



รู้ให้เท่า ก้าวให้ทันในยุค Digital Explosion ในโลกทวีคูณ (The Exponential World)

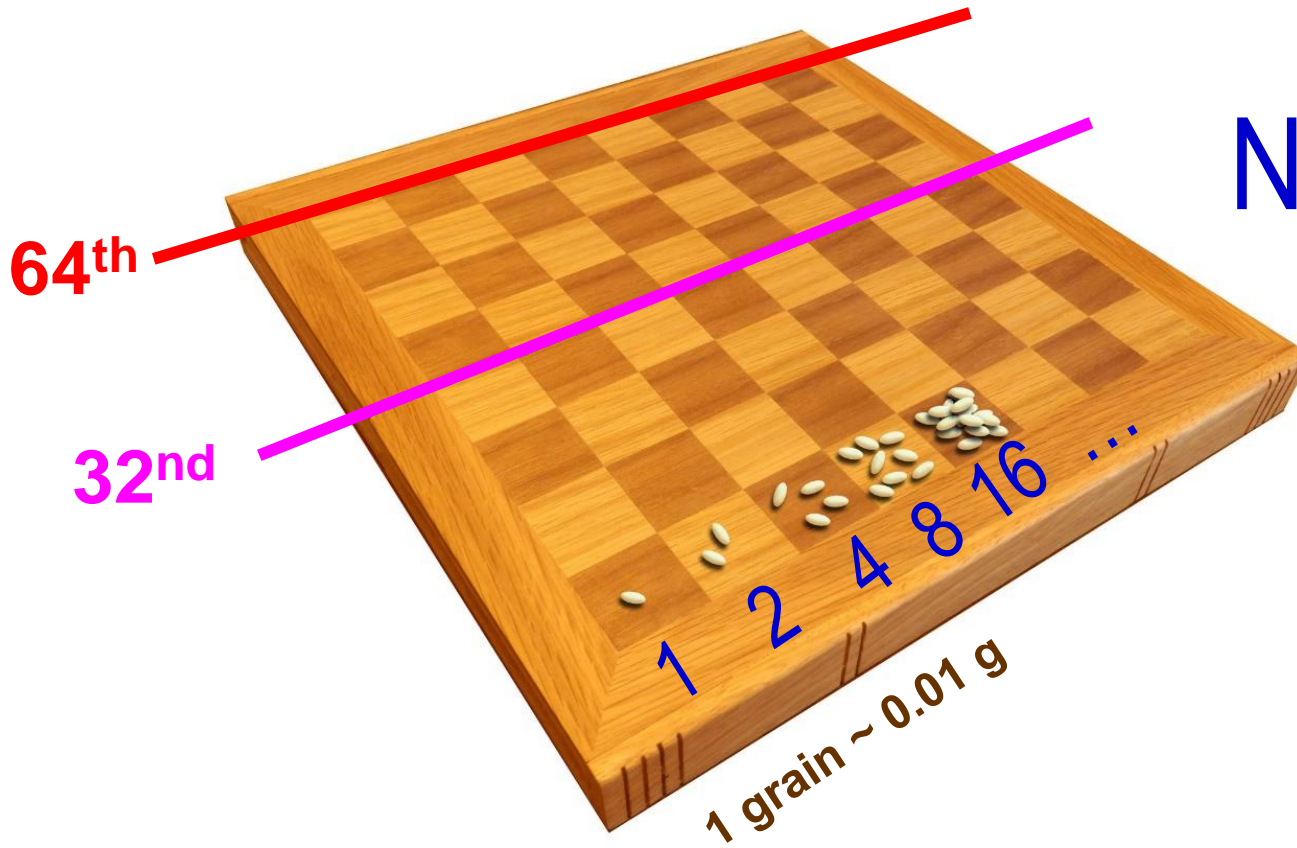


พุทธอุทยานวัดเขาศาลา สุนทร

นิรันดร มาแทน

สำนักวิชาวิศวกรรมศาสตร์และเทคโนโลยี
ศูนย์ความเป็นเลิศด้านวิทยาศาสตร์และวิศวกรรมไม้
มหาวิทยาลัยวลัยลักษณ์ อ่างทองท่าศาลา จังหวัดนครศรีธรรมราช

The Chess Board Problem

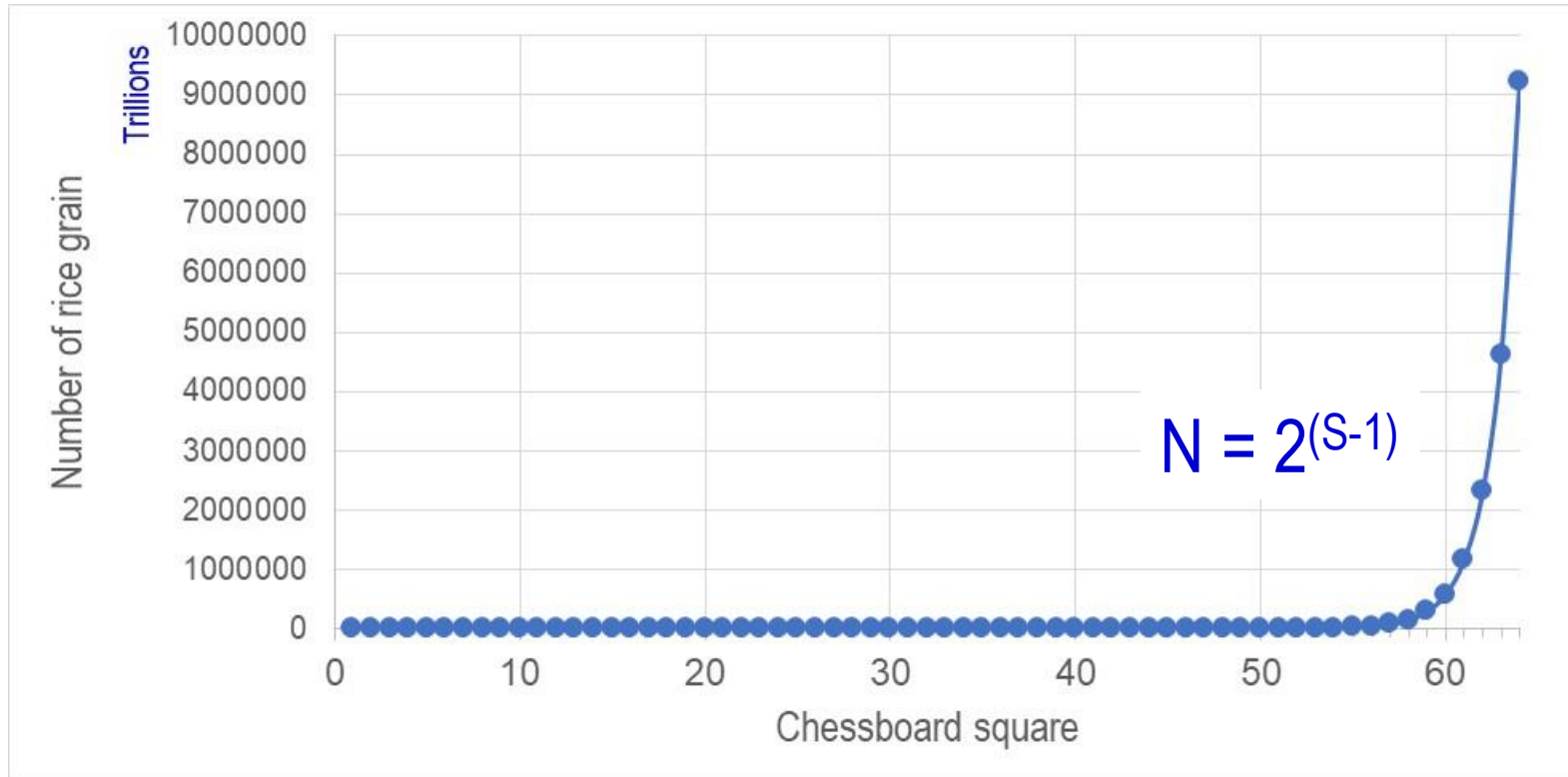
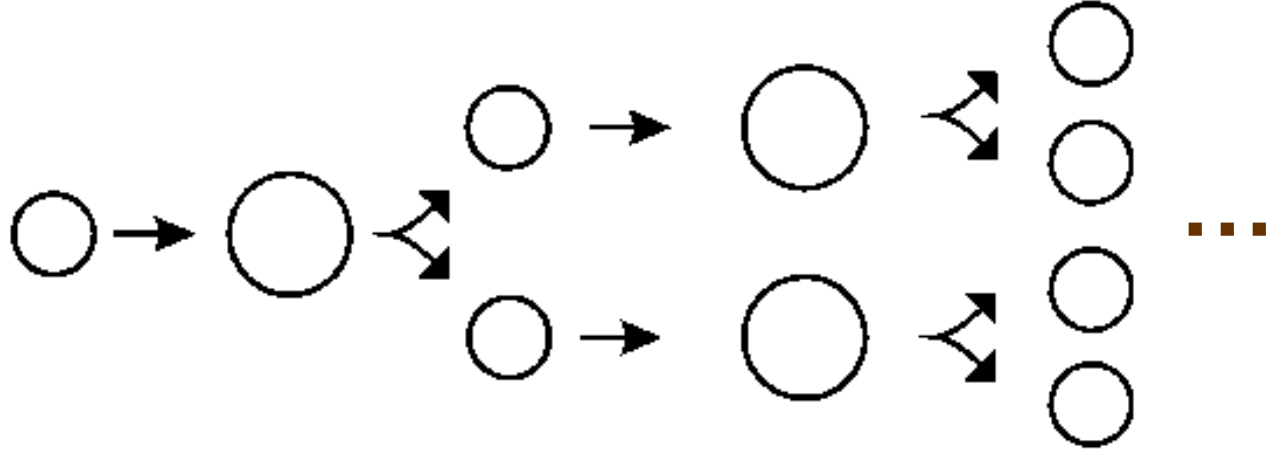


$$N = 2^{(S-1)}$$

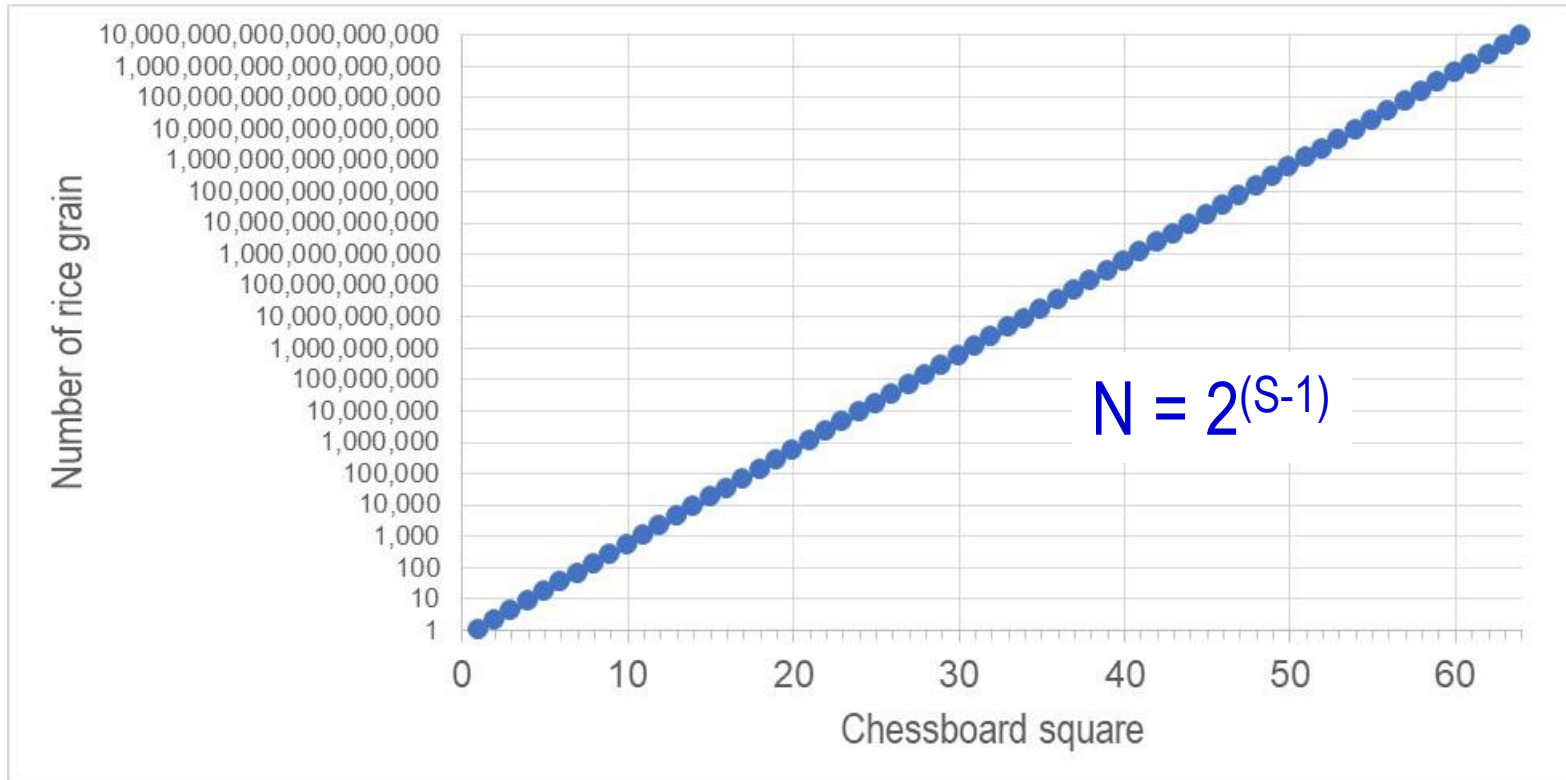
32nd : 4,294,967,295 grains (43 tons)

64th : 18,446,744,073,709,551,615 grains
(184,467 million tons > Mt. Everest)

The Exponential World



The Exponential World



Talk outline

1. Biological explosion

(~3,000 million years ago)

2. Knowledge explosion

(~7 million years ago)

3. Digital explosion

(The 21st century)

4. Robotic explosion?

(Next hundreds years?)

1

A brief history of the WORLD

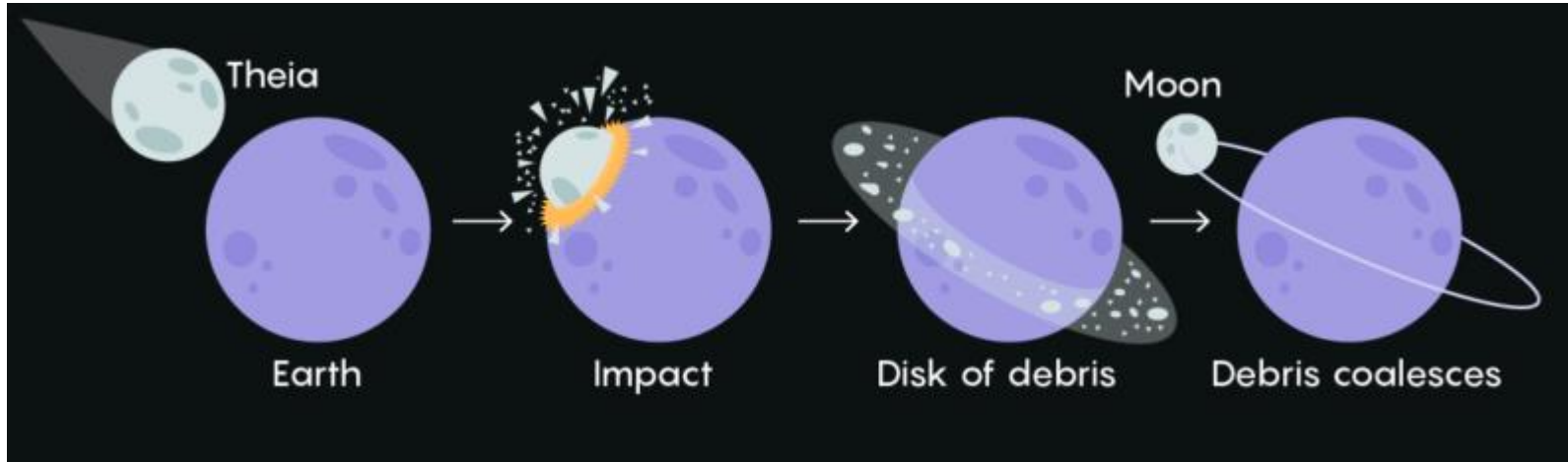
THE SOLAR SYSTEM



<http://sci.esa.int/collaborative-missions/46754-formation-of-the-solar-system/>

Formation of the solar system: ~5,000 mya

The Earth and Moon



https://en.wikipedia.org/wiki/Giant-impact_hypothesis



<https://www.youtube.com/watch?v=PnhfIL7-I3I>

Earth and Moon formation: ~4,500 mya

Amino acids: Origin of Life

The Miller–Urey experiment

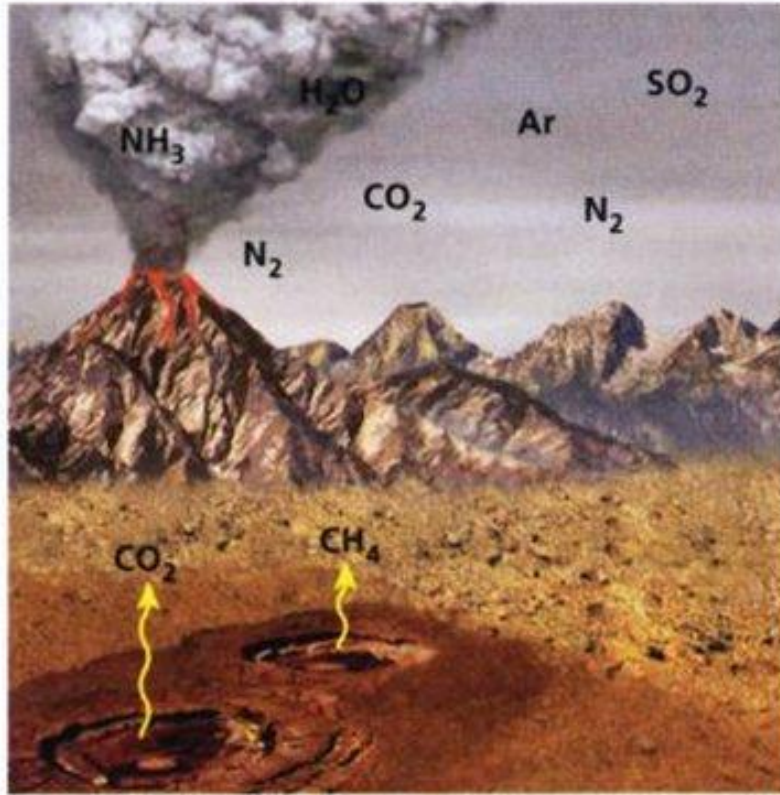
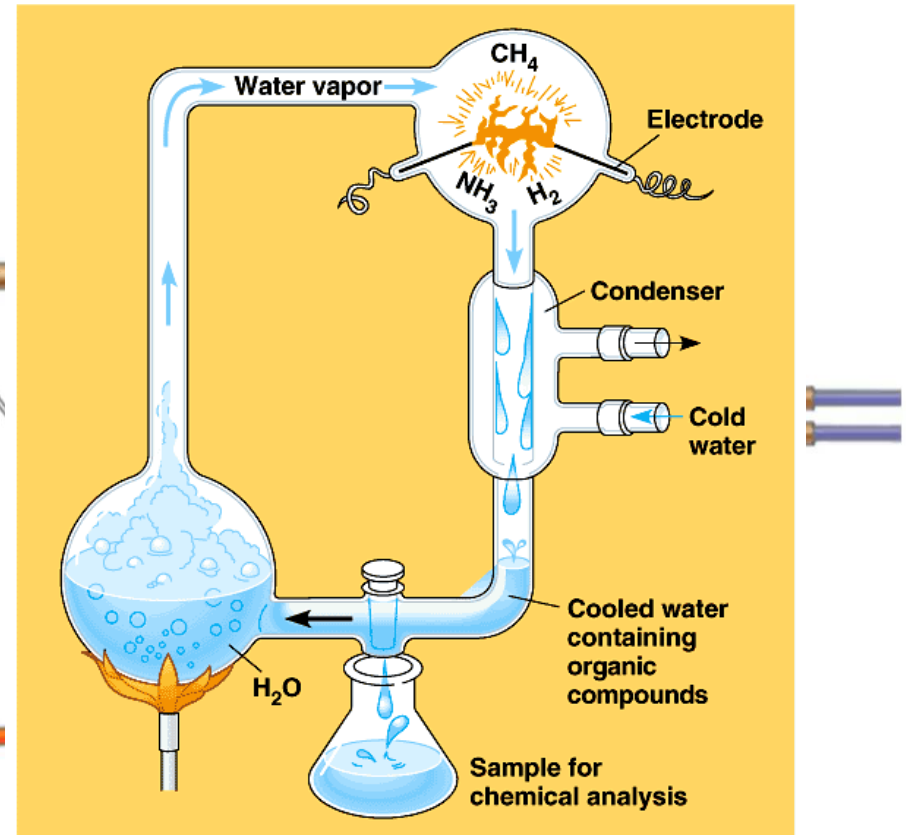
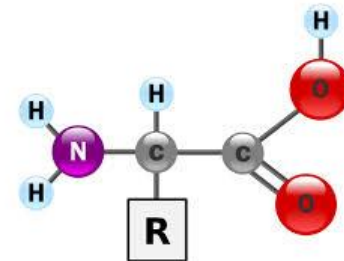


Figure 4 ▶ Earth's early atmosphere formed as volcanic eruptions released nitrogen, N_2 ; water vapor, H_2O ; ammonia, NH_3 ; methane, CH_4 ; argon, Ar ; sulfur dioxide, SO_2 ; and carbon dioxide, CO_2 .



