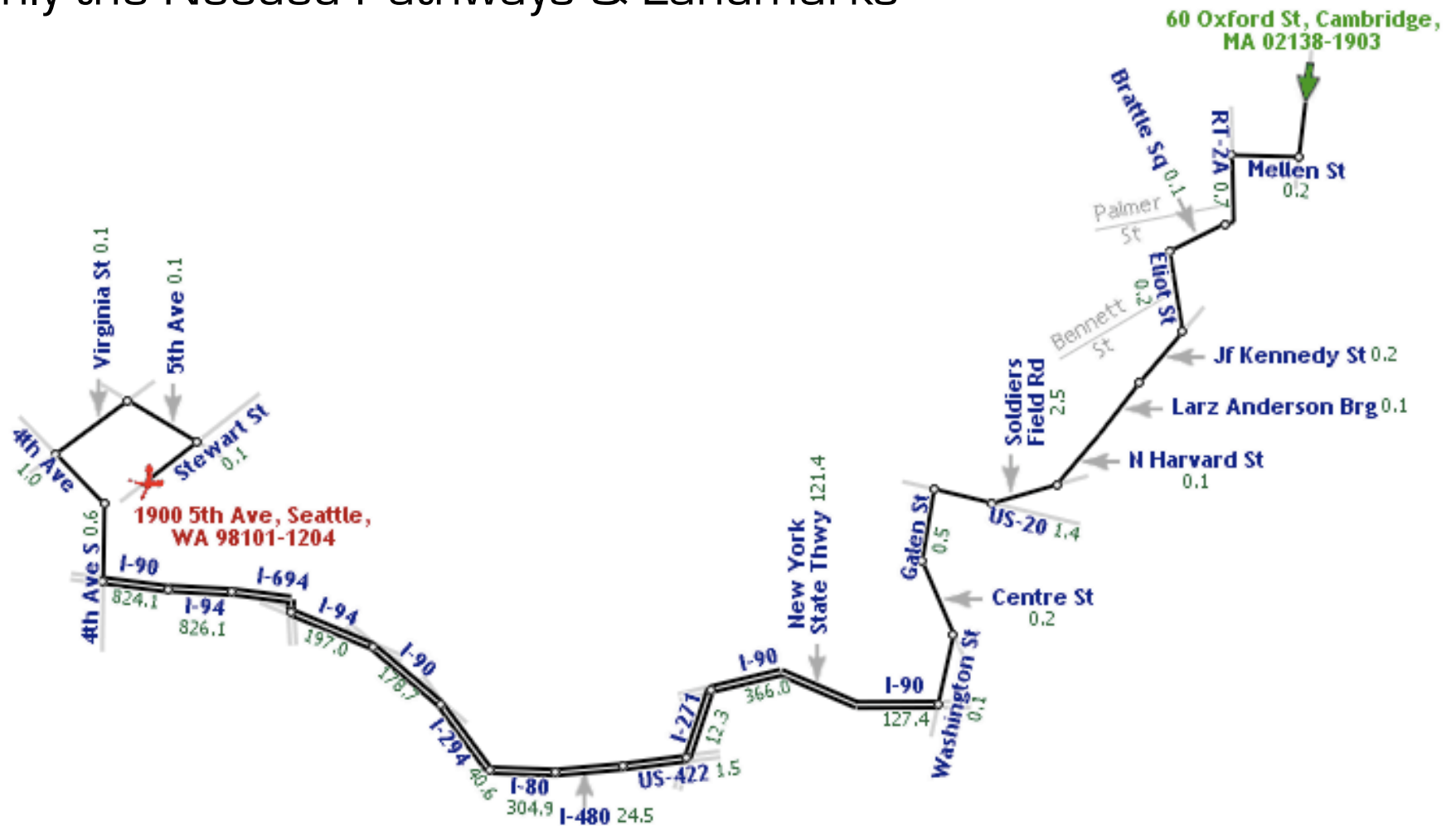


Until you identify
a synapse
(one connection out of many
thousand in the circuit)

300 nm

“Smart Maps”

Only the Needed Pathways & Landmarks



LineDrive (Microsoft & Maneesh Agrawala)

Scalability

10^6 pixels

10^7 voxels

10^8 voxels

10^{14} voxels

10^{16} pixels

10^{19} voxels

10^{22} voxels

this projector

an MRI of your brain, at 0.5 mm resolution

Perseus COMPLETE data cube

the **Connectome**, 0.5 mm^3 of brain tissue

Google **Earth Imagery** at 1 foot resolution

Google **Earth 3D**, ± 1000 feet of elevation, 1 ft. res.

