

TODAY : Computers are Fun !

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SIGGRAPH 2008 - Animation Festival

Computing and "Computers" : Early days

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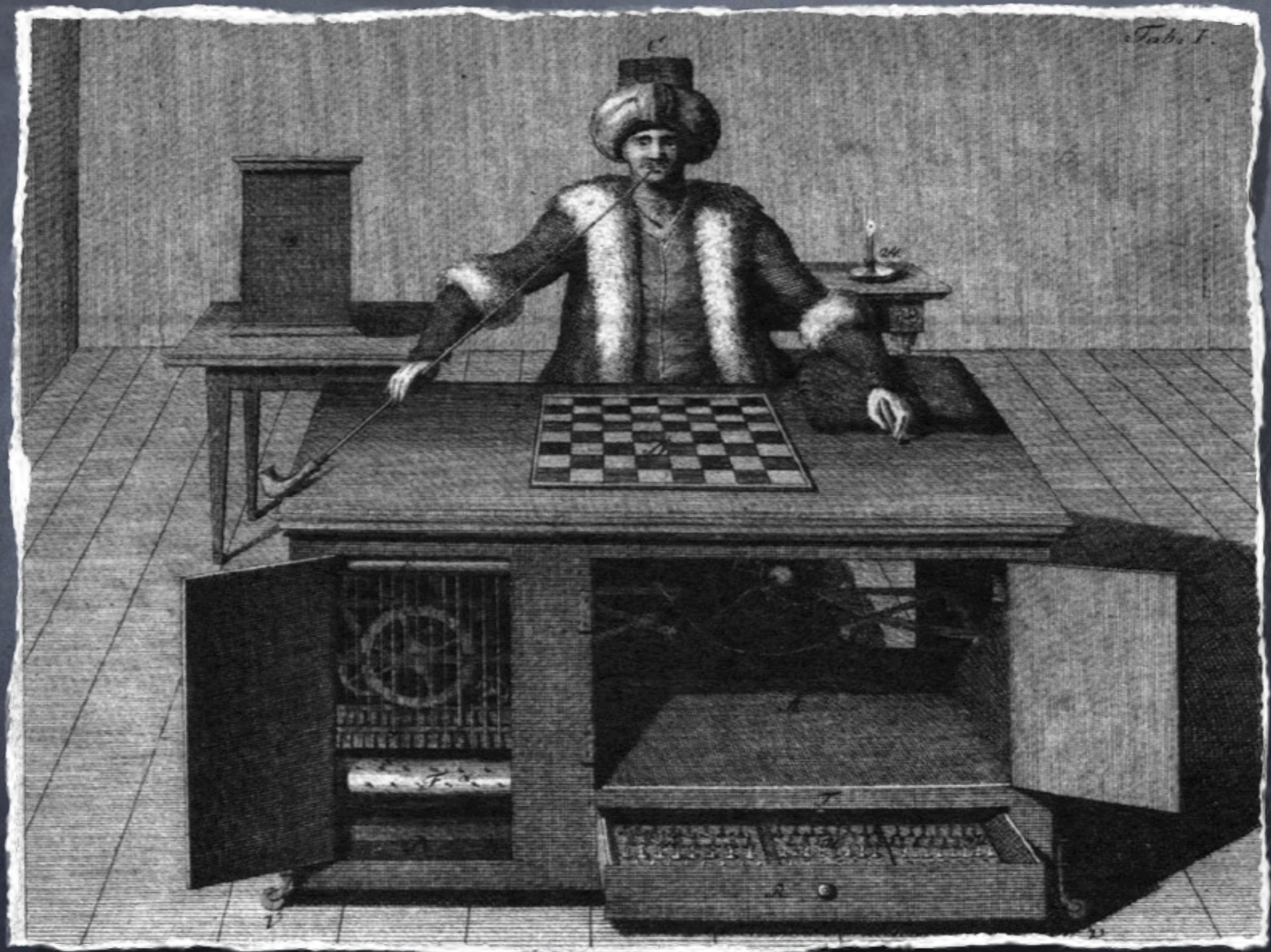
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- ❑ **1725** At the **Heilbrunn chateau** in Germany, a mechanical theatre is created featuring 119 animated figures that perform a play about village life to the accompaniment of a water-powered organ.

Computing and "Computers" : The Early days



1769 : Von Kempelen's Chess Playing Turk

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Computing and "Computers" : The Early days



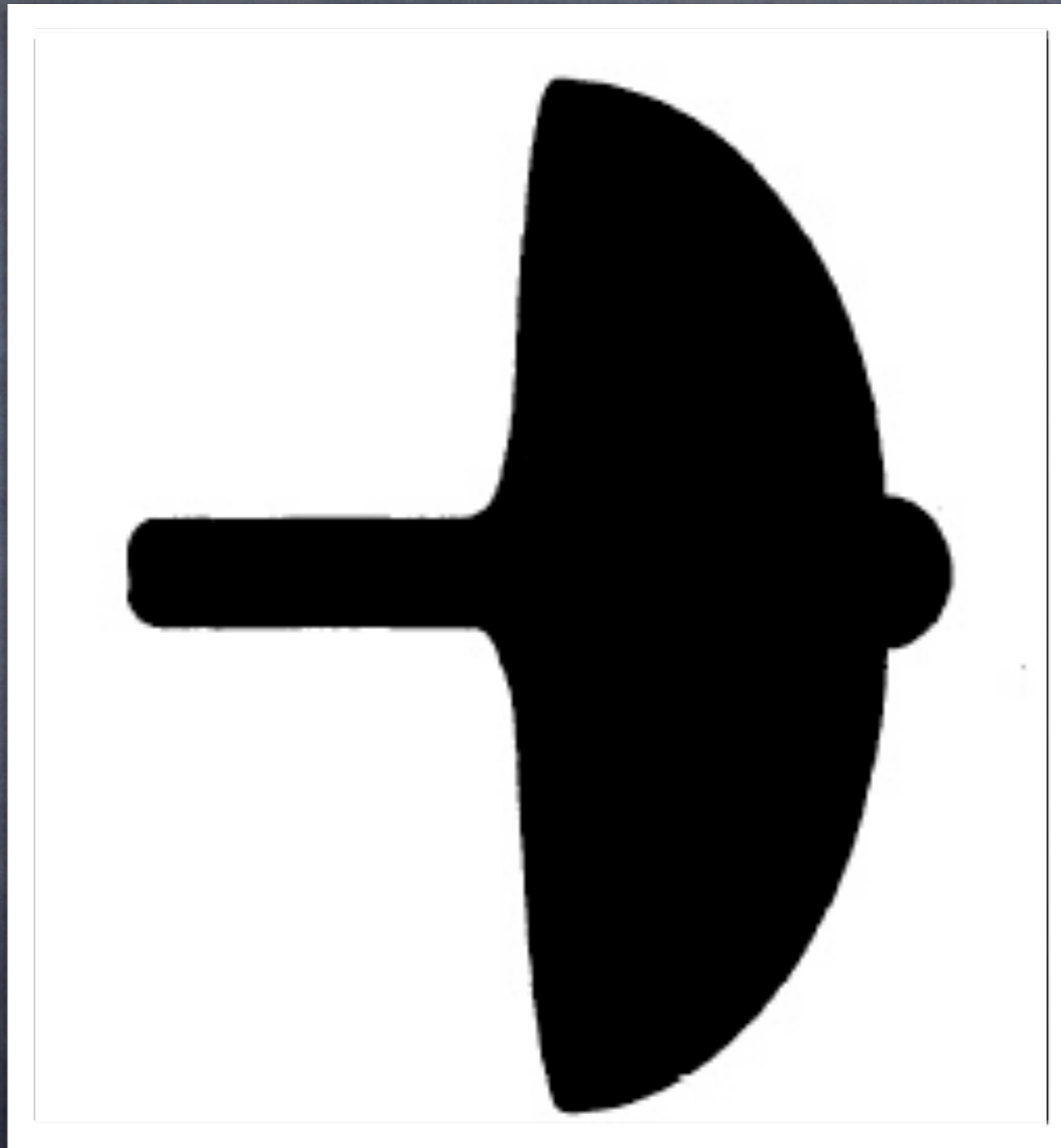
Modern Computing : How did it all start ?

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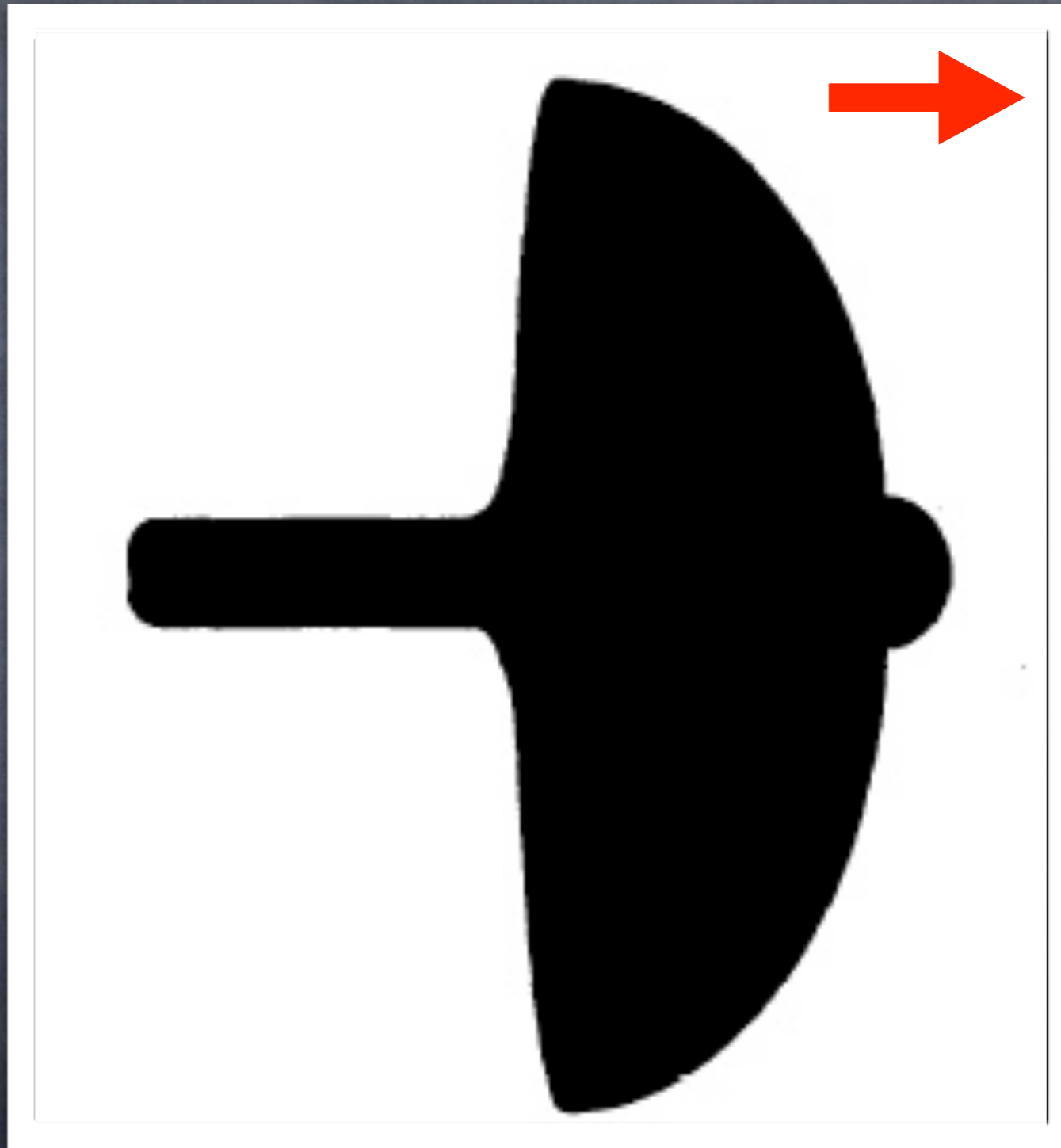


Computers :

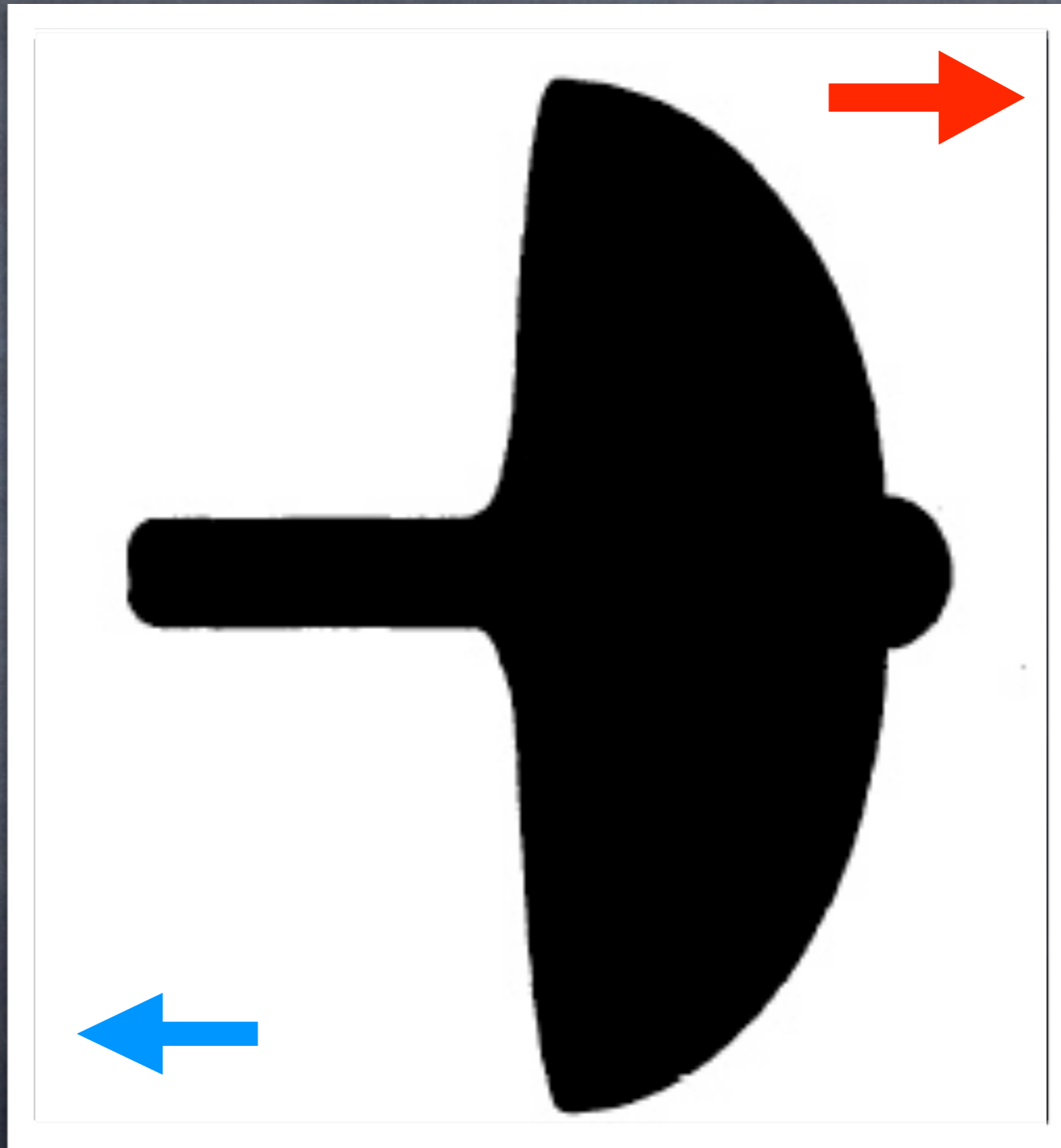
Computers :



Computers :



Computers : **Goose** or **Hawk** ?



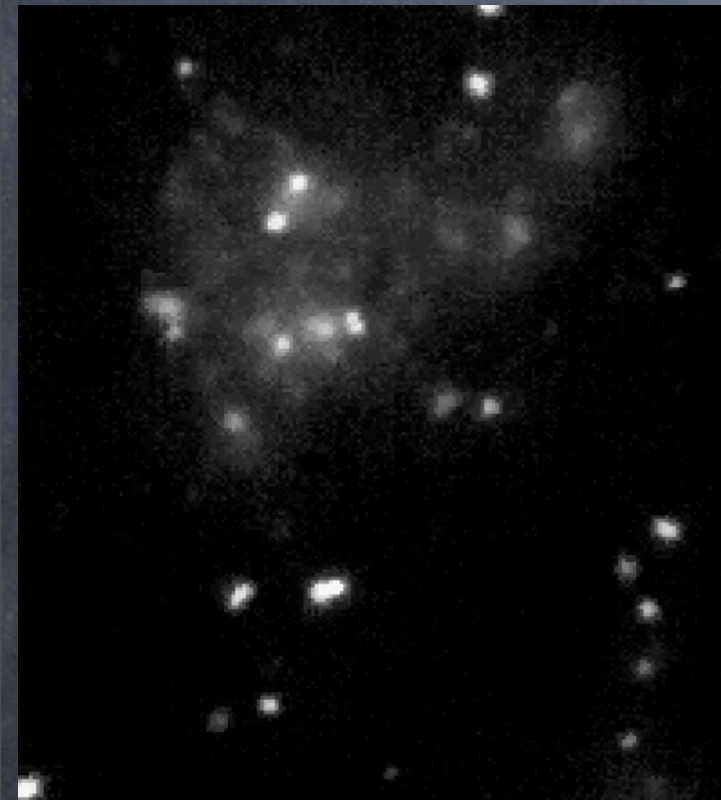
Lorenz (1939, Zool. Anz. Suppl., 12, 69-109)