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Organic from inorganic



Bacteria

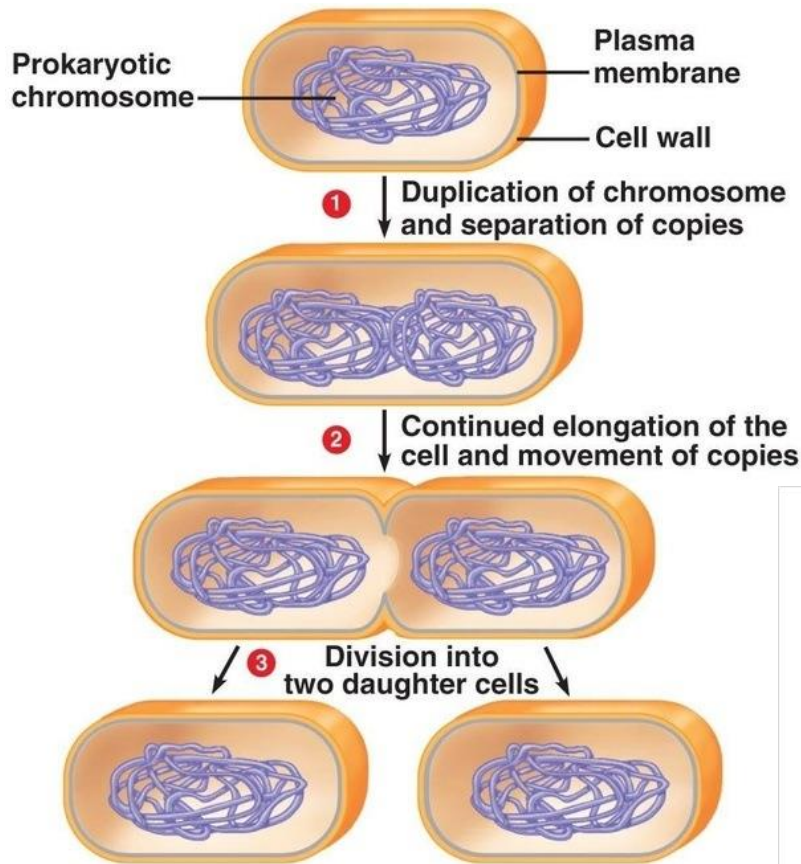
Photosynthesis/Oxygen production



Oxygen production by **Cyanobacteria**: ~3,800 mya

(38 ล้านชาติ)

Cell division & Mutation

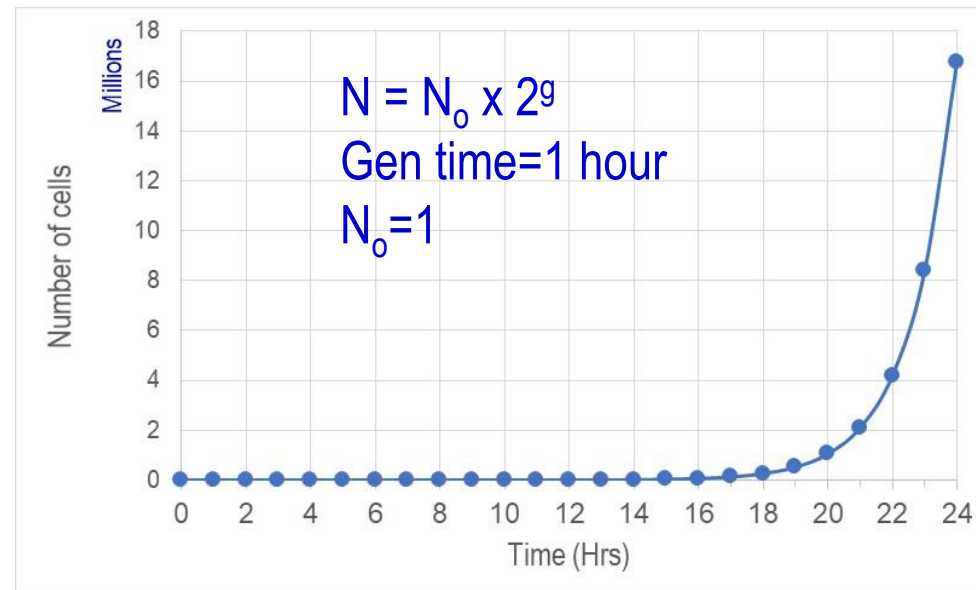


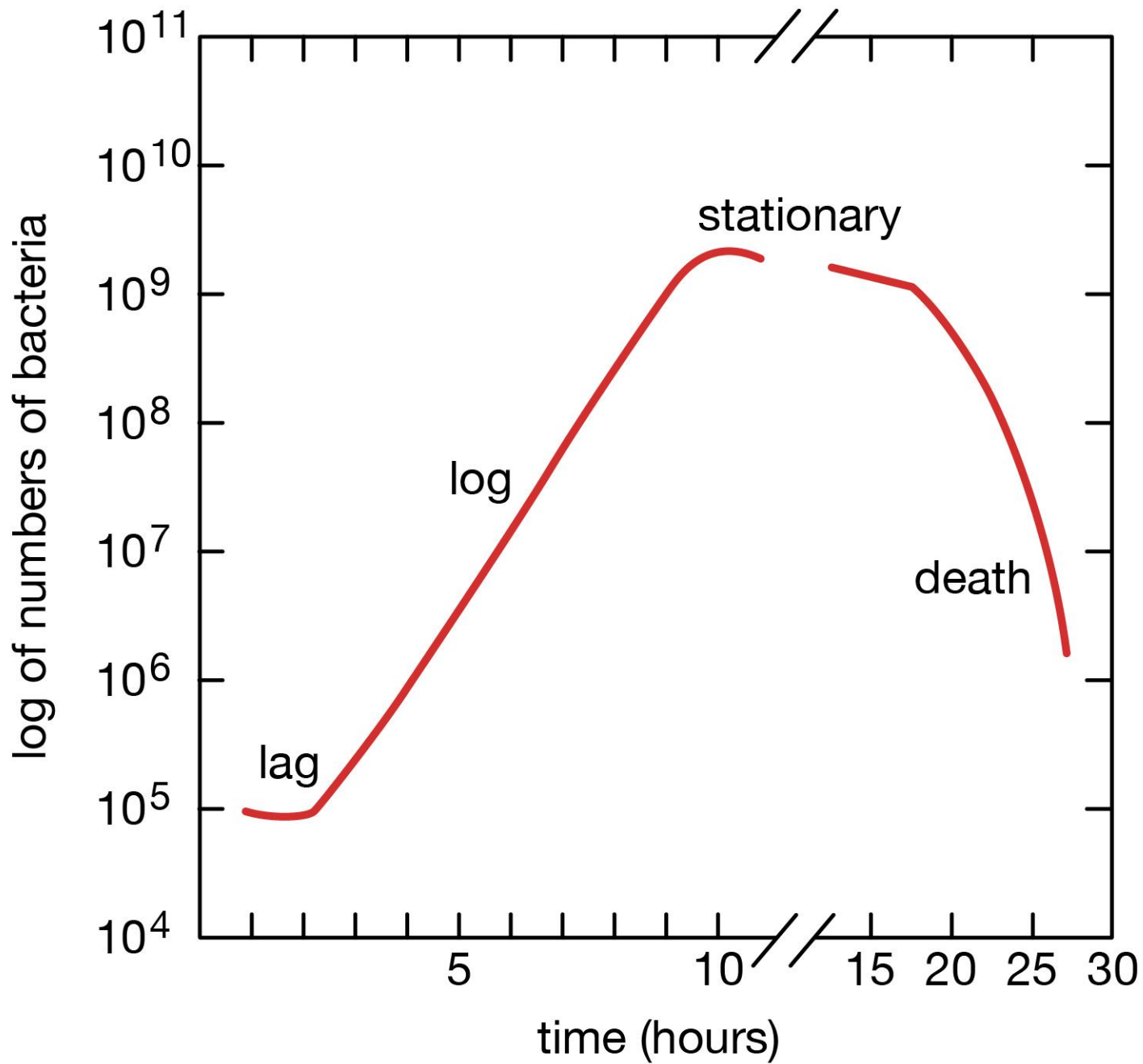
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Prokaryotic cell

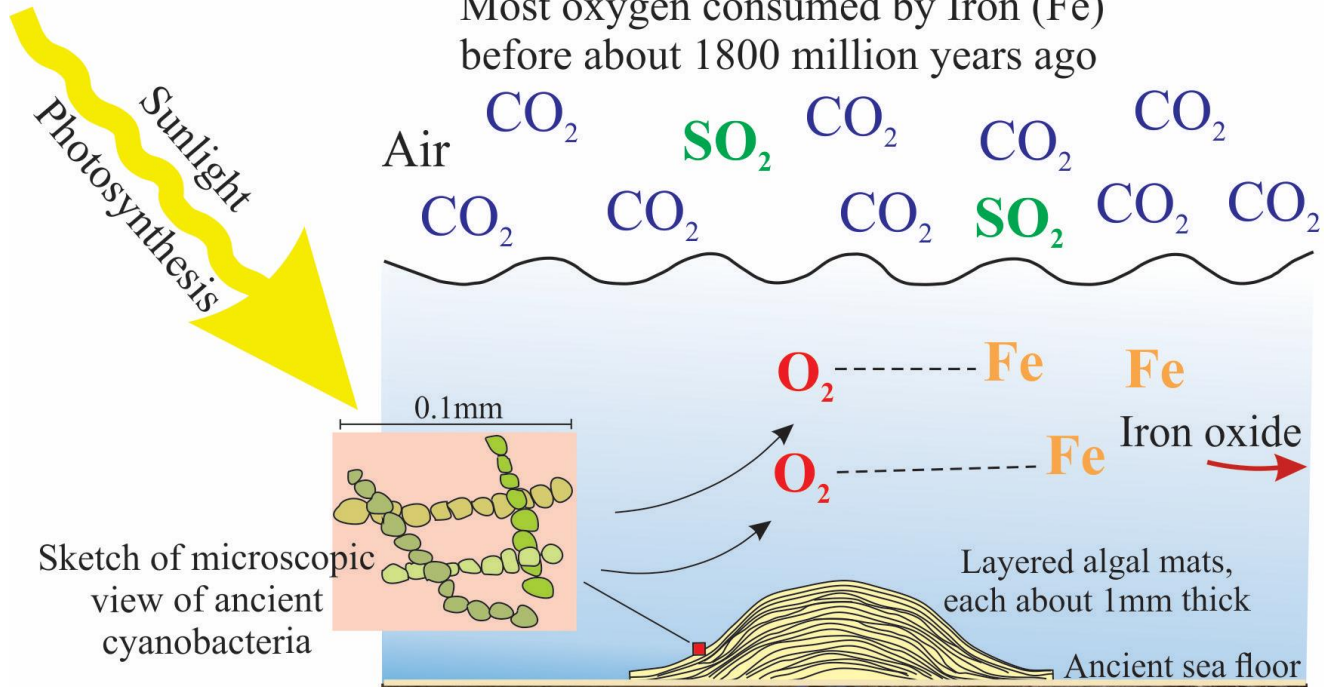


Escherichia coli / E. coli

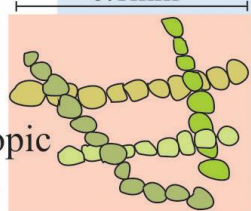




Most oxygen consumed by Iron (Fe)
before about 1800 million years ago



Sketch of microscopic view of ancient cyanobacteria



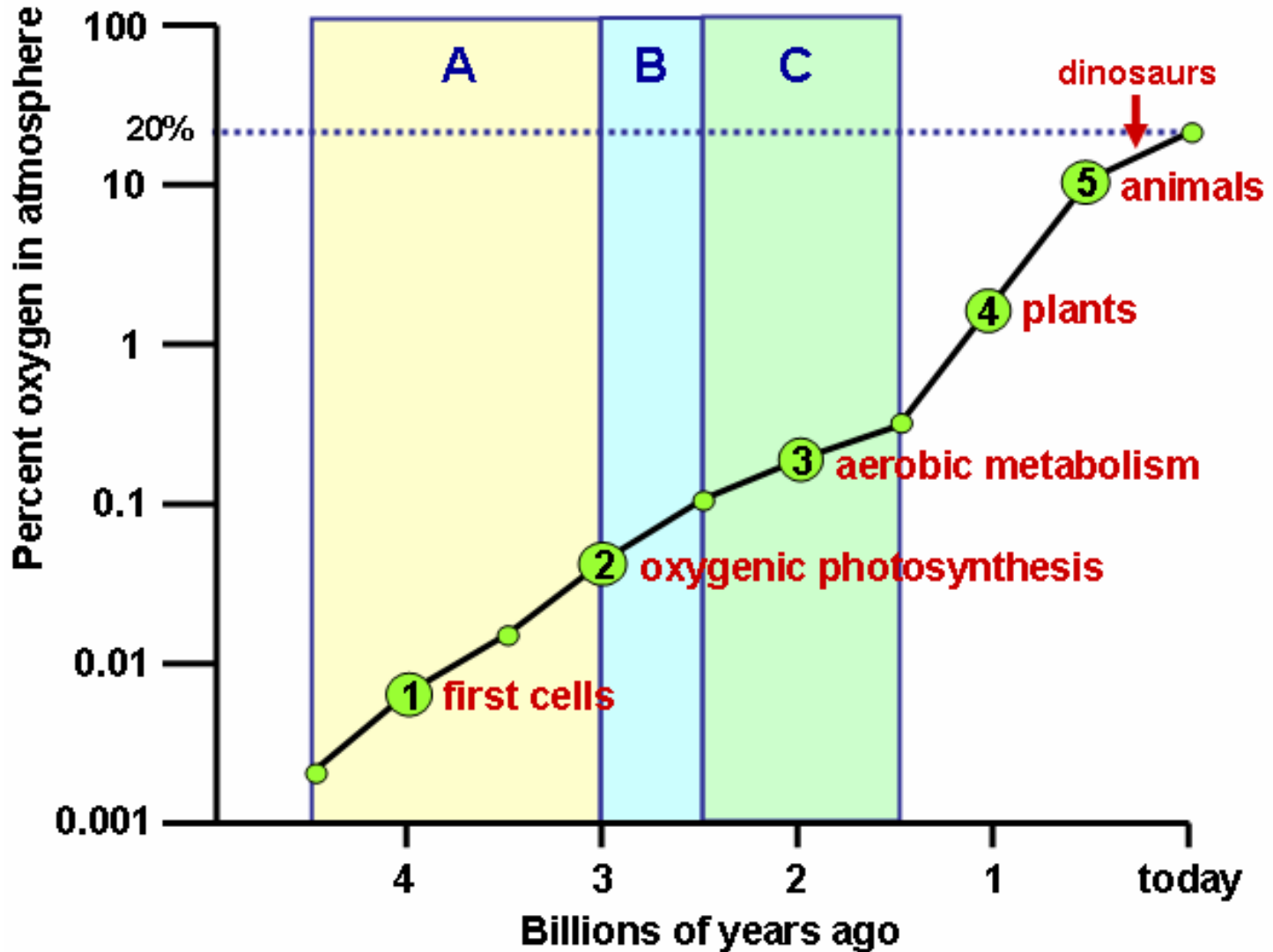
Large stromatolite (cryptalgal) mounds, 1-2m high

© Brian Ricketts

Stromatolites from the Belcher Islands, Hudson Bay about 2000 to 1800 million years old

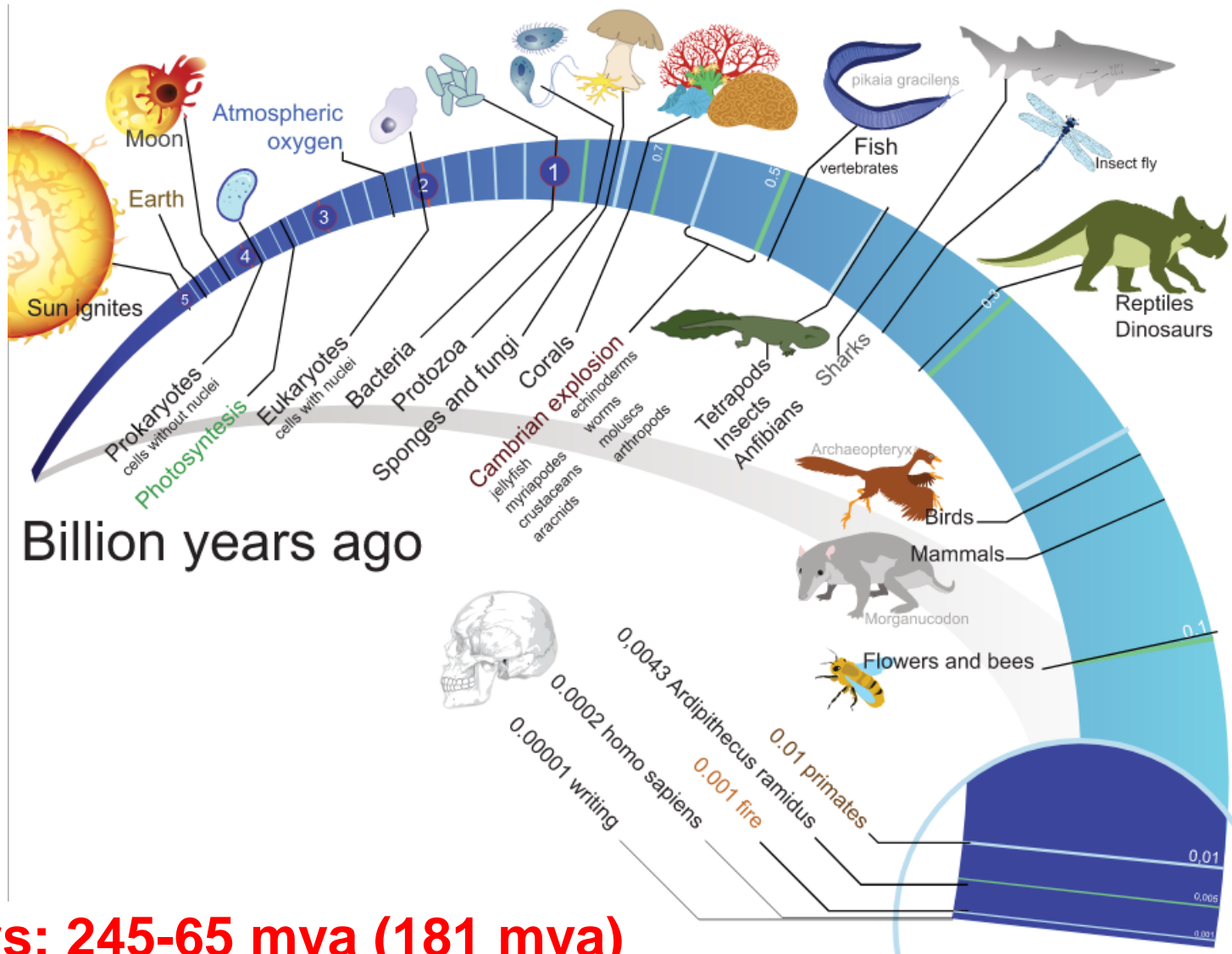
Bacteria

Oxygen production



History of the world

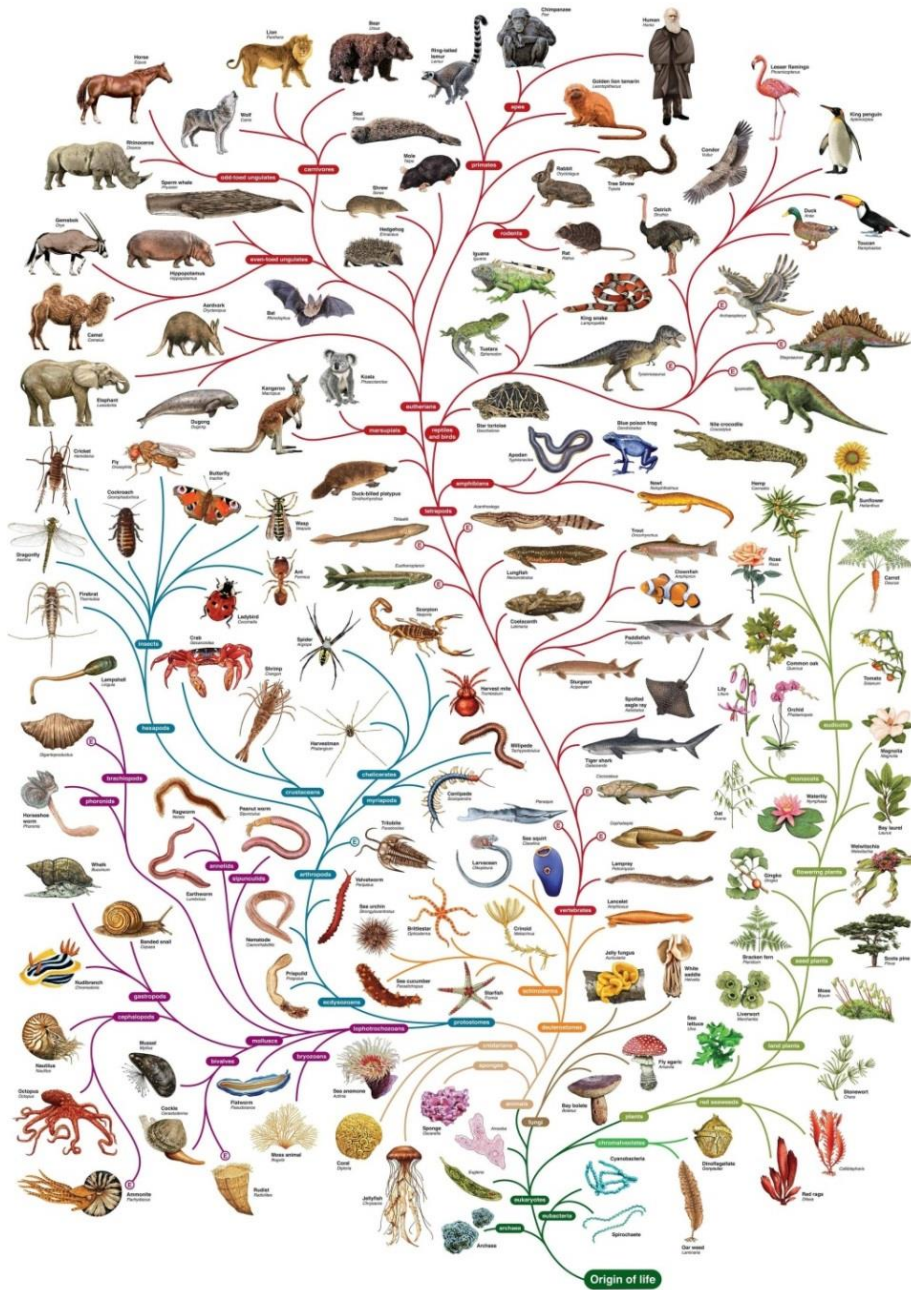
Biological Explosion (~3,000 million years ago)



