

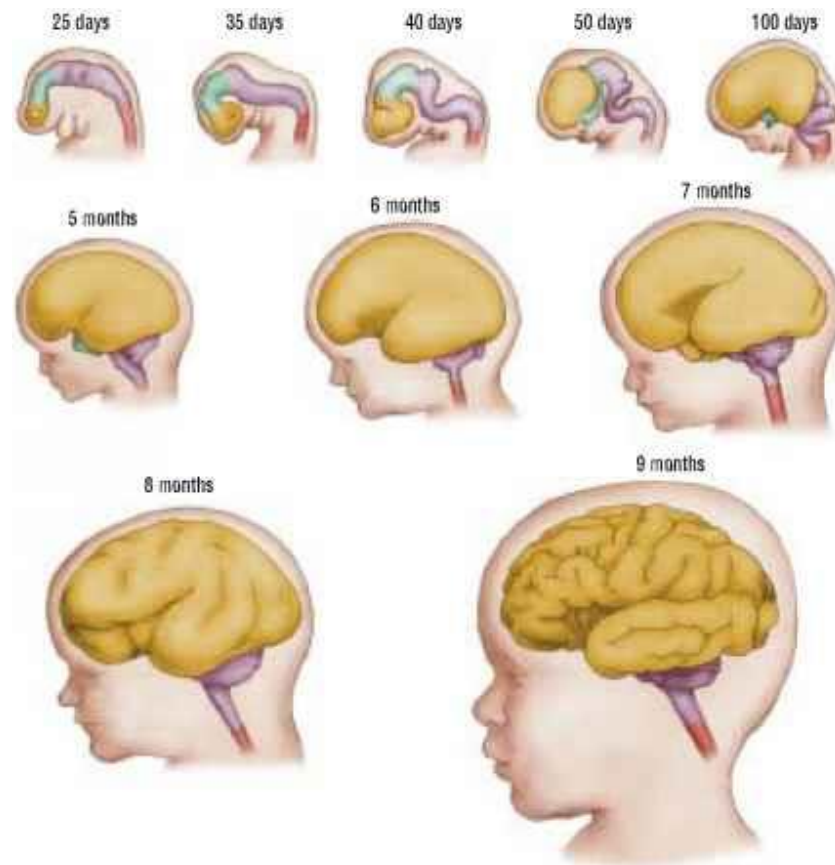


BioDynamo

from scientific ingenuity to a big computing challenge

Marco Manca, MD

CERN open lab
Medical Applications



Who am I

What do I do

How do I live



Medical Doctor – 2006 University of Bologna
Dutch license to practice (BIG-register) #79914834901
Italian license to practice (Medical register of Bologna)

How do you imagine biomedical research?