the **Connectome**, full human brain

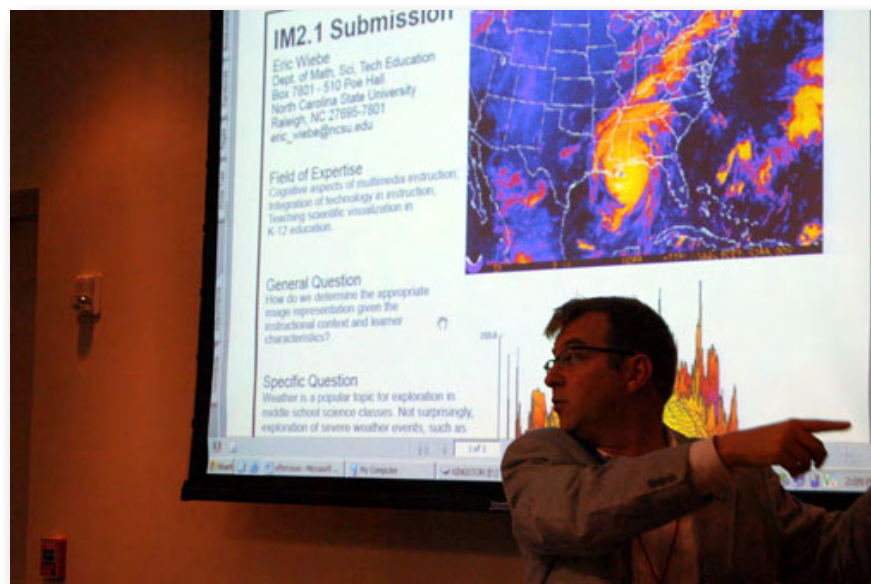
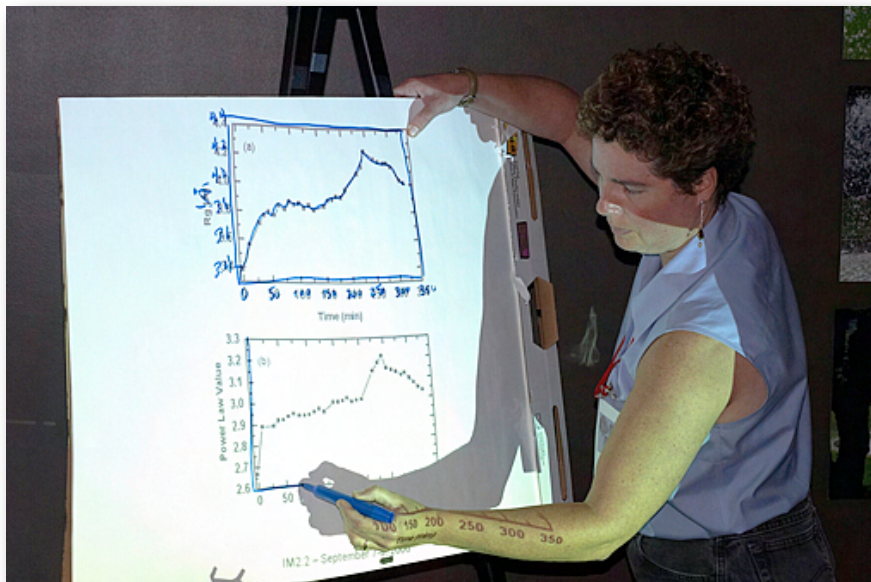


the envisioning science program



┌ NSF supported ─┐





face-to-face  virtual

the virtual graphical collaborative project

synchronous and/or asynchronous, ENGAGED, small,
interdisciplinary, groups

- researchers (via Image and Meaning program)
- students (via Picturing to Learn program)

to create and archive unique “libraries” showing:
the process = the evolution of conversations
commonalities = tagging beyond the nouns
of disciplines

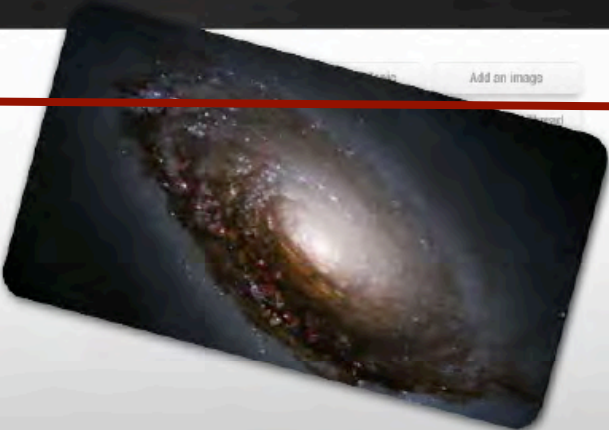
Title: The Milky Way
Initiator: Ross B
Initiated: May 24th, 2007

Image:
Uploaded:
By:



- Josh Beckett
- Manny Delcarmen**
- Javier Lopez
- Daisuke Matsuzaka**
- Hideki Okajima
- Jonathan Papelbon
- Joel Pinero**
- Curt Schilling**
- Kyle Snyder**
- Julian Tavarez
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- Kevin Youkilis**
- Coco Crisp
- J.D. Drew**
- Eric Hinske
- Wily Mo Pena**
- Manny Ramirez

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Add an image

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

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- J.D. Drew**
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- Manny Ramirez

“ross”
uploads
fly-in image

workspace
collaborators,
active and others



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Initiator: Ross B
Initiated: May 24th, 2007

Image: 01
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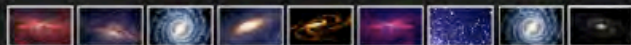
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reference
library

navigation



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[Kyle Snyder](#)

[Julian Tavarez](#)

Mike Timlin



*Beatae vitae dicta sunt explicata.
Nemo enim ipsam fugit, sed quia
consequuntur qui ratione voluptat.*

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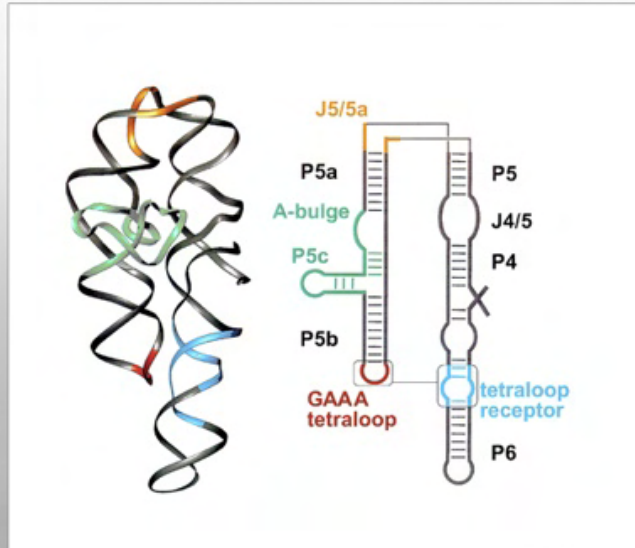
[J.D. Drew](#)



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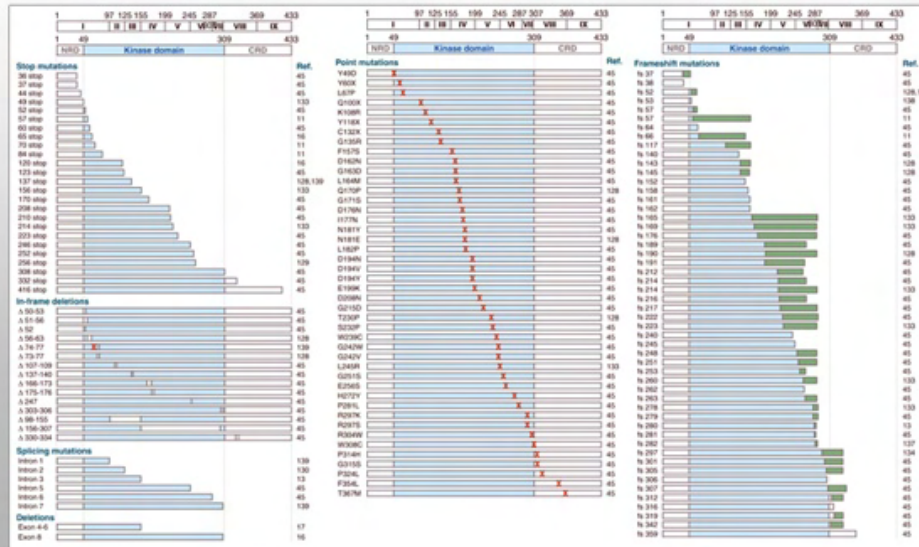




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Initiator: Ross B
Initiated: May 24th, 2007