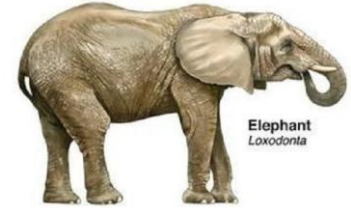
Dinosaurs: 245-65 mya (181 mya)

Human (anatomy): 200,000 ya

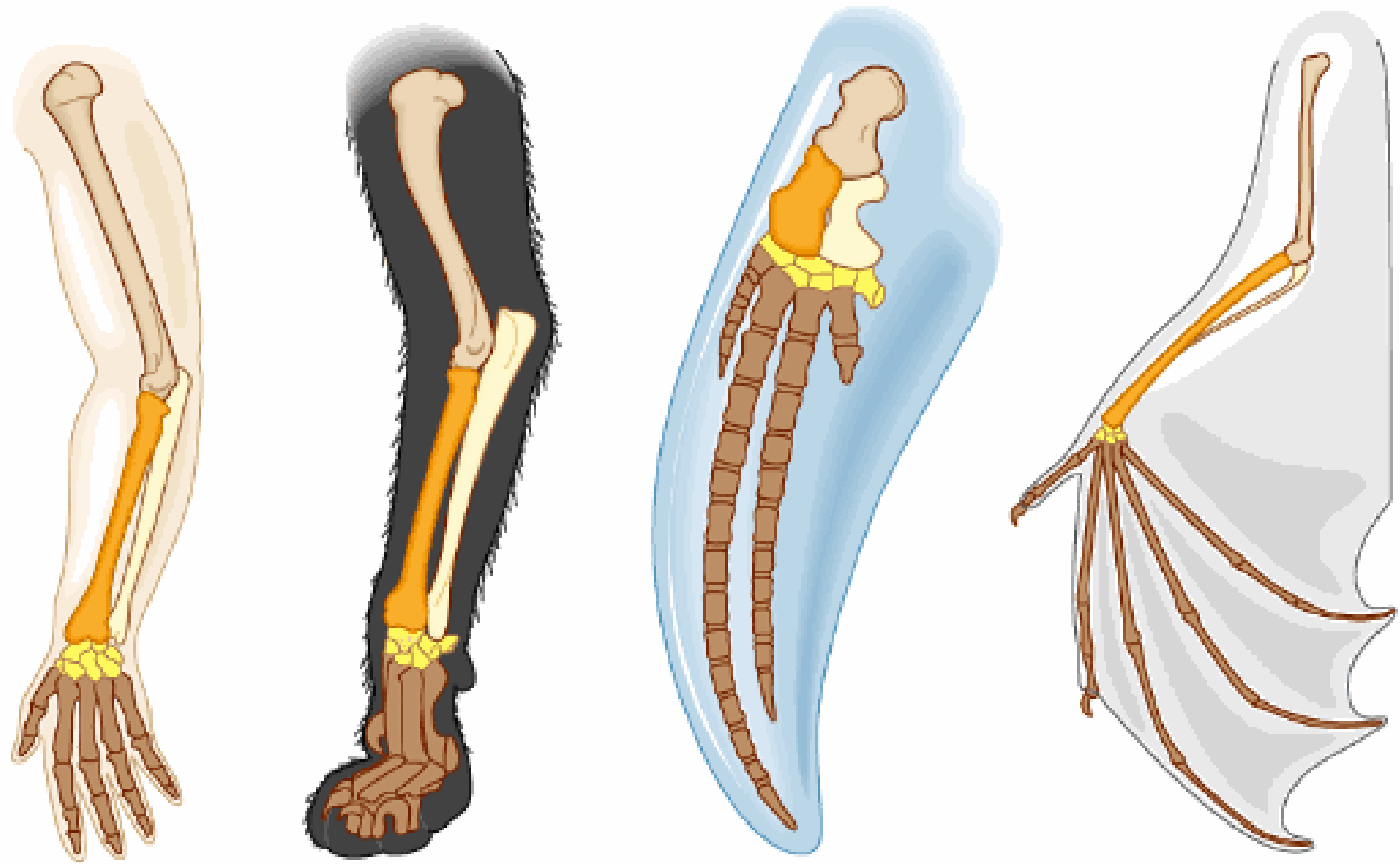
What makes us different?



Mutation & Natural selection



What makes us different?



Human

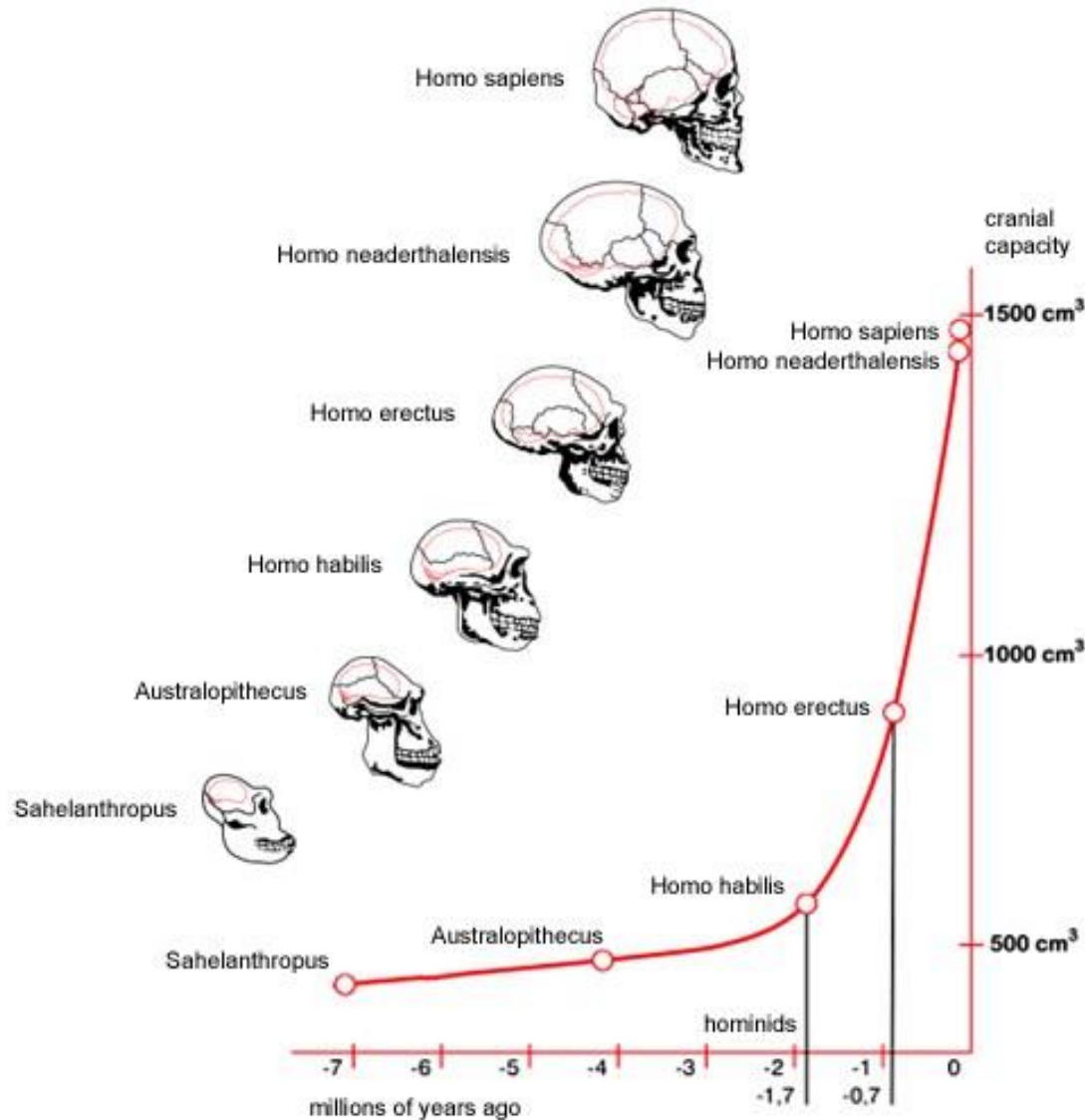
Cat

Whale

Bat

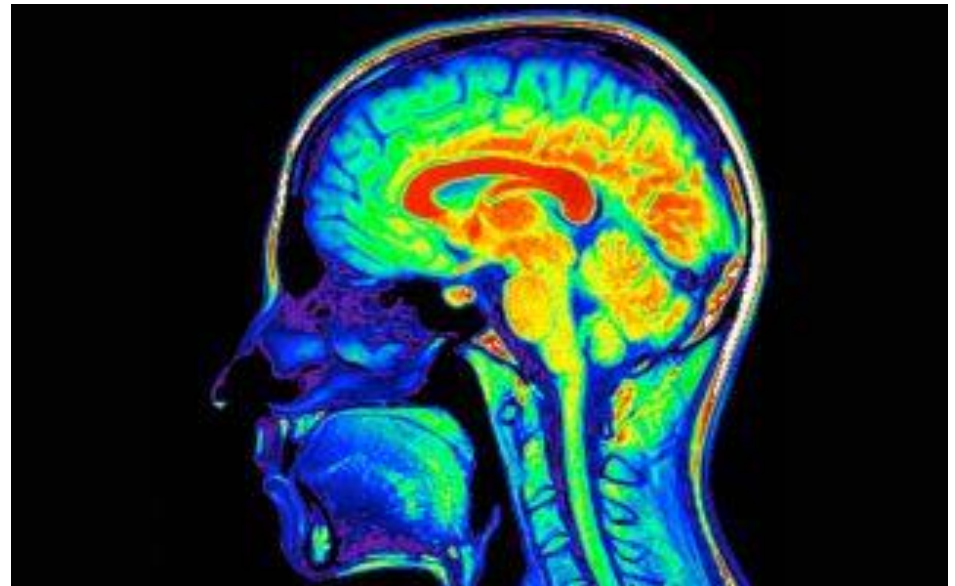
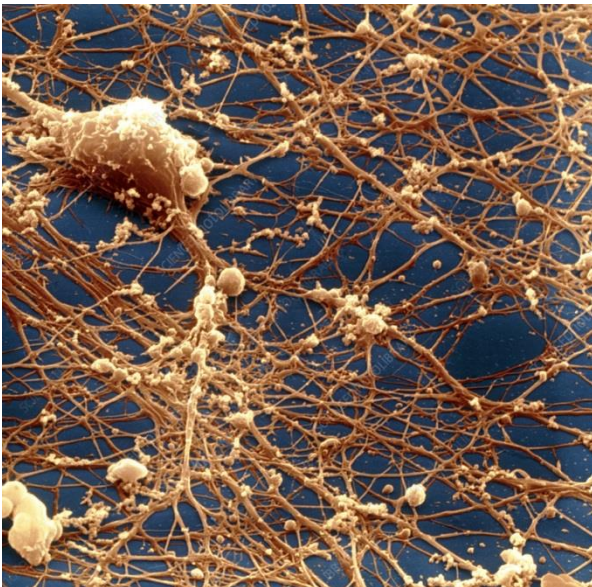
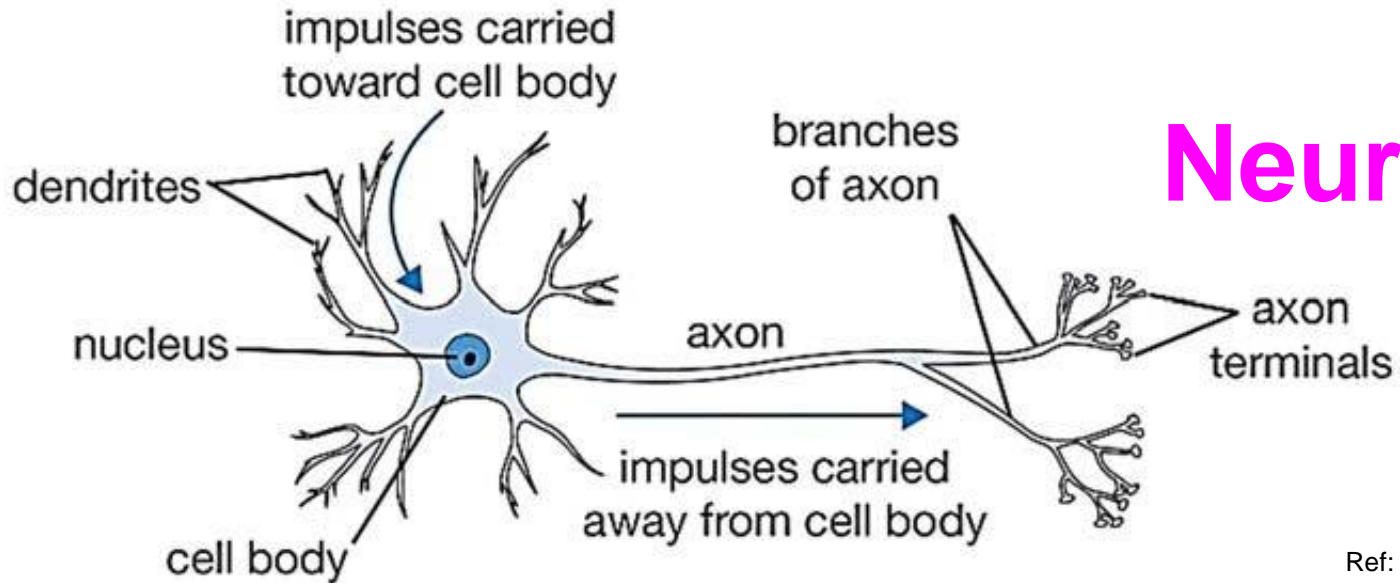
The Human Brain

The Exponential World #2

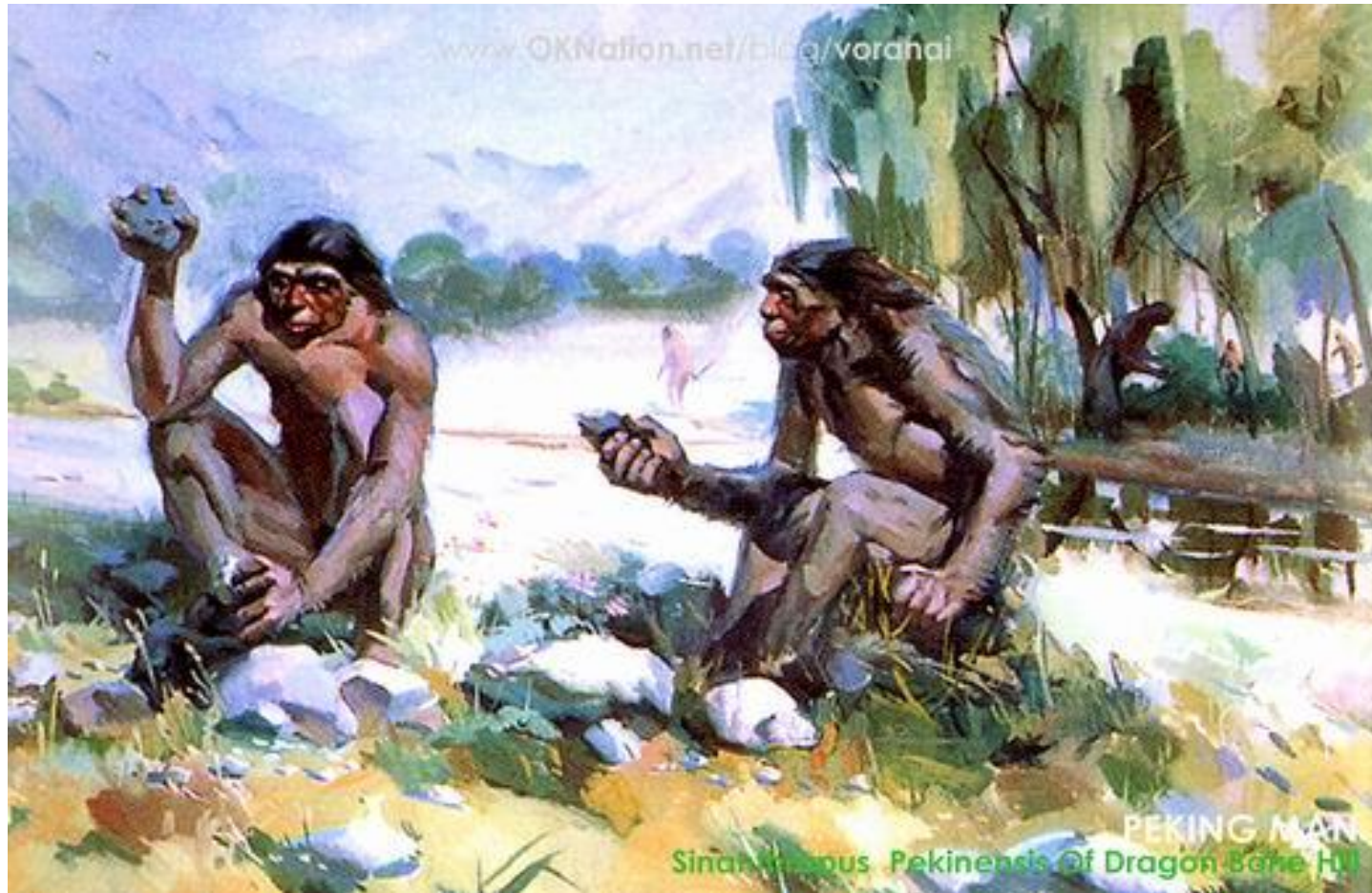


Homo sapiens: 200,000 ya (20,000 ชาติ)

The Human Brain



Accumulation of knowledge



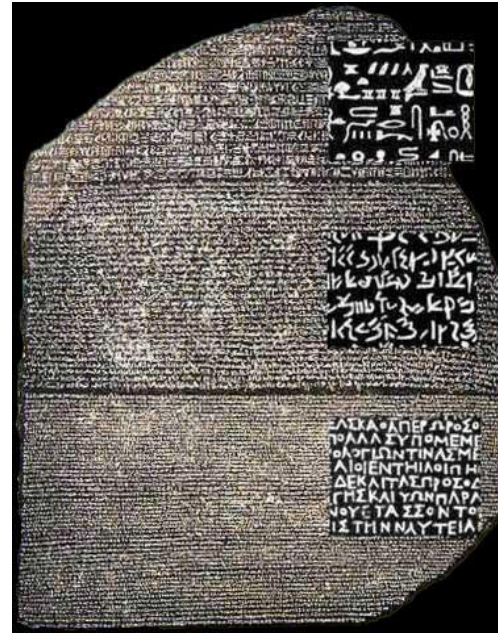
<http://www.oknation.net/blog/print.php?id=151642>

Man dies but acquired knowledge can be passed on to the next generation.