COMPUTERS for EXPERIMENTS

Advances in Hardware - Theory - Data Processing

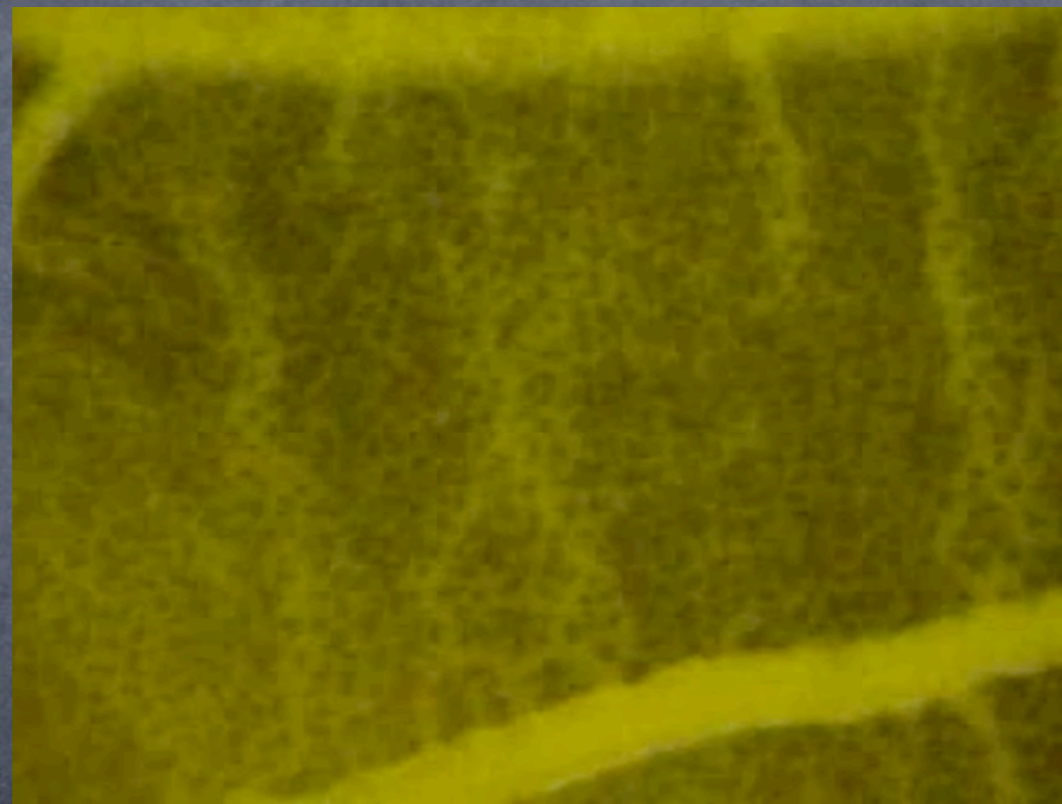
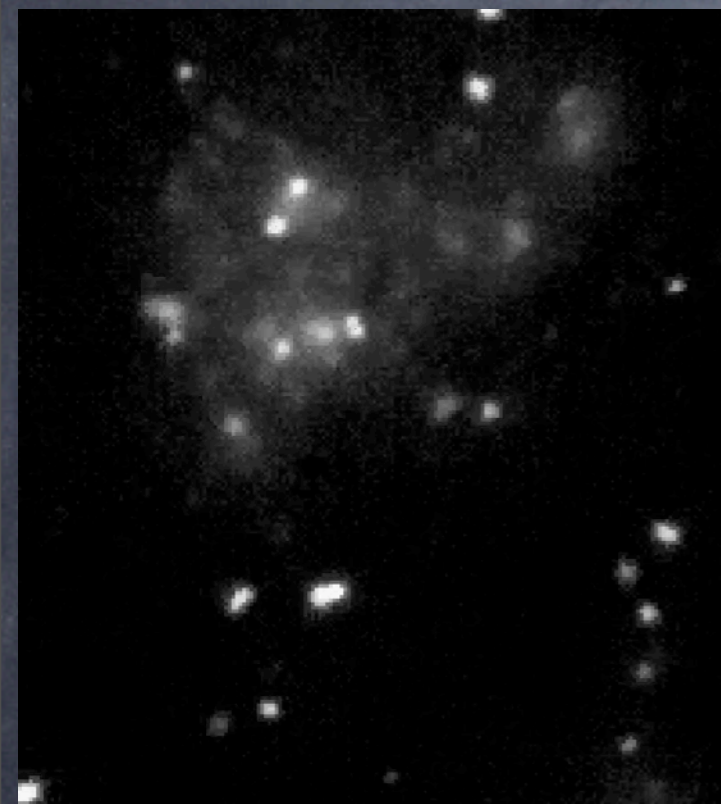
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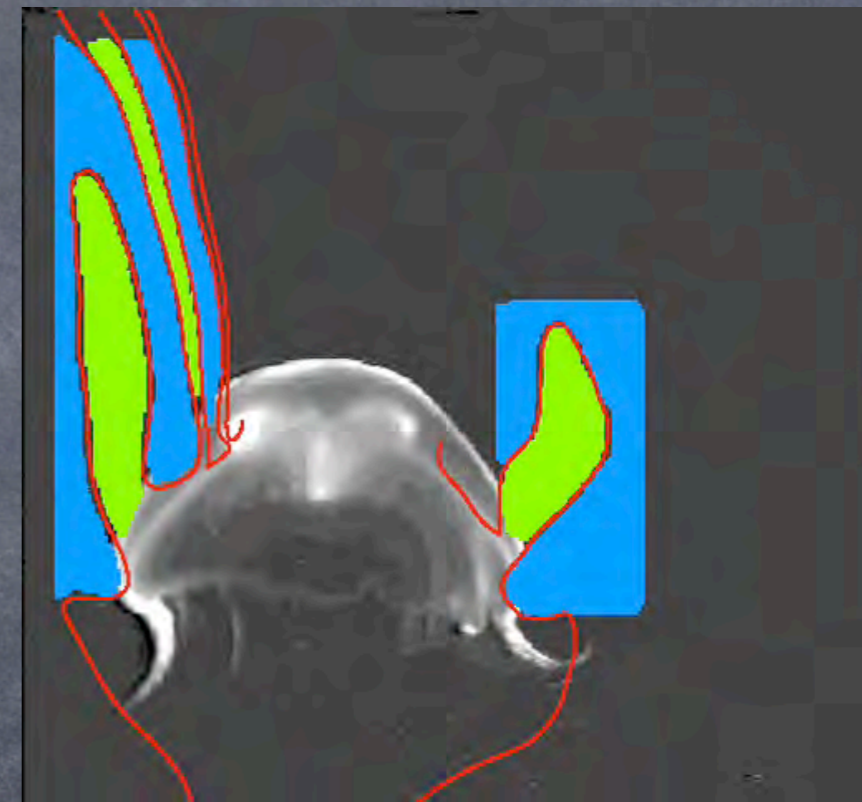
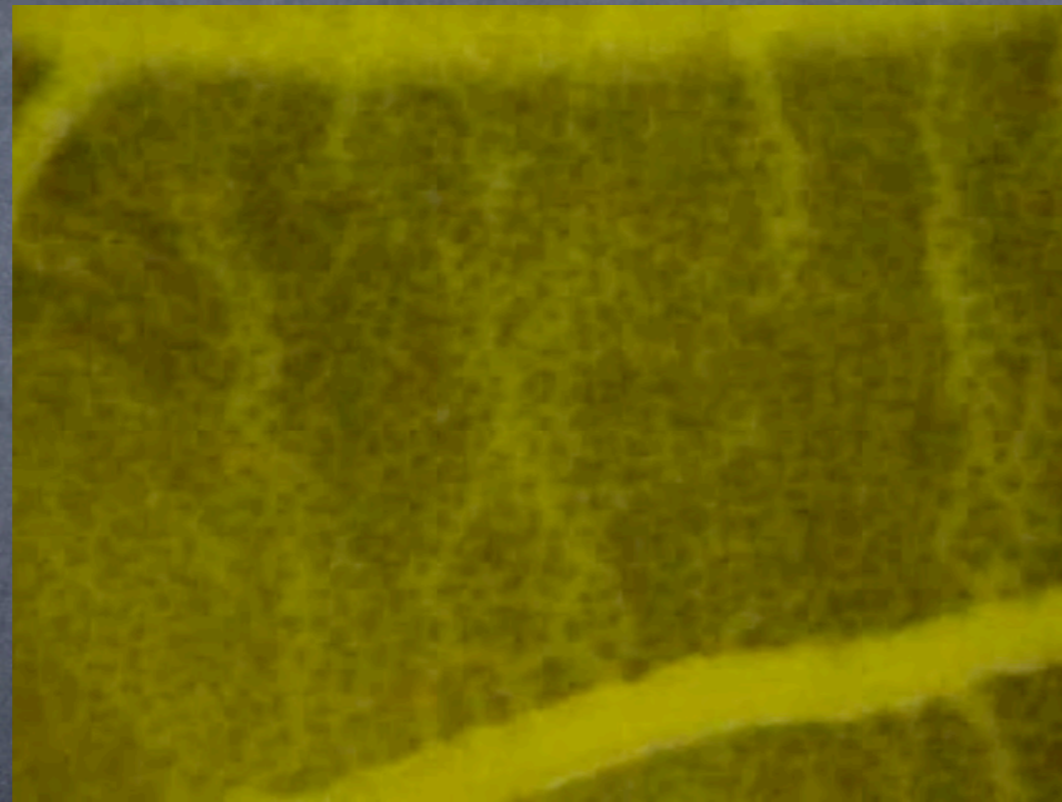
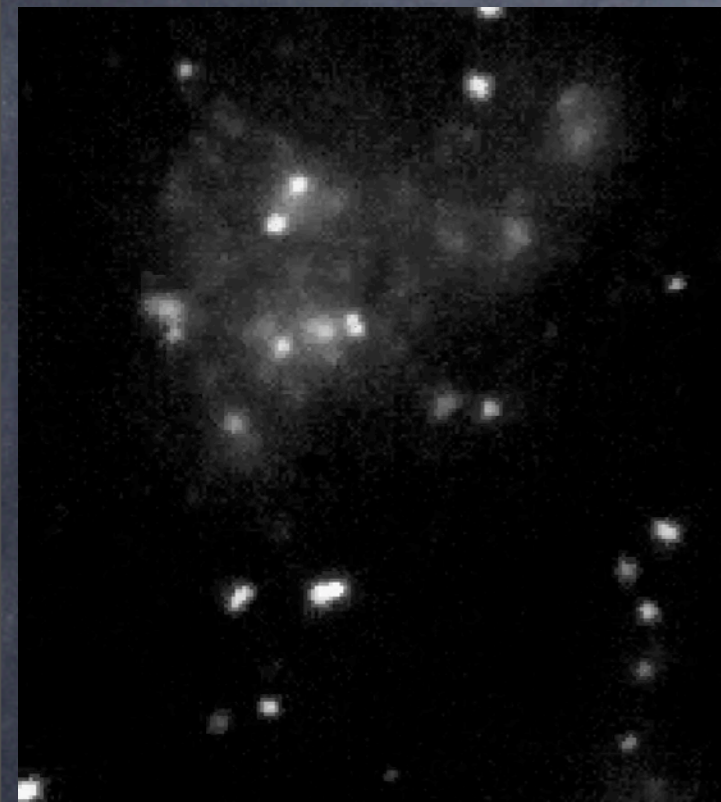
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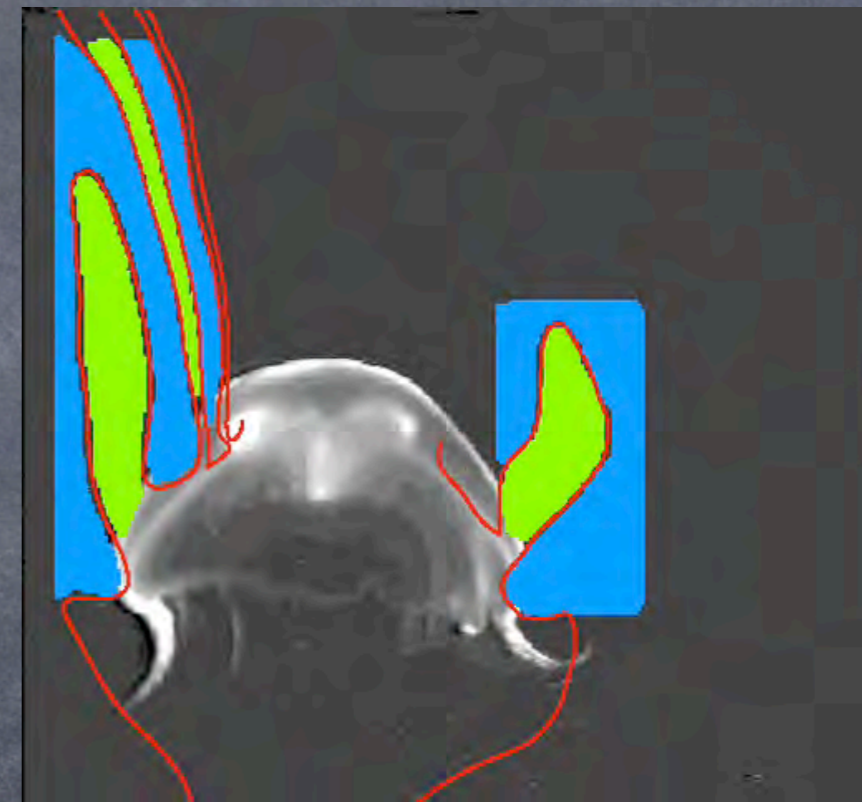
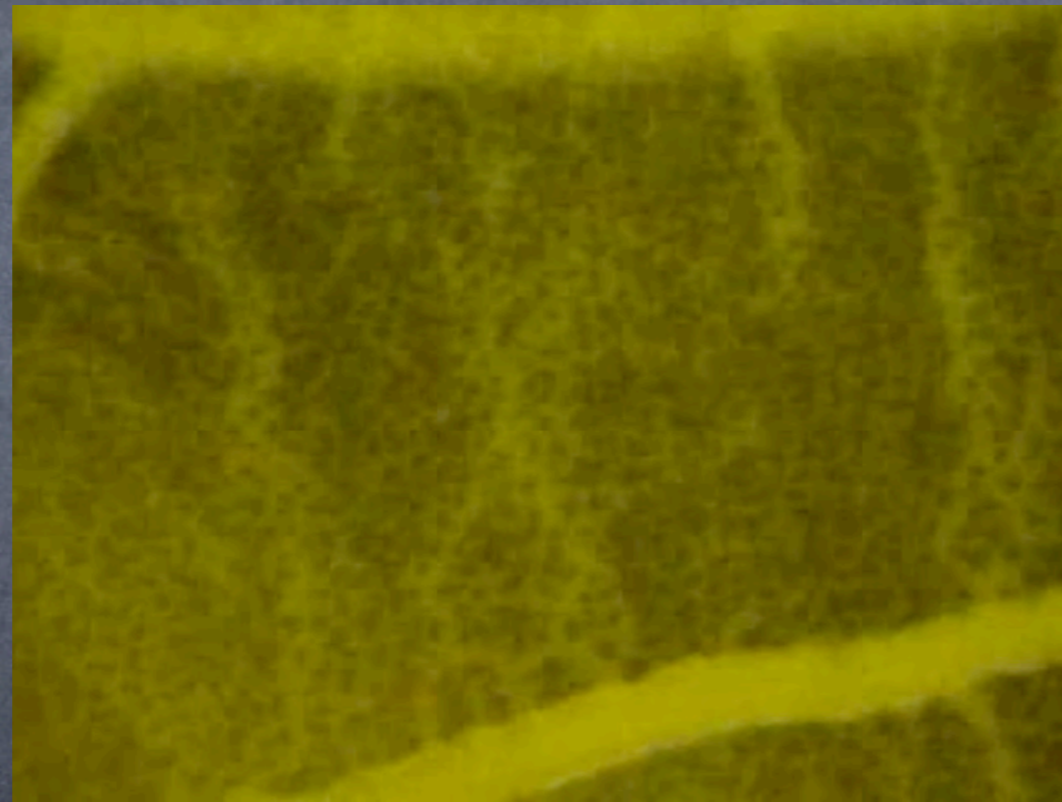
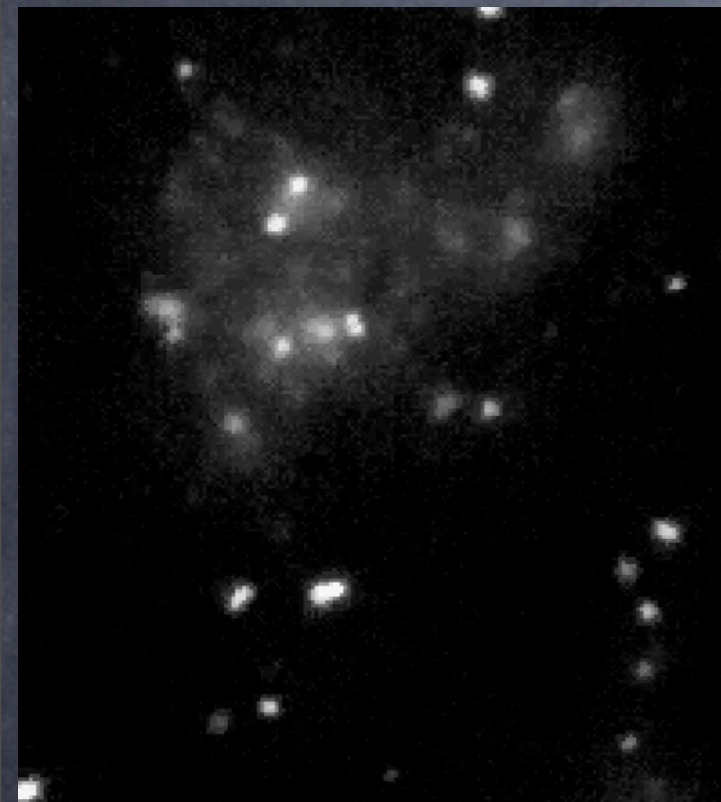
COMPUTERS for EXPERIMENTS

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COMPUTERS for EXPERIMENTS

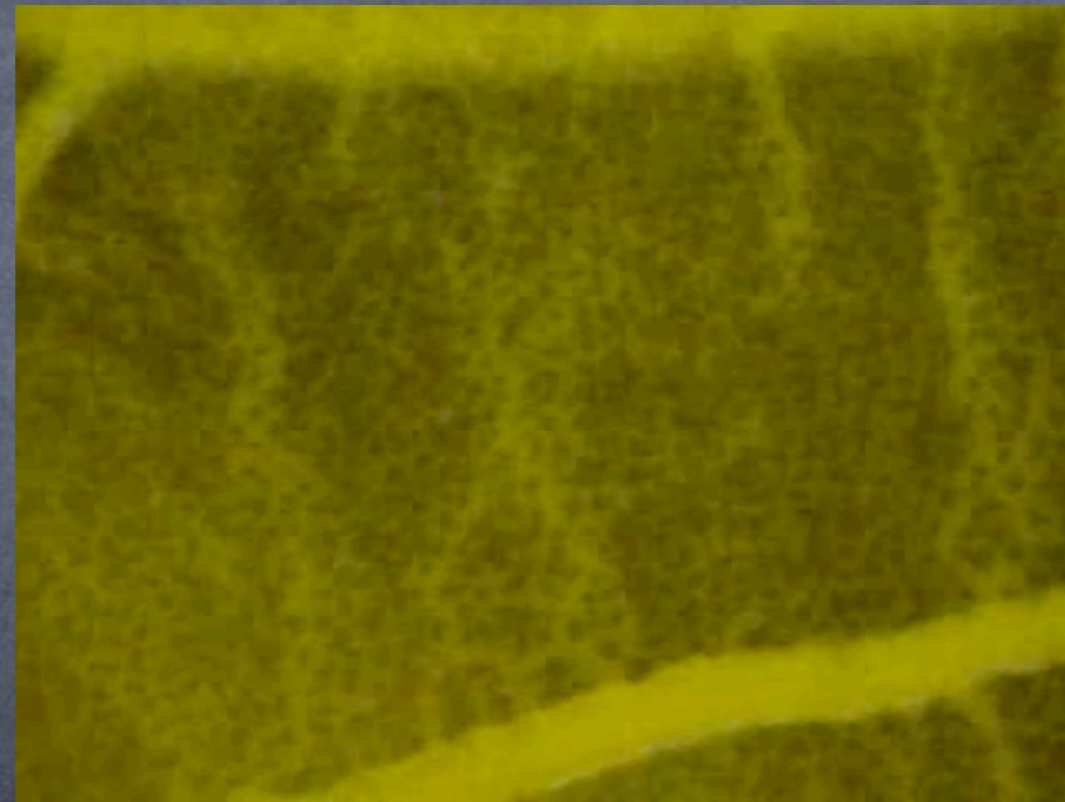
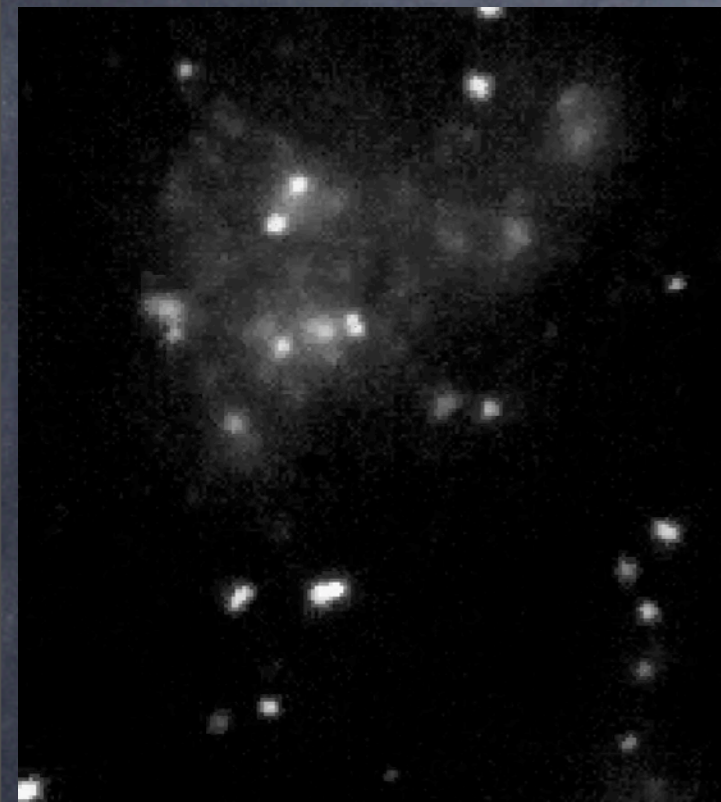
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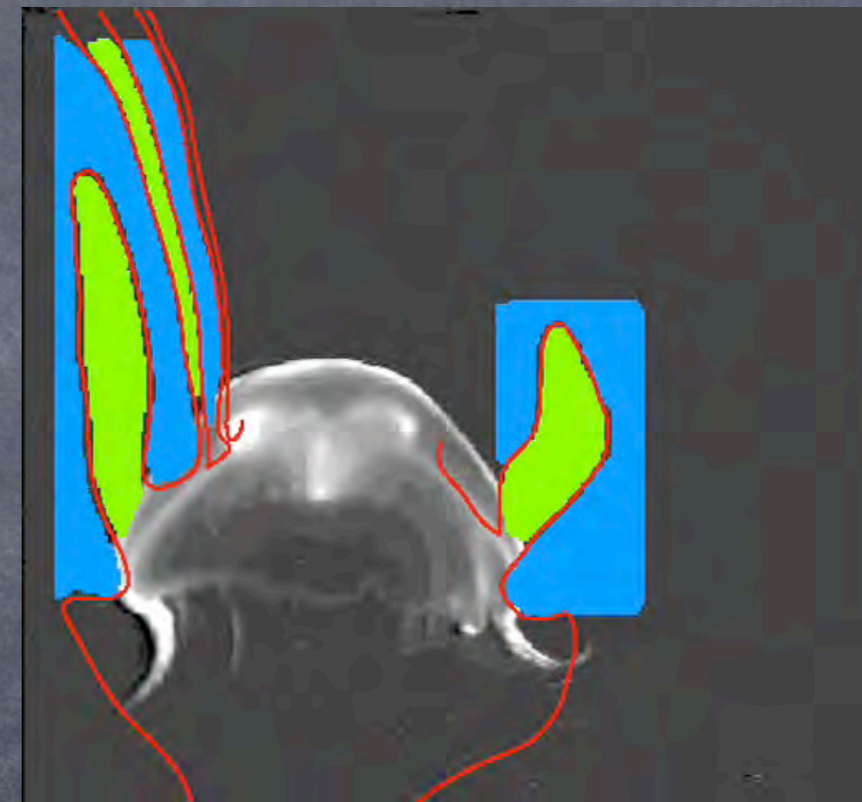
Swimming Medusa,
Dabiri Lab, Caltech

COMPUTERS for EXPERIMENTS

Advances in Hardware - Theory - Data Processing



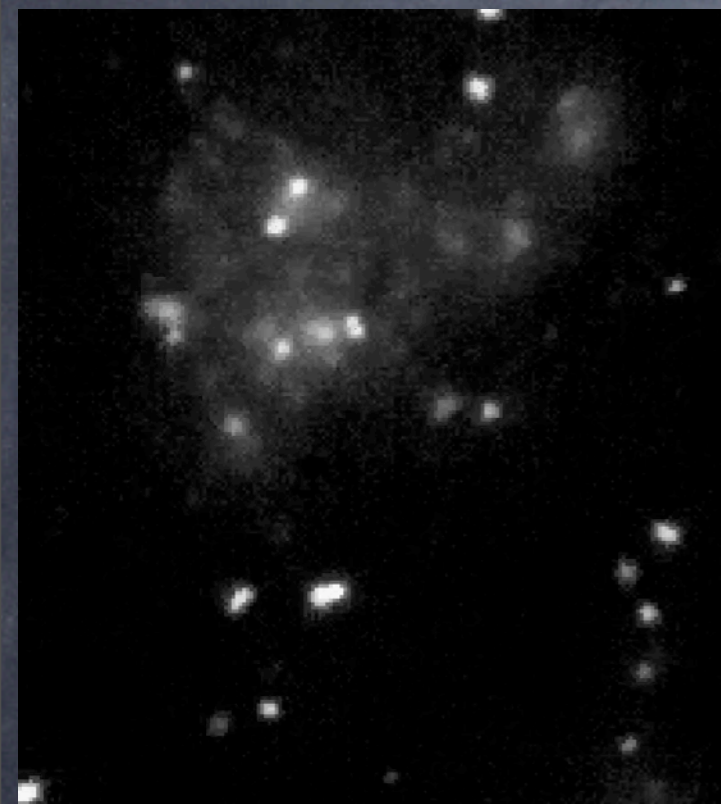
Intussusceptive Angiogenesis in the growing Chick CAM
Djonov&Burri Lab, Uni Bern



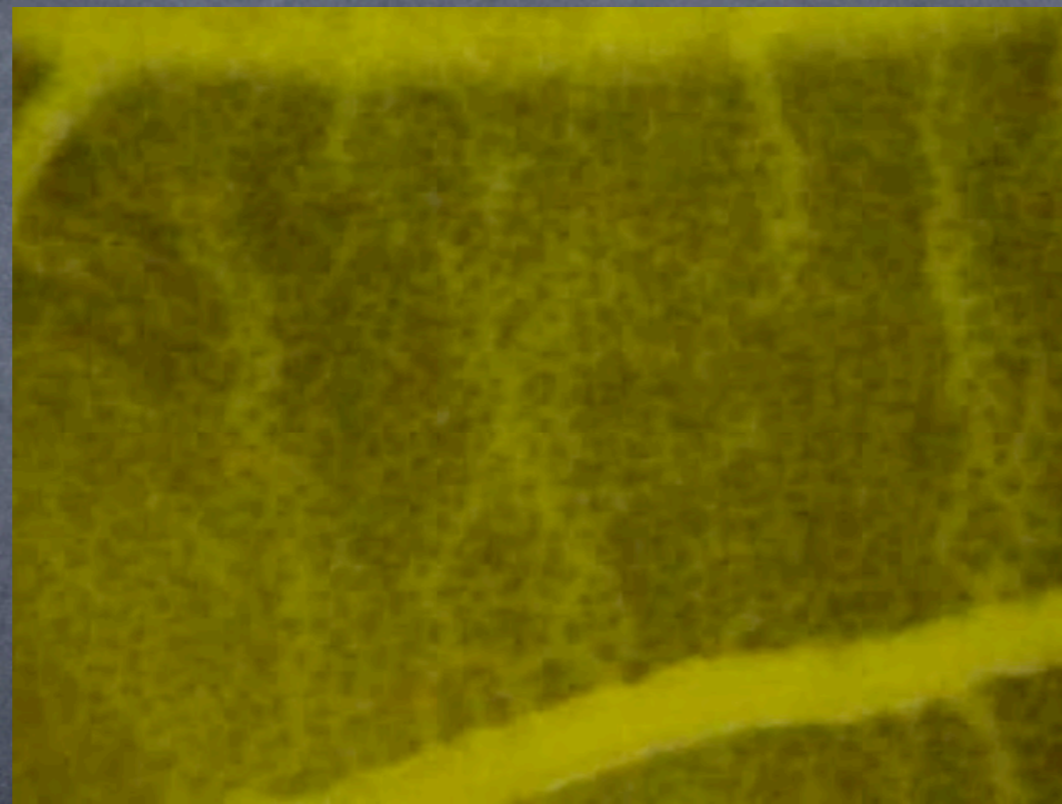
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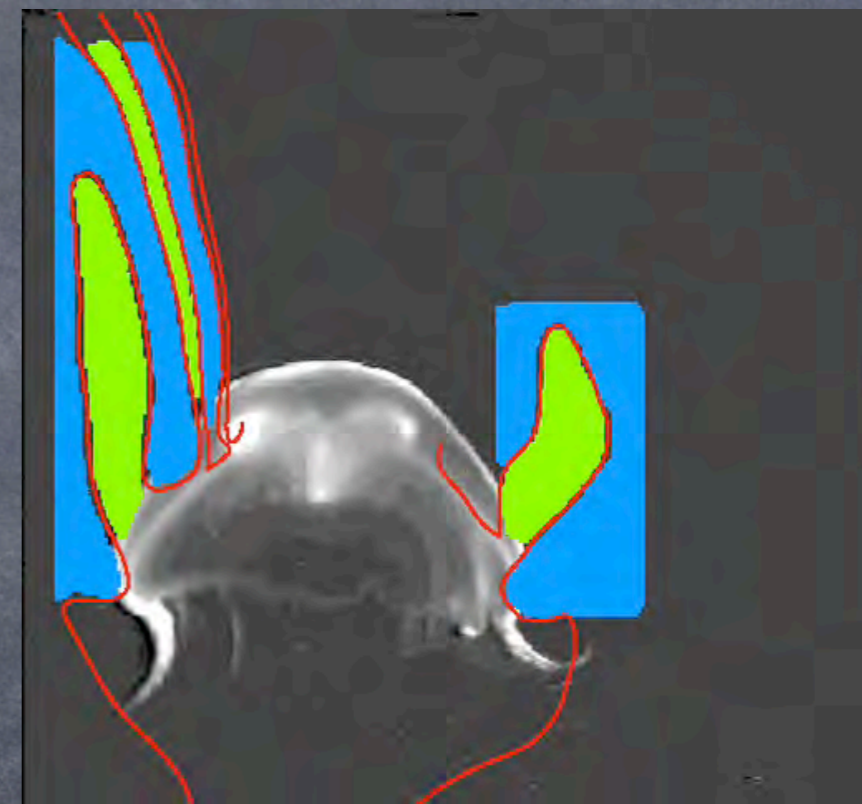
Advances in Hardware - Theory - Data Processing