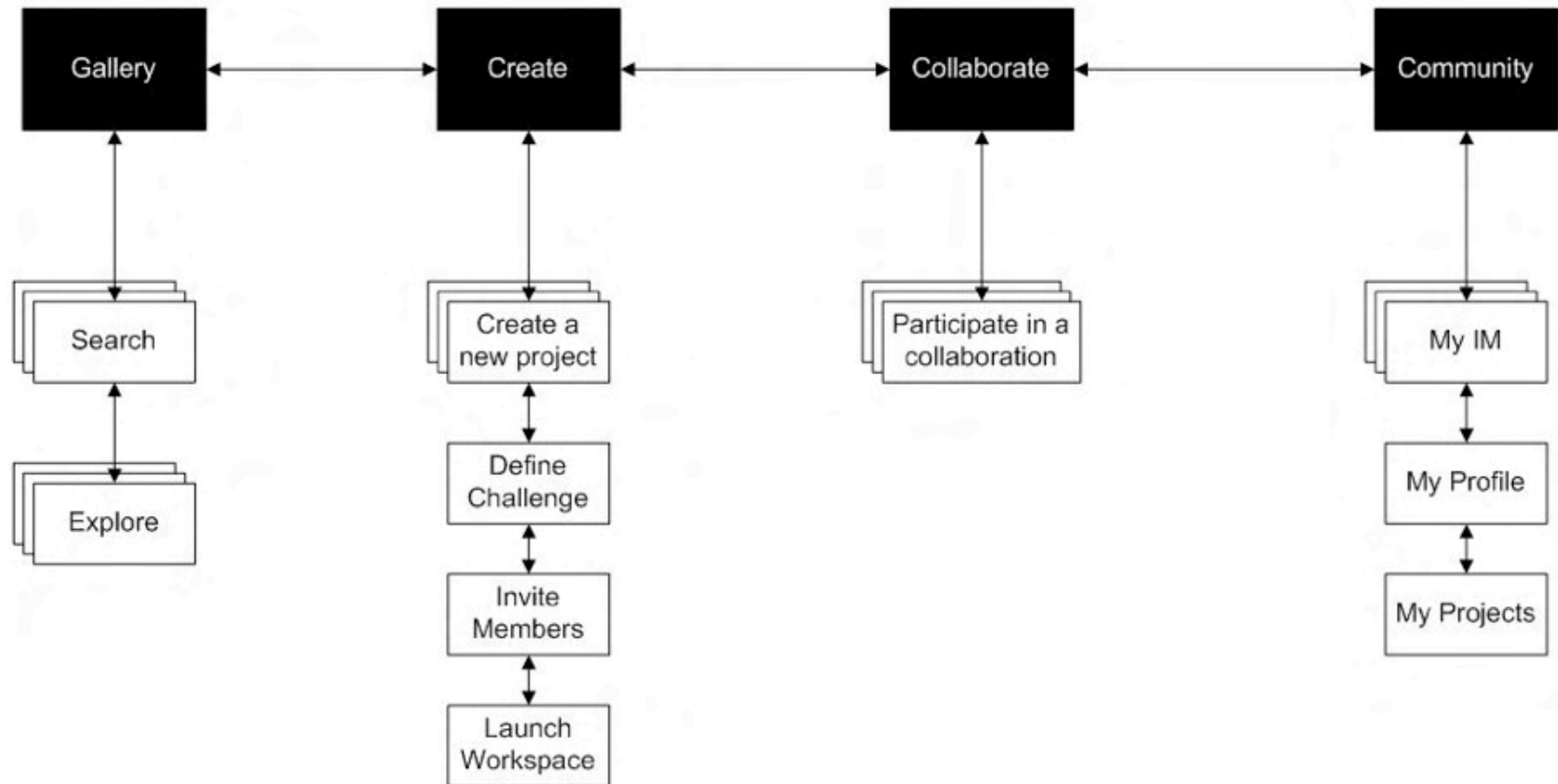
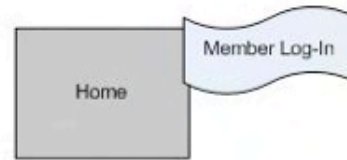
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iStem is an internal collaboration tool for members of HSCI.

If you are a Principal or Affiliated Faculty member and don't yet have an iStem account, click

iSTEM: A “Collaboratory” for the Stem Cell Research Community at Harvard (An IIC-HSCI Joint Project)

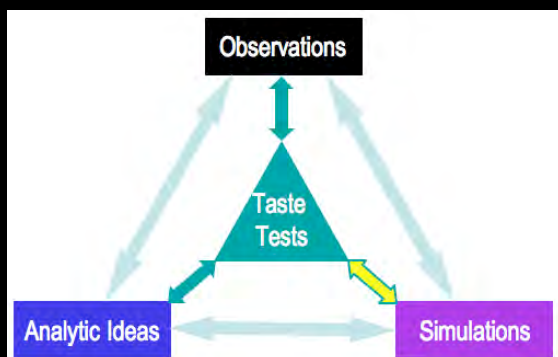
Goals

- communicate digitally in multiple ways (text, speech, graphics, video)
- share, annotate, archive and retrieve digital content
- share and search joint resources (reagents, protocols publications and computational tools)

Features

- web-based "social technology" framework
- based on reusable open-source components
- intended to be generalizable at Harvard, and on an international scale

“Taste Tests”: Simulations, Observations, and Delicious Insight



Star Formation Taste Tests > Overview

https://iic.grouphub.com/projects/700257/pr

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Star Formation Taste Tests CFA

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Project overview

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Welcome to the Tasting Room



This is the collaborative space for those who do simulations of star forming regions, and those who observe them. It was inspired, in the Fall of 2006, by the NSF proposal entitled "Star Formation Taste Tests," by A. Goodman & E. Rosolowsky. Today, it is used to host conversations about and short descriptions of simulations, along with links to longer descriptions (e.g. Journal articles & web sites). In the future, we are planning to connect more enhanced descriptions of those simulations directly to online code bases and sample outputs (likely with help from our friends at NCSA). So, stay tuned.