Cuneiform



<https://www.ancient.eu/cuneiform/>



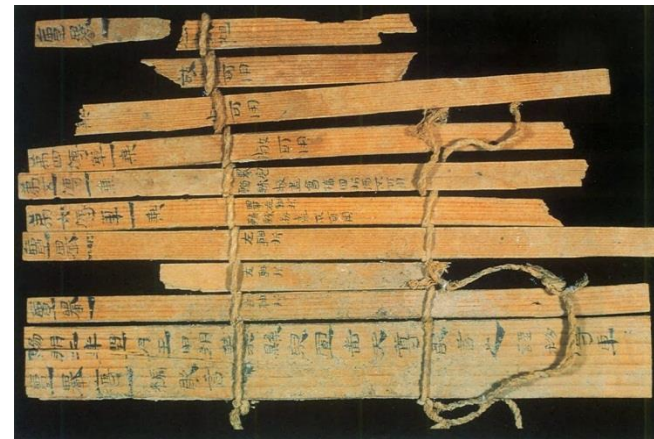
Hieroglyphic,
Demotic,
Greek

Rosetta
stone

<https://discoveringegypt.com/>



Hieroglyphic script on
papyrus paper



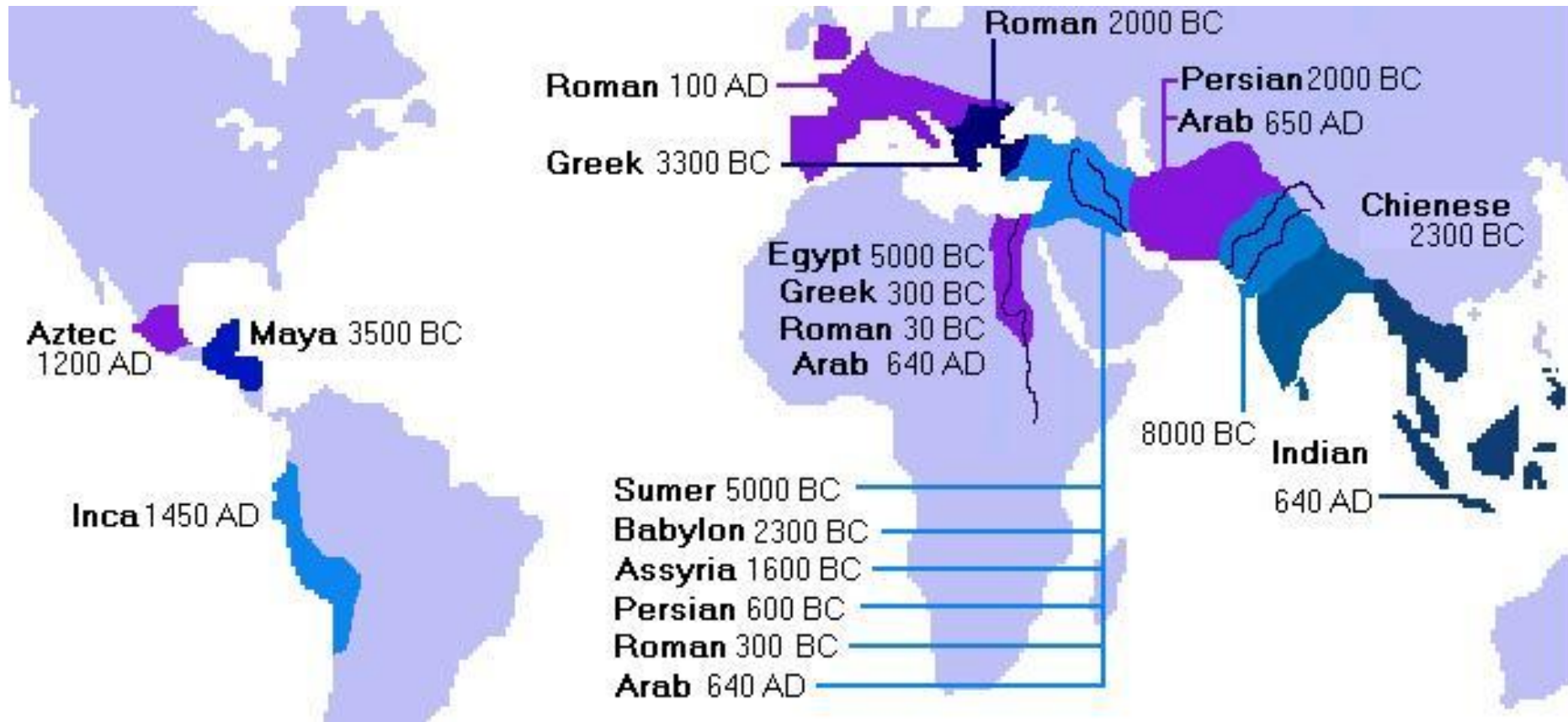
<https://archaeologynewsnetwork.blogspot.com/>

~5,000 years ago

(50 ชาติ)

Knowledge Explosion
(~5,000 years ago)

Ancient Civilizations of the Old World



UNIVERSITY



**The University of Bologna
1088 AD**



**The University of Paris
1160 AD**



**The University of Oxford
1170 AD**



**The University of
Cambridge
1209 AD**

An important idea in the definition of a university is the notion of academic freedom.

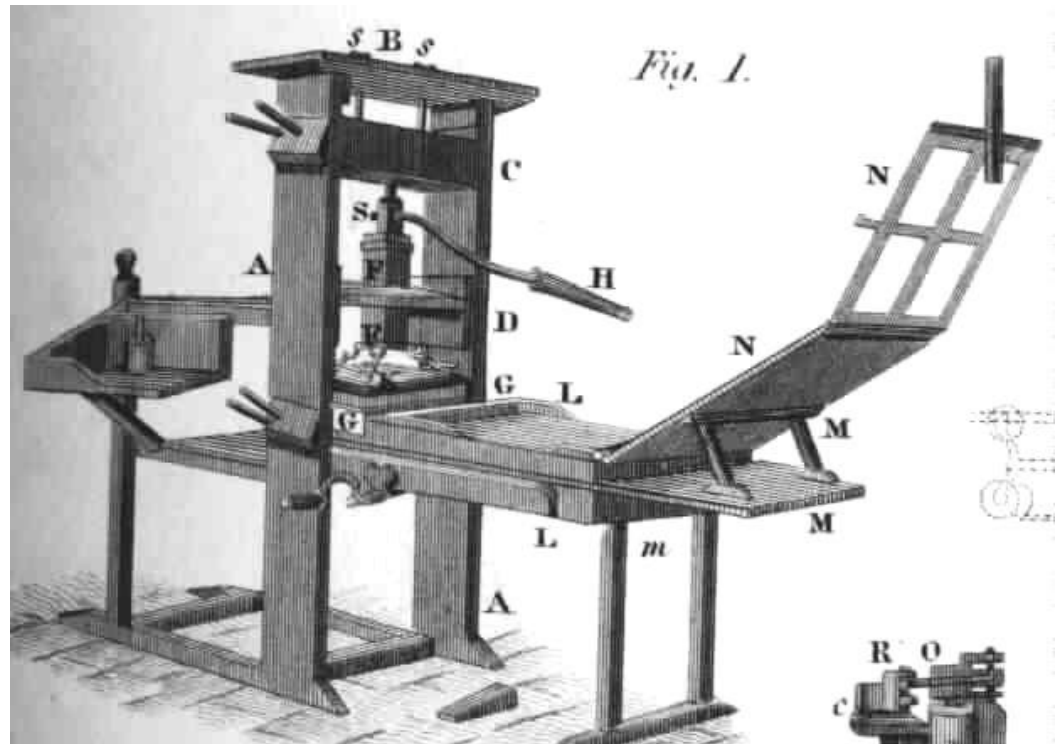
Printing press

“Facebook” of the past



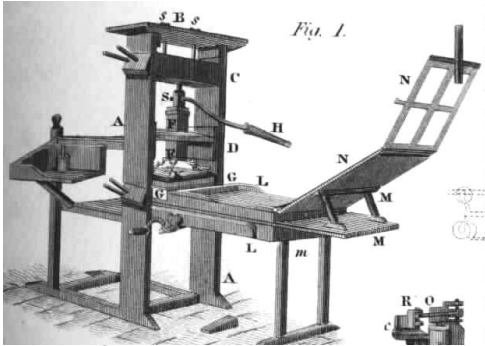
Johann Gutenberg
1397-1468 AD

In 1436, Gutenberg invented the printing press. Books were reprinted so it helped knowledge to spread around Europe and the world. The first book printed was the Bible.

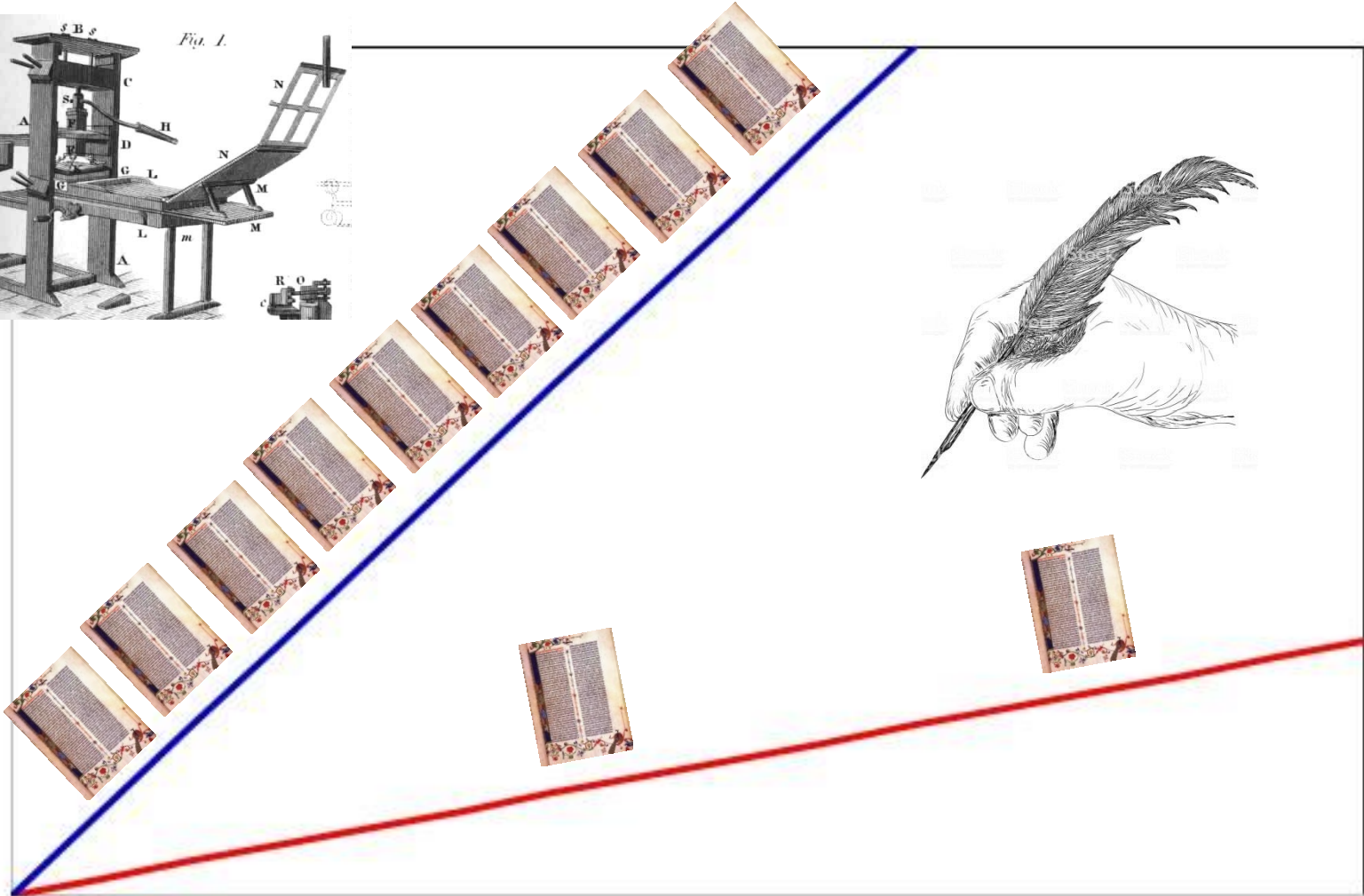


The Linear World

Printing press

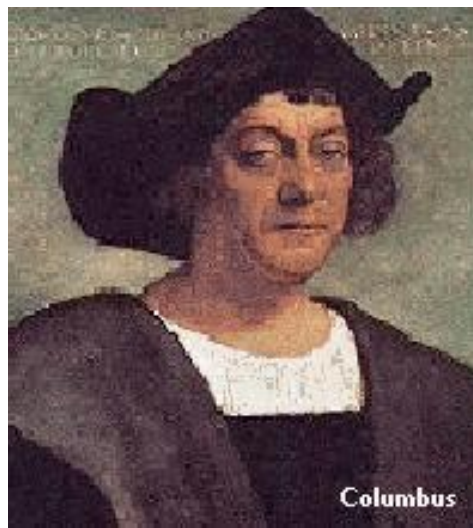


Number



Time

The Renaissance



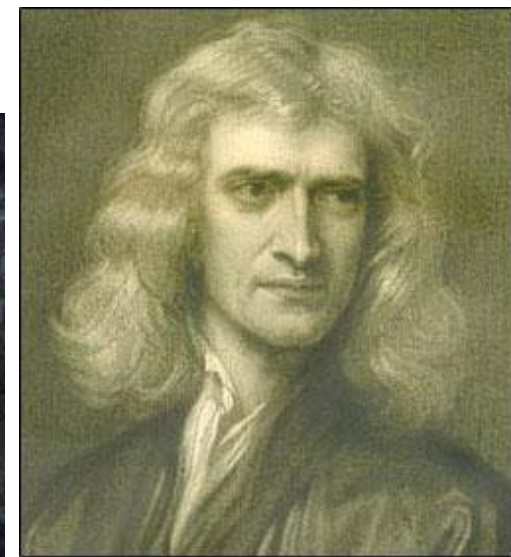
Columbus
1451-1506 AD



Copernicus
11473-1543 AD



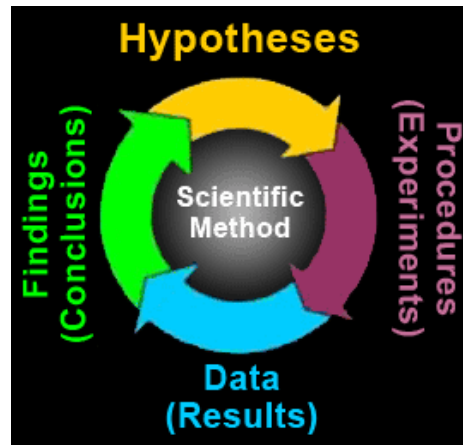
Galileo
1564-1642 AD



Newton
1642-1727AD



Francis Bacon
1561-1626 AD

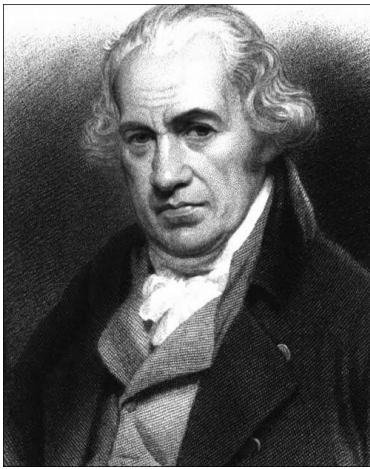


The Royal Society

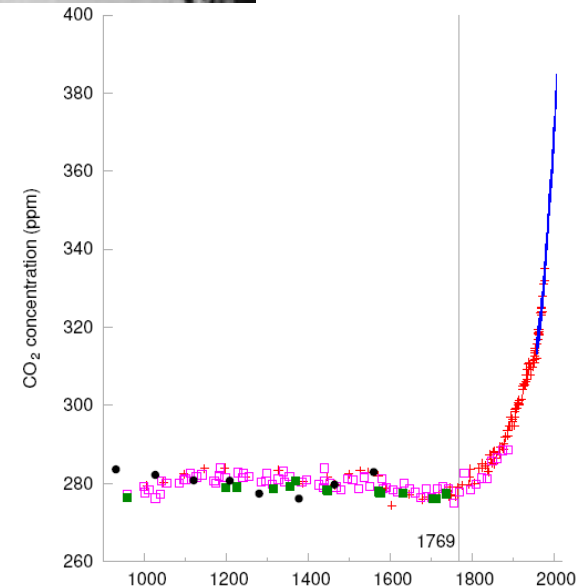
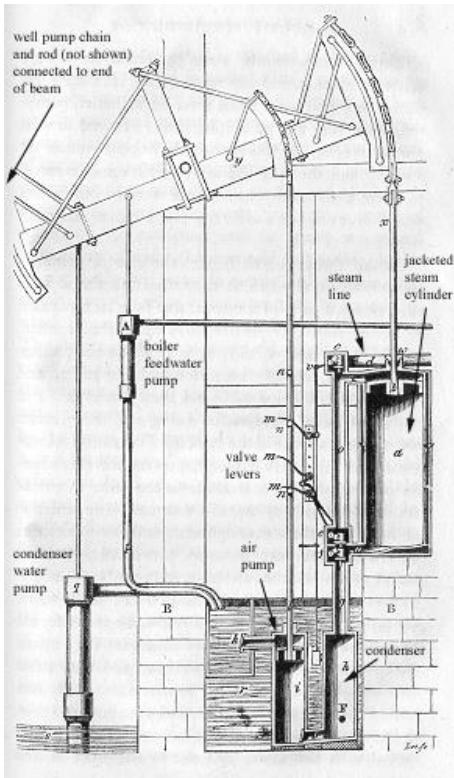
The Royal Society of London
1665AD

The Scientific Revolution

Industrial Revolution



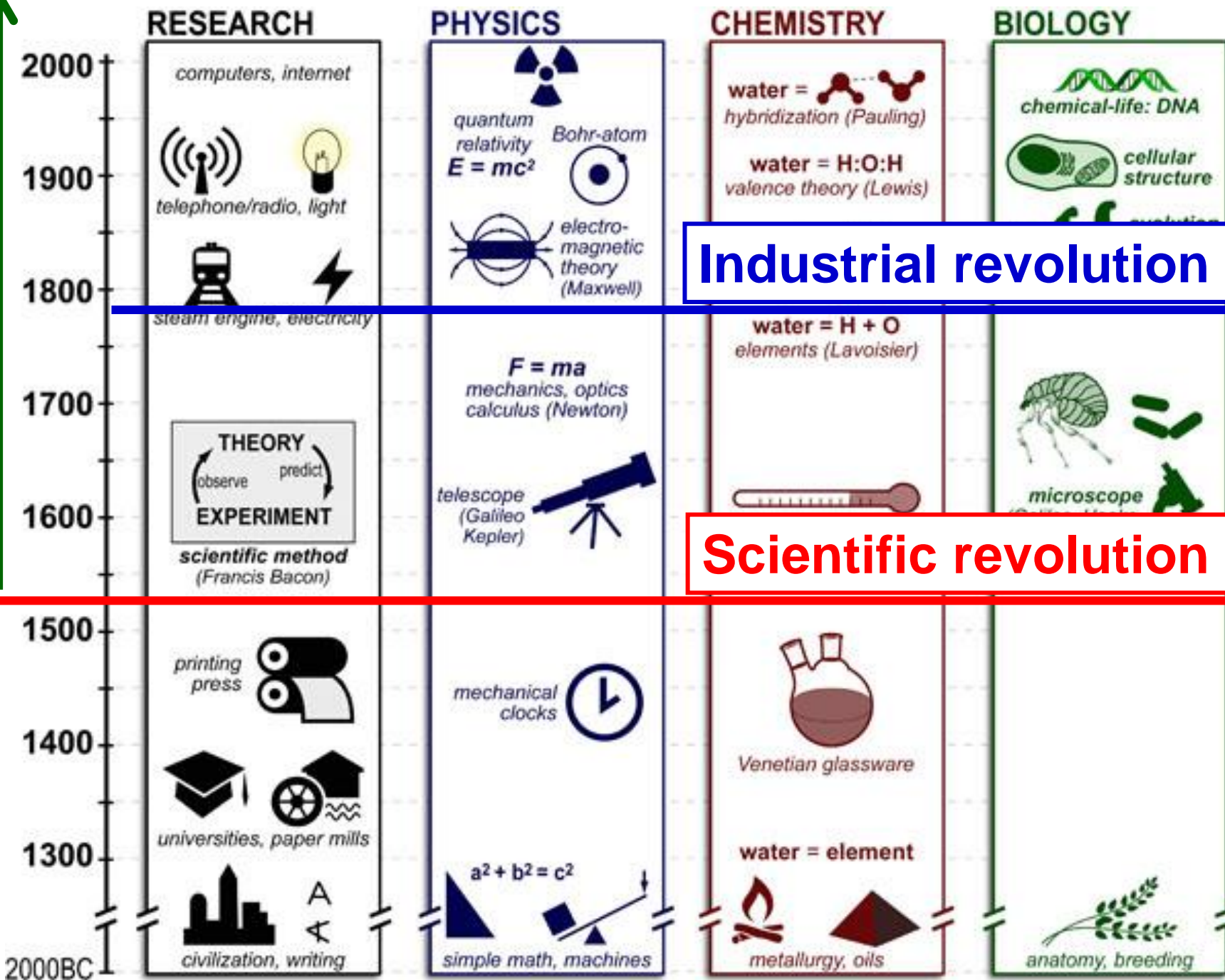
James Watt
1736-1819AD



Abrupt rise in atmospheric CO₂

< 500 years ago

(< 5 ชาติ)





FIRST [1784]