Tracking of Adeno Virus
Helenius/Greber Lab, ETHZ/UniZH



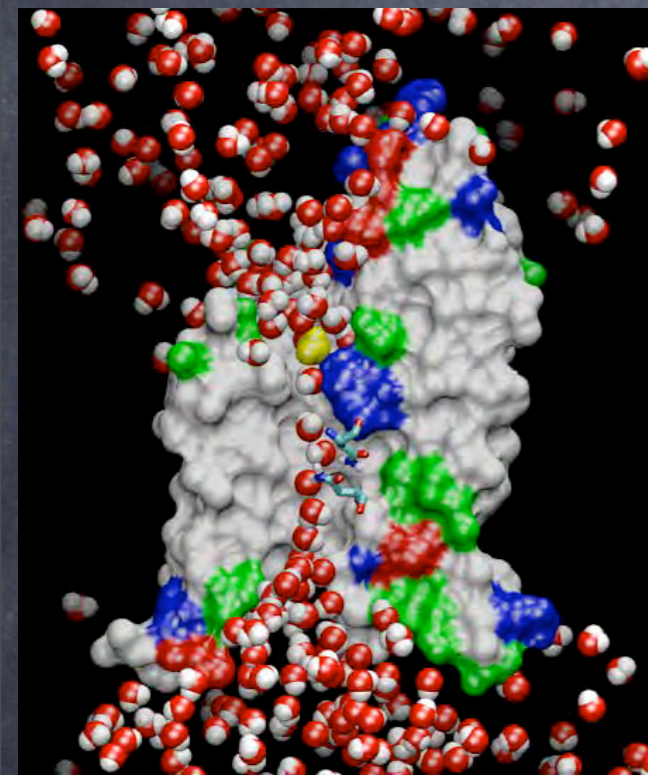
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COMPUTERS for SIMULATIONS

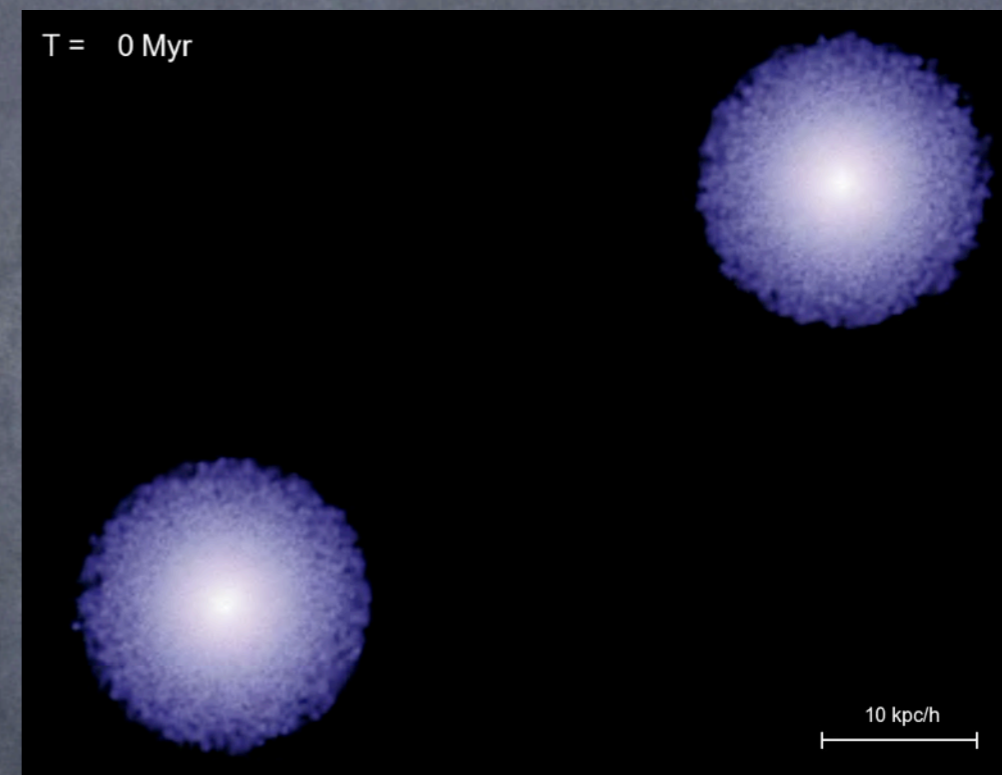
Advances in Hardware - Theory - Data Processing



Transport in aquaporins
Schulten Lab, UIUC



Anguiform Swimmers
Koumoutsakos Lab, ETHZ



Growth of Black Holes
Springel, MPI - Hernquist, Harvard

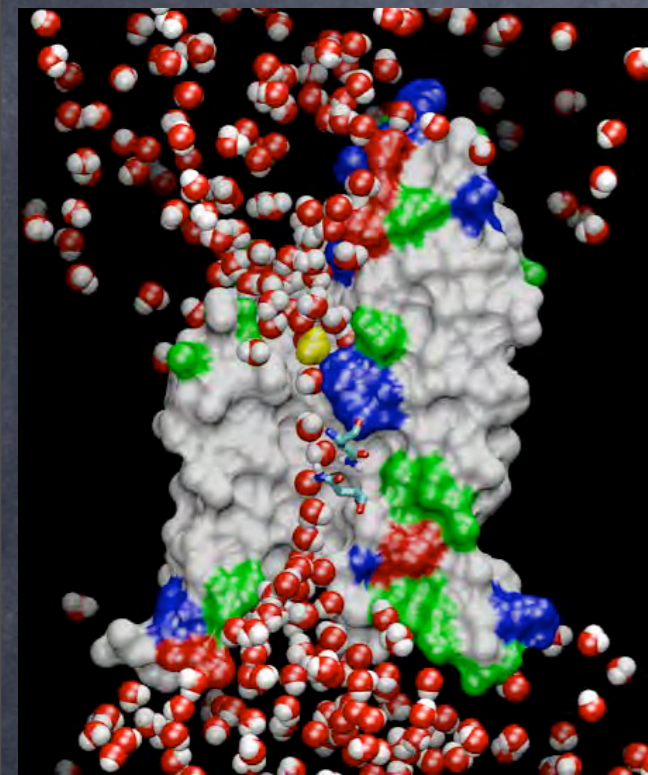
COMPUTERS for SIMULATIONS

Advances in Hardware - Theory - Data Processing

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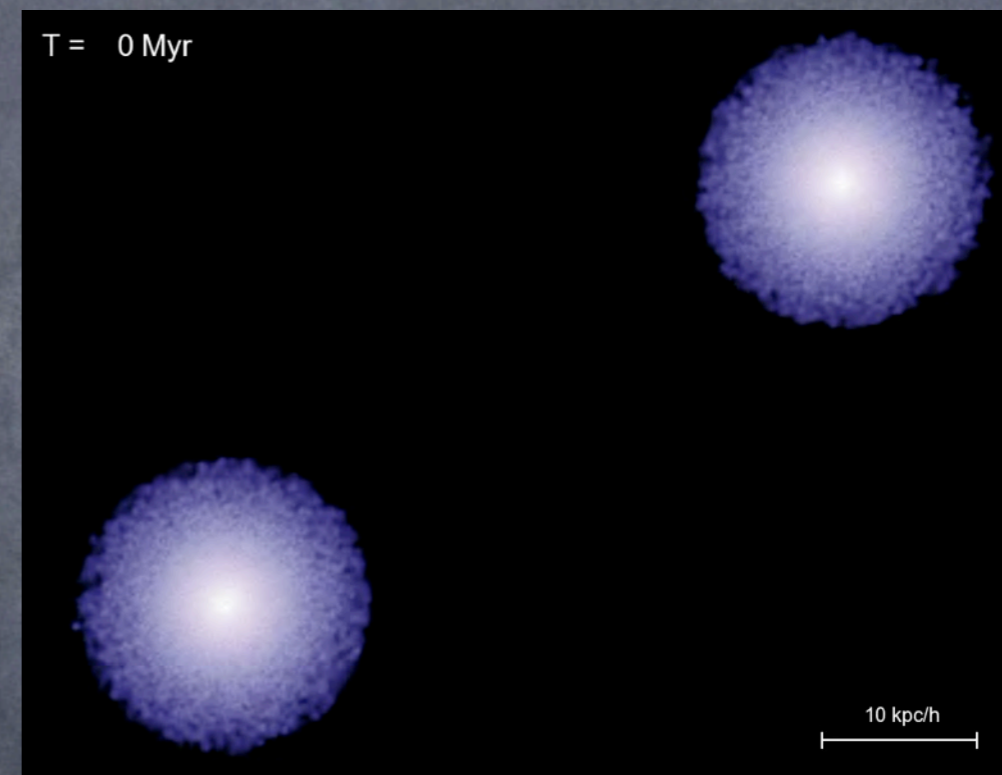
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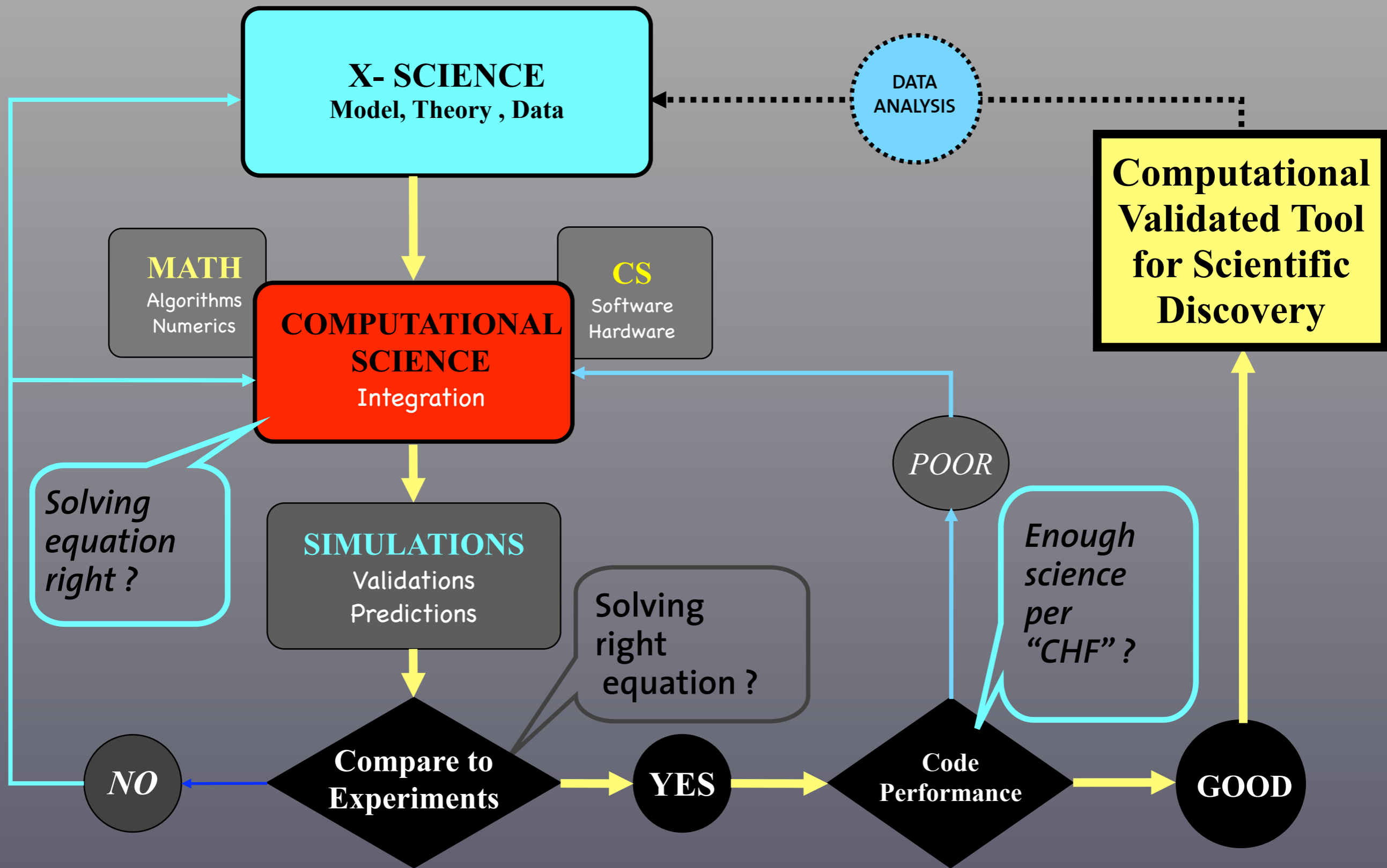
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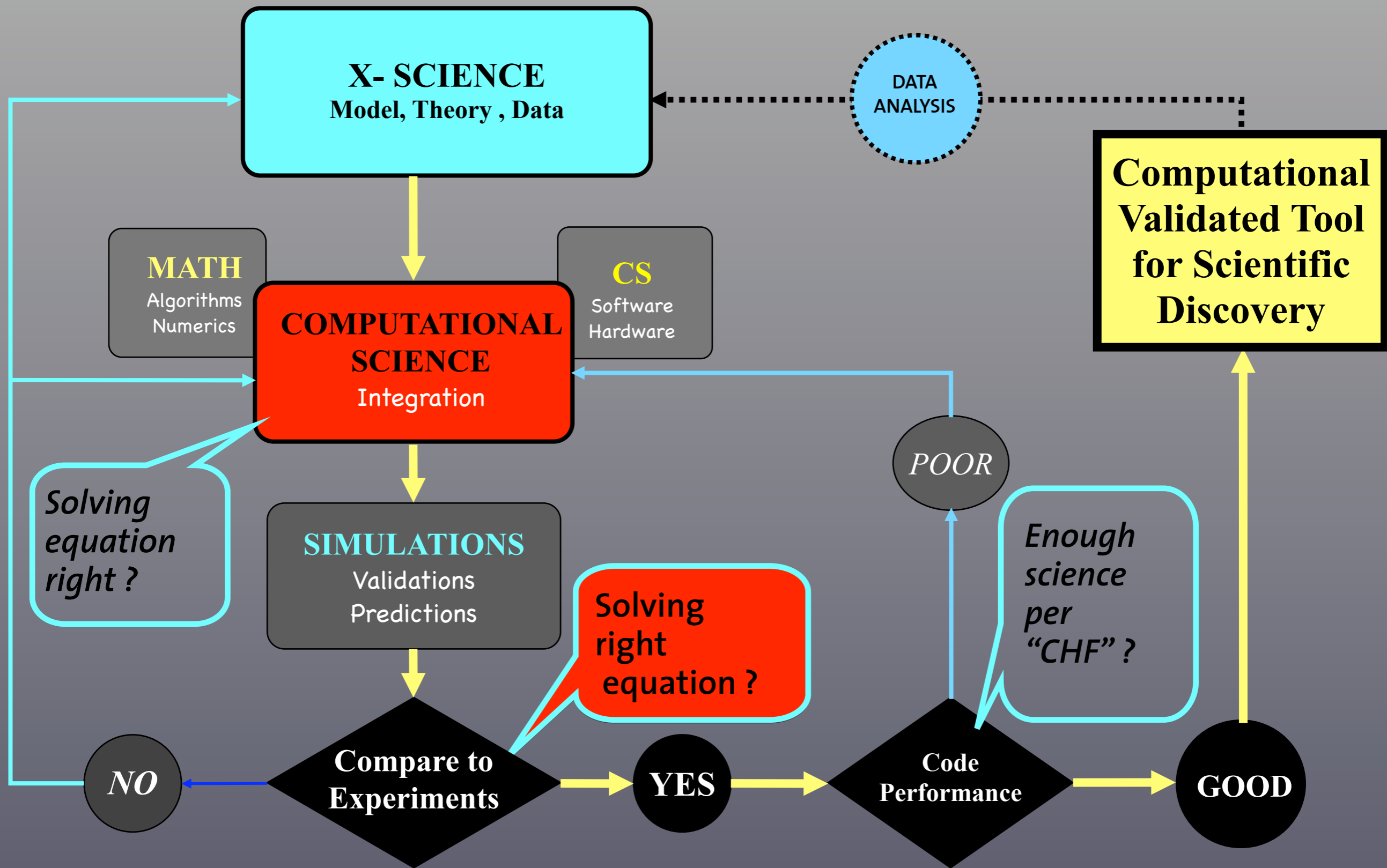


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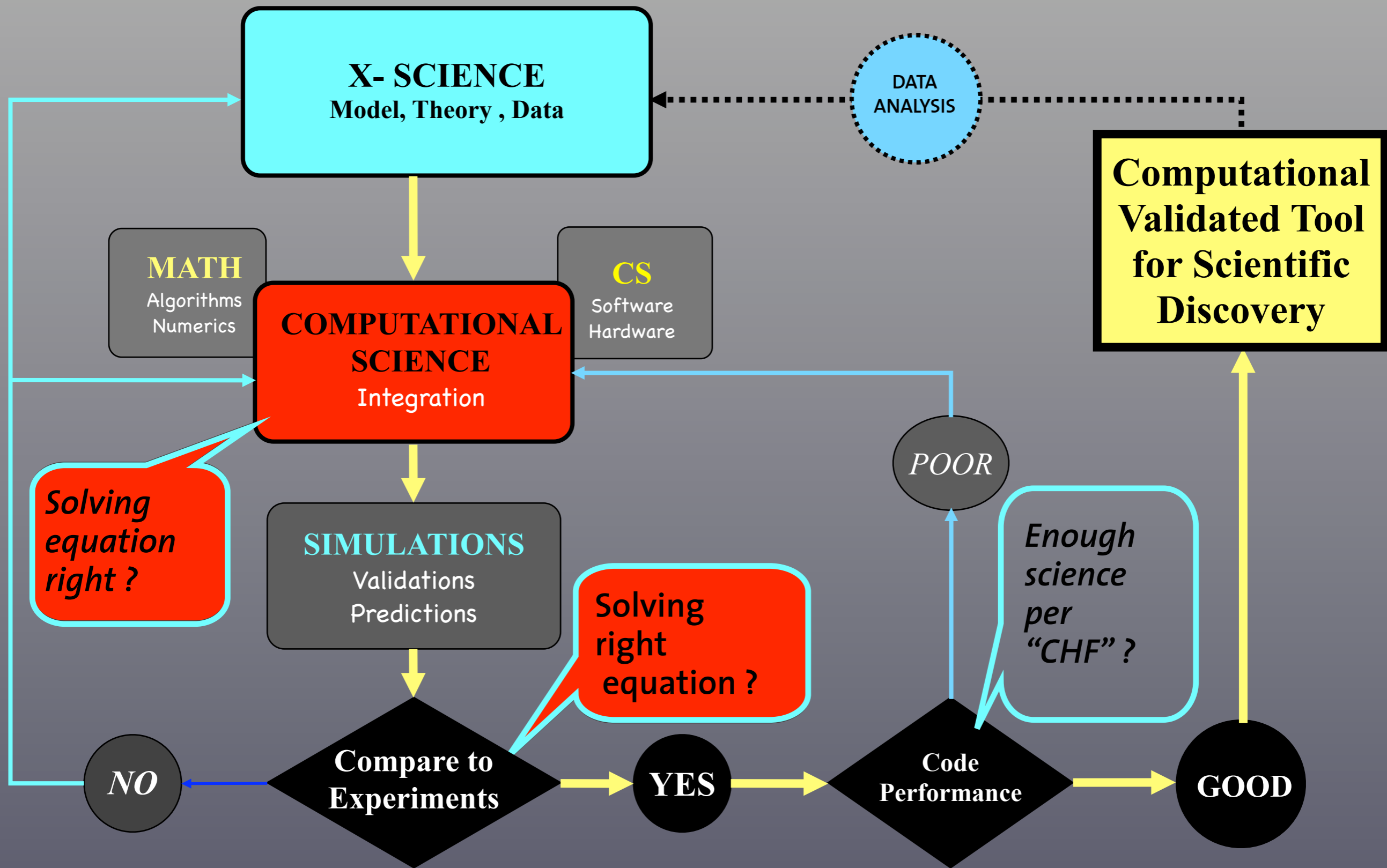
Adapted from : US DOE , 2000

Computational Science : Validated, Verifiable, Efficient
 Simulations of Complex, Real World Problems



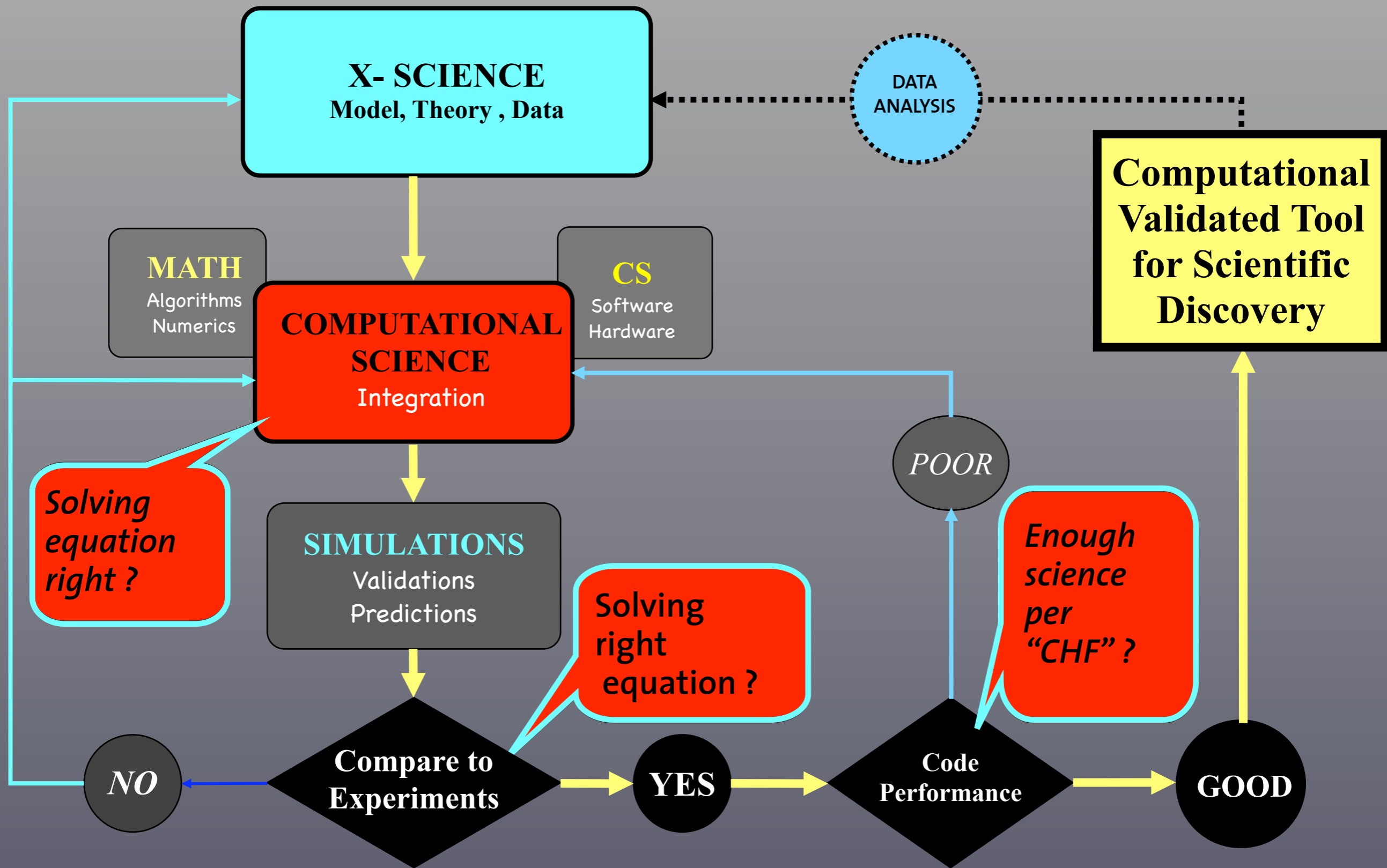
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Why Compute ?