What's fresh?

Today

No activity today

Yesterday

MESSAGE [General Remarks and Suggestions](#)
by Jürgen S. in [Full Group Communications](#), 23 Nov

Before Yesterday

FILE [GoodmanNSF1106Basecamp.pdf](#)
(PDF, 3151K) uploaded by Alyssa G., 17 Nov

MESSAGE ["Taste Test" NSF Proposal Uploaded](#)

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Want to be notified any time someone posts a message, comment or file, or adds or completes a to-do item or milestone in this project? Just [subscribe to your project RSS feed](#) **RSS** ([What is RSS?](#))

People on this project

[IIC](#)

- Alyssa Goodman
Last login about 22 hours ago
- Douglas Alan
Last login about 22 hours ago
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Last login 2 days ago
- Jens Kauffmann
Last login 18 days ago
- Tim Clark
Last login 105 days ago

American Museum of Natural History

Mordecai-Mark Mac Low
Last login 28 days ago

Cardiff University

Anthony Whitworth
No login yet

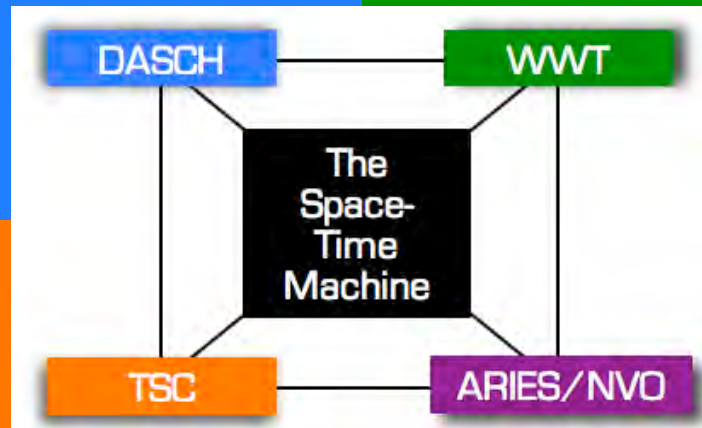
CFA

Go to "https://iic.grouphub.com/P4080344"

The Space-Time Machine

Digital Access to a Sky
Century at Harvard

The World Wide Telescope,
v2.0



The Time Series Center @ IIC

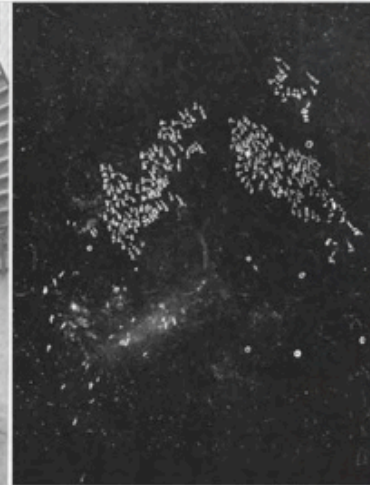
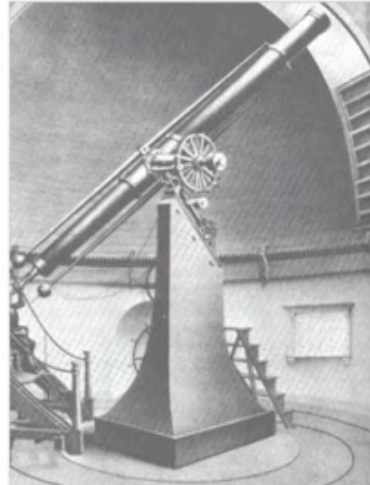
Advanced Research Interface
for Exploring the Sky/
National Virtual Observatory



The Space- Time Machine: DASCH



A Trip Back in Time and Space



The Great Refractor, left, which captured the first picture of a star in 1850, and an image of the Large Magellanic Cloud taken in 1900. [More Photos >](#)

By GEORGE JOHNSON
Published July 10, 2007

In the summer of 1889, when this was still an analog world, a young astronomer named Solon I. Bailey carefully packed two crates of glass photographic plates taken at his outpost in the Peruvian Andes for shipment to [Harvard](#) College Observatory. Carried down the mountain on muleback and across a suspension bridge to the village of Chosica, the fragile load was put on a train bound for Lima and the long voyage to Boston Harbor.