Mechanical production,
railroads, and steam
power

Industrie 1.0

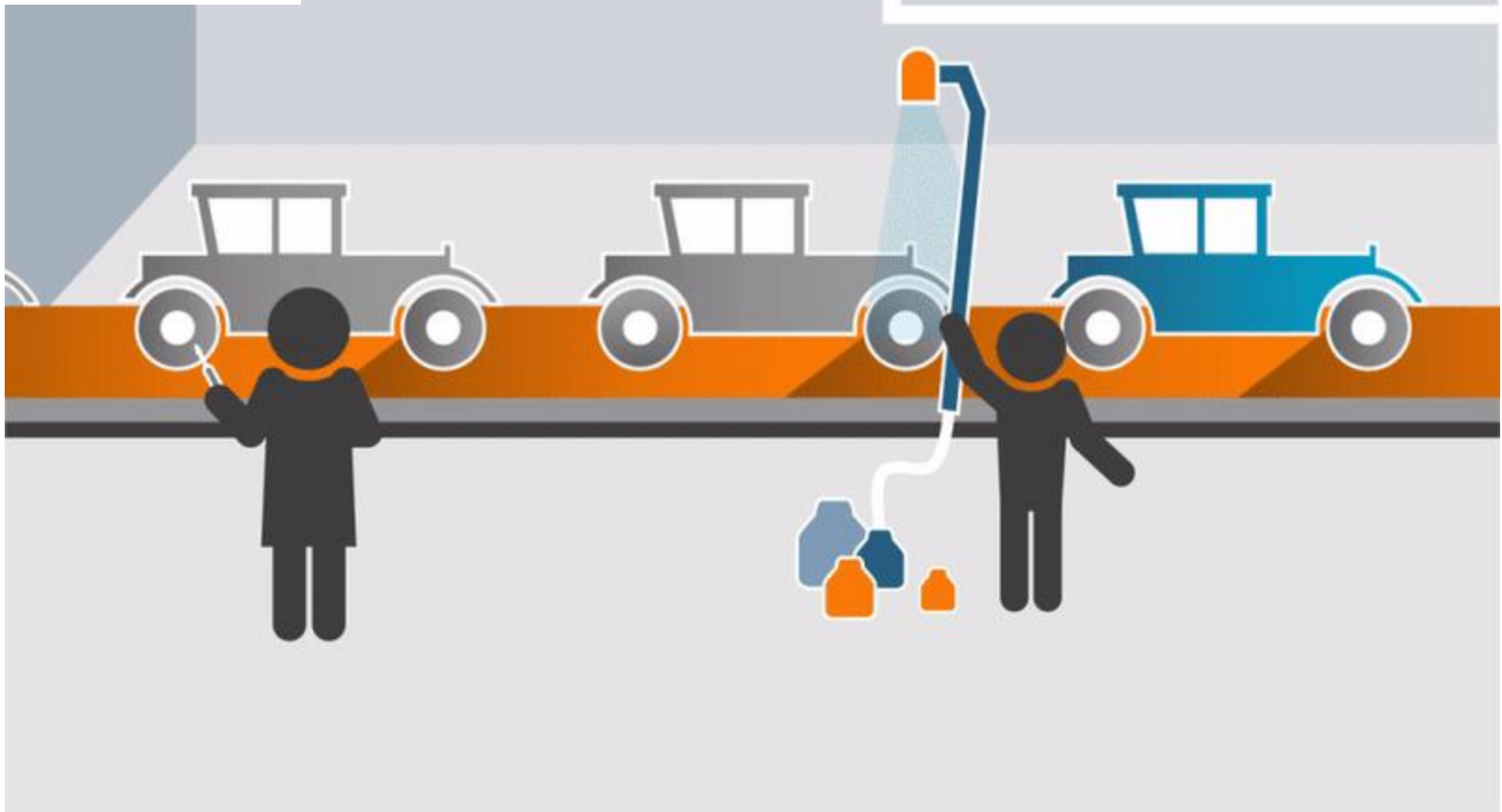




SECOND [1870]

Mass production, electrical power, and the advent of the assembly line

Industry 2.0

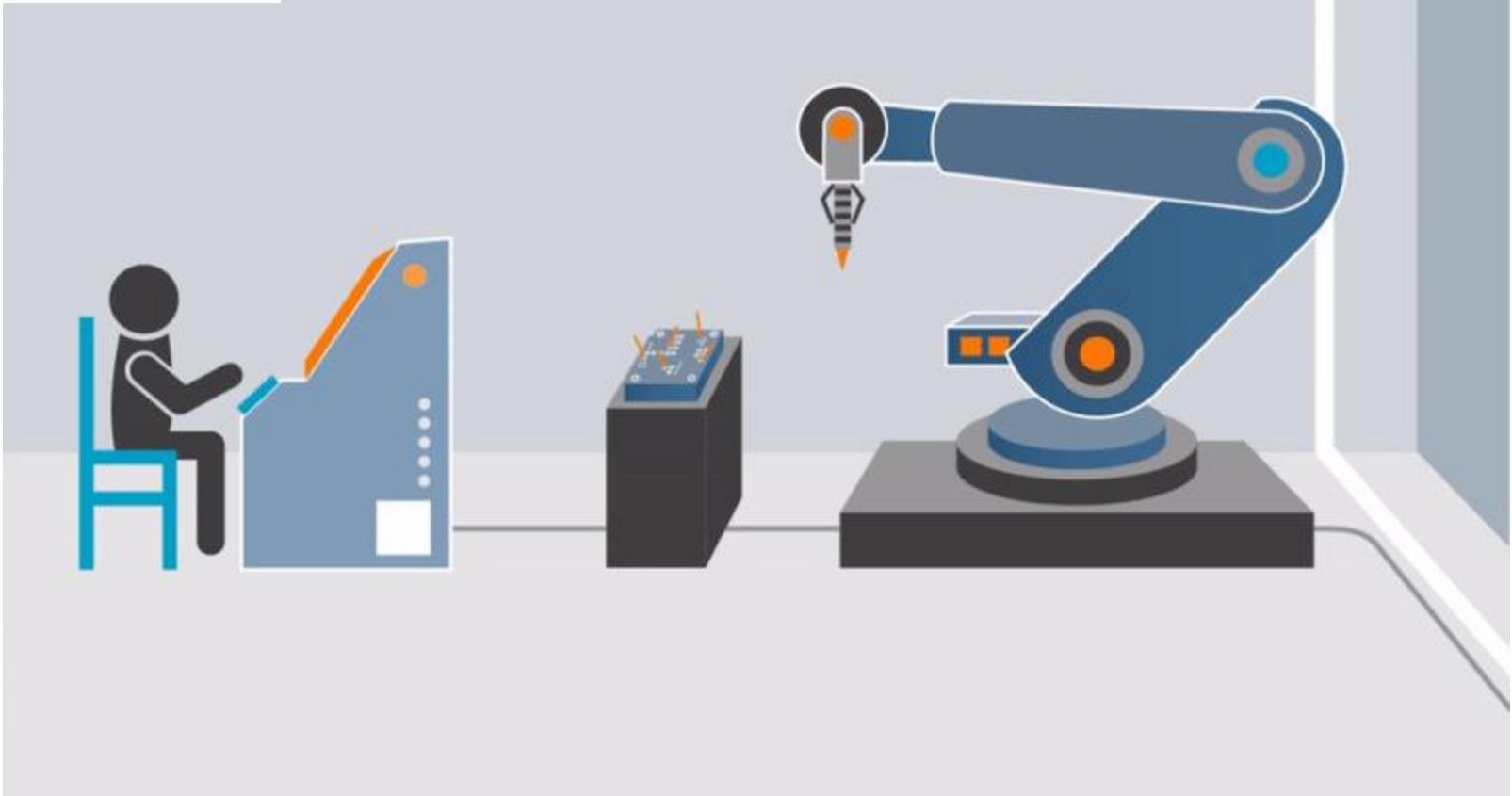




THIRD [1969]

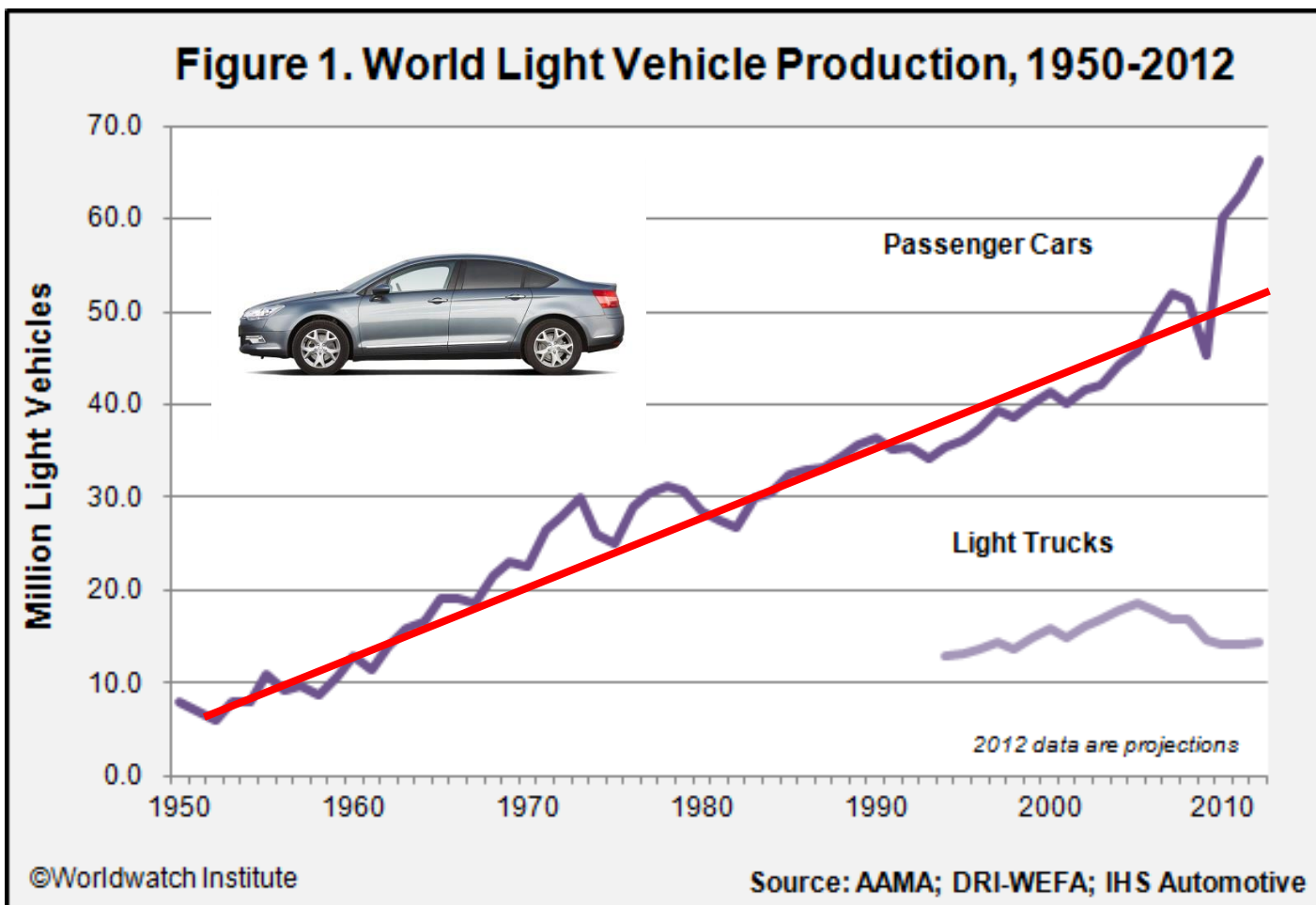
Automated production,
electronics, and
computers

Industry 3.0



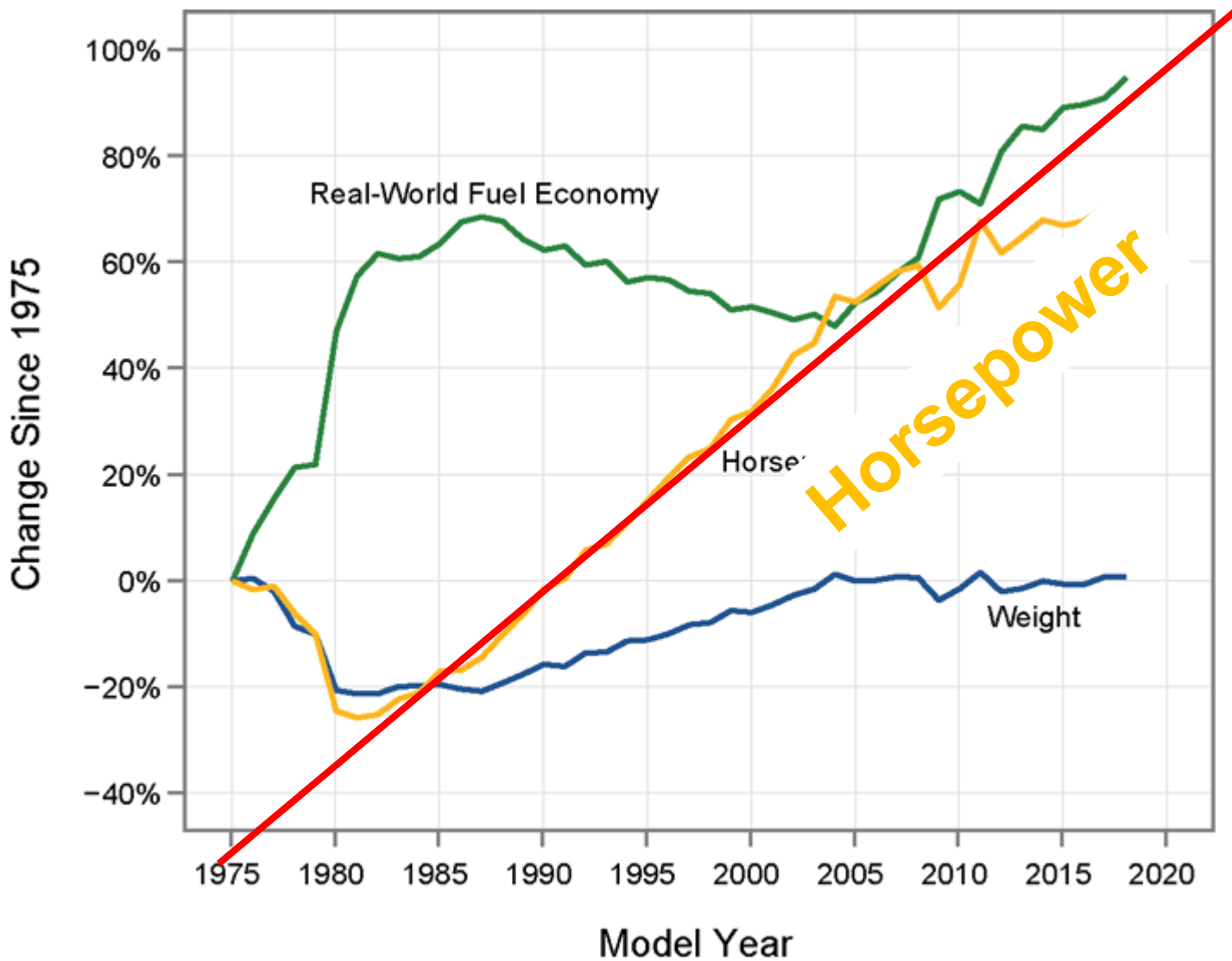
1st – 3rd Industrial Revolution

The Linear World



1st – 3rd Industrial Revolution

The Linear World



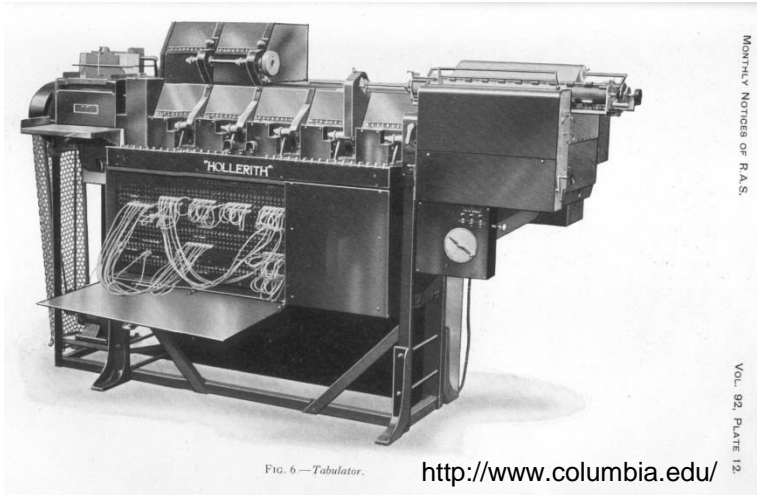
2

The 21st century

Digital disruption

Machine Calculations

Electro-mechanical machine (IBM Tabulators, 1890)



Vacuum tubes (ENIAC, 1946) World War II

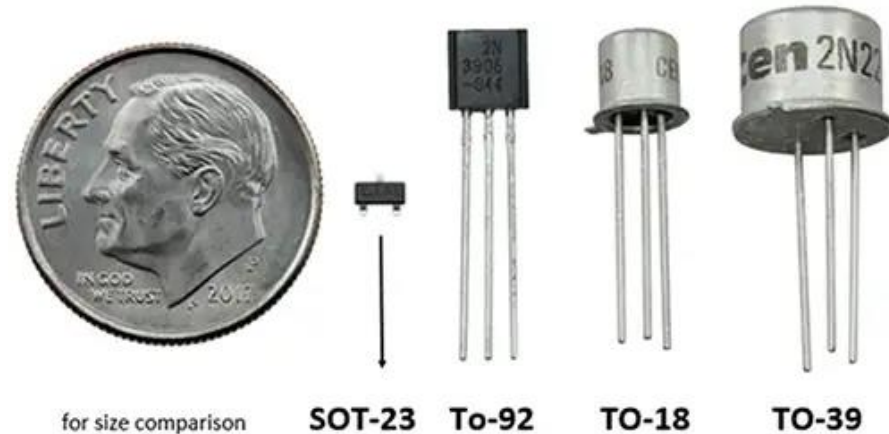


Integrated circuit, 1958



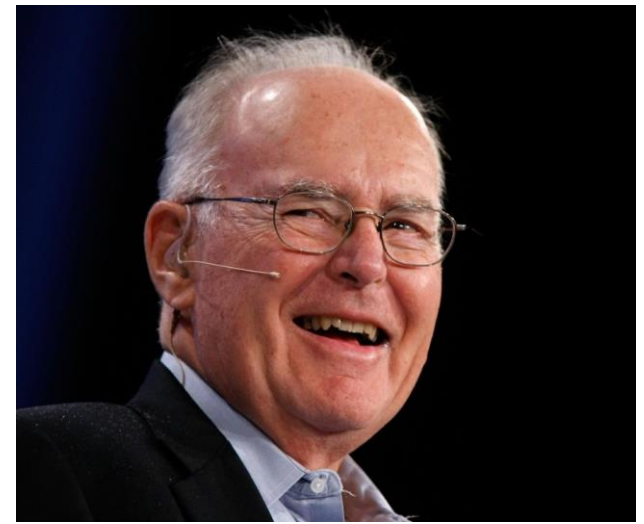
Graphcore C2, 2018
(24 billion transistors)

Transistor, 1947



Moore's law

since 1965



Gordon Moore

$$N = N_0 \times 2^g$$

Gen time ~2 years

The number of transistors in a dense integrated circuit doubles approximately every two years.

Moore's law since 1965

1 The accelerating pace of change ...



2 ... and exponential growth in computing power ...

Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years

COMPUTER RANKINGS

By calculations per second per \$1,000



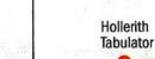
Analytical engine
Never fully built, Charles Babbage's invention was designed to solve computational and logical problems



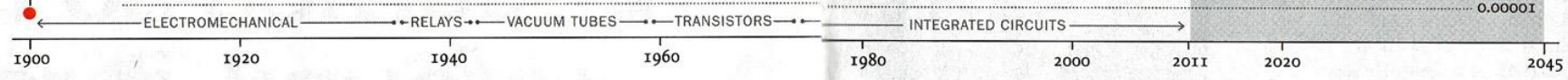
Colossus
The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II



UNIVAC I
The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.



Hollerith Tabulator
IBM Tabulator
National Ellis 3000



3 ... will lead to the Singularity

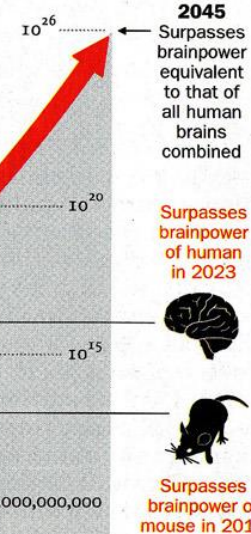


Apple II
At a price of \$1,298, the compact machine was one of the first massively popular personal computers



Power Mac G4
The first personal computer to deliver more than 1 billion floating-point operations per second

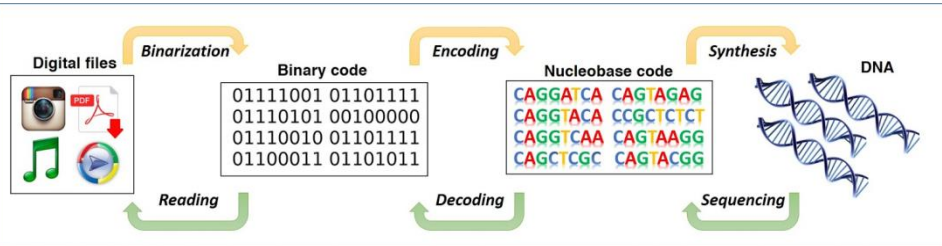
Mac Pro
Dell Dimension 8400
Pentium II PC
Pentium PC
Compaq Deskpro 386
IBM PC
Data General Nova
DEC PDP-4
IBM 1130
DEC PDP-10
Intellec-8
Whirlwind
BINAC
ENIAC
Zuse 3
IBM SSEC
EDVAC
Datamatic 1000
IBM 1620



The number of transistors in a dense integrated circuit doubles approximately every two years.