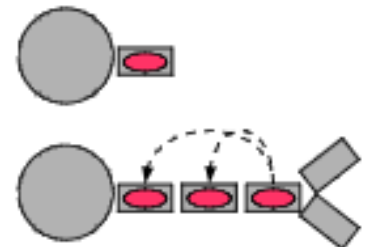
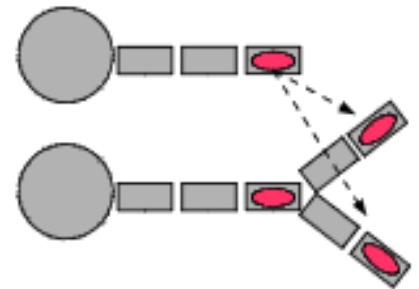
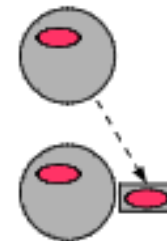
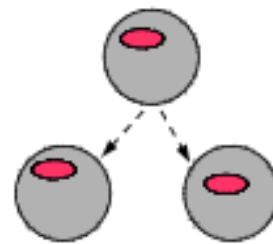
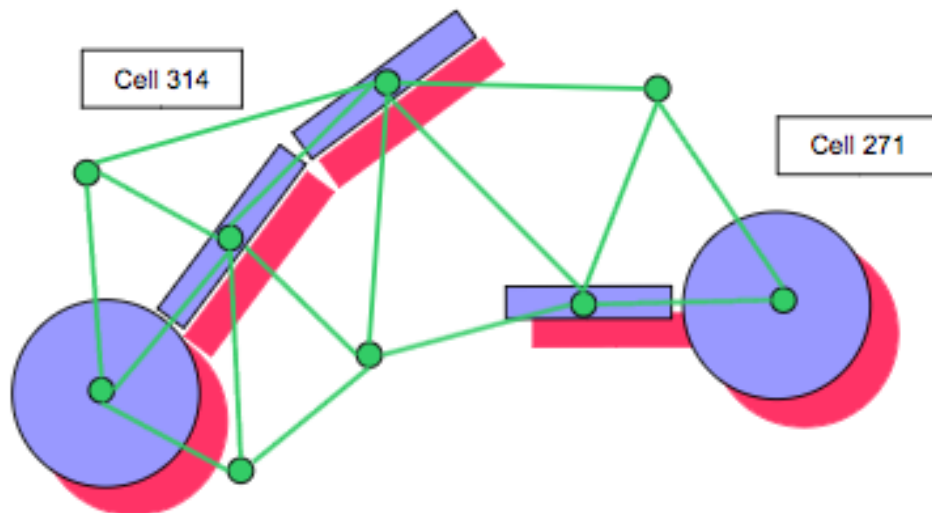
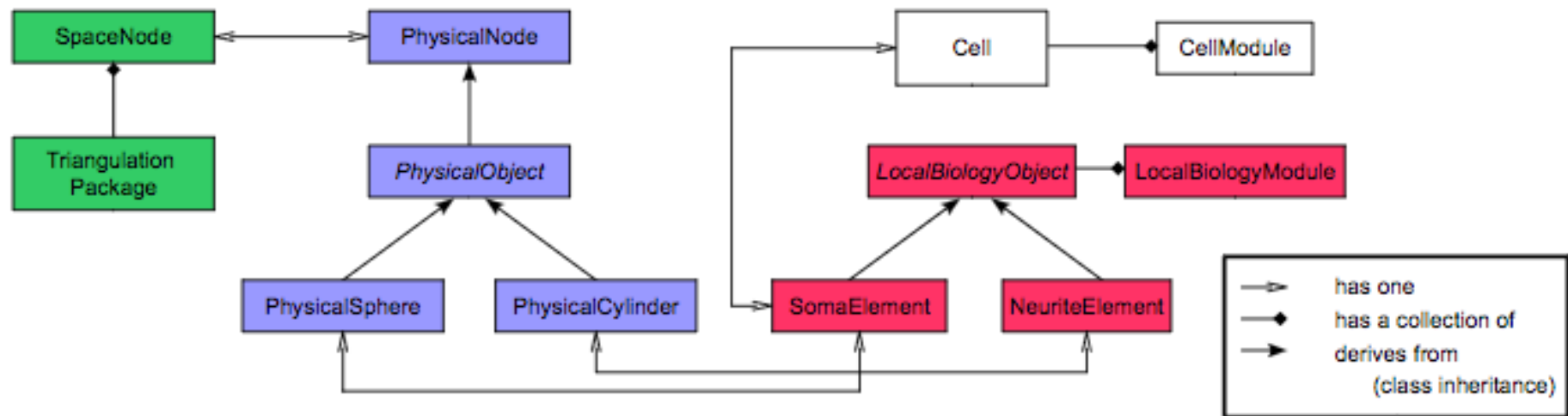
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2

Every new insight into the brain functioning so far, came from new technologies, it came not from new ideas about the brain.