Multimedia



Slide Show
Harvard's Cosmos

Enlarge This Image



For nearly 18 months the data stream continued — more than 2,500 plates from what Mr. Bailey had quaintly named Mount Harvard — followed in the coming years by tens of thousands more from a second Peruvian station in Arequipa. Over the decades more streams came from Chile, South Africa and New Zealand, joining the growing piles produced by telescopes in Massachusetts.

The accumulated result weighs heavily on its keepers on Observatory Hill, just up Garden Street from Harvard Square: more than half a million images constituting humanity's only record of a century's worth of sky.

*Besides being 25 percent of the world's total of

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Video
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BEHOLD THE iPhone

Watch David Pogue put the iPhone to the test

The Space-Time Machine: A Public-Private Partnership

Digital Access to a Sky
Century at Harvard: Private
Donor + NSF

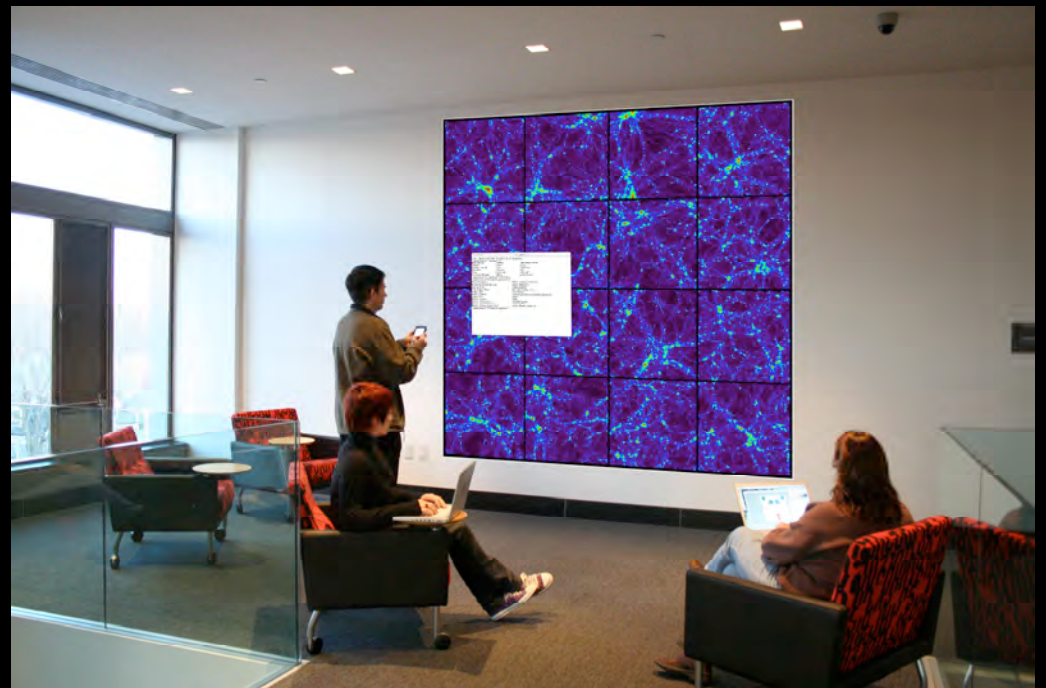
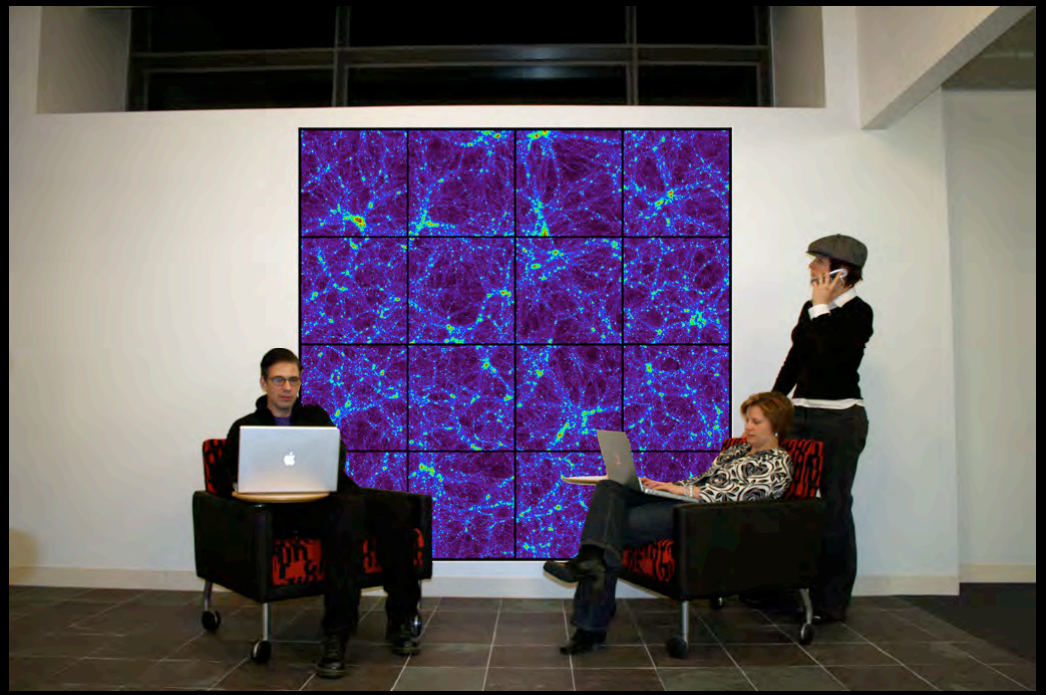
The World Wide Telescope,
v2.0: Microsoft Research +
Private Foundation (+ NSF?)