DNA computing

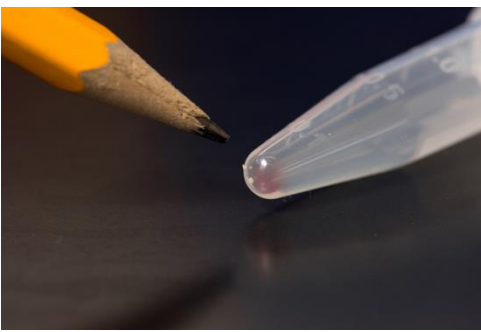
Quantum computing



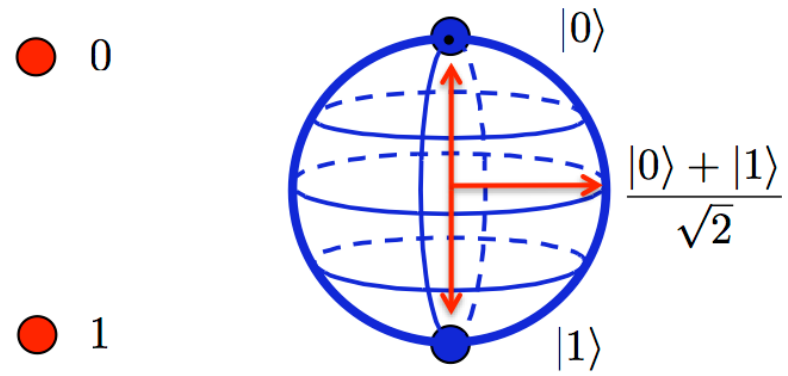
STORAGE LIMITS
Estimates based on bacterial genetics suggest that digital DNA could one day rival or exceed today's storage technology.

	Hard disk	Flash memory	Bacterial DNA	WEIGHT OF DNA NEEDED TO STORE WORLD'S DATA
Read-write speed (μs per bit)	~3,000-5,000	~100	<100	~1 kg
Data retention (years)	>10	>10	>100	
Power usage (watts per gigabyte)	~0.04	~0.01-0.04	<10 ⁻¹⁰	
Data density (bits per cm ³)	~10 ¹³	~10 ¹⁶	~10 ¹⁹	

©nature



1 gram of DNA can store 4.5x10¹⁸ byte

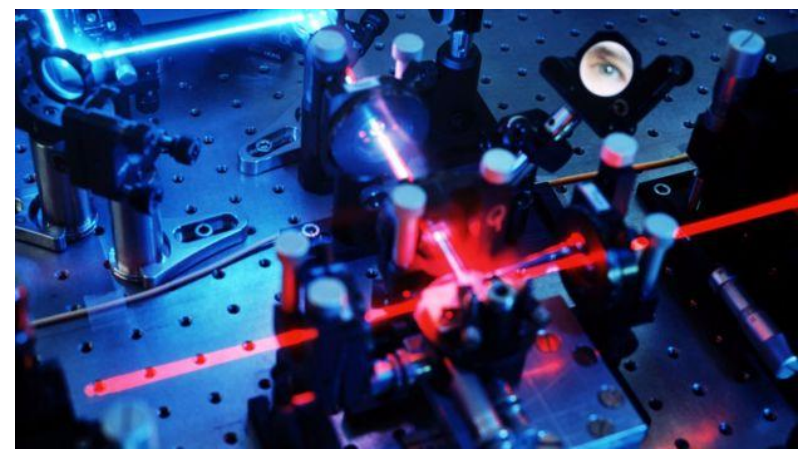


Classical Bit

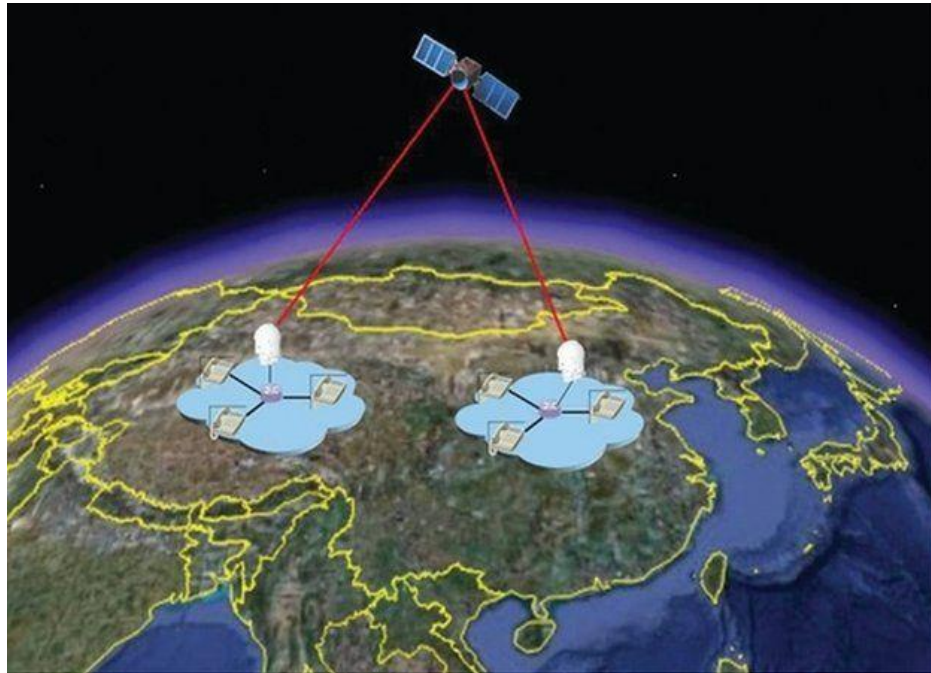
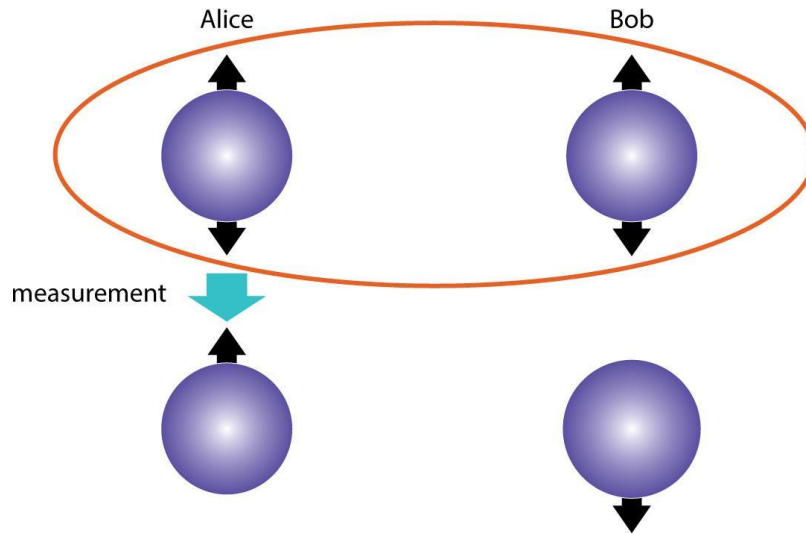
Qubit

BBC

China's quantum satellite in big leap

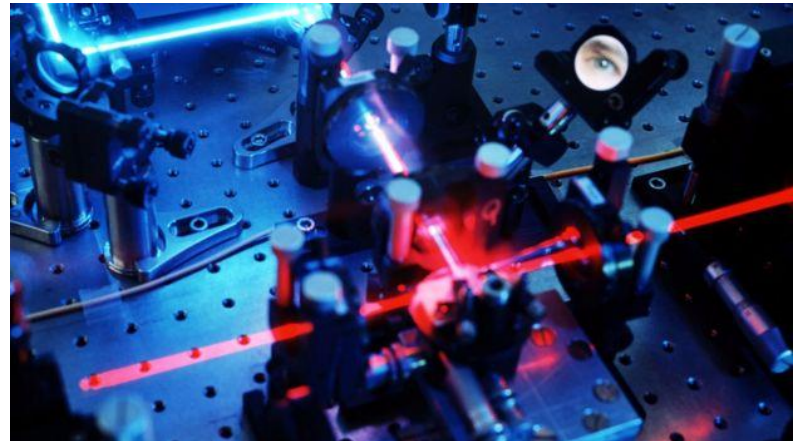


ความพัวพัน (Entanglement)



BBC

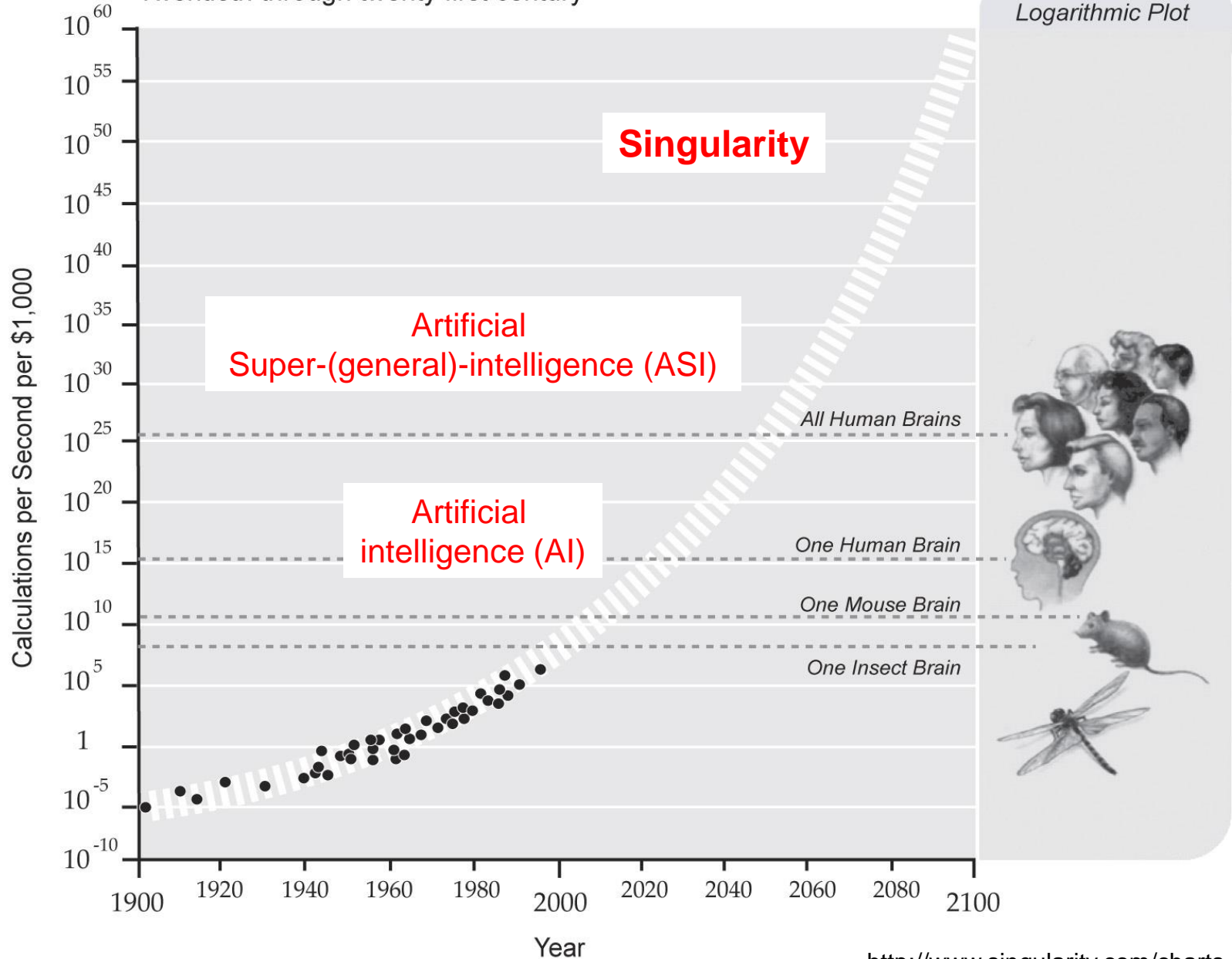
China's quantum satellite in big leap



The Exponential World #3

Exponential Growth of Computing

Twentieth through twenty first century



Machine Learning

CHESS

GO

 Deep Blue vs. Kasparov



Deep Blue
IBM chess computer

Garry Kasparov
World Chess Champion



AlphaGo
(Google DeepMind)

Lee Sedol
(18-time world Go champion)

1996: **Kasparov-Deep Blue**: 4-2

1997: **Deep Blue- Kasparov**: 3.5-2.5

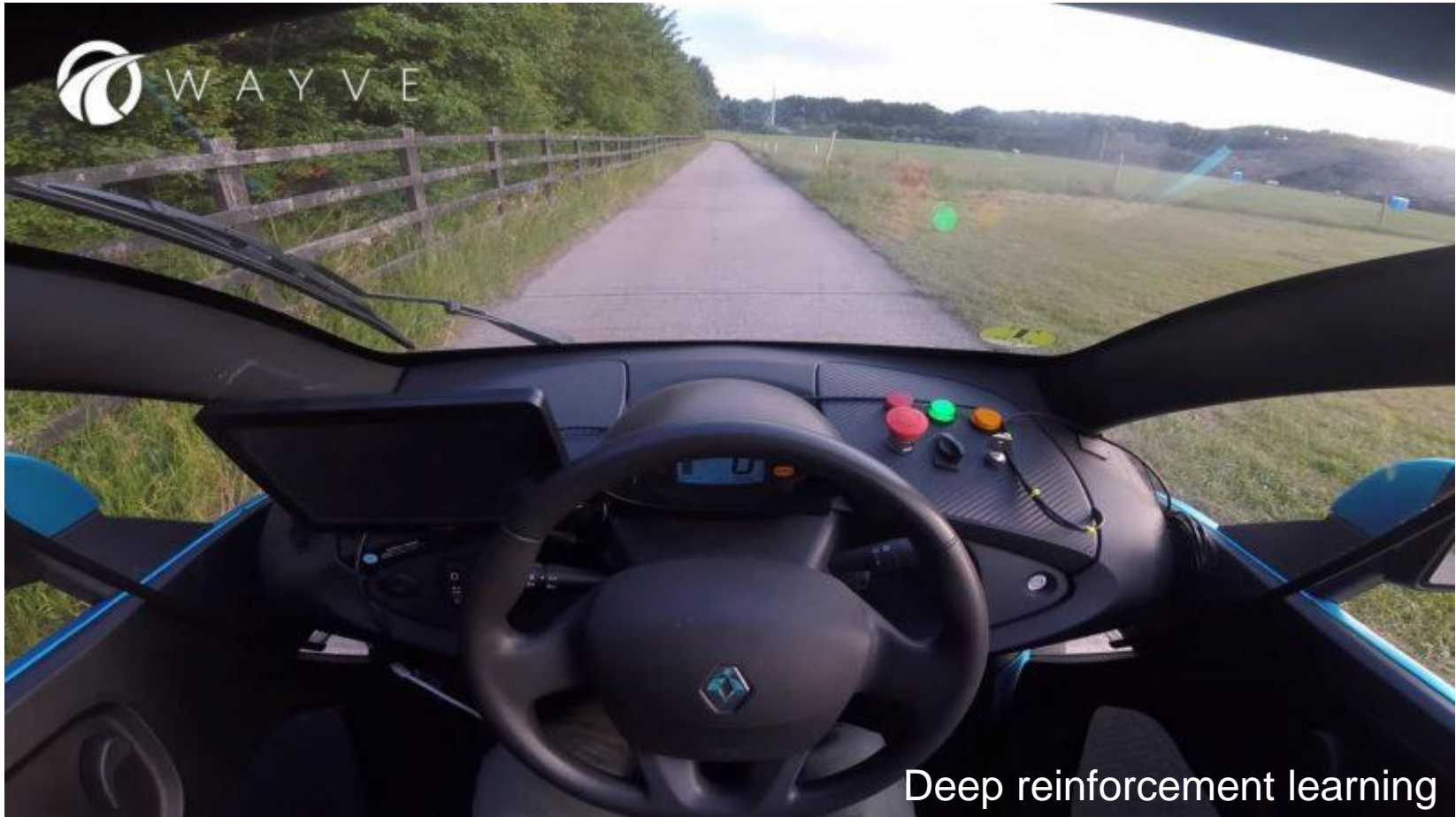
2016: **AlphaGo**: Sedol: 4-1

Artificial General Intelligence (AGI)

Artificial Intelligence (AI)

Autonomous vehicle

Learning to drive within 20 mins

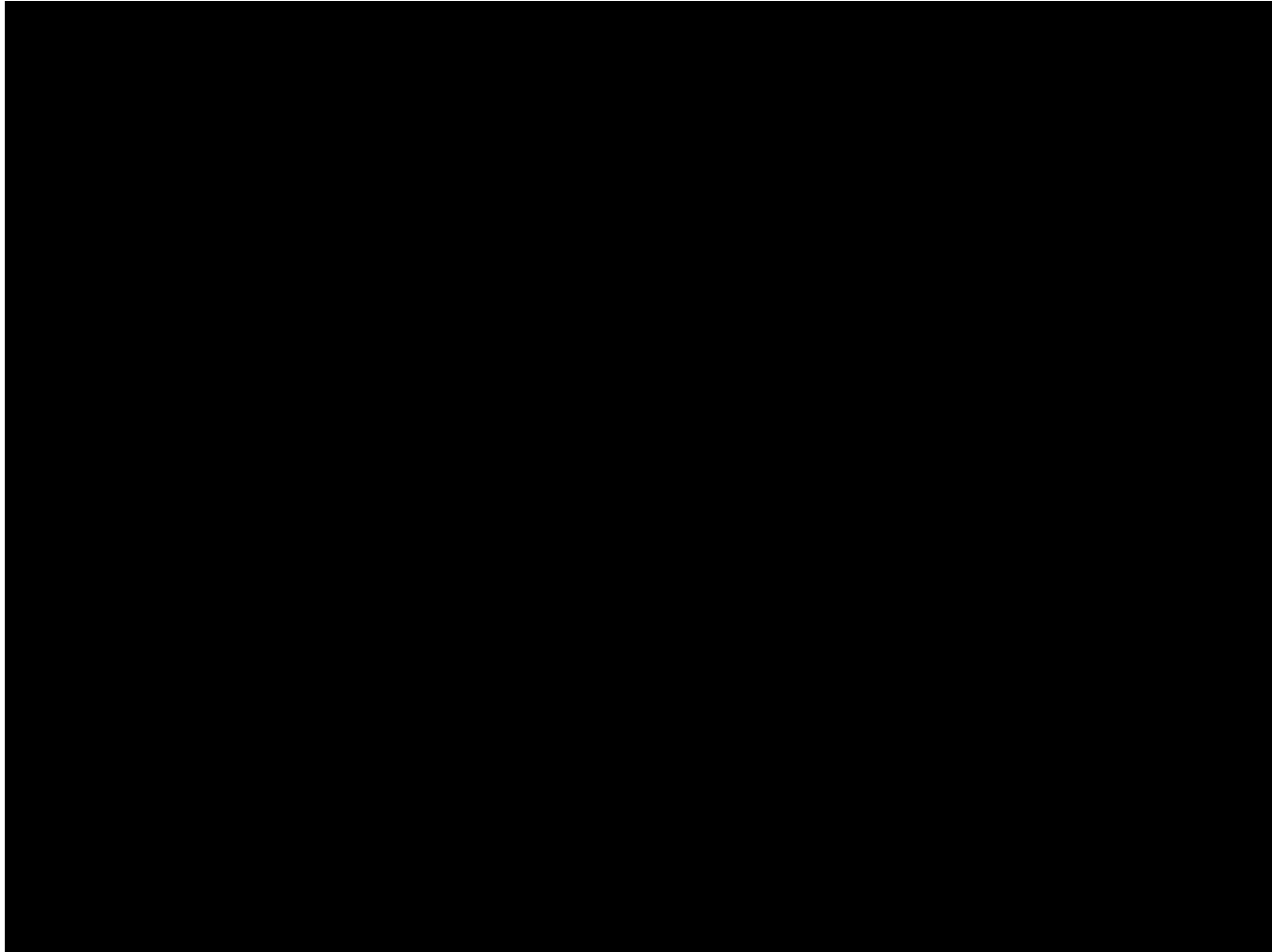


Cambridge University, UK

Autonomous vehicle

Learning to drive within 20 mins

Digital Explosion
(NOW)