Tooling up: agent based simulation of brain development



Understanding brain diseases

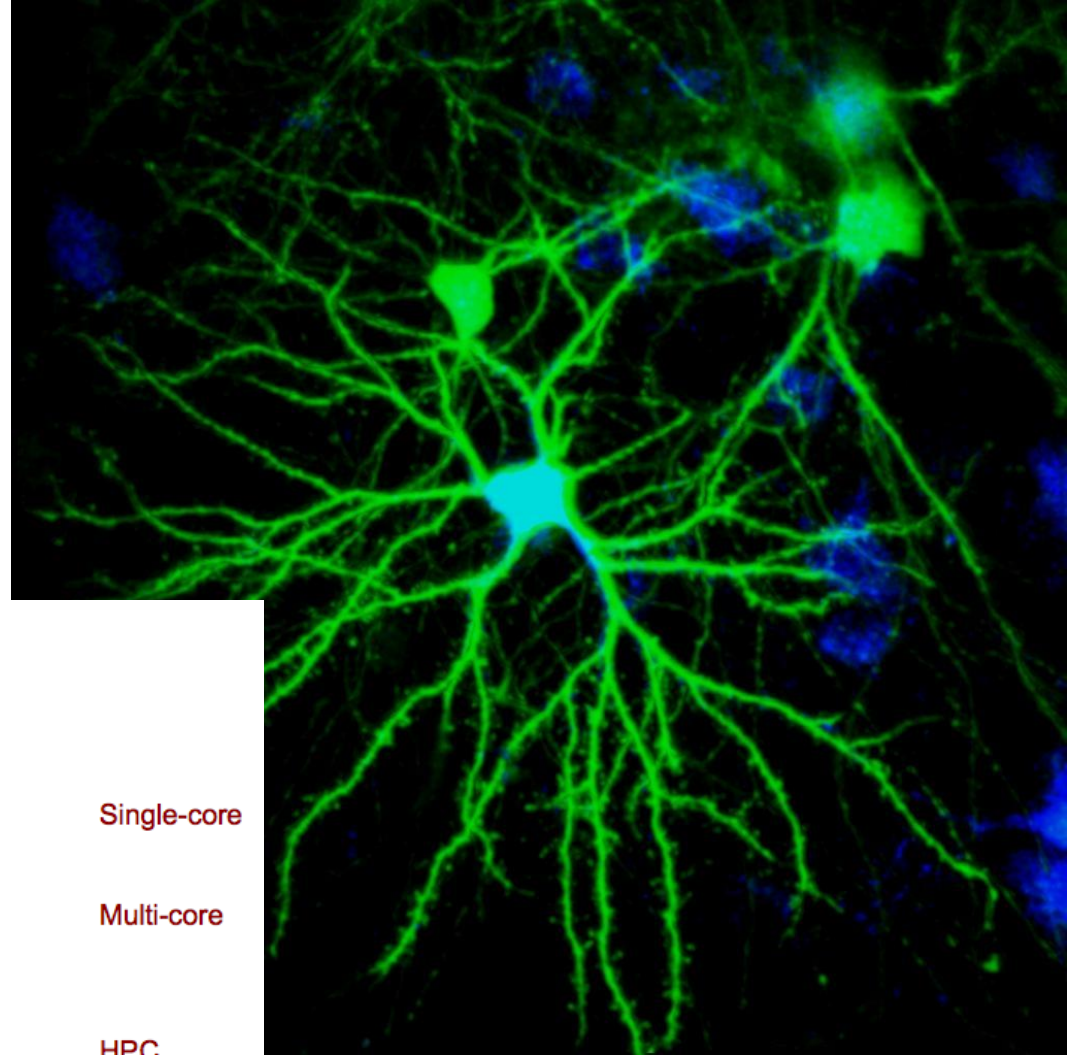
Brain Disease	Estimated Prevalence (worldwide)
Epilepsy	50 million
Schizophrenia	25 million
Autism	45 million
Dementia	35 million



Total cost of brain diseases in Europe: 798 billion €

numbers from recent WHO reports, Elsabbagh et al. (2012) and Olesen et al. (2012)