The Time Series Center @ IIC:
NSF + Microsoft Technical
Computing Initiative

Advanced Research Interface
for Exploring the Sky/National
Virtual Observatory (NSF?!)

Going “Off-the-Desktop”



Going Off-the-Desktop in Research & Education: The Scientists' Discovery Room



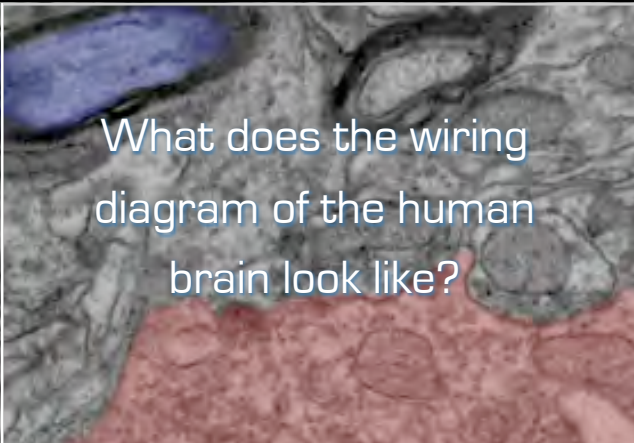
The Scientists' Discovery Room: Version 0.01



iic.harvard.edu

The screenshot shows a web browser window with the URL <http://iic.harvard.edu/index.html>. The page features a large header with the 'iic' logo and the Harvard University crest. A navigation menu on the left includes links for home, about iic, projects, education, people, and seminars. Below the header, a red banner reads 'Initiative in Innovative Computing at Harvard'. The main content area is divided into several sections: 'employment', 'links of interest', 'reaching the iic', 'iic login', and a mailing list sign-up form. A 'featured project' section highlights 'Astronomical Medicine' with a 3D star model and a description of the project's goal. A 'mission' section details the center's interdisciplinary research focus. A 'news' section lists recent articles from the New York Times and an inaugural symposium. A 'strategic role of the iic' section discusses the center's leadership in interdisciplinary collaboration. The 'iic' logo is also visible in the bottom left corner of the page.





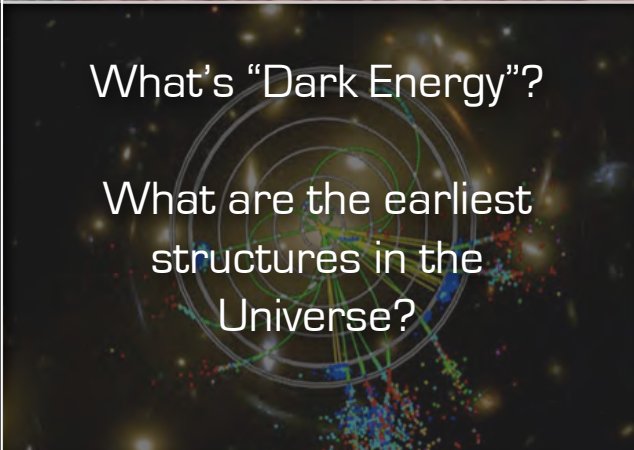
What does the wiring diagram of the human brain look like?