Why Compute ?

THEORY : Problem Complexity

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EXPERIMENTS: Costs - Data - Not Possible

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COMPUTATIONAL SCIENCE

Why Compute ?

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EXPERIMENTS: Costs - Data - Not Possible

COMPUTATIONAL SCIENCE

The 3rd Pillar of Scientific Investigation

COMPUTATIONAL SCIENCE

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I. Understand – Predict – Optimize

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II. Explore Possibilities & Ideas

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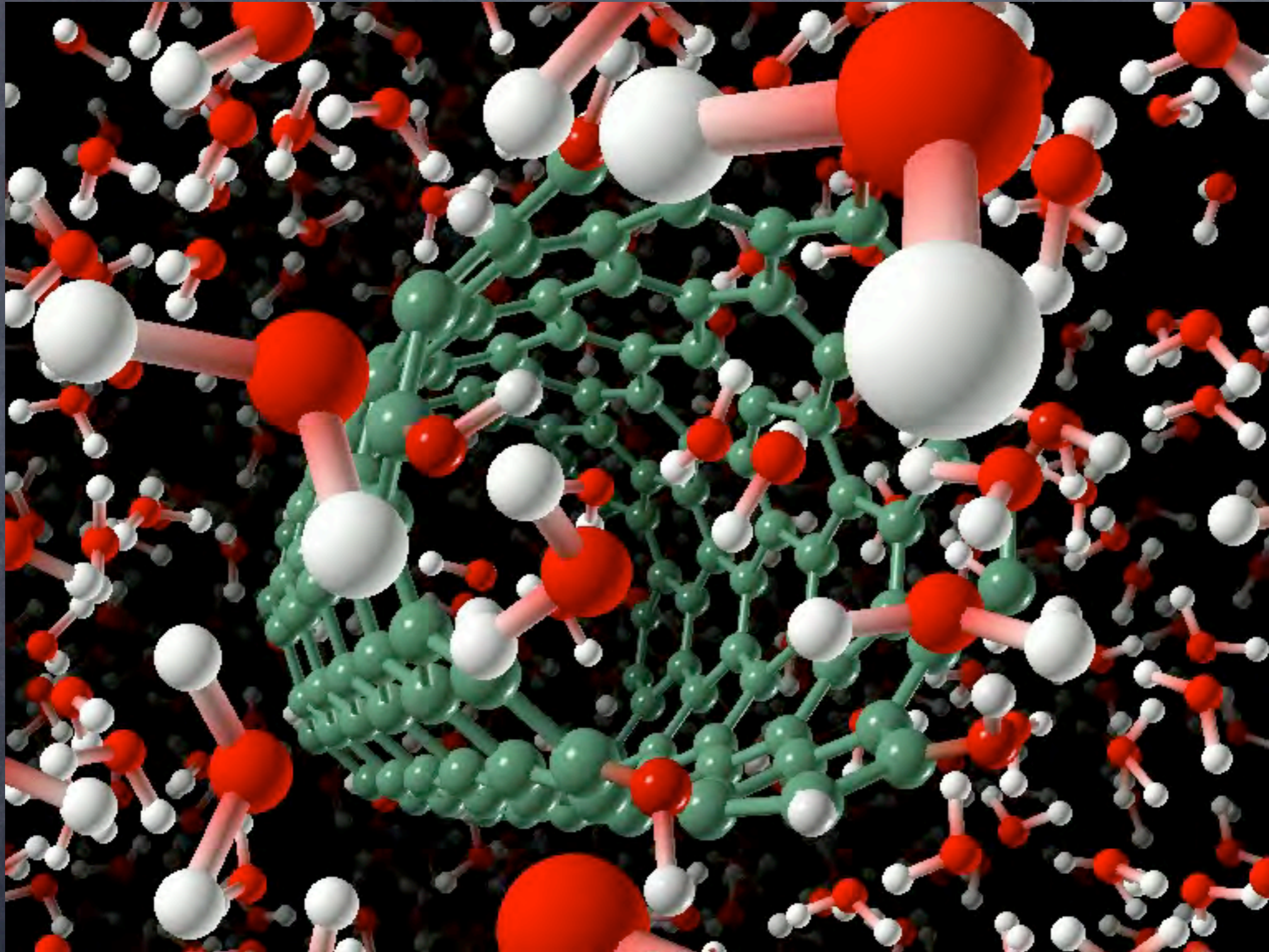
COMPUTATIONAL SCIENCE

I. Understand – Predict – Optimize

II. Explore Possibilities & Ideas

III. Save the World OR The Problem with Computers

I. Understanding when EXPERIMENTS cannot see (yet !)



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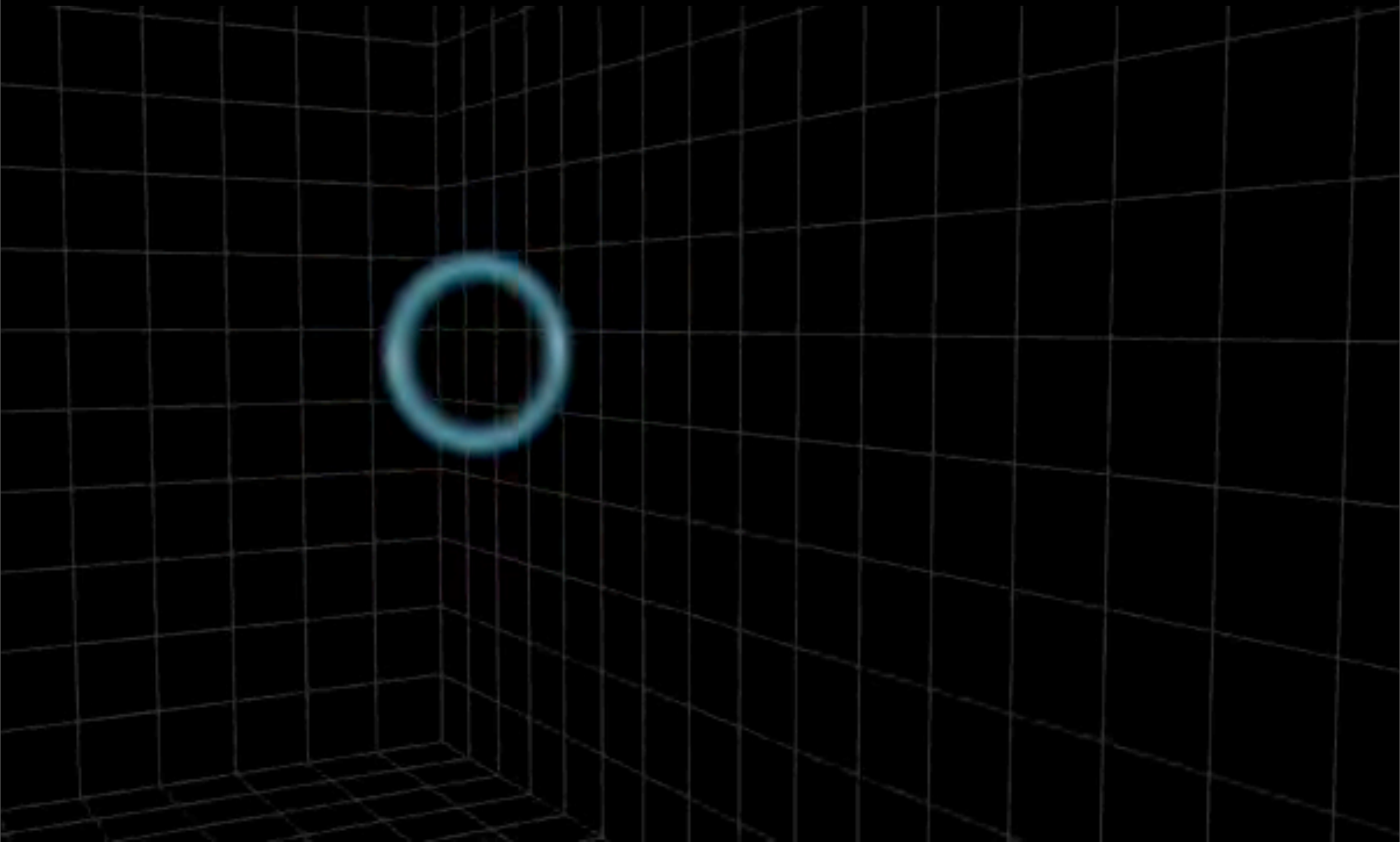
DOLPHIN PLAYING WITH VORTEX RINGS

I. Understanding NATURE

THE POWER OF UNDERSTANDING !!!



Vortices at home



Vortex Rings in the Computer

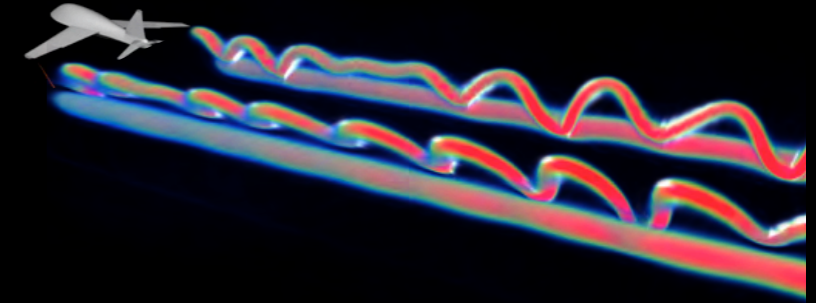
Vorticity $\boldsymbol{\omega} = \nabla \times \mathbf{u}$



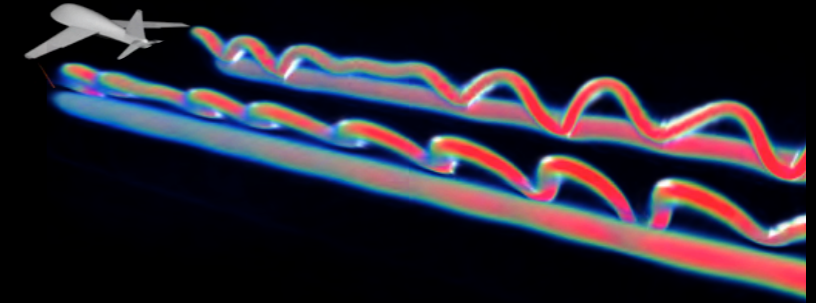
$$\frac{D\boldsymbol{\omega}}{Dt} = \boldsymbol{\omega} \cdot \nabla \mathbf{u} + \nu \nabla^2 \boldsymbol{\omega}$$

Vortex Rings in the Computer

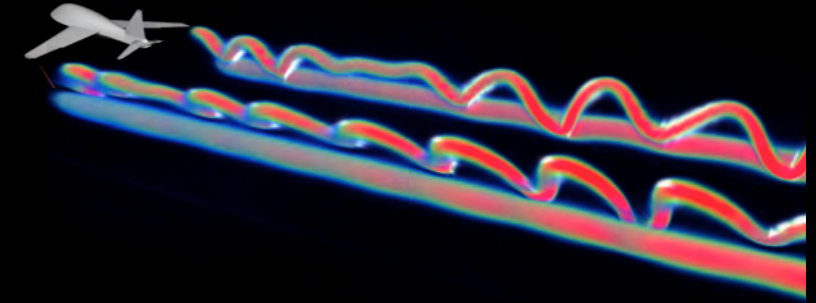
The Flow and Growth of Aircraft Wakes



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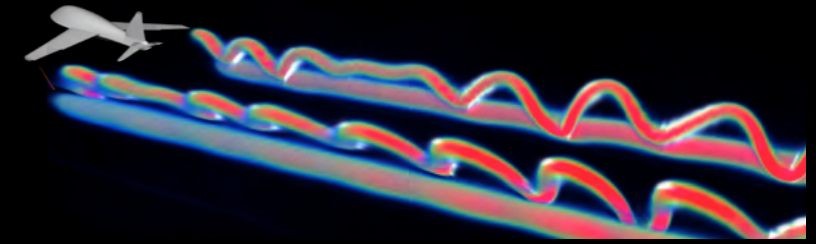


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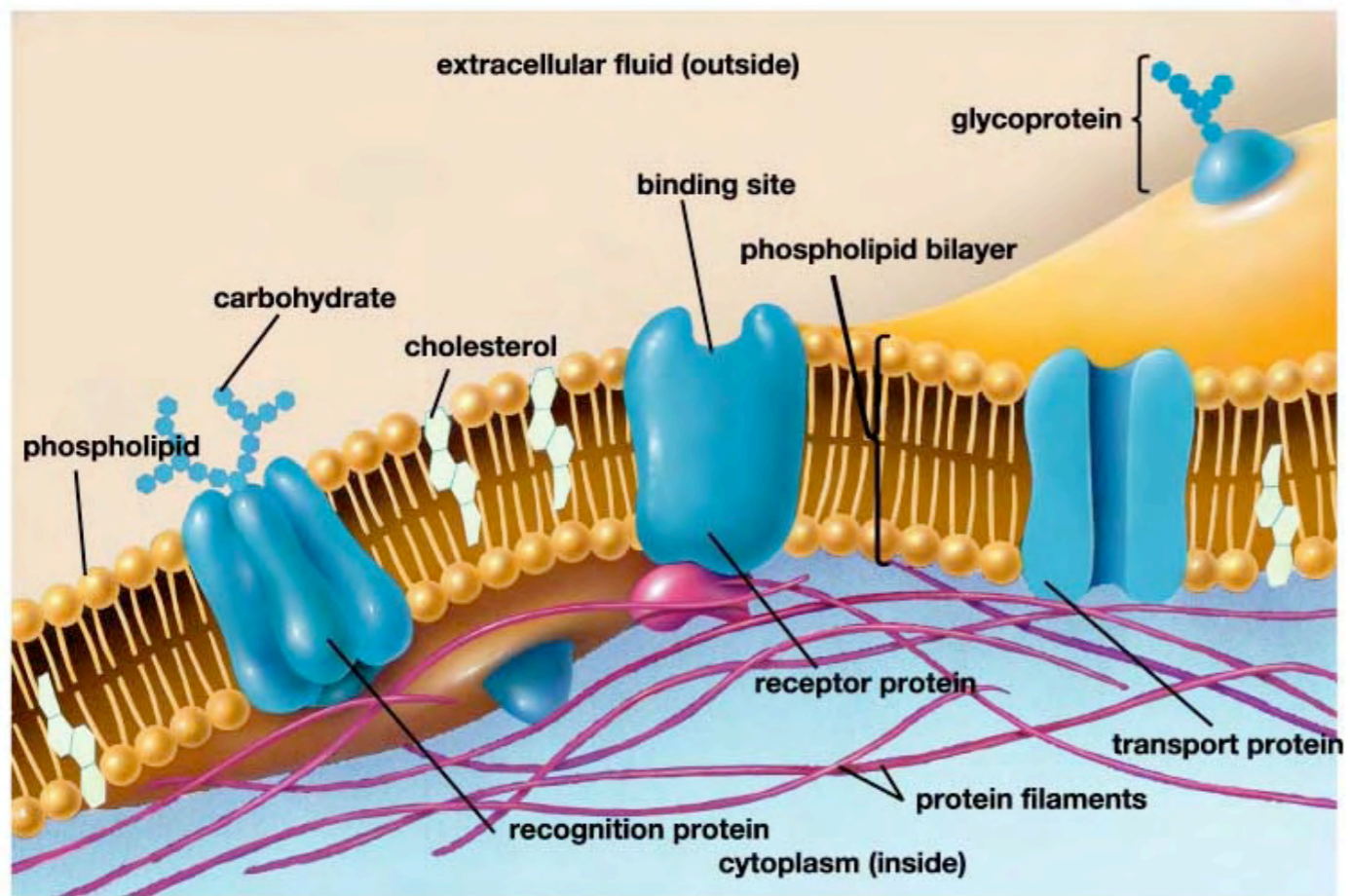
16384 Cores - 10 Billion Particles - 60% efficiency

Runs at IBM Watson Center - BLue Gene/L

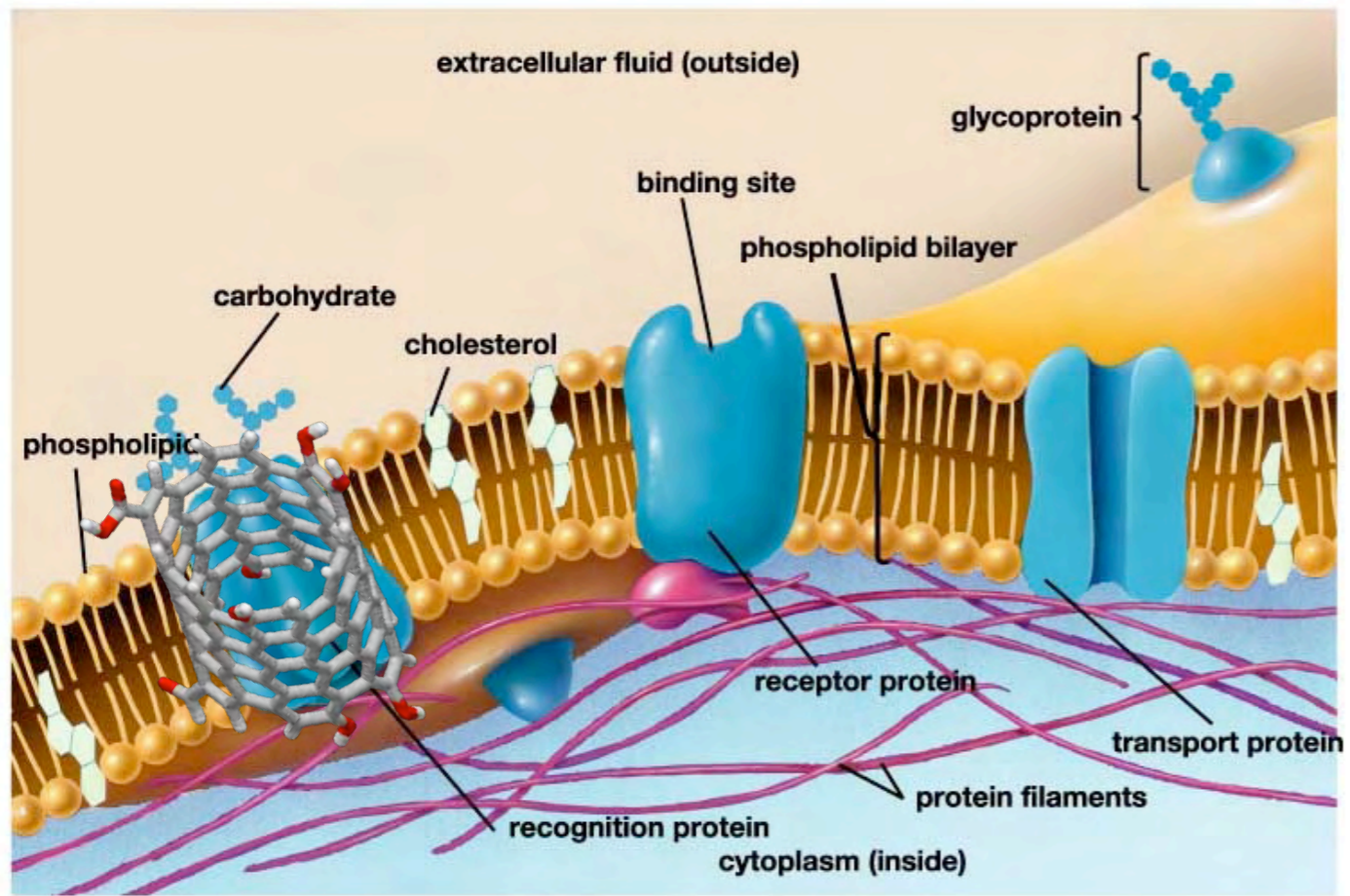


II. Exploring Possibilities

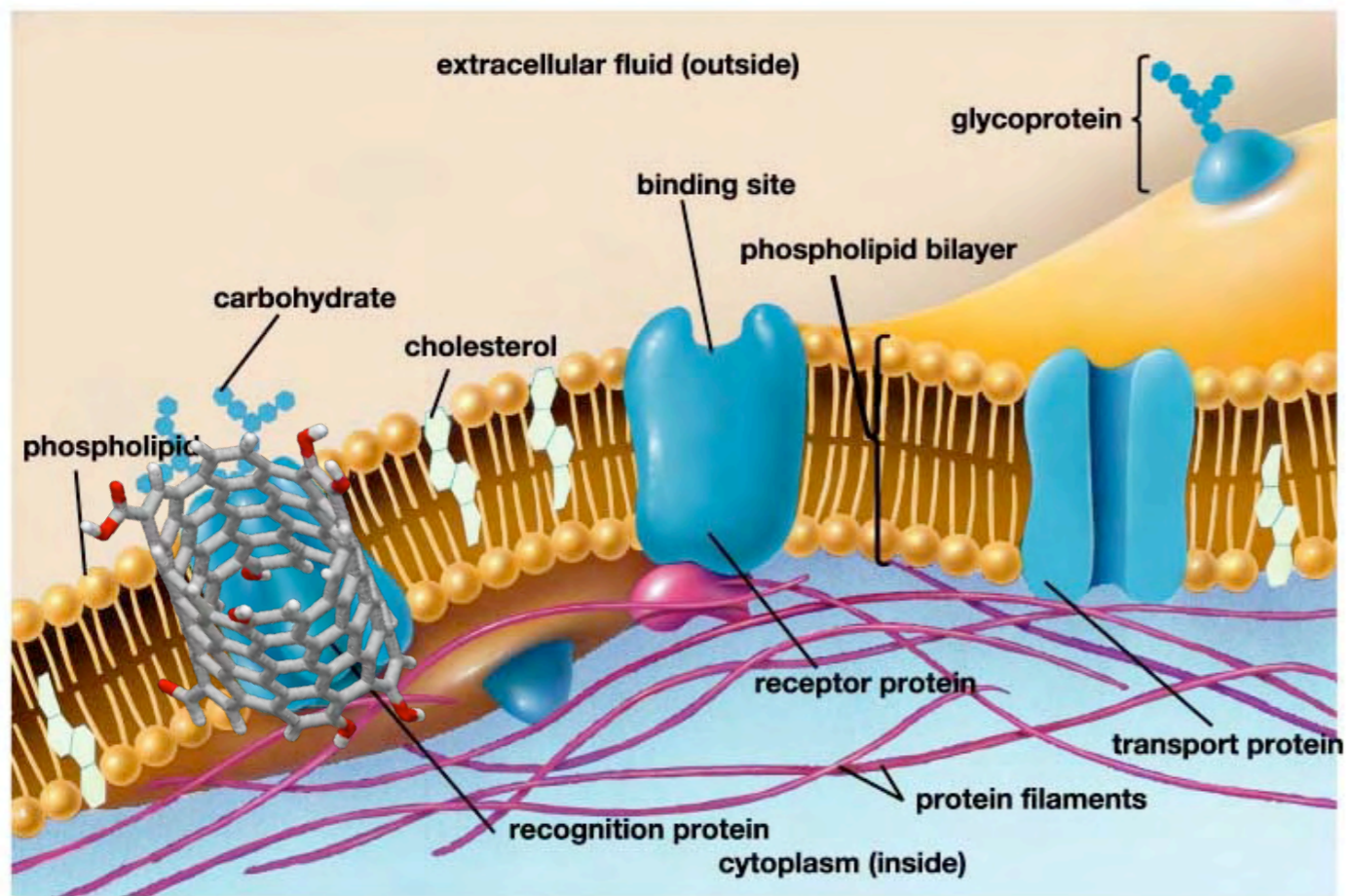
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Teresa and Gerald Audesirik. Biology, Life on Earth. Prentice Hall, New Jersey, 1999