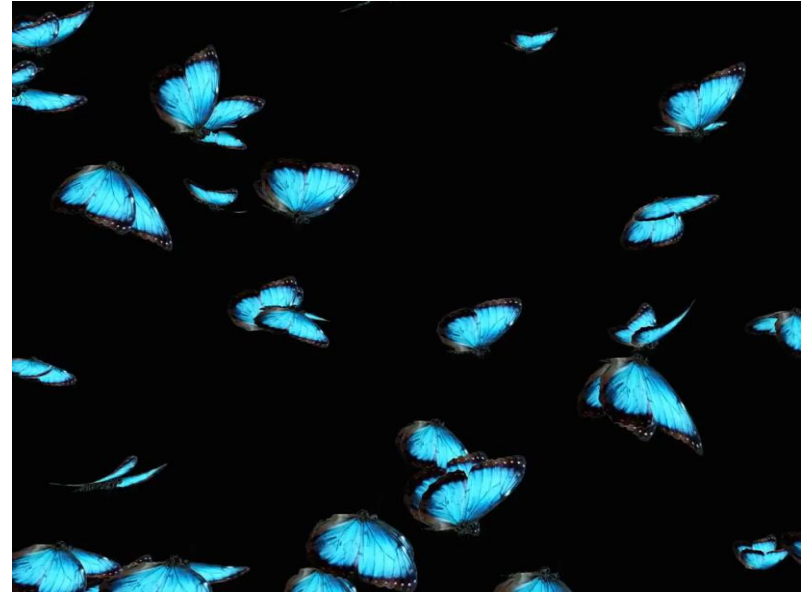


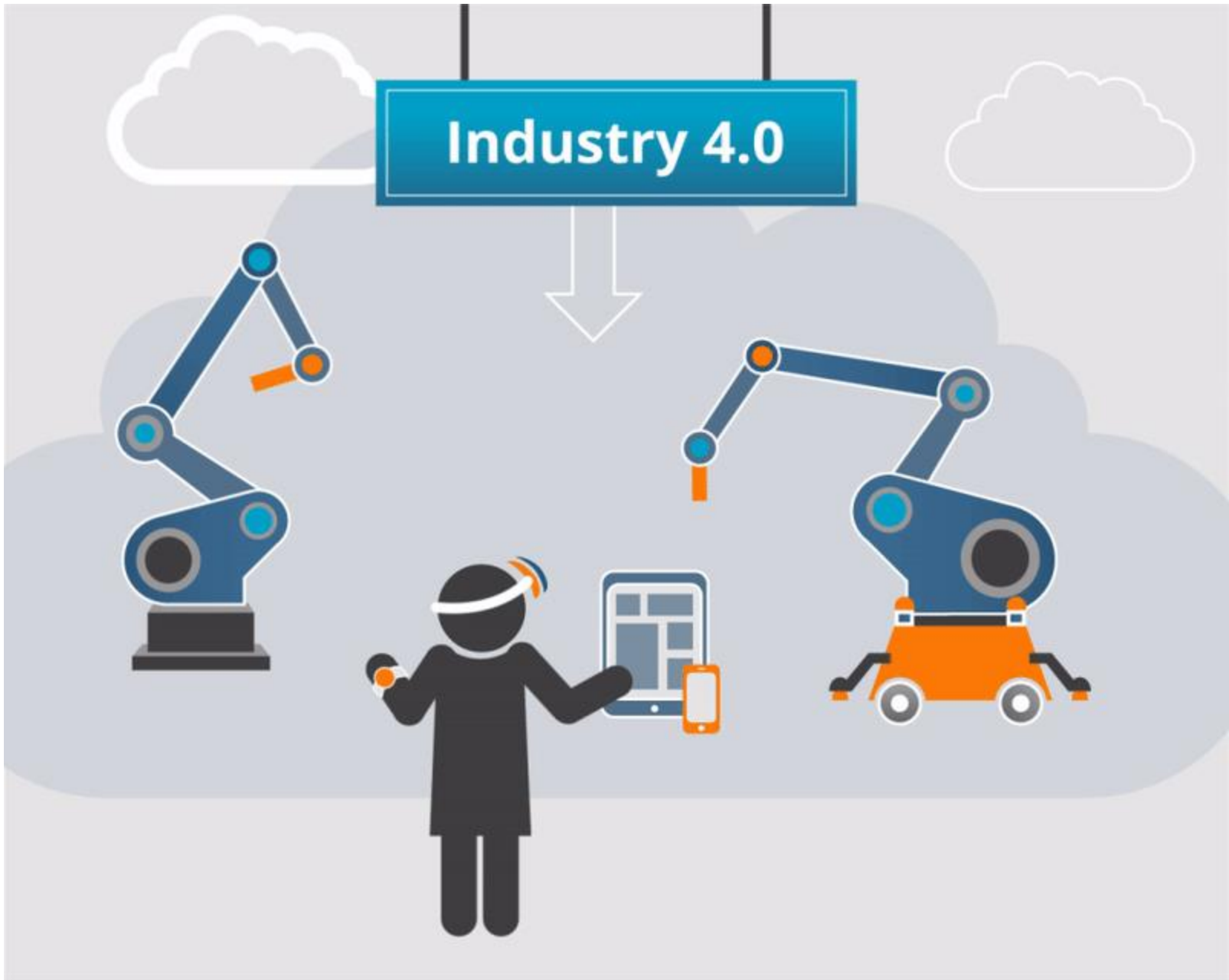
Deep reinforcement learning



WAYVE

Cambridge University, UK

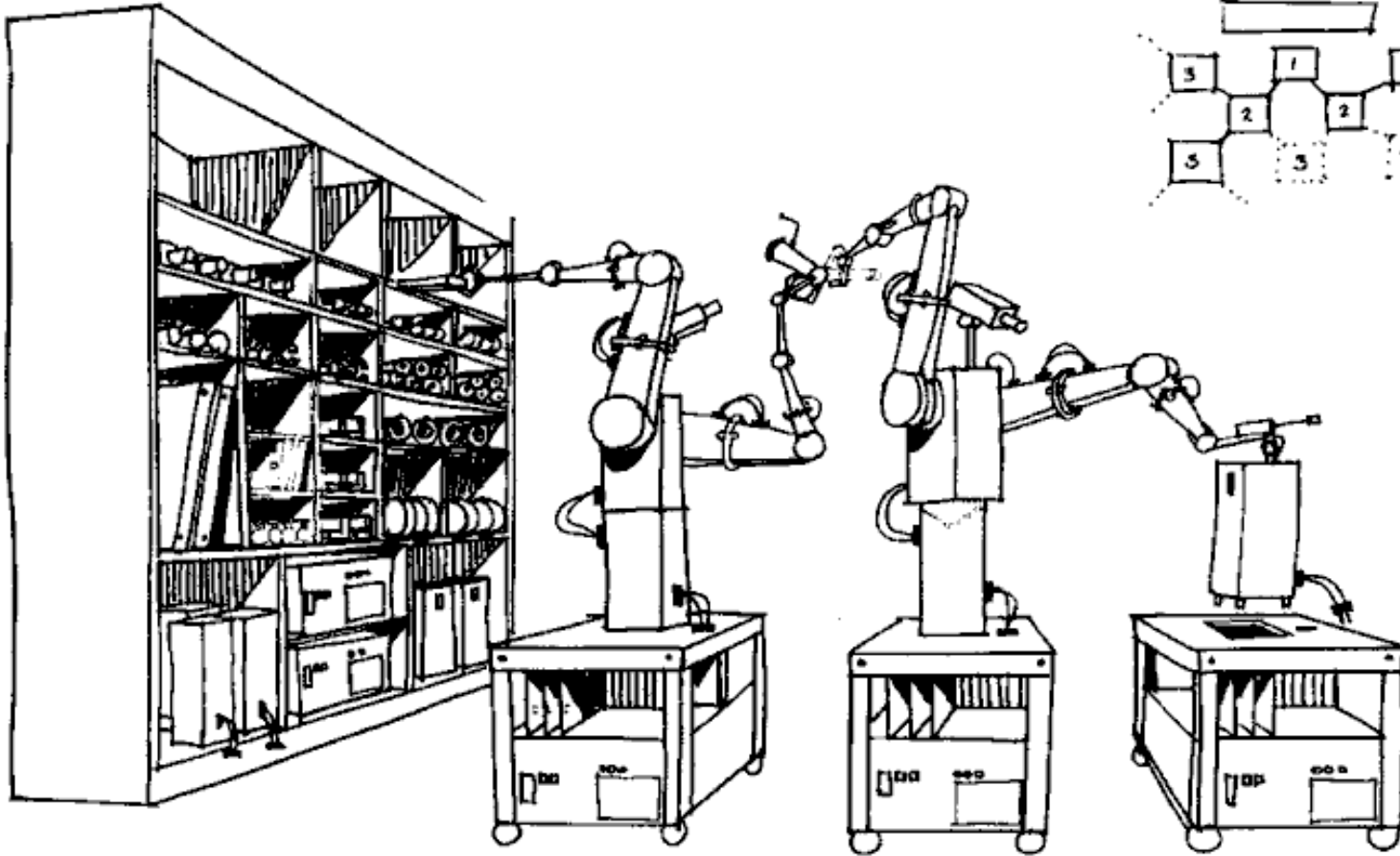




Robotic Explosion

(next hundreds years?)