86 billion neurons
≈ quadrillion of connections



Scaling up

Cortical column: 10k neurons

lamination (layer formation) - brain cancer

Cortical sheet: 10m neurons

gyrification (folding of regions) – epilepsy

Cortex: 100m - 10bn neurons

changes in connectivity between brain regions - schizophrenia

Single-core

Multi-core

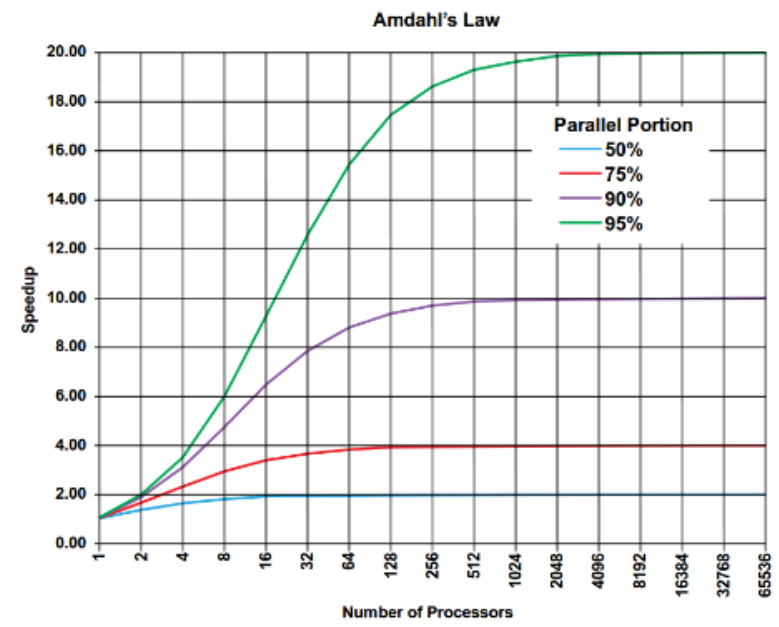
HPC

Cloud?



Goal

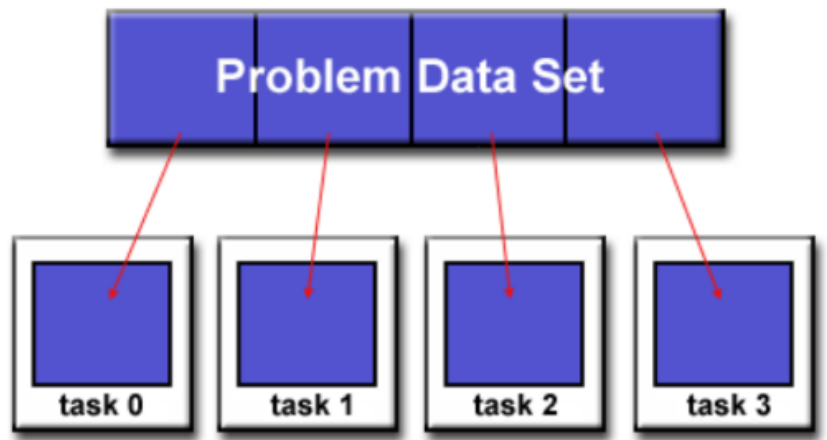
- ▶ Maximize Speedup
$$\frac{\text{wall clock time of serial execution}}{\text{wall clock time of parallel execution}}$$
- ▶ Minimize Parallel Overhead
 - ▶ Task startup time
 - ▶ Data communications
 - ▶ Synchronizations
 - ▶ Software overhead imposed by parallel languages, libraries, operating system, etc.
 - ▶ Task termination time



Source: Blaise Barney. *Introduction to Parallel Computing*. Lawrence Livermore National Laboratory, https://computing.llnl.gov/tutorials/parallel_comp/, https://en.wikipedia.org/wiki/Amdahl's_law