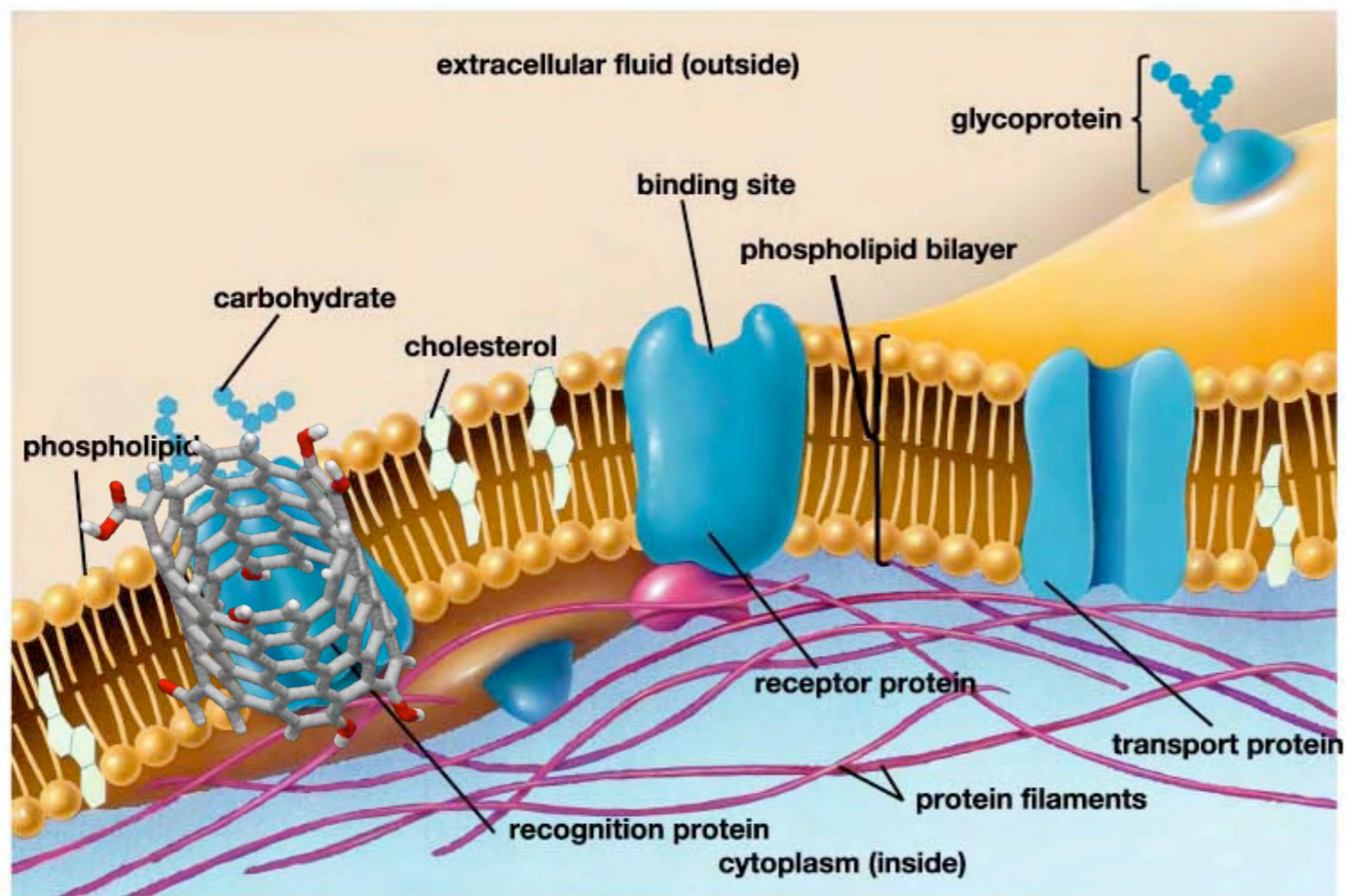


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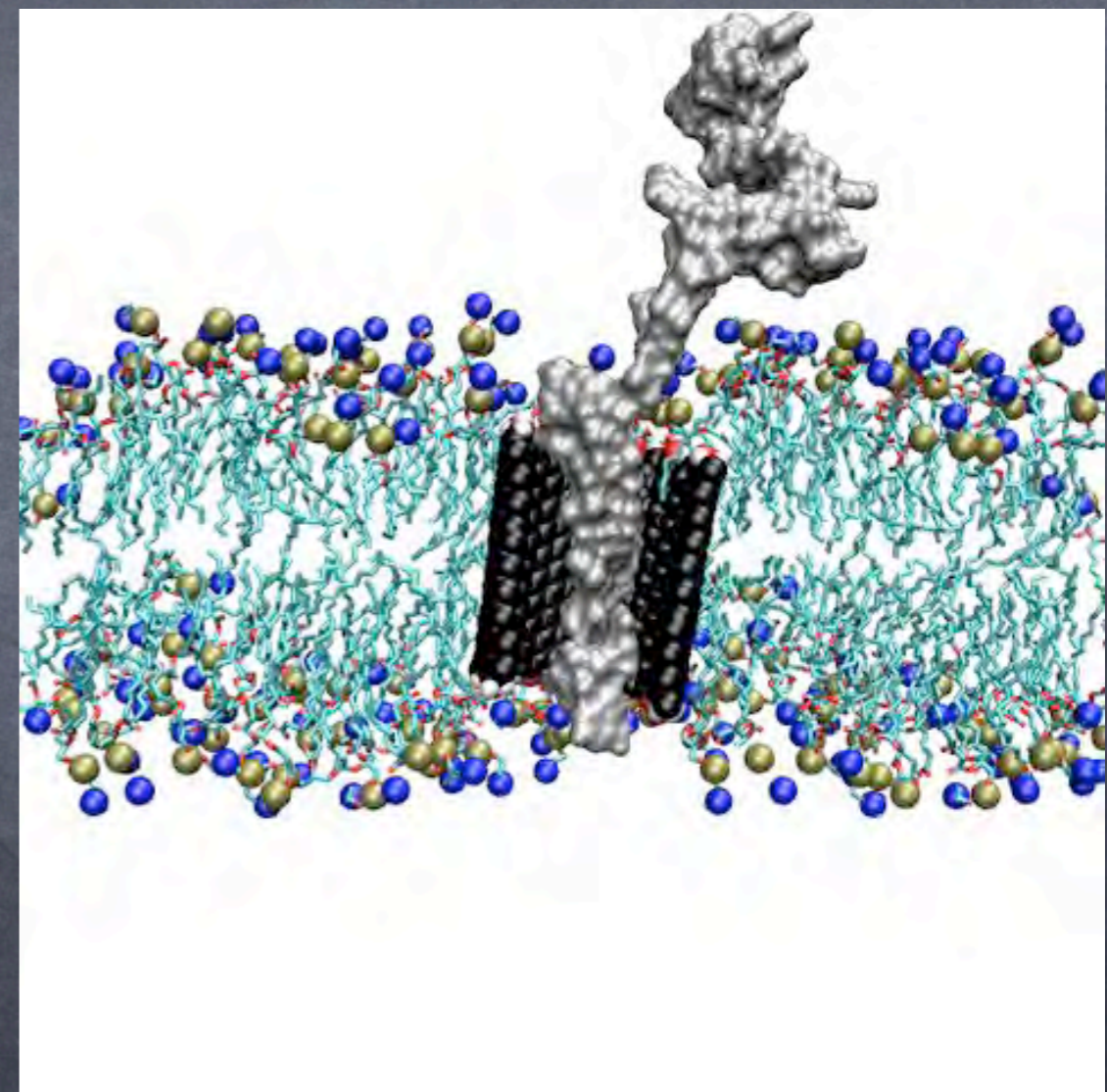


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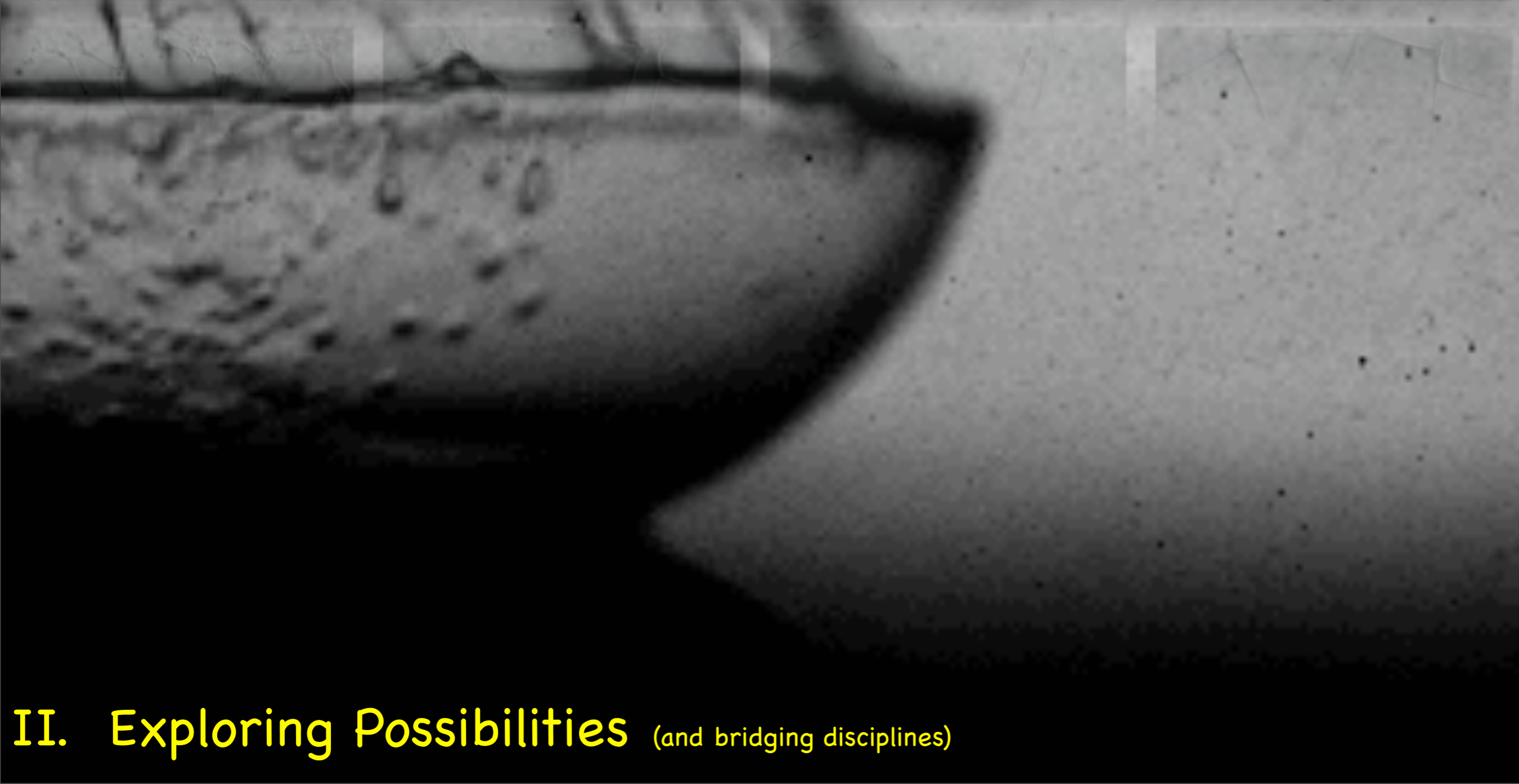
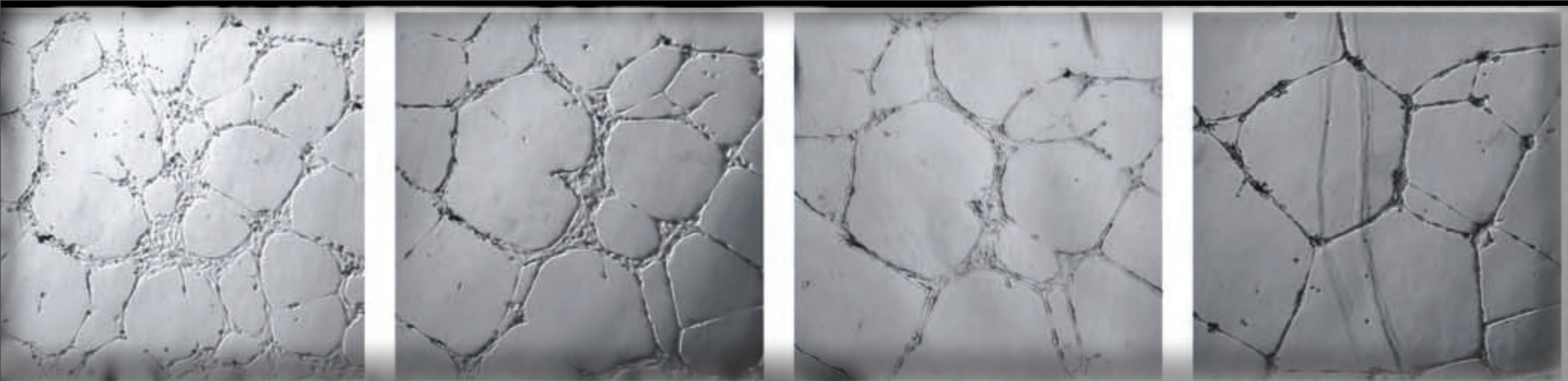


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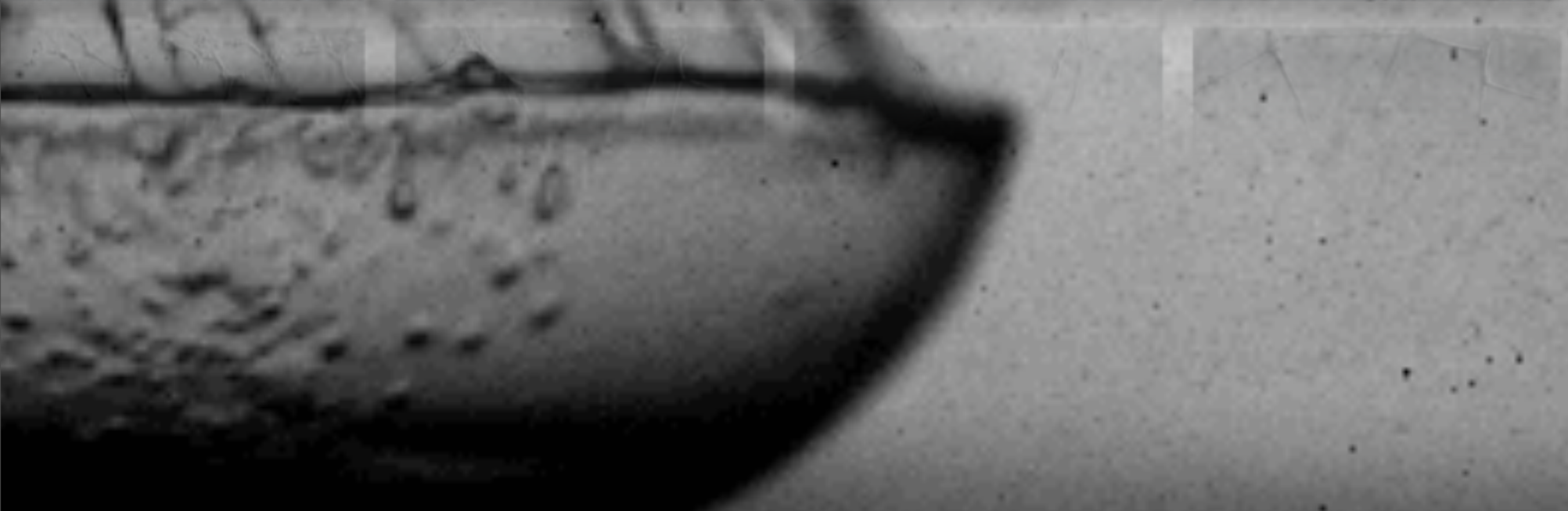
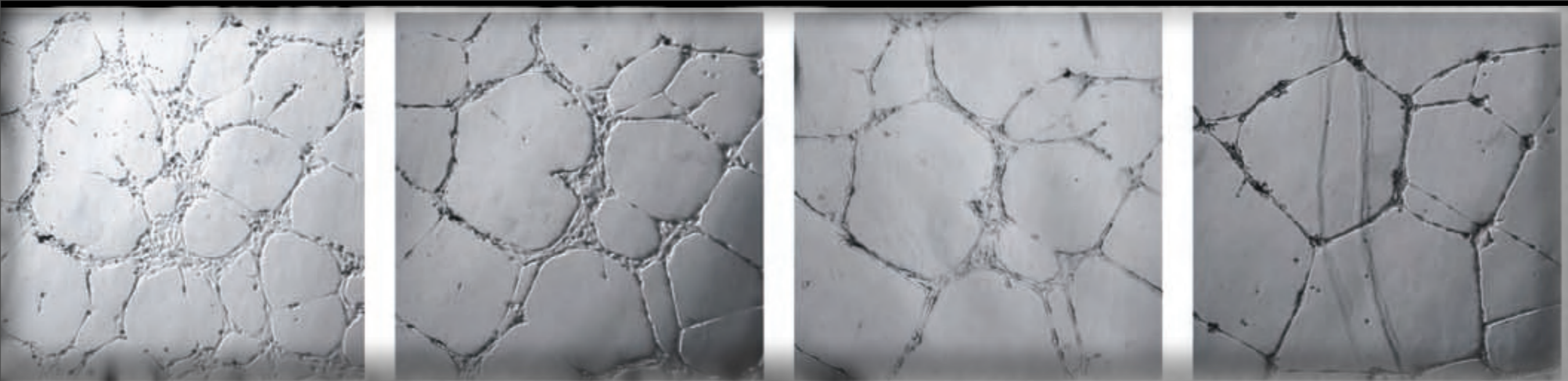
II. Exploring Possibilities (and bridging disciplines)



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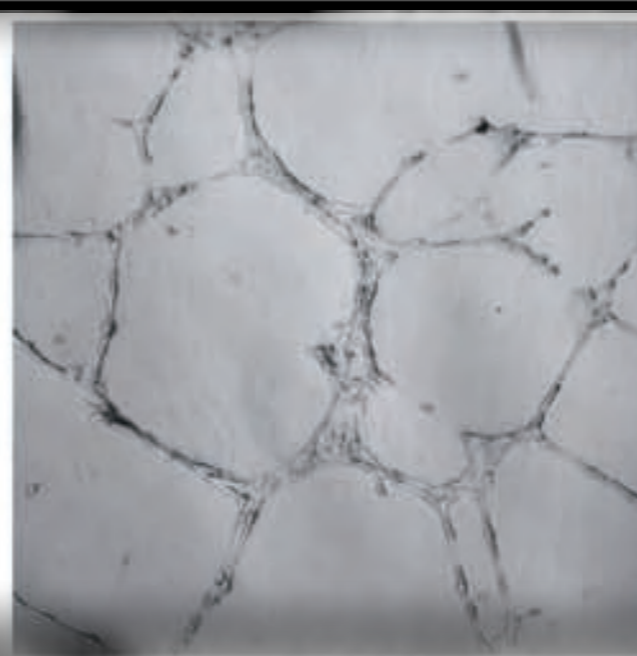
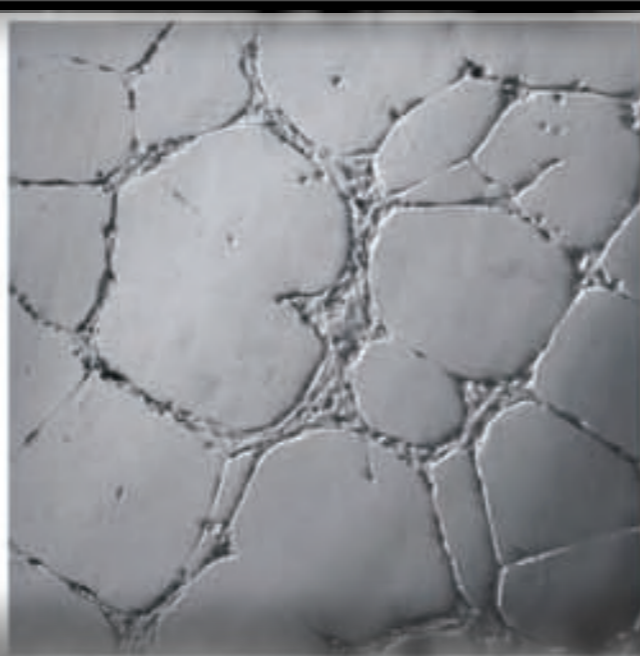
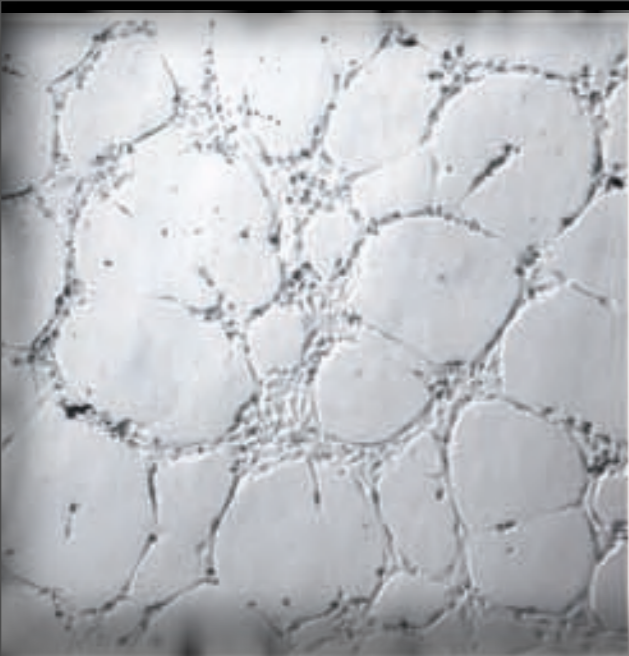


II. Exploring Possibilities (and bridging disciplines)



Crown Breakup - maragoni instability
drop impact onto an ethanol sheet

II. Exploring Possibilities (and bridging disciplines)



Vasculogenesis

blood vessel formation in embryonic development

R. M. H. MERKS, S. V. BRODSKY, M. S. GOLIGORSKY, S. A. NEWMAN, AND J. A. GLAZIER. CELL ELONGATION IS KEY TO IN SILICO REPLICATION OF IN VITRO VASCULOGENESIS AND SUBSEQUENT REMODELING. *DEVELOPMENTAL BIOLOGY*, 289(1): 44–54, 2006.