Singularity



Self-replicating machine

Survival in the 21st century

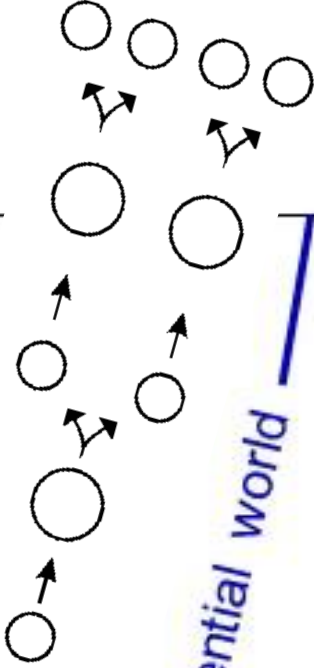
PERFORMANCE

1st_₃rd Industrial revolutions



Linear world

4th Industrial revolution

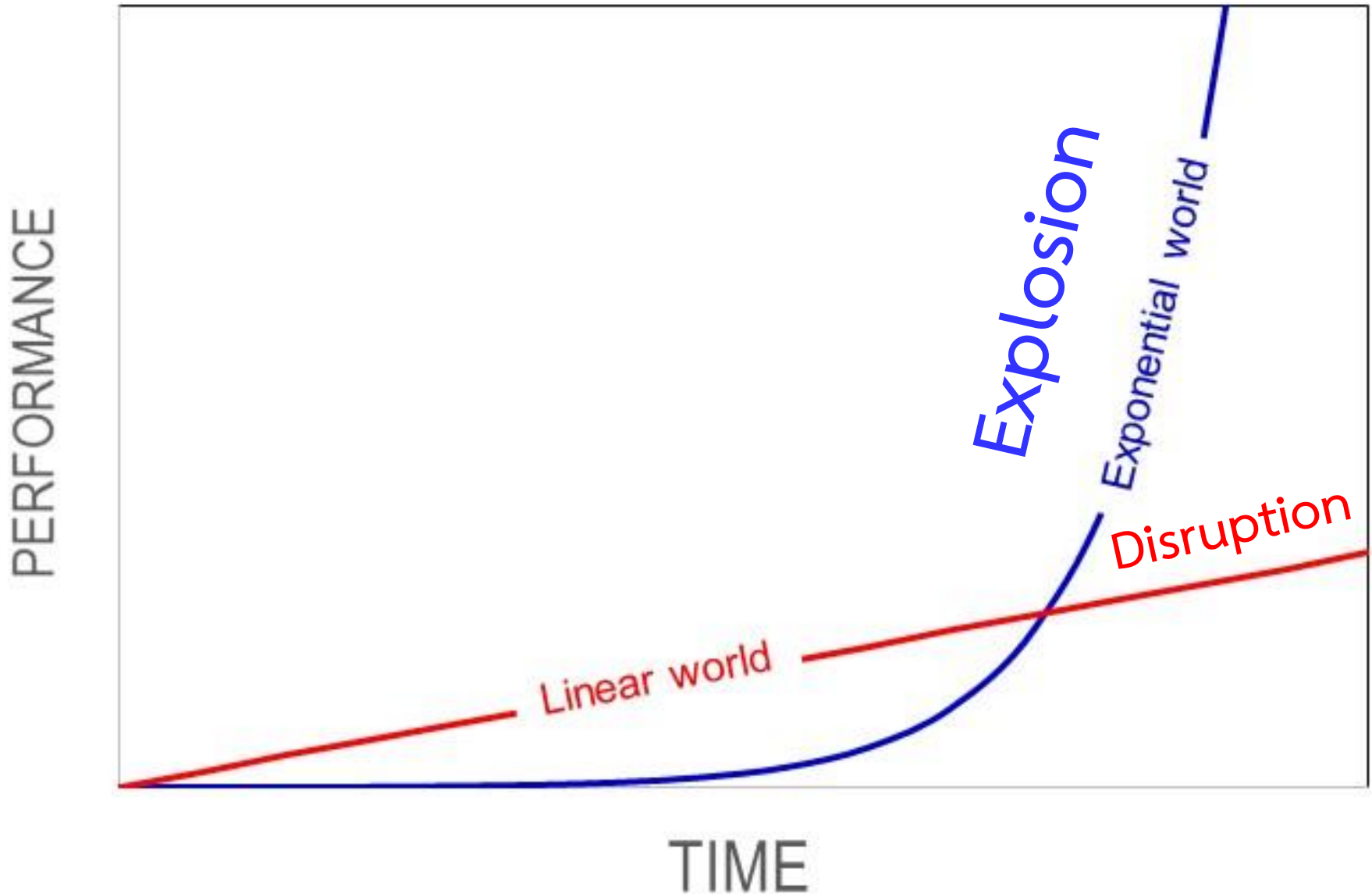


Exponential world

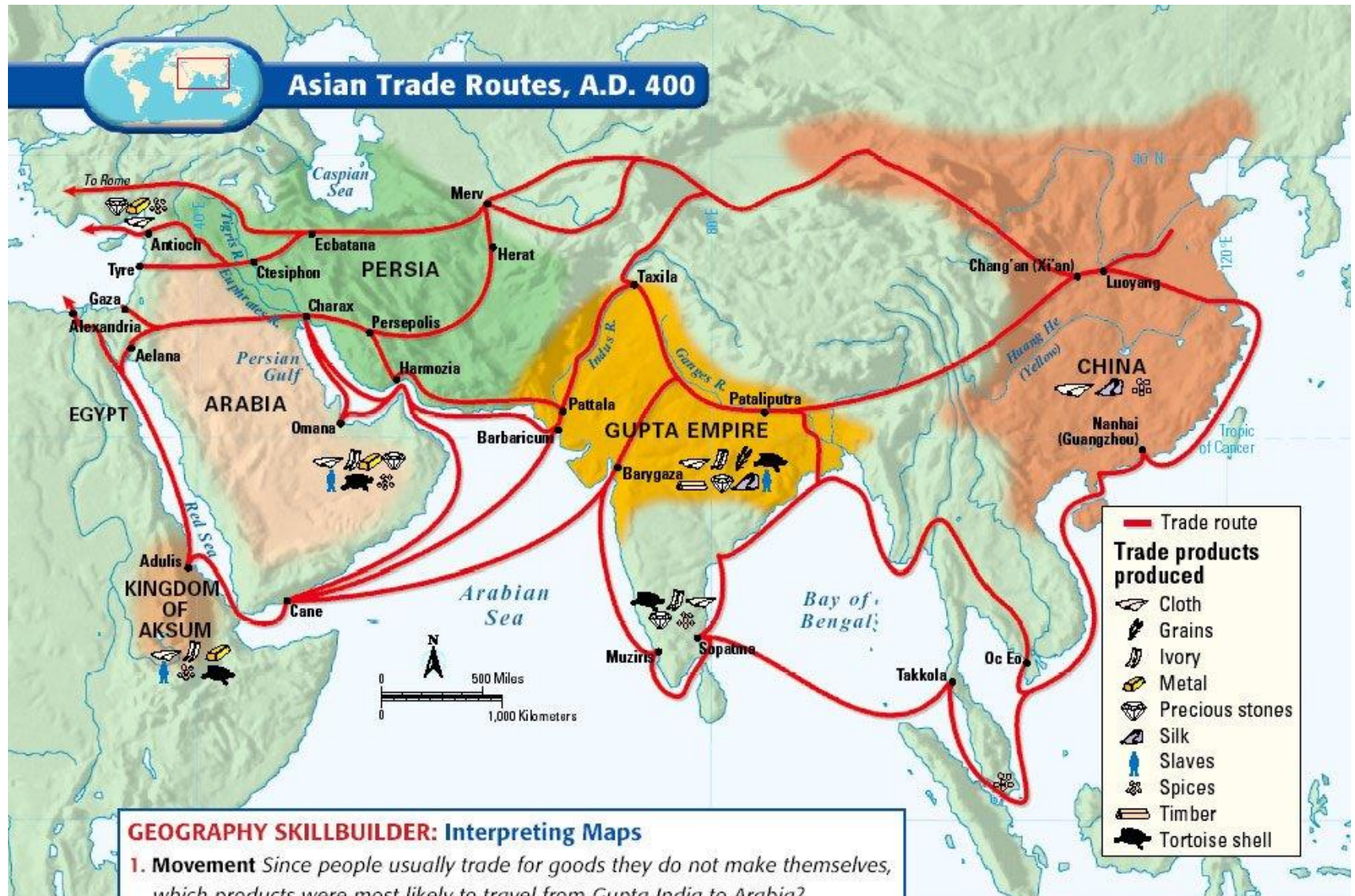
TIME

Disruption versus Explosion

Survival in the 21st century



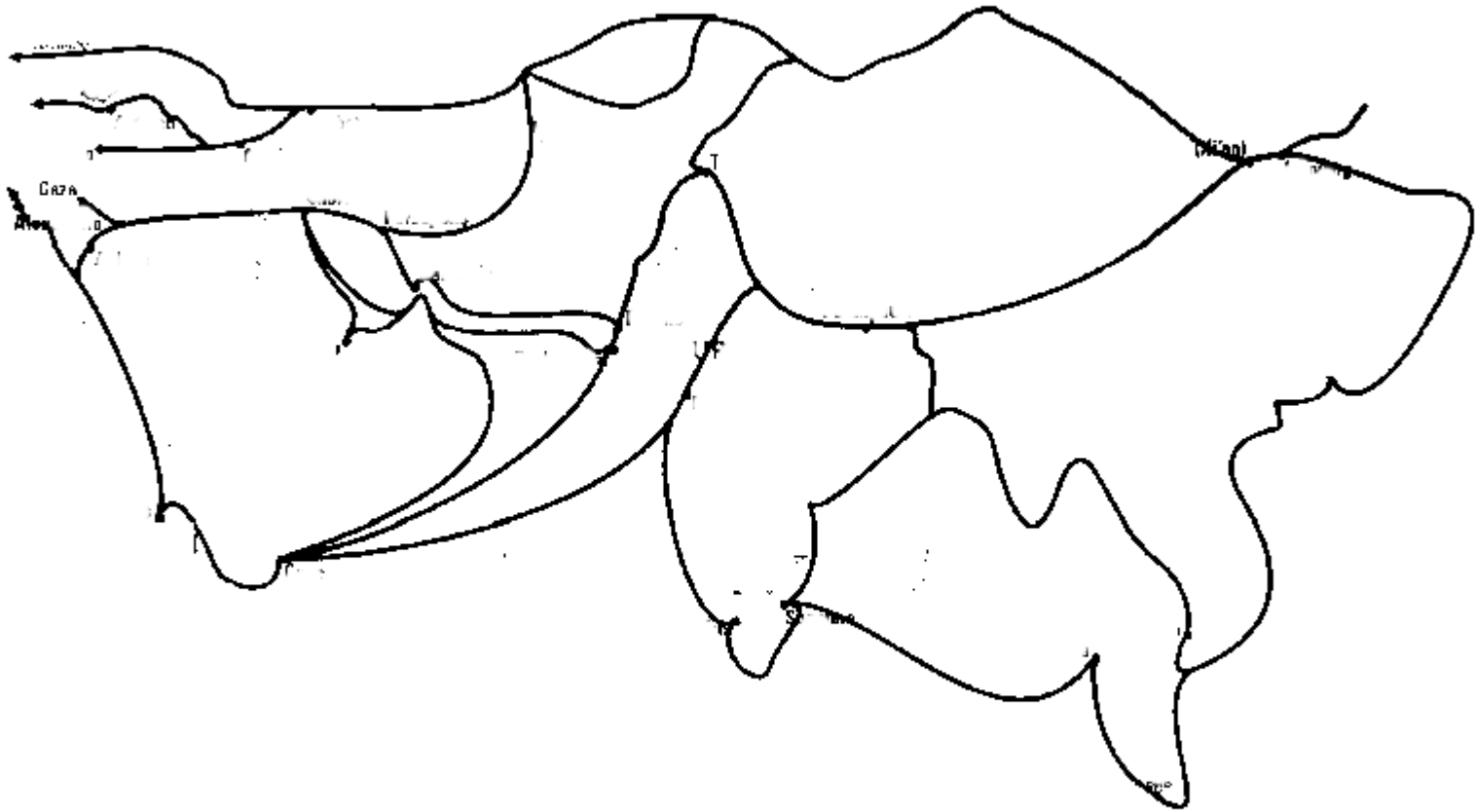
The 4th century connection



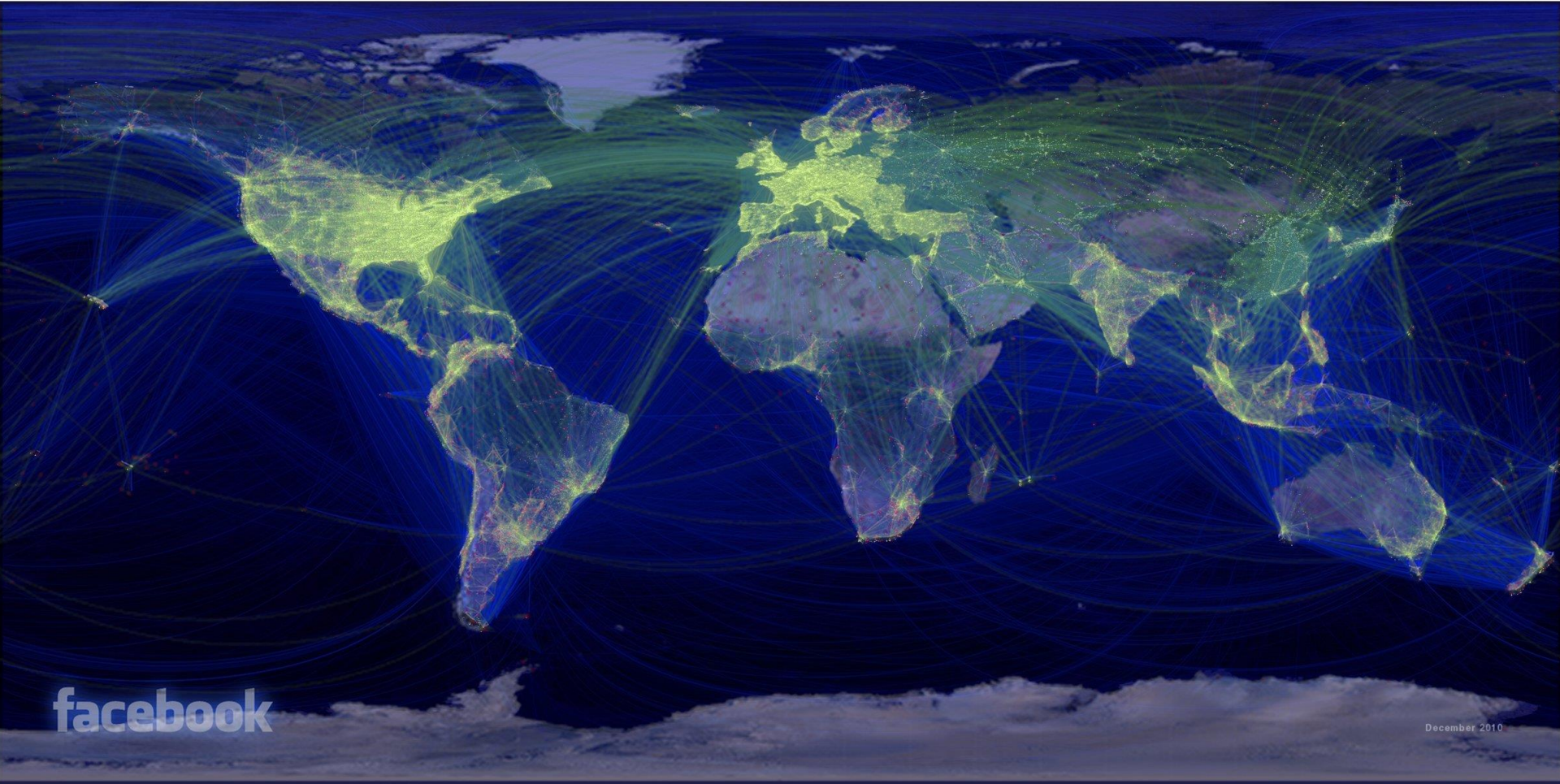
GEOGRAPHY SKILLBUILDER: Interpreting Maps

- 1. Movement** Since people usually trade for goods they do not make themselves, which products were most likely to travel from Gupta India to Arabia?
- 2. Movement** How far did trade goods travel to get from Luoyang in China to Alexandria in Egypt?

The 4th century connection



The 21st century connection



facebook

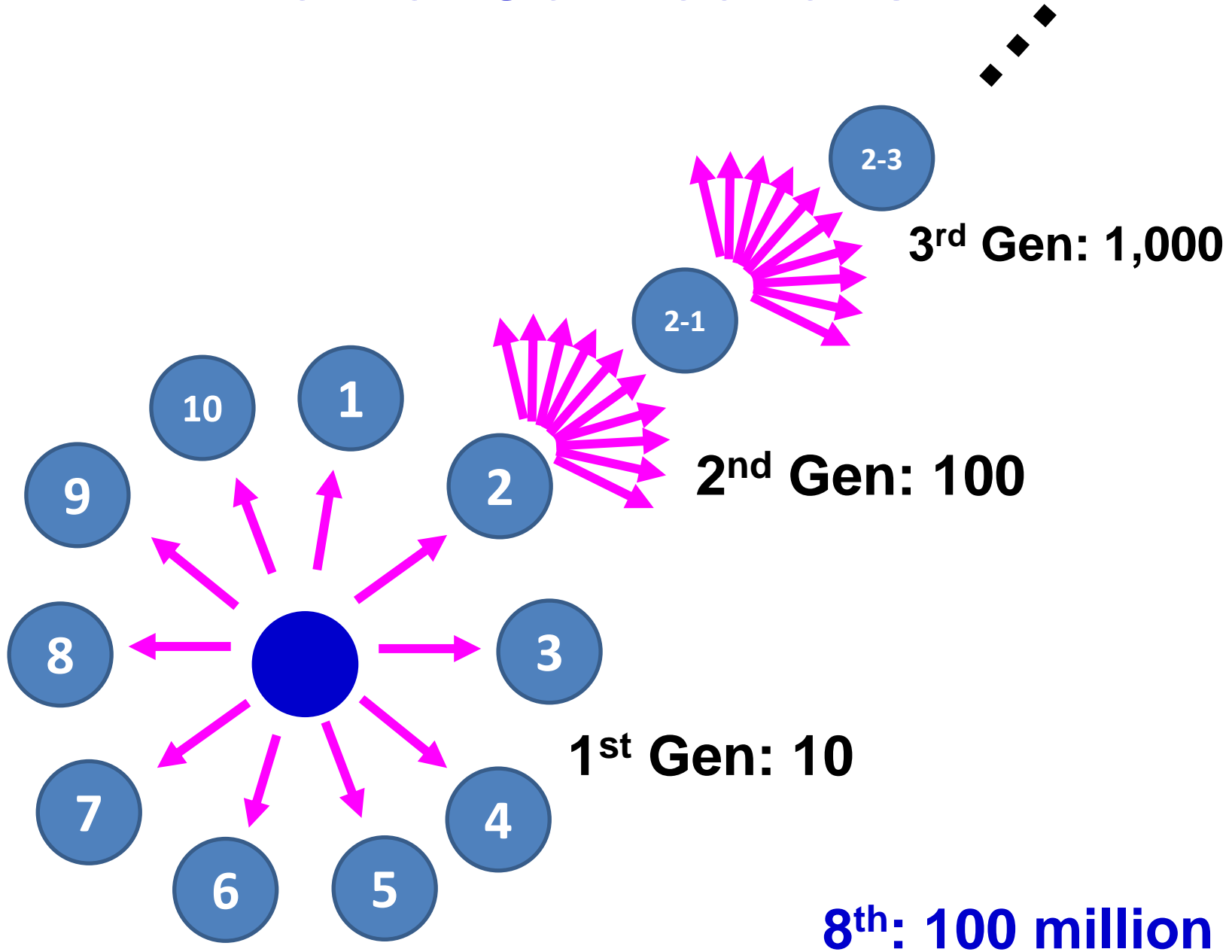
December 2010

The 21st century connection

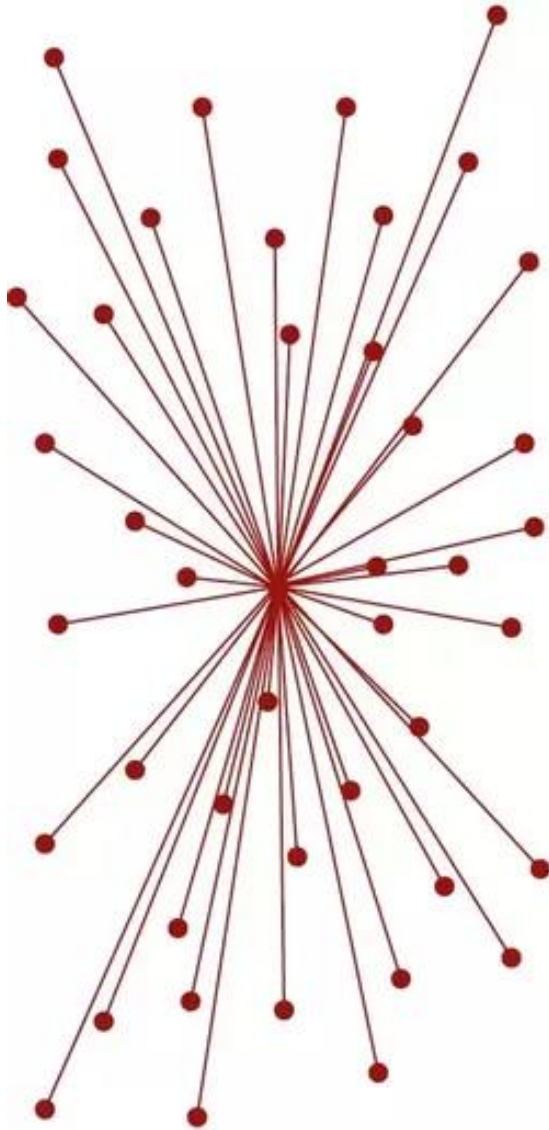


Internet Connections

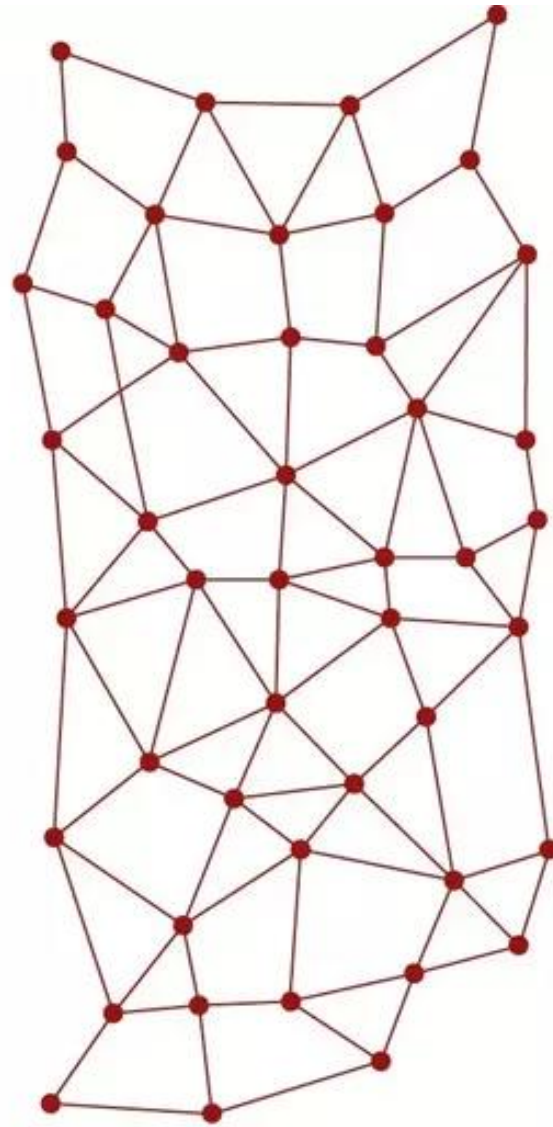
The Exponential World #4



BLOCKCHAIN



Centralized Network



Distributed Network

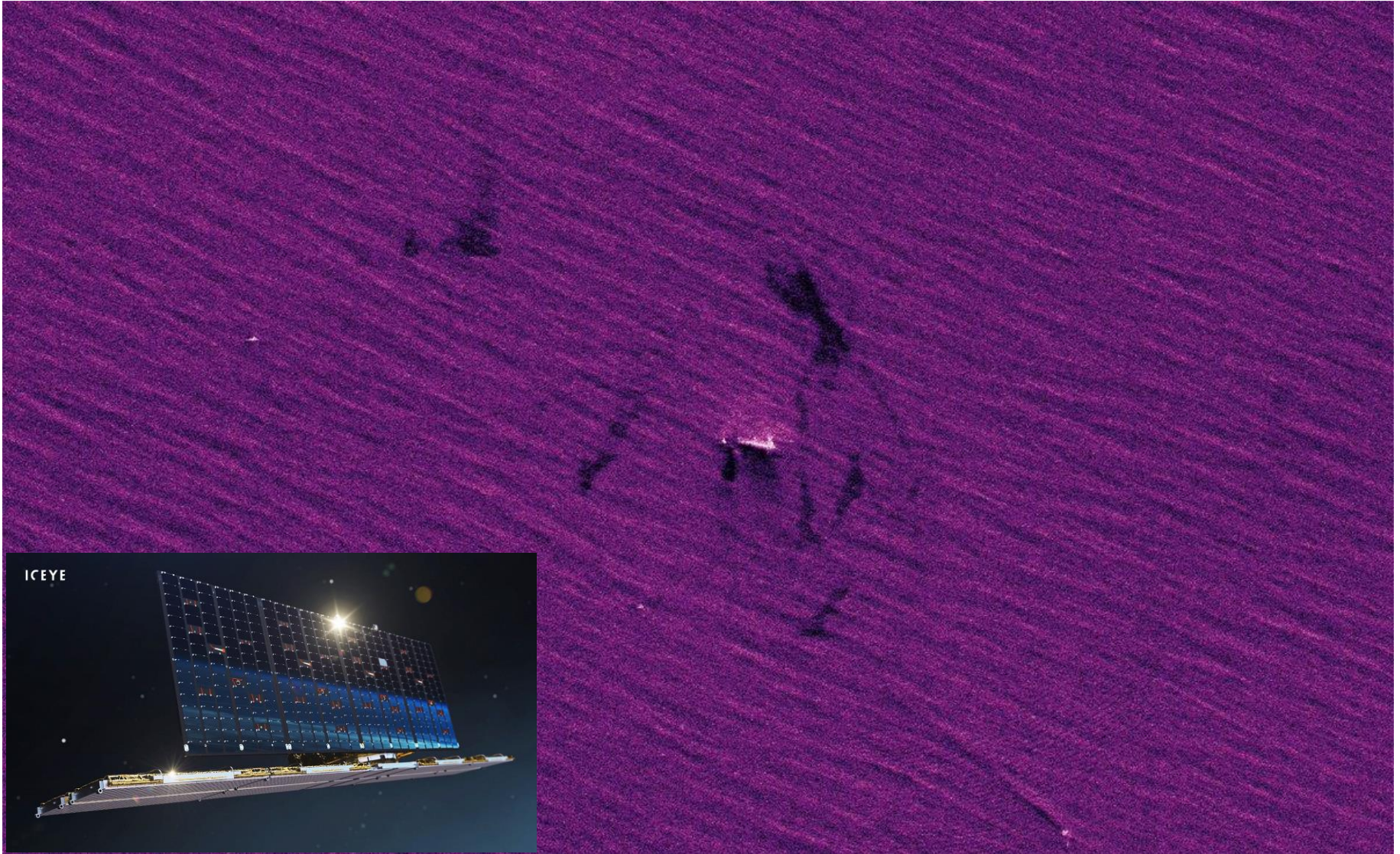
ICEYE - Every Square Meter, Every Hour



Low cost radar satellites produce **sub-1m resolution images** of the Earth's surface.

<https://www.iceye.com/>

ICEYE - Every Square Meter, Every Hour

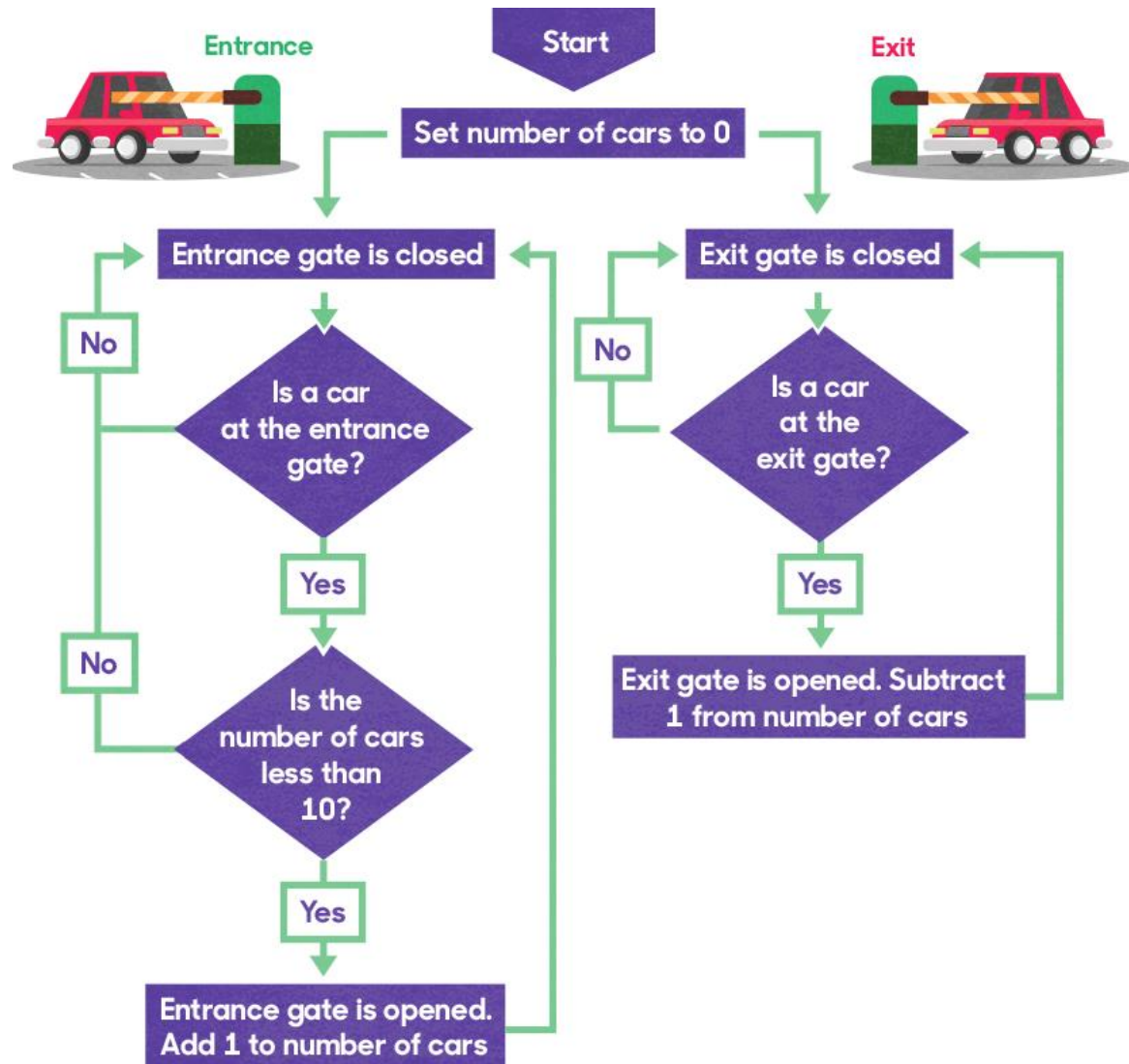


<https://www.iceye.com/>

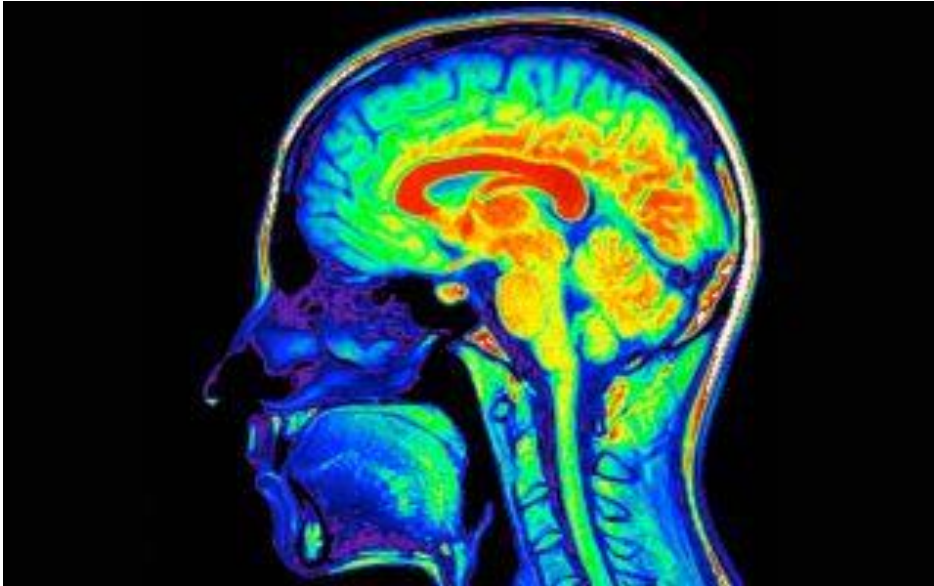
3

MIND: The internal world

ALGORITHM



HUMAN BRAIN



INTEGRATED CIRCUIT



Graphcore C2, 2018
(24 billion transistors)

ALGORITHM

MIND