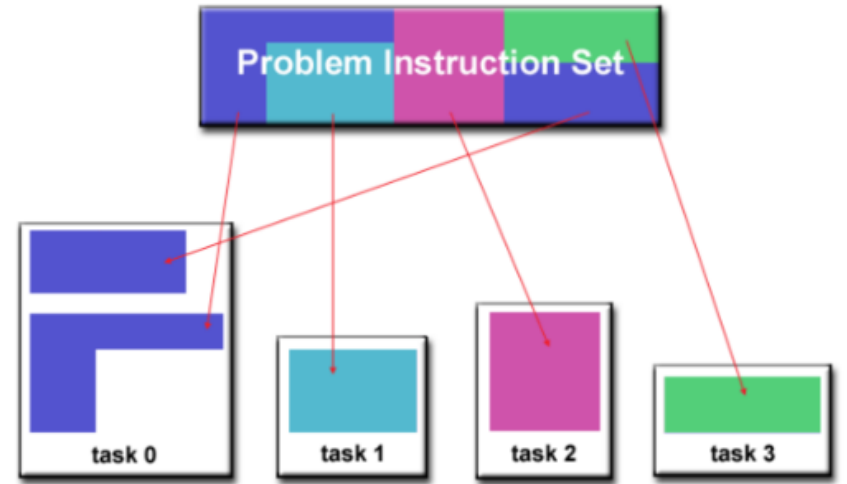
Programming Models

Data Parallel



+ in most cases ideal scalability

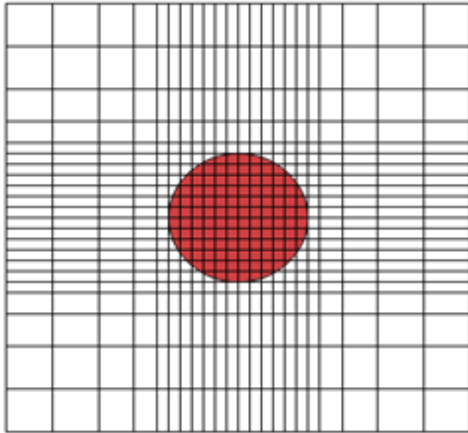
Task Parallel



- limited degree of parallelism

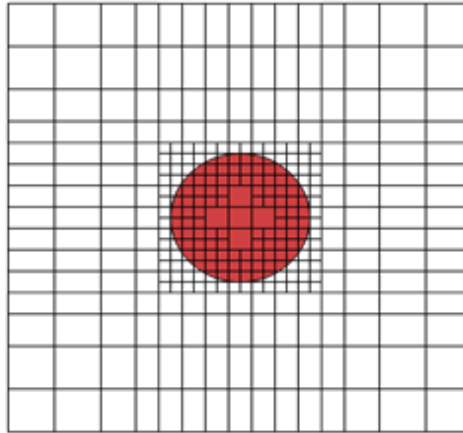
Source:
Blaise Barney. *Introduction to Parallel Computing*. Lawrence Livermore National Laboratory https://computing.llnl.gov/tutorials/parallel_comp/
Ralf-Peter Mundani. *Lecture Notes: High Performance Computing – Programming Paradigms and Scalability*. TU Munchen 2015

Graded mesh

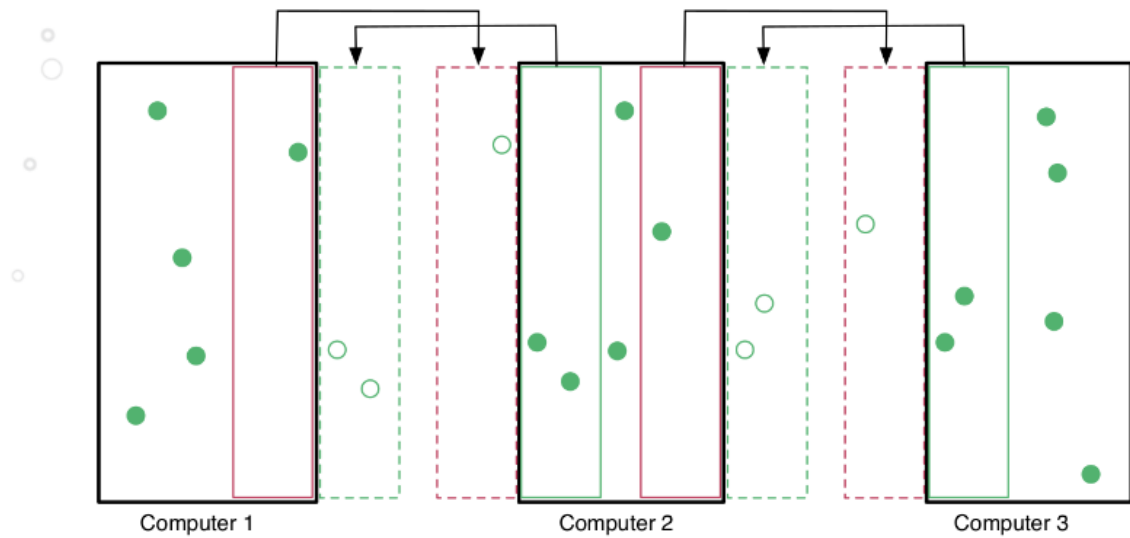
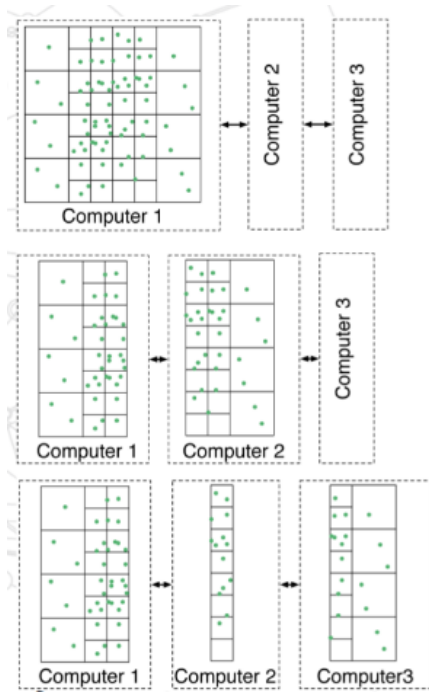