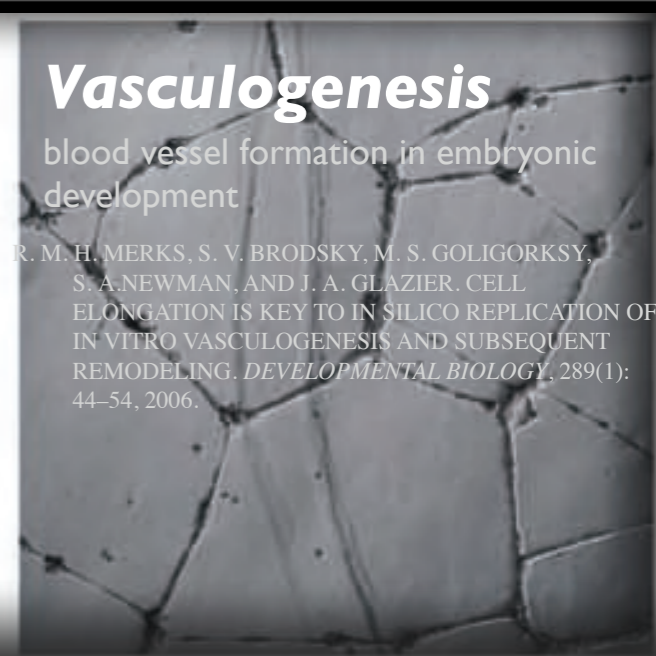
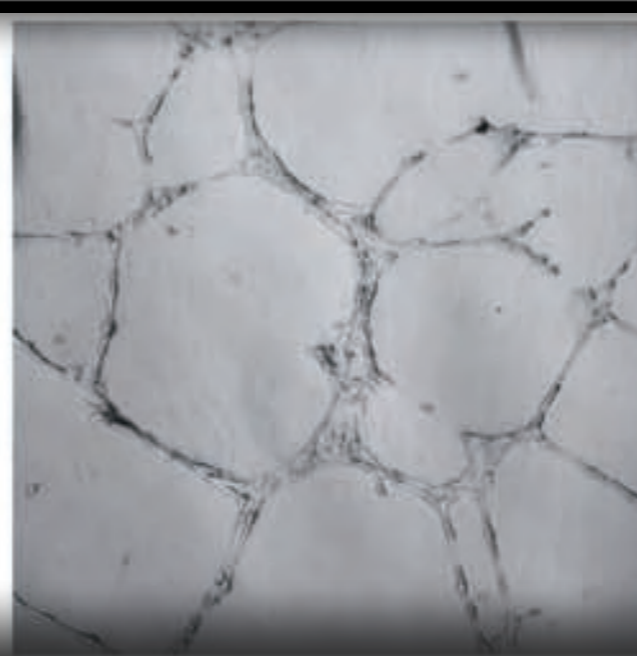
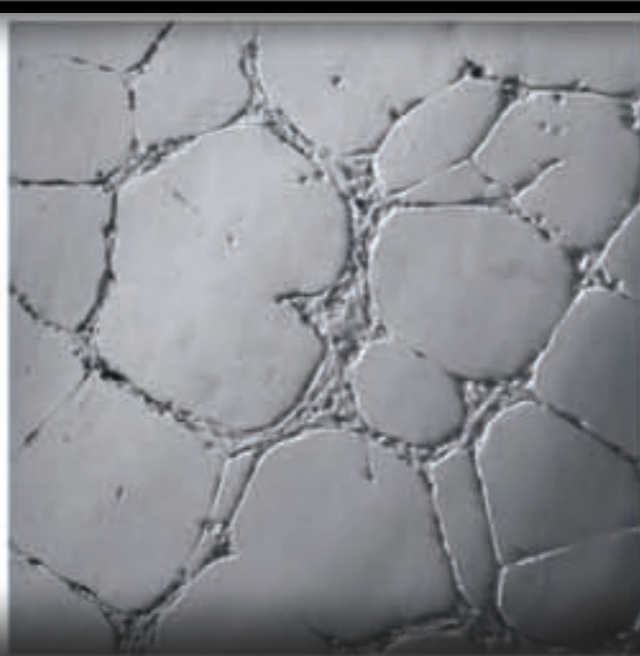
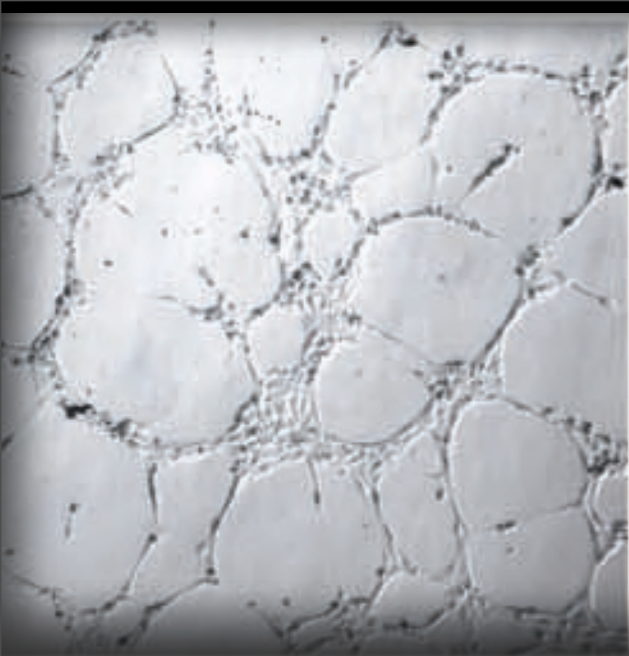


Crown Breakup - marangoni instability

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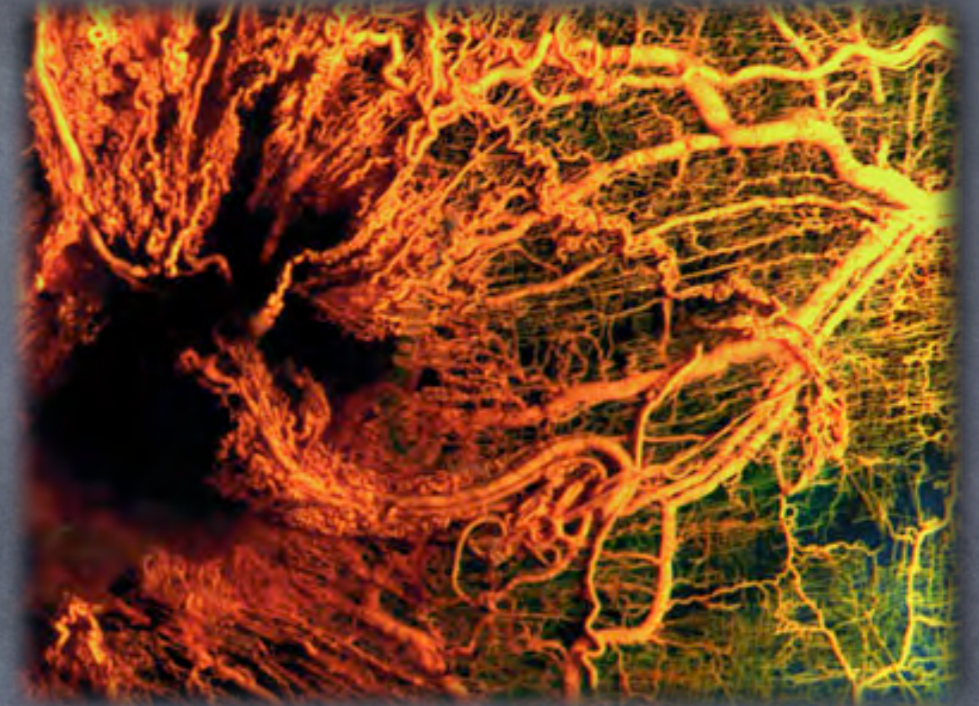
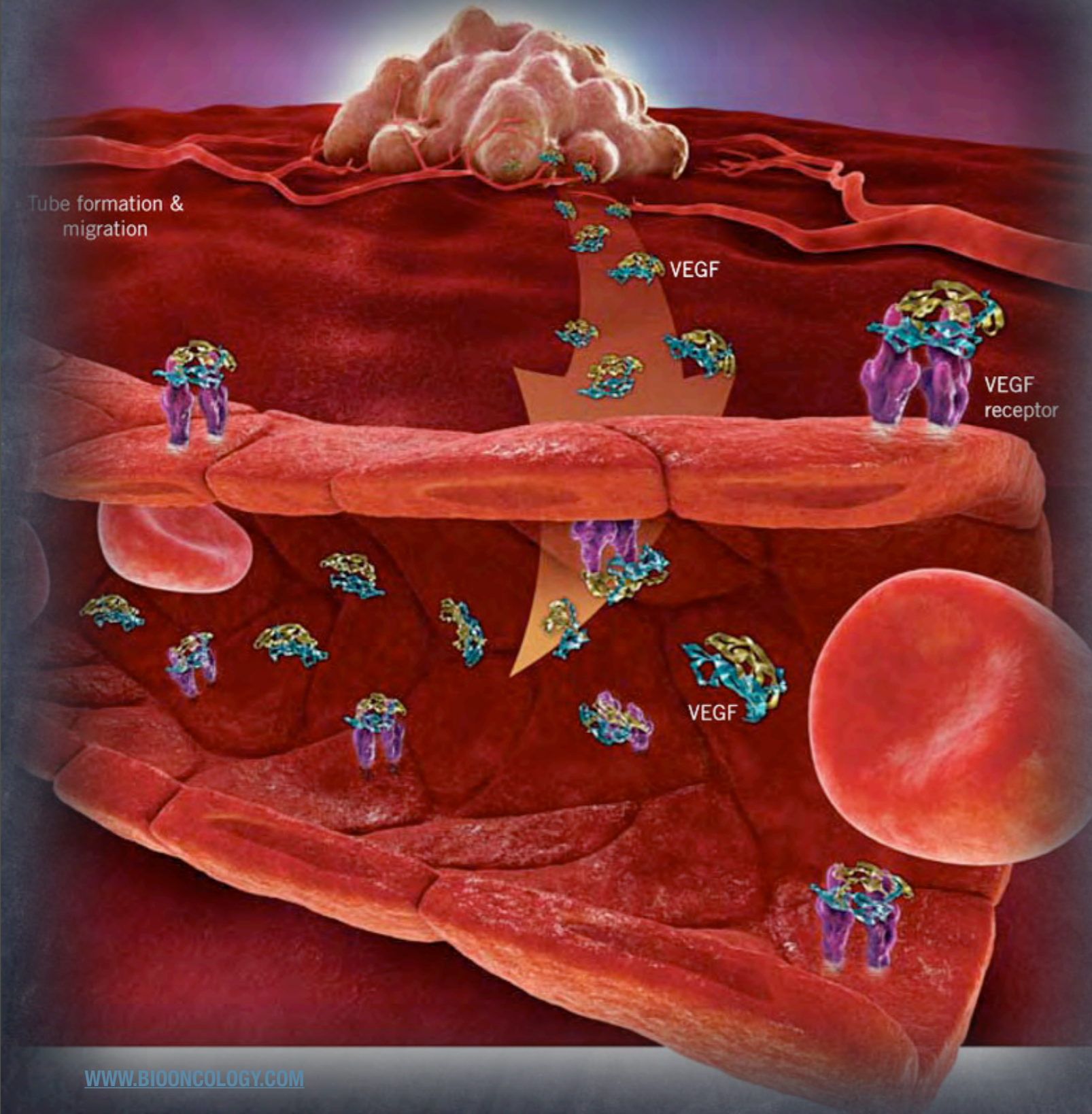


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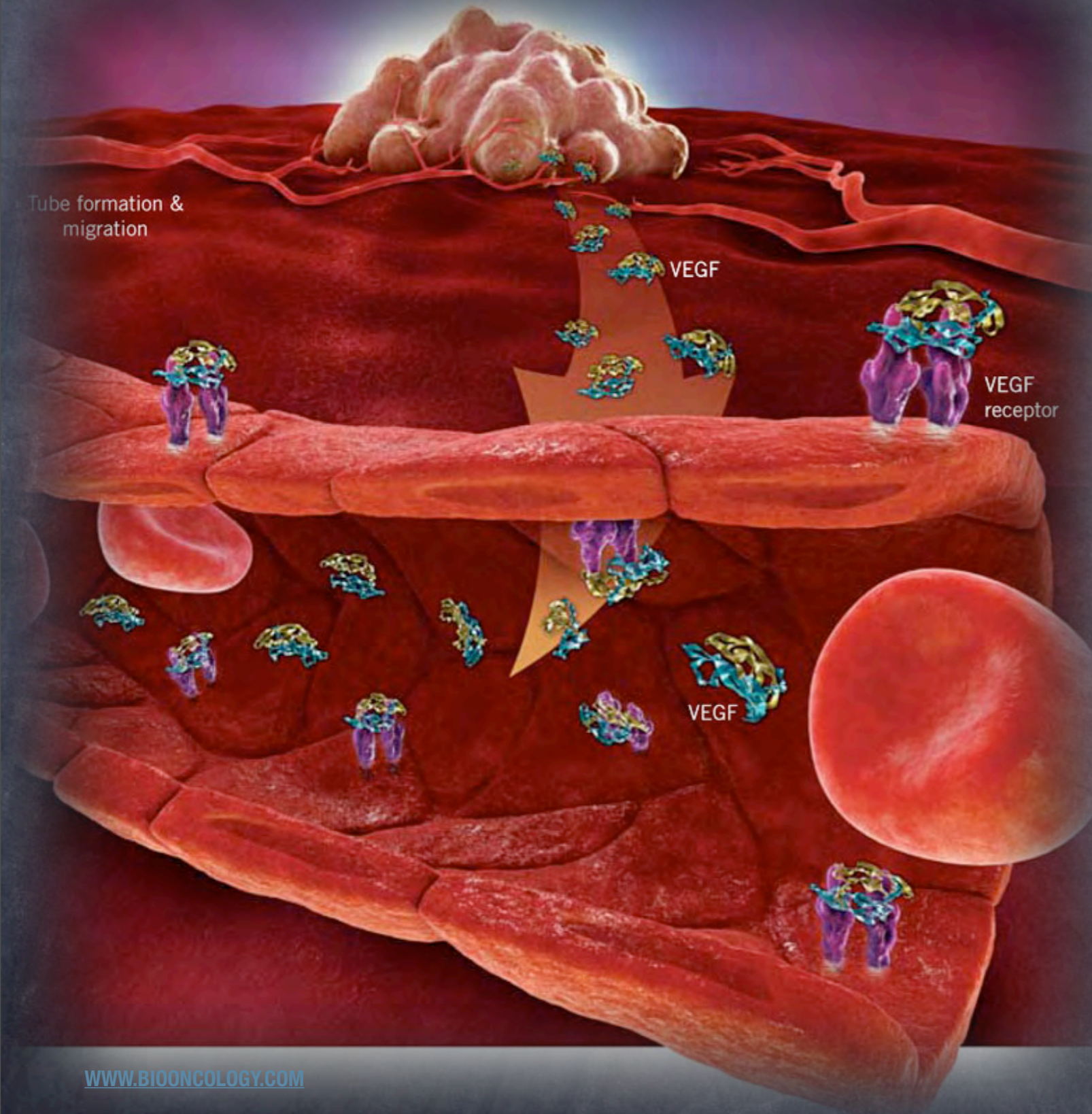
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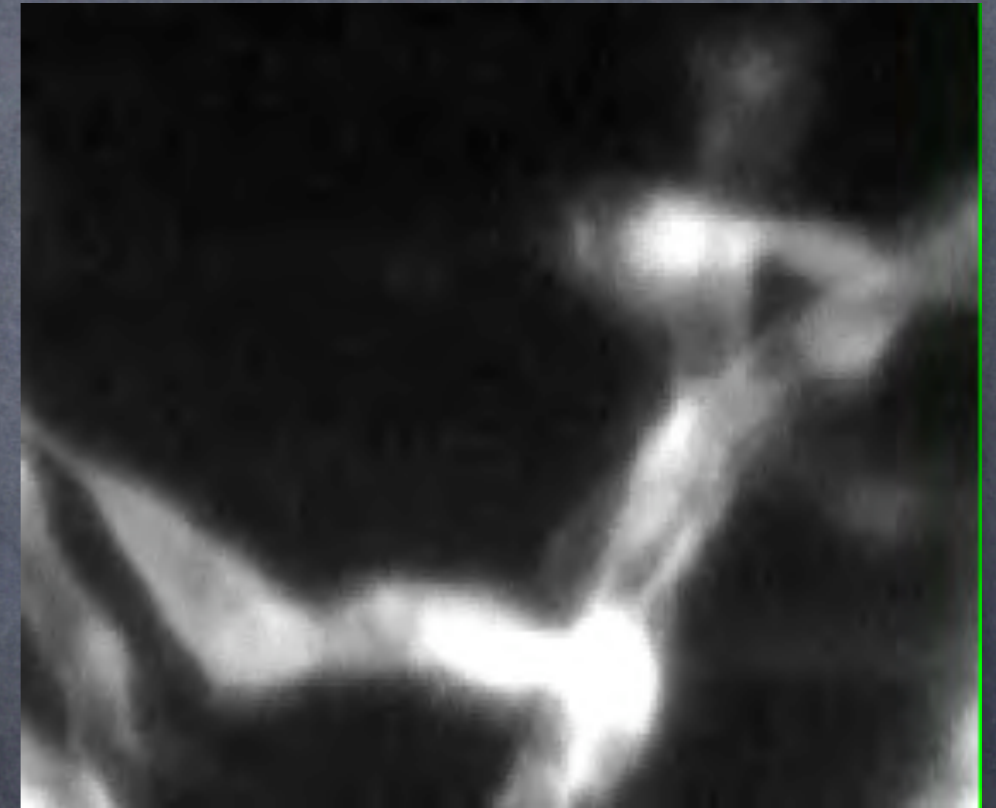
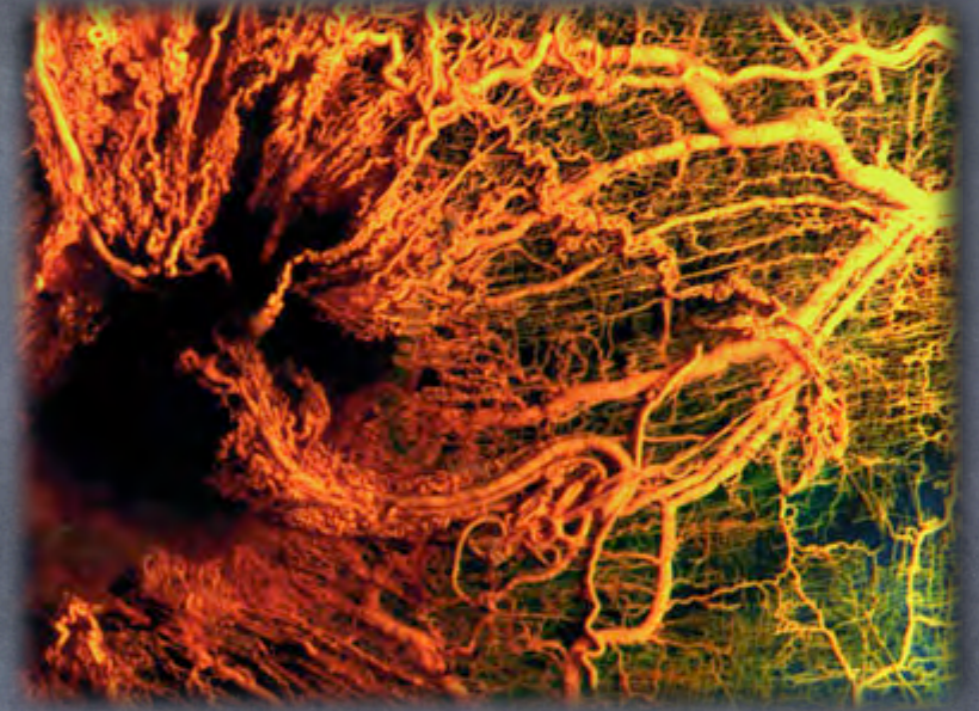
WWW.BIOONCOLOGY.COM

CRANIAL VESSEL ANGIOGENESIS IN ZEBRAFISH
[HTTP://ZFISH.NICHD.NIH.GOV/ZFATLAS/FLI-GFP/FLI_MOVIES.HTML](http://ZFISH.NICHD.NIH.GOV/ZFATLAS/FLI-GFP/FLI_MOVIES.HTML)