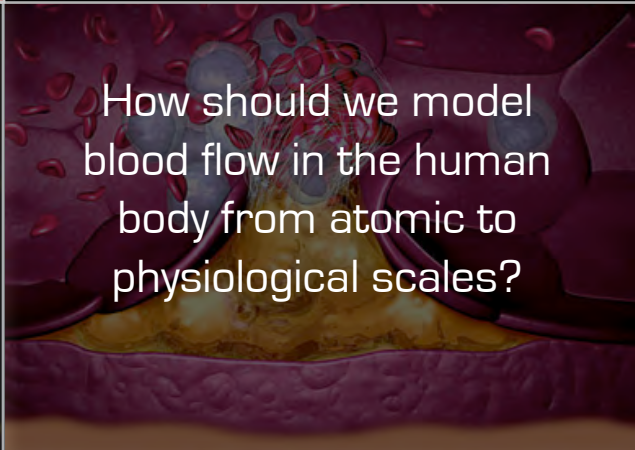
How do stars form in our Galaxy today?



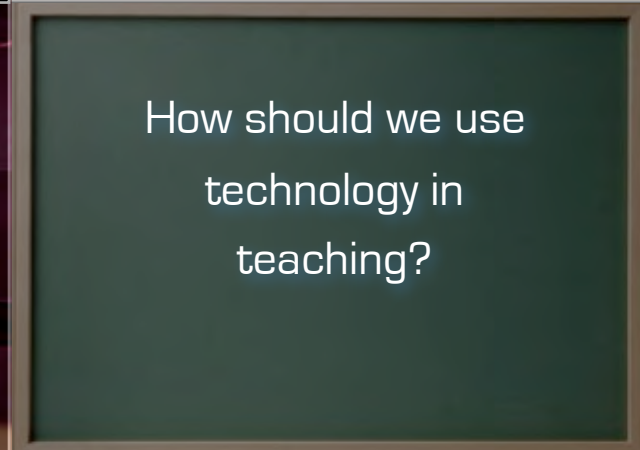
How do humans interact with "big data"?



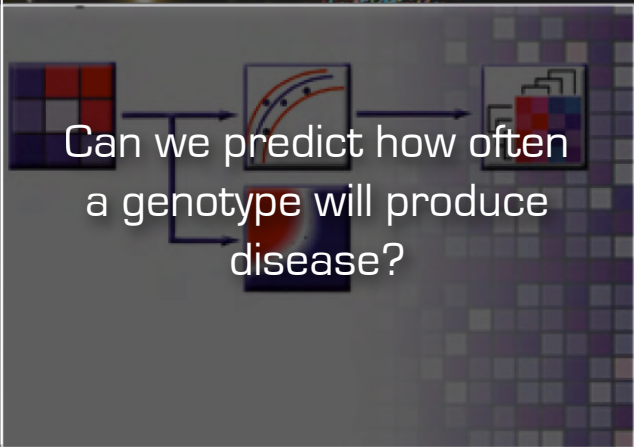
What's "Dark Energy"?
What are the earliest structures in the Universe?



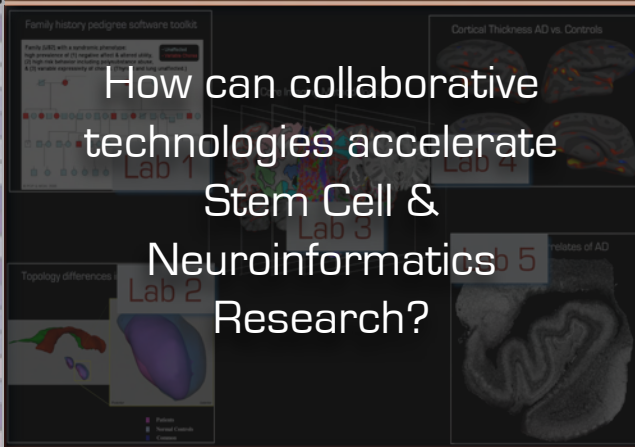
How should we model blood flow in the human body from atomic to physiological scales?



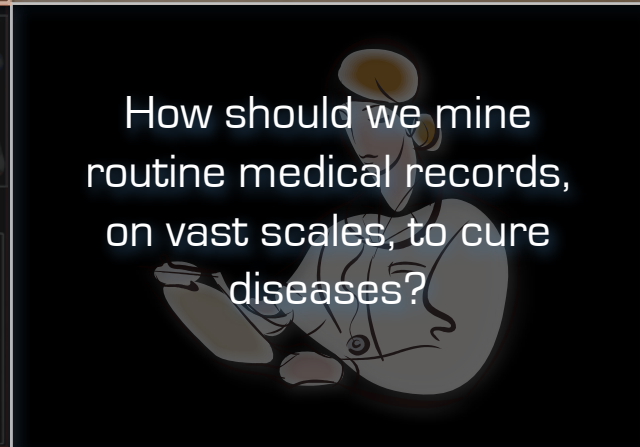
How should we use technology in teaching?



Can we predict how often a genotype will produce disease?



How can collaborative technologies accelerate Stem Cell & Neuroinformatics Research?



How should we mine routine medical records, on vast scales, to cure diseases?