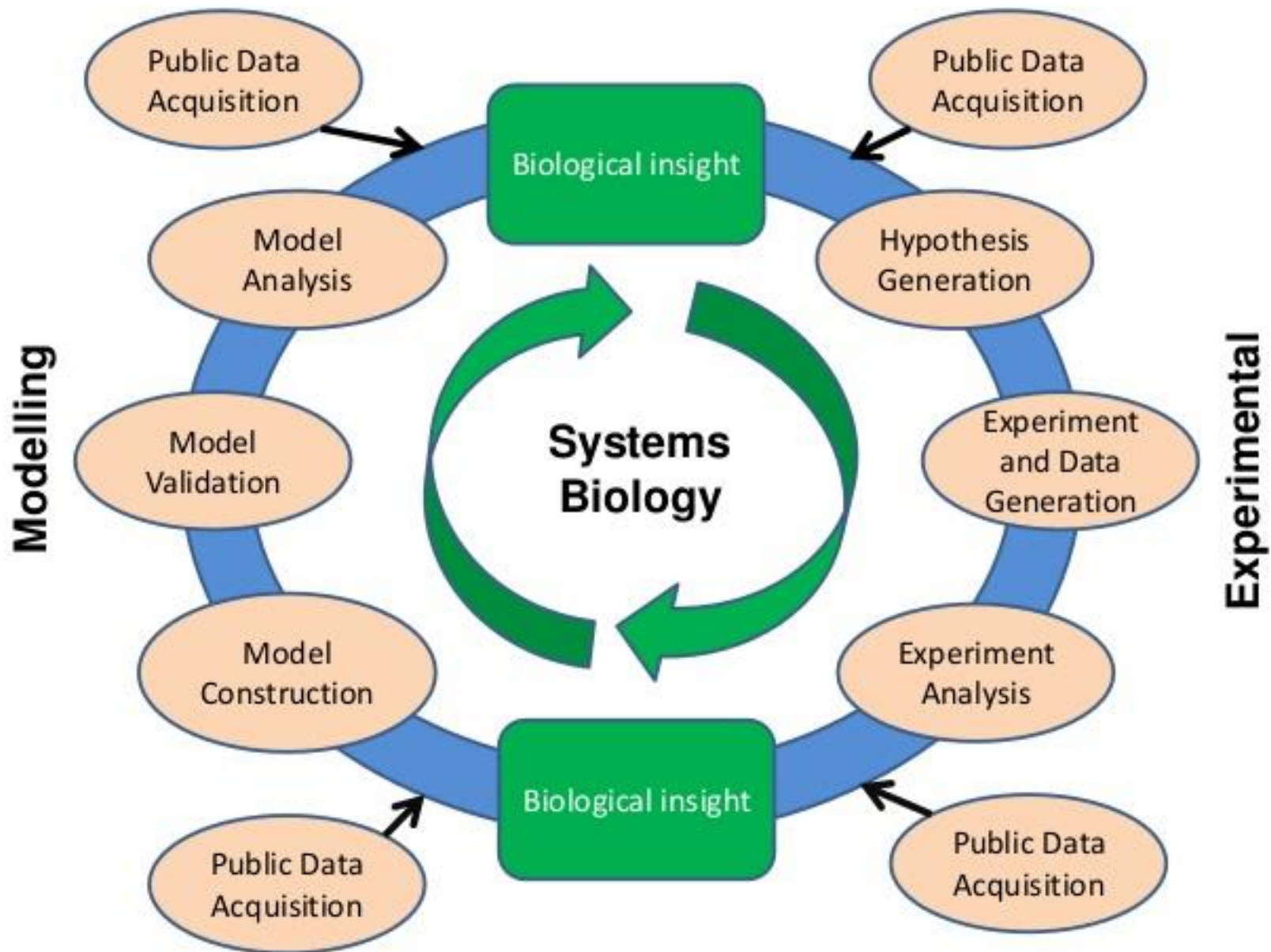
Mesh "bleeds"

Octree mesh



Localized fine mesh







HPC vs Cloud

Aim for

HPC

Performance
capability of particular component
to provide a certain amount of
capacity, throughput, or "yield"