The Fluid Mechanics of Cancer : **Angiogenesis**



WWW.BIOONCOLOGY.COM

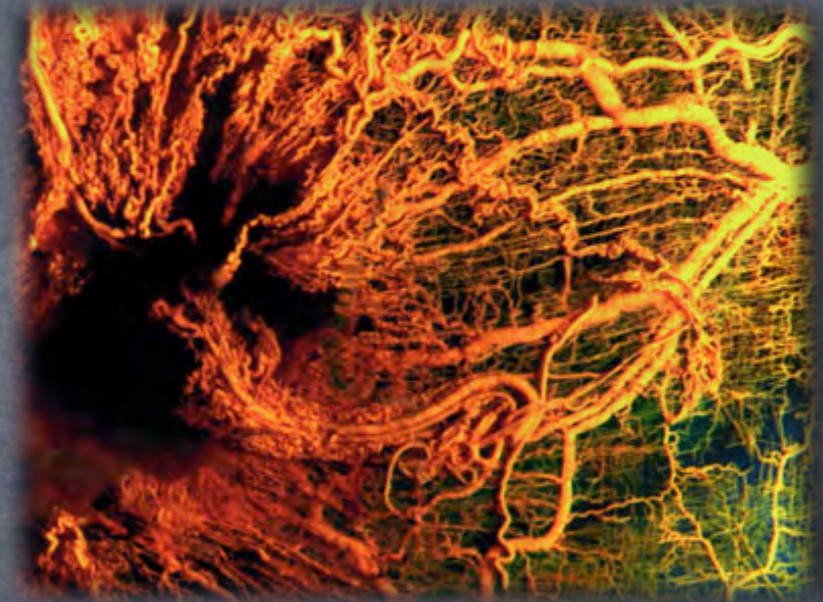
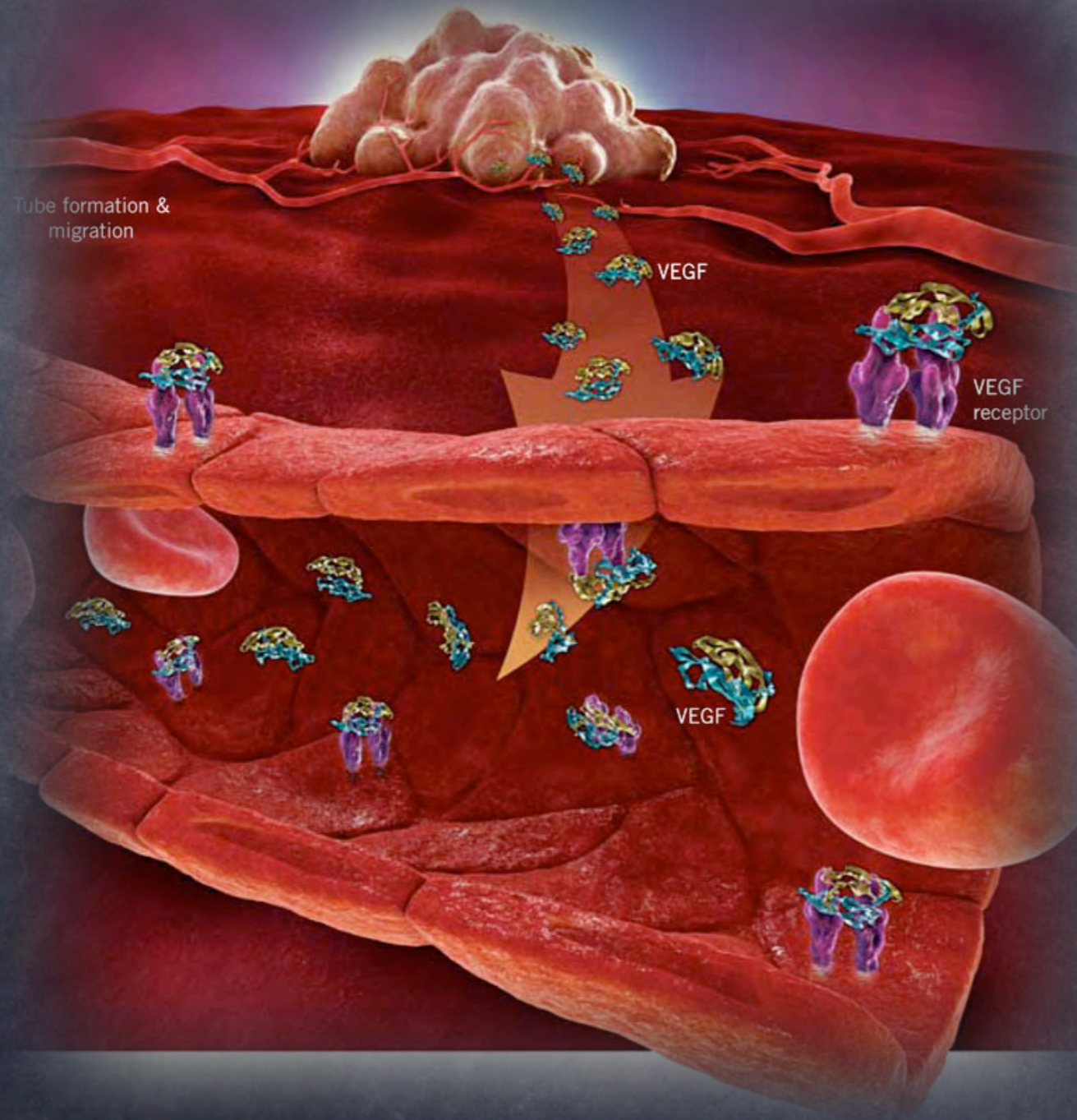


CRANIAL VESSEL ANGIOGENESIS IN ZEBRAFISH
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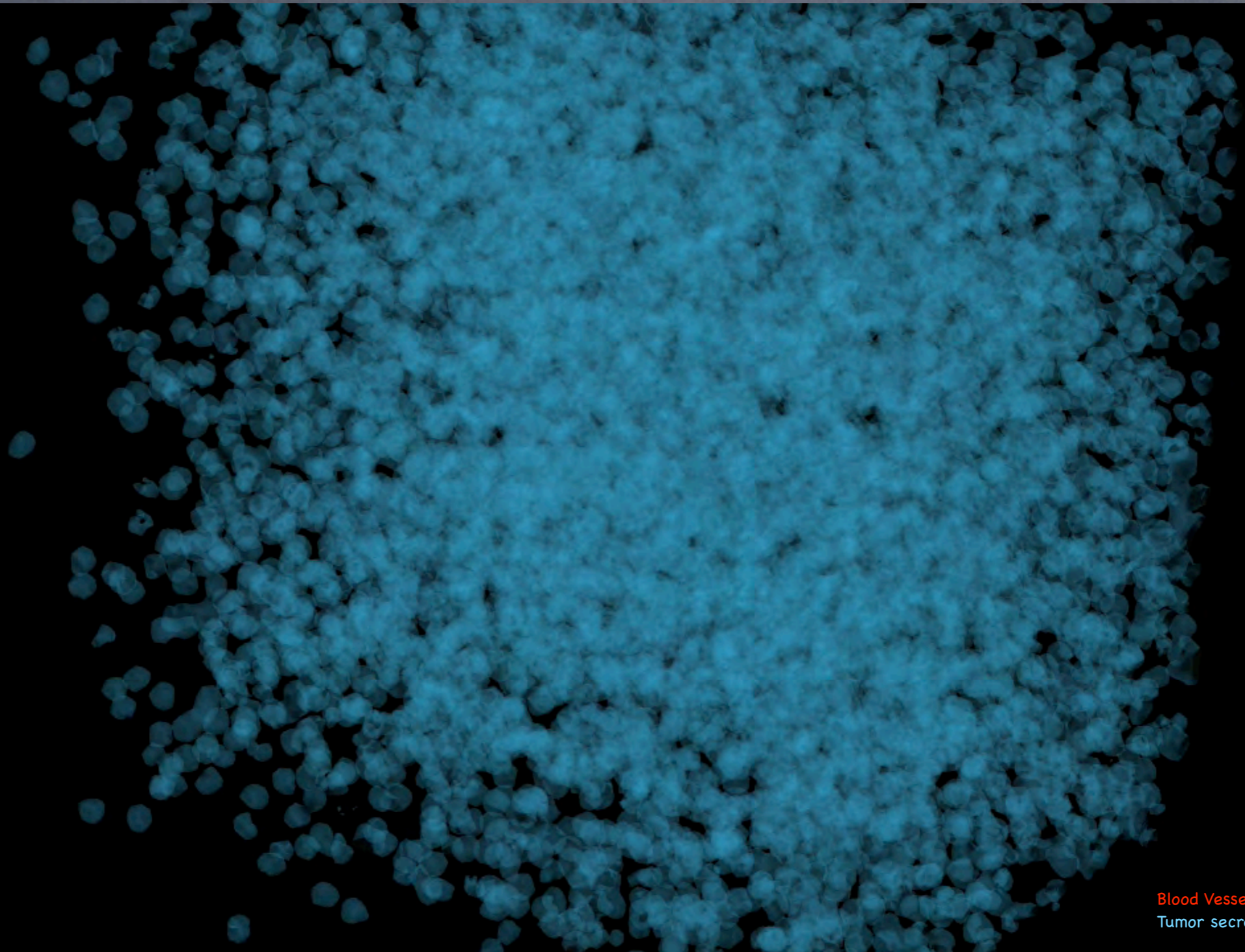
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Tumor Induced Angiogenesis

Tumor Induced Angiogenesis



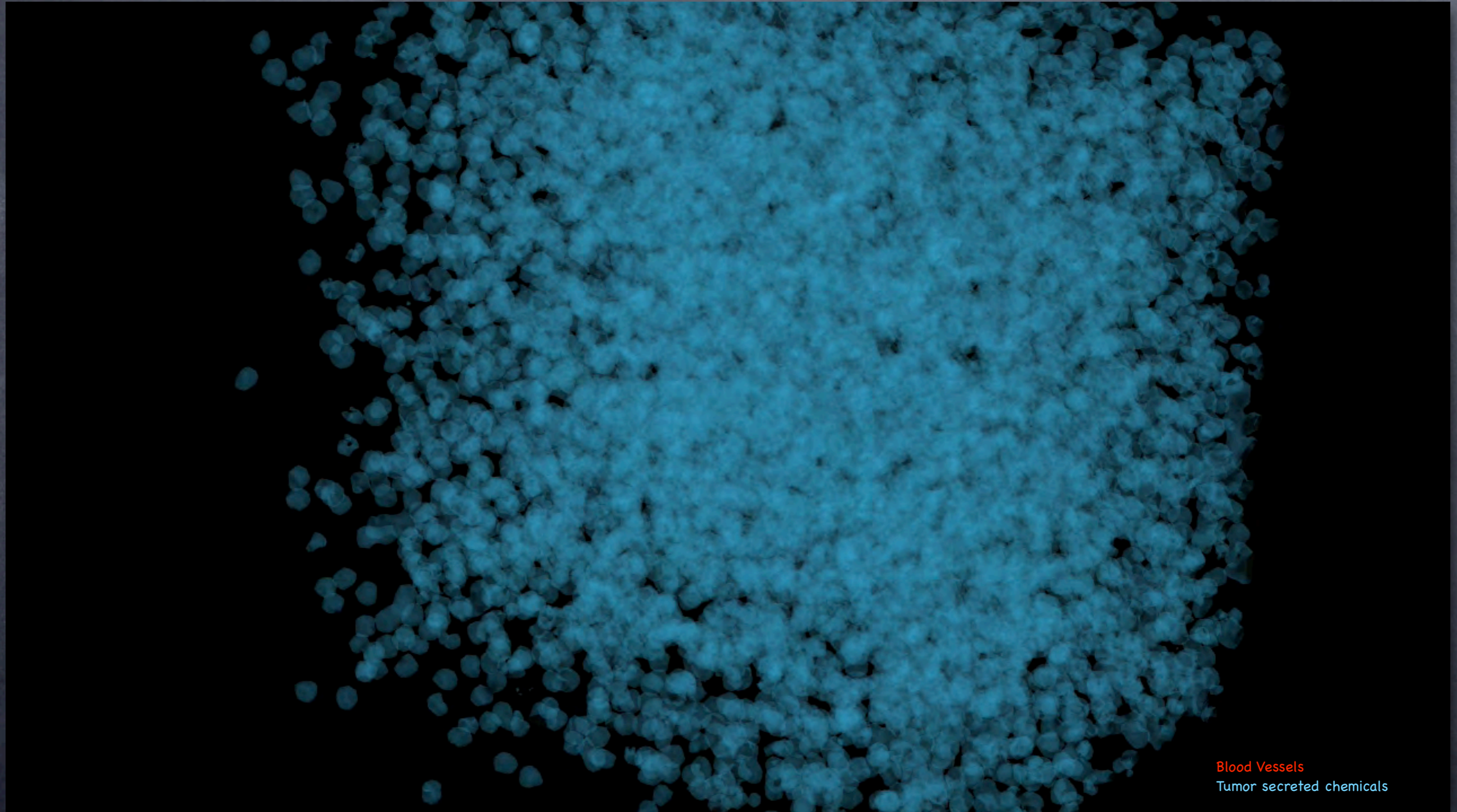
Tumor Induced Angiogenesis



Blood Vessels
Tumor secreted chemicals

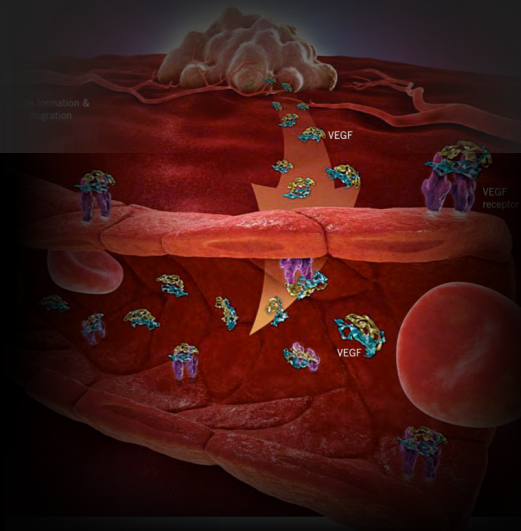


Aircraft Wakes to Tumor Induced Angiogenesis

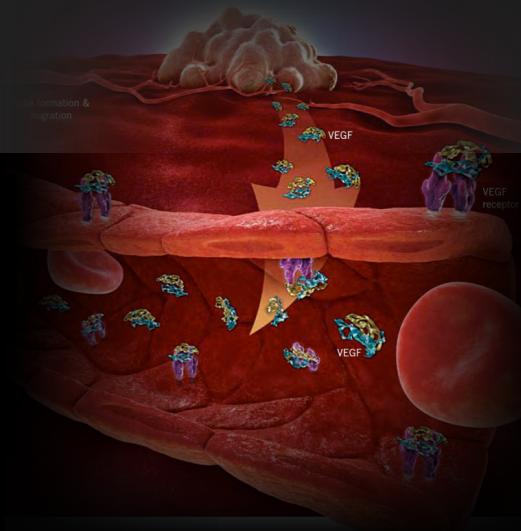


Blood Vessels
Tumor secreted chemicals

The Flow and Growth of Cancer

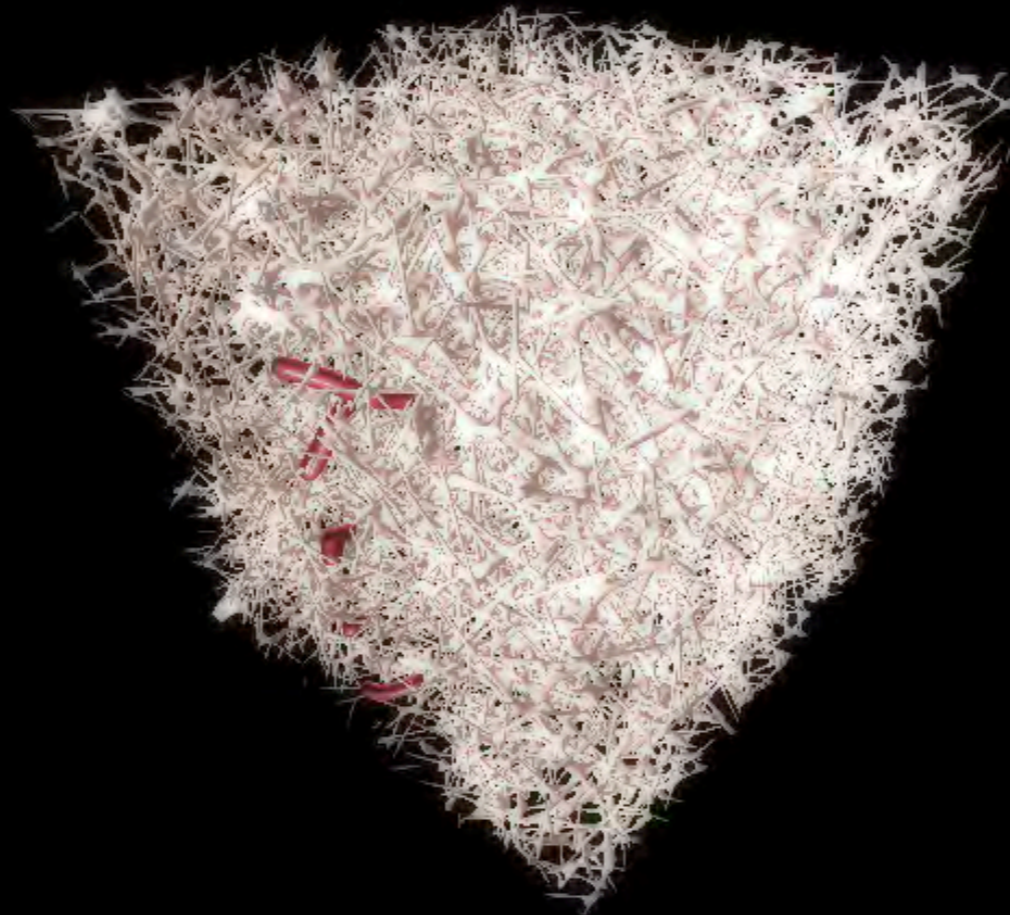
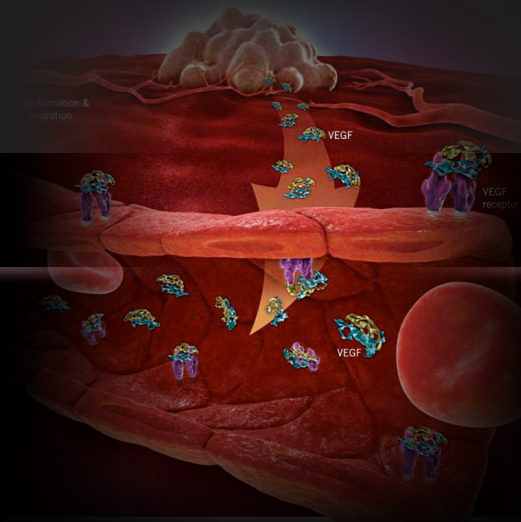


The Flow and Growth of Cancer



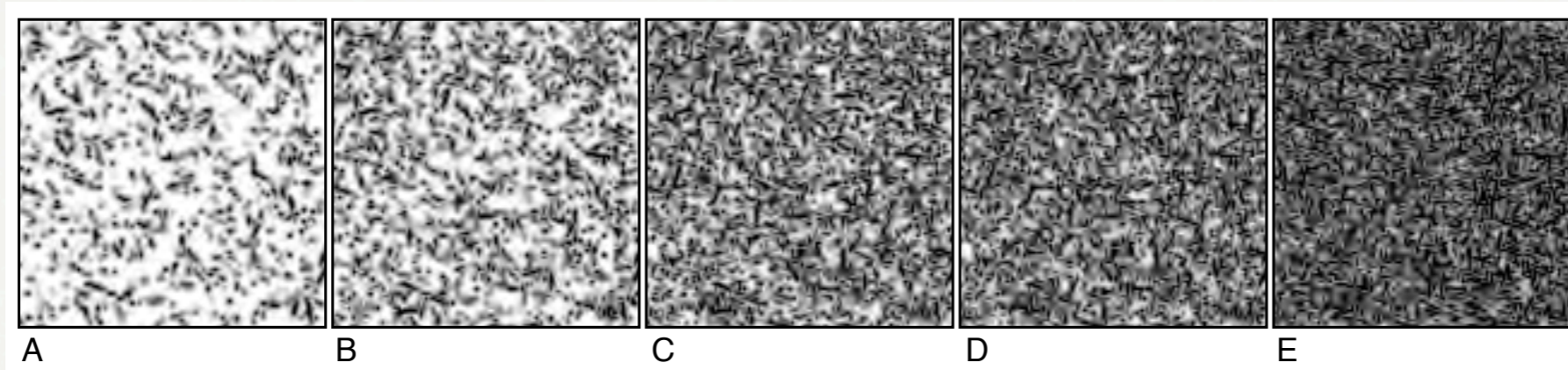
Milde F., Bergdorf M., Koumoutsakos P., A hybrid model of sprouting angiogenesis, Biophysical J.. 2008

The Flow and Growth of Cancer



Milde F., Bergdorf M., Koumoutsakos P., A hybrid model of sprouting angiogenesis, Biophysical J.. 2008

Extra-cellular Matrix density



**FIBER
DENSITY:**

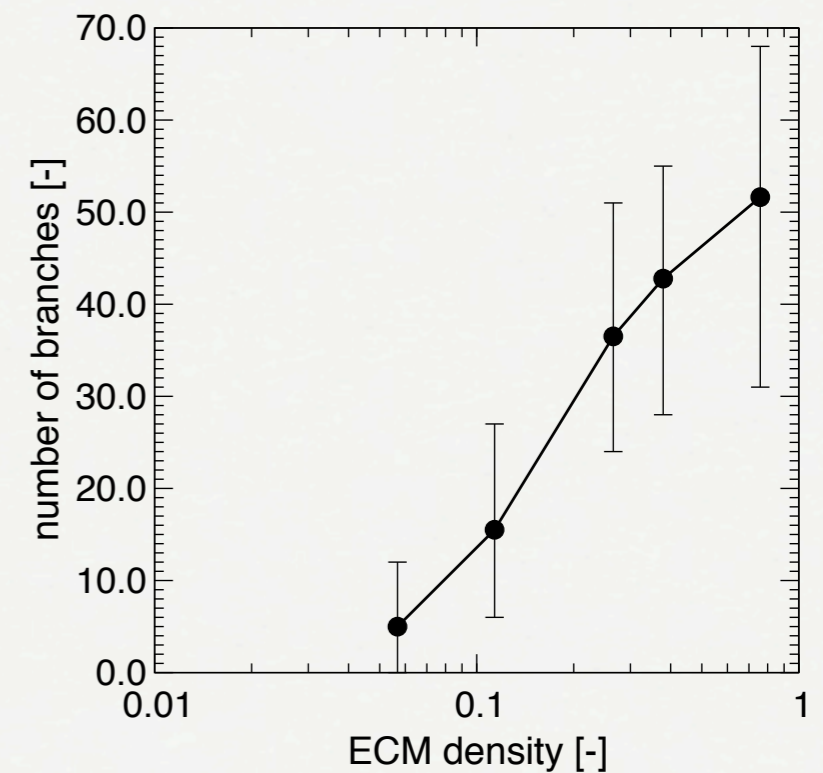
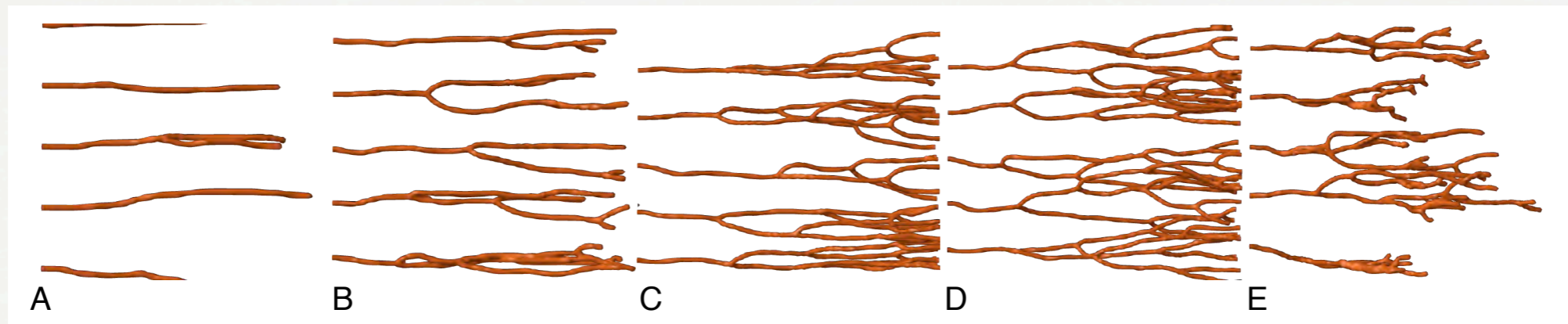
A: 6%,

B: 11%,

C: 26%,

D: 48%

E: 75%



(source : UN)

III. SAVE THE WORLD !

or THE PROBLEM WITH COMPUTERS

1 Desktop

(source : UN)

III. SAVE THE WORLD ! or THE PROBLEM WITH COMPUTERS

1 Desktop

=

(source : UN)

III. SAVE THE WORLD ! or THE PROBLEM WITH COMPUTERS

1 Desktop

=

240 Kg Fossil Fuels

(source : UN)

III. SAVE THE WORLD ! or THE PROBLEM WITH COMPUTERS

1 Desktop
=
240 Kg Fossil Fuels
+

(source : UN)

III. SAVE THE WORLD ! or THE PROBLEM WITH COMPUTERS

1 Desktop
=
240 Kg Fossil Fuels
+
22 Kg Chemicals

(source : UN)

III. SAVE THE WORLD ! or THE PROBLEM WITH COMPUTERS

1 Desktop
=
240 Kg Fossil Fuels
+
22 Kg Chemicals
+

(source : UN)

III. SAVE THE WORLD ! or THE PROBLEM WITH COMPUTERS

1 Desktop
=
240 Kg Fossil Fuels
+
22 Kg Chemicals
+
1500 Kg. Water

(source : UN)

III. SAVE THE WORLD ! or THE PROBLEM WITH COMPUTERS

THE PROBLEM WITH COMPUTERS

(source : Borderstep Institute)

THE PROBLEM WITH COMPUTERS

28 MT CO₂ in Germany

(source : Borderstep Institute)

THE PROBLEM WITH COMPUTERS

28 MT CO₂ in Germany

Airtraffic

(source : Borderstep Institute)

THE PROBLEM WITH COMPUTERS

28 MT CO₂ in Germany

Airtraffic

=

(source : Borderstep Institute)

THE PROBLEM WITH COMPUTERS

28 MT CO₂ in Germany

Airtraffic

=

2006 ICT related emissions

(source : Borderstep Institute)

THE PROBLEM WITH COMPUTERS

38 TWh in 2006 for

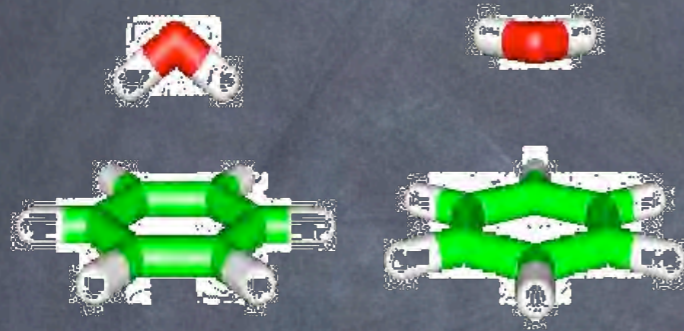
Electricity demands of domestic electricity in CH

=

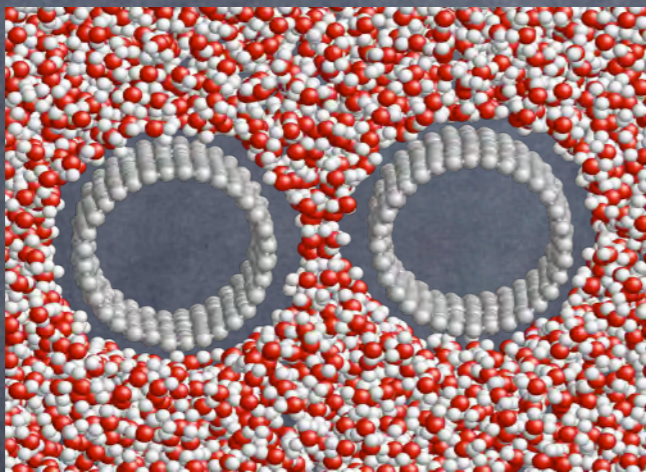
Electricity demands of Computer Centers in EU and CH

(source : EU)

PEAK PERFORMANCE (%)



Quantum ~ 60-70 %

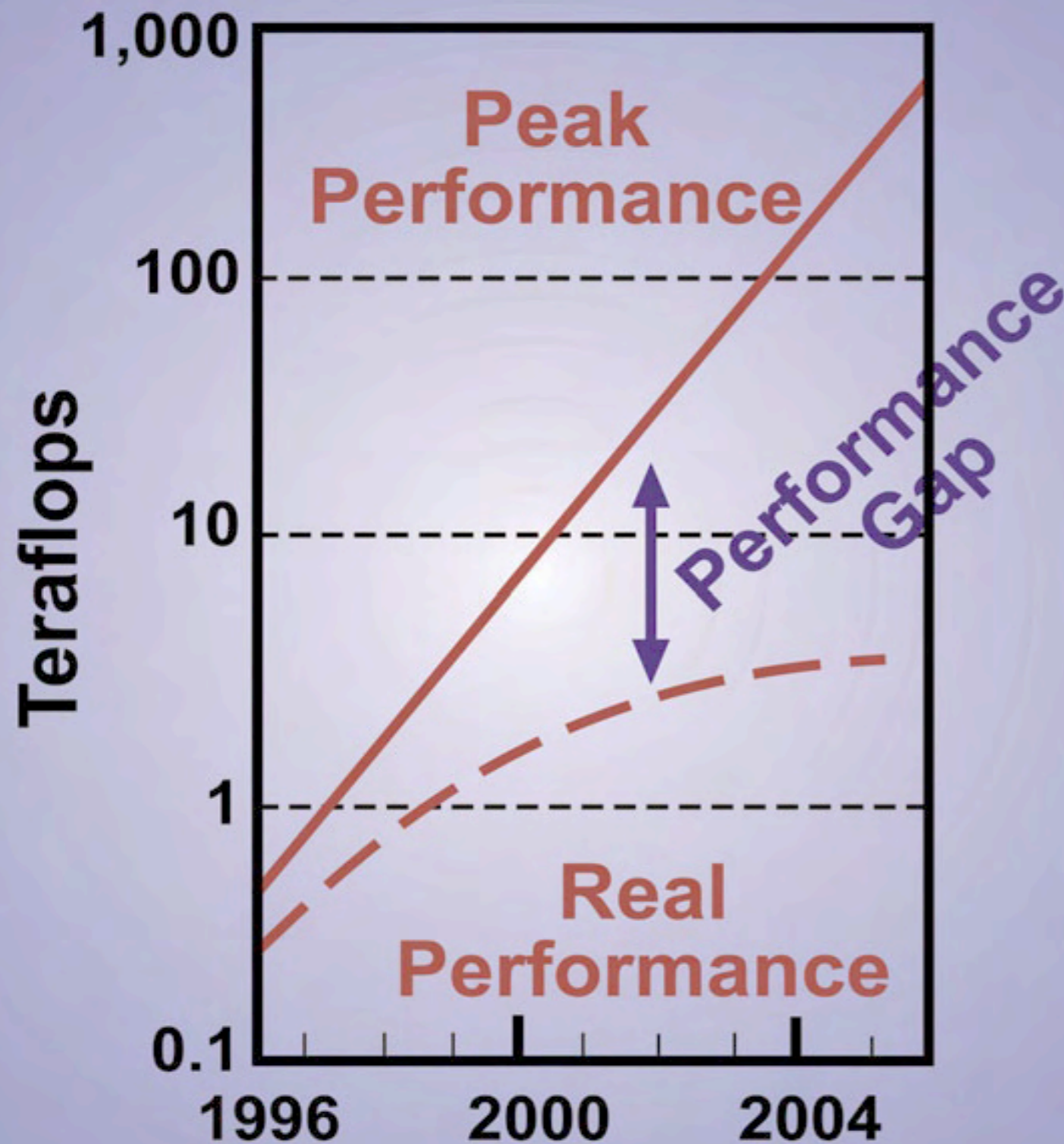


Atomistic ~ 10-30%



Continuum ~ 5-30%

Hardware & Software : Need a Bridge over Troubled Waters



■ CLOSE THE GAP !

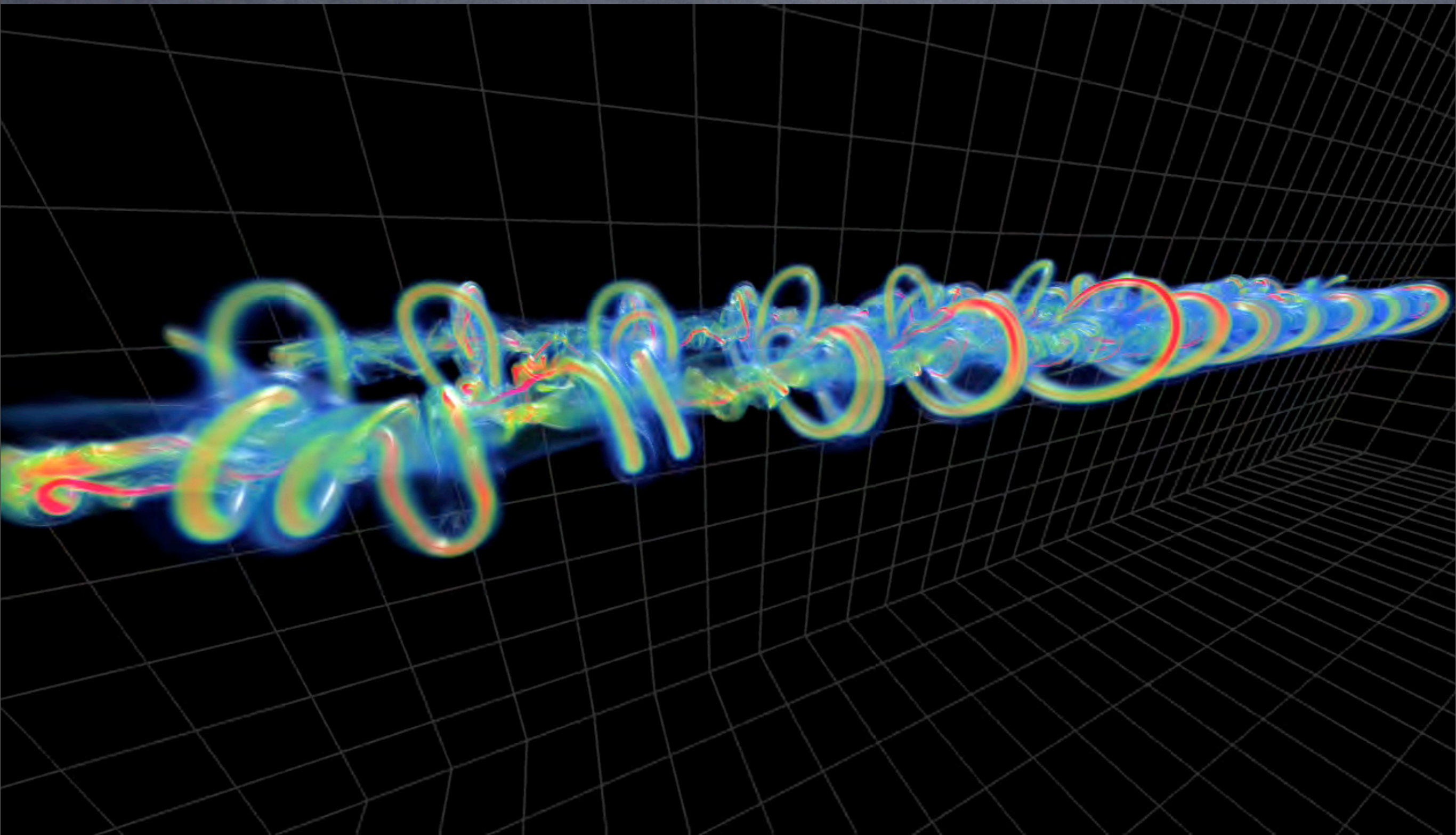
■ NEW GENERATION

■ Methods

■ Codes

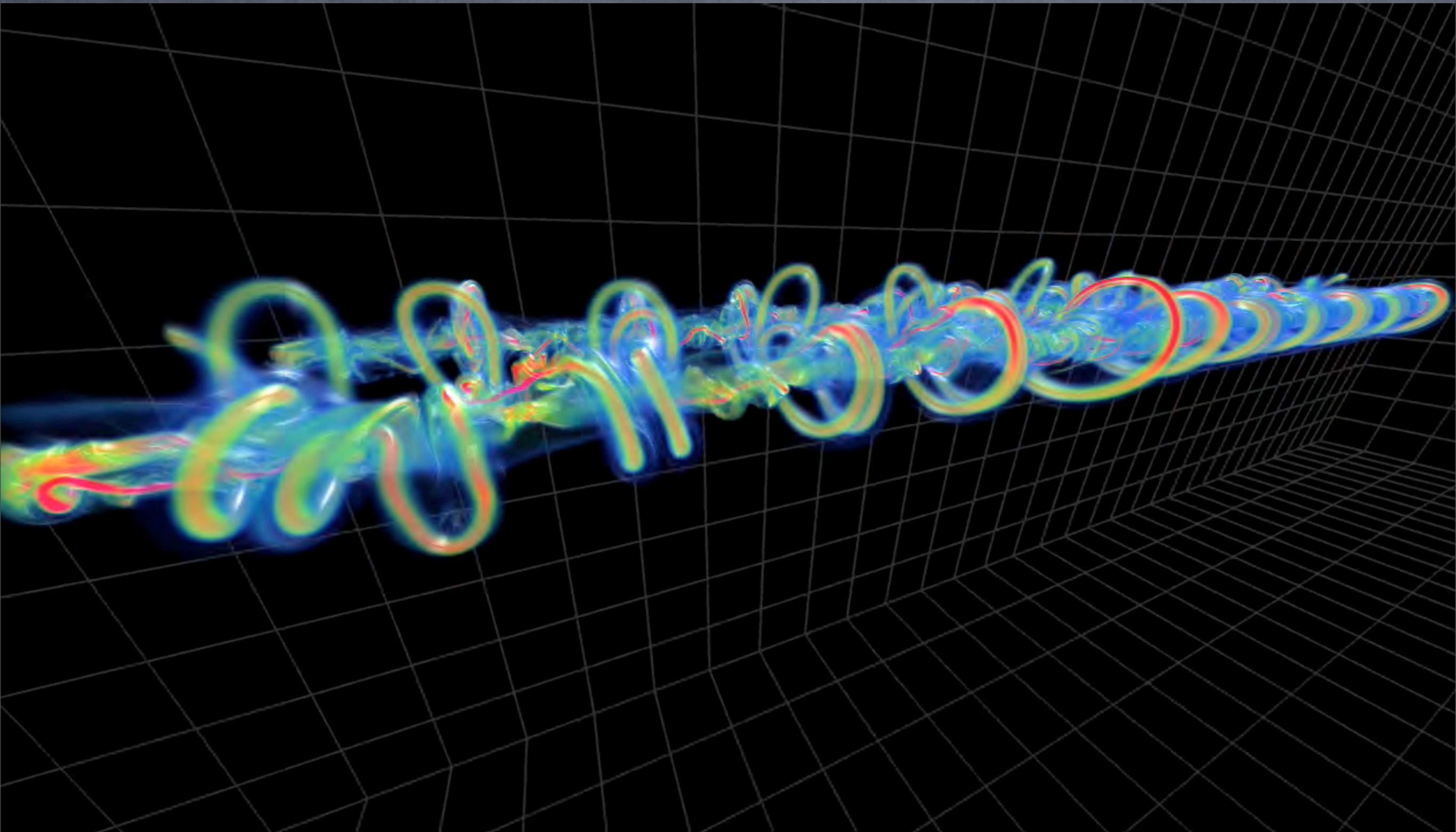
■ Researchers

■ COLLABORATION

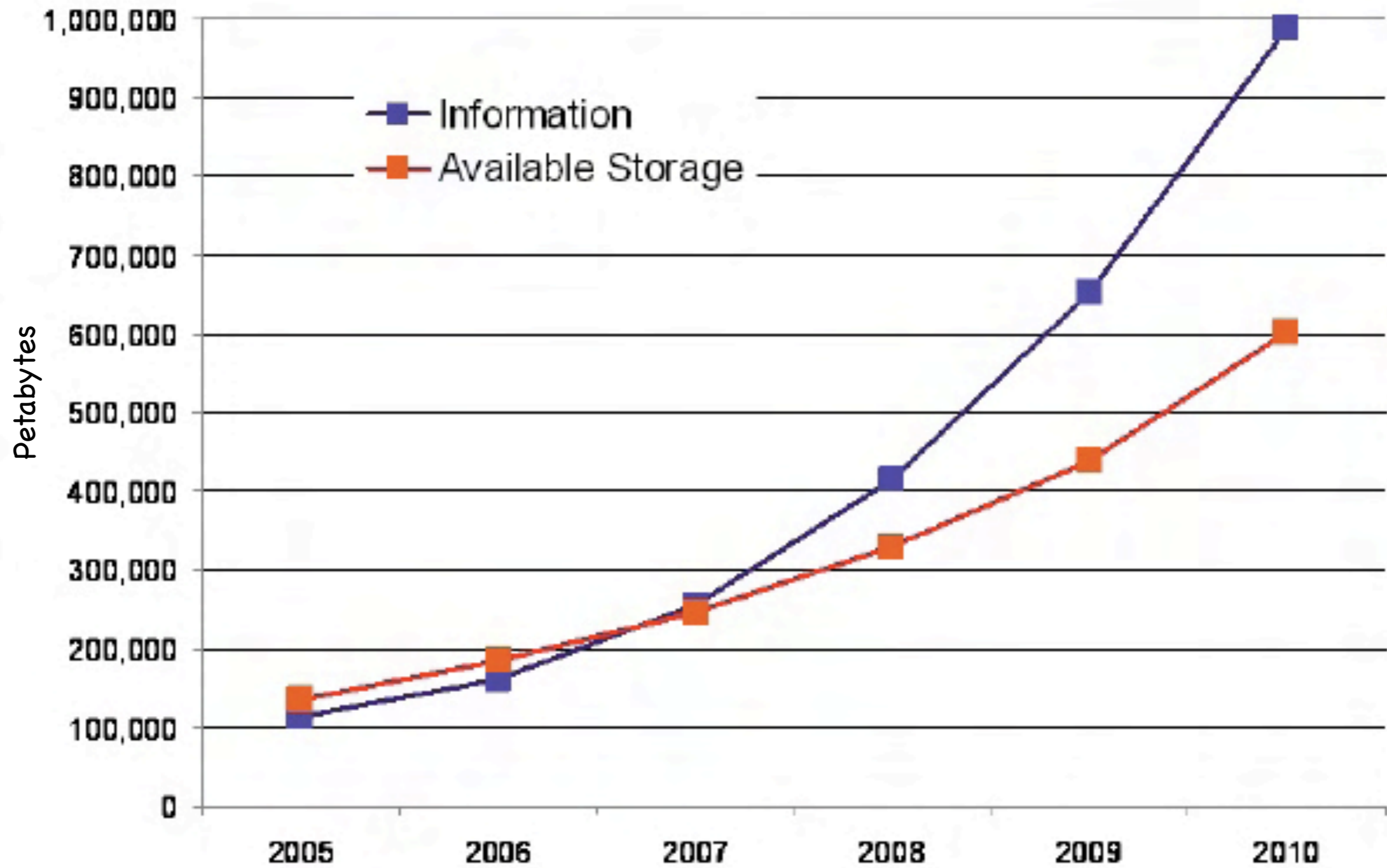


10 Billion Particles - 16,000 Processors

Data per time step : 40 Gb

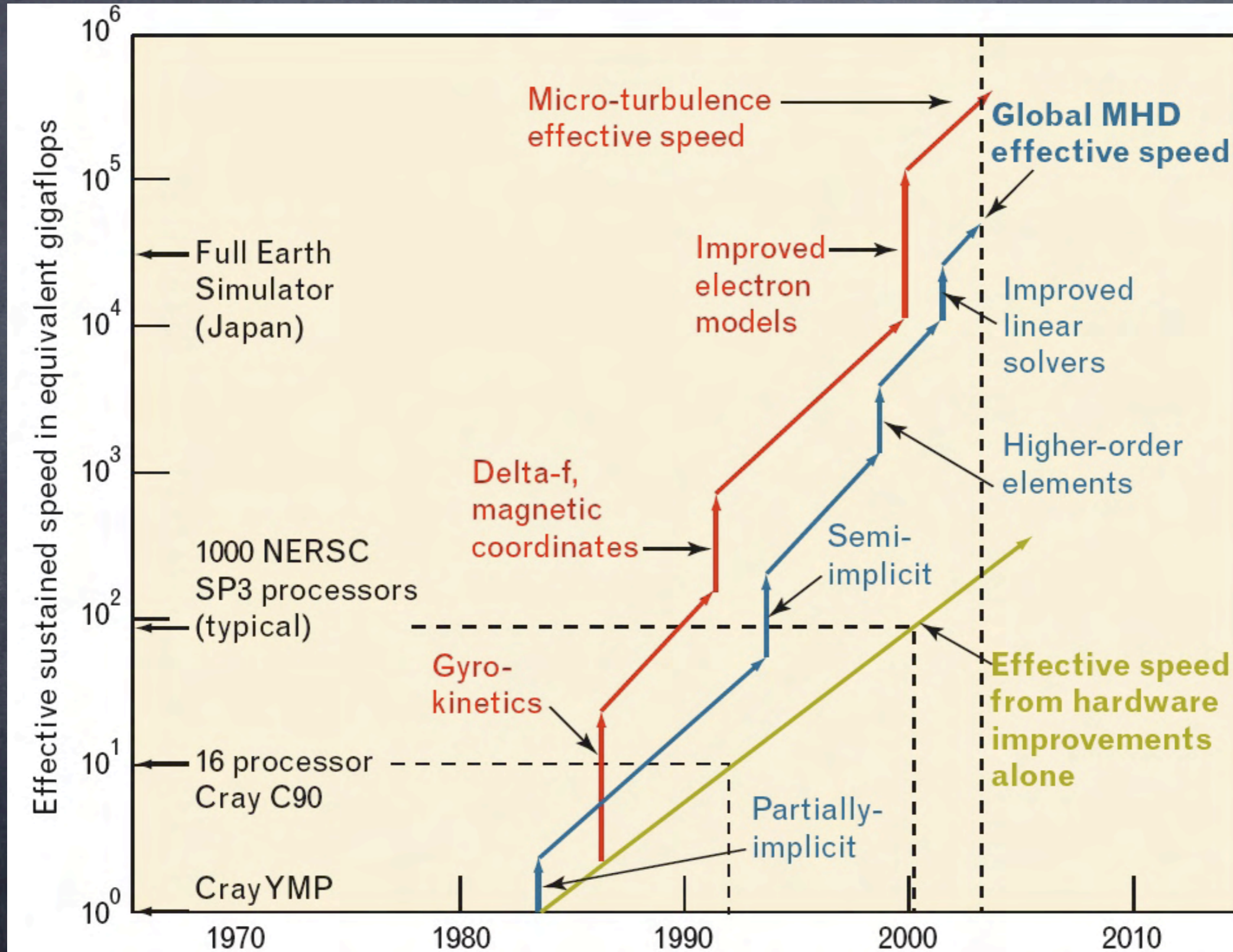


Information and Available Storage



source : IDC 2007

Moore and Algorithms



Source: S. Jardin
NERSC 2003
Report

S. Jardin (Princeton) : "Effective speed" increases in fusion codes from faster hardware and improved algorithms.

OBSERVATIONS :

Application - Interfaces/People - Machines

Good Algorithms can replace Thousands of Proc(f)essors

TODAY : Software burdens Hardware

*HOW ? People are the enabling/disabling middleware -
Education and Support*

re-think CHALLENGES

re-think **CHALLENGES**

HARDWARE - MODELS - DATA

re-think CHALLENGES

YOU!

HARDWARE - MODELS - DATA