Hardware

specialized
Processors, fault tolerance,
network high bandwidth and low latency

Cloud

Scalability, Elasticity
ability to grow; to meet a demand

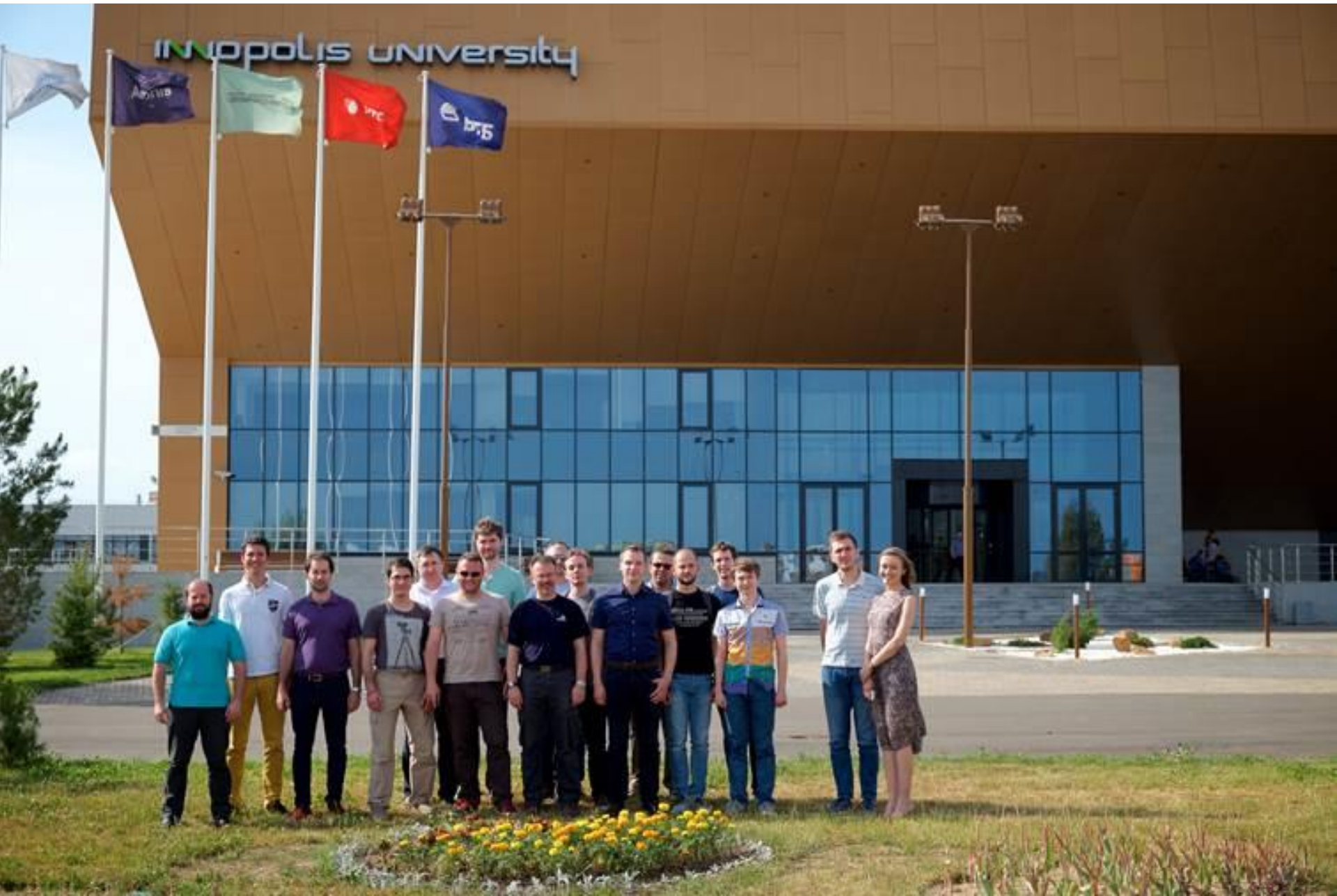
commodity

Despite the differences:

- ▶ Possible to run a cloud on a HPC Cluster
- ▶ and vice versa – Amazon has HPC on Cloud offering

Source:
<http://www.cloudscaling.com/blog/cloud-computing/grid-cloud-hpc-whats-the-diff/>
<http://www.hpcwire.com/2014/01/29/researchers-implement-hpc-first-cloud-approach/>

This project would not exist without a fantastic team



Thank you for your attention

Questions are welcome 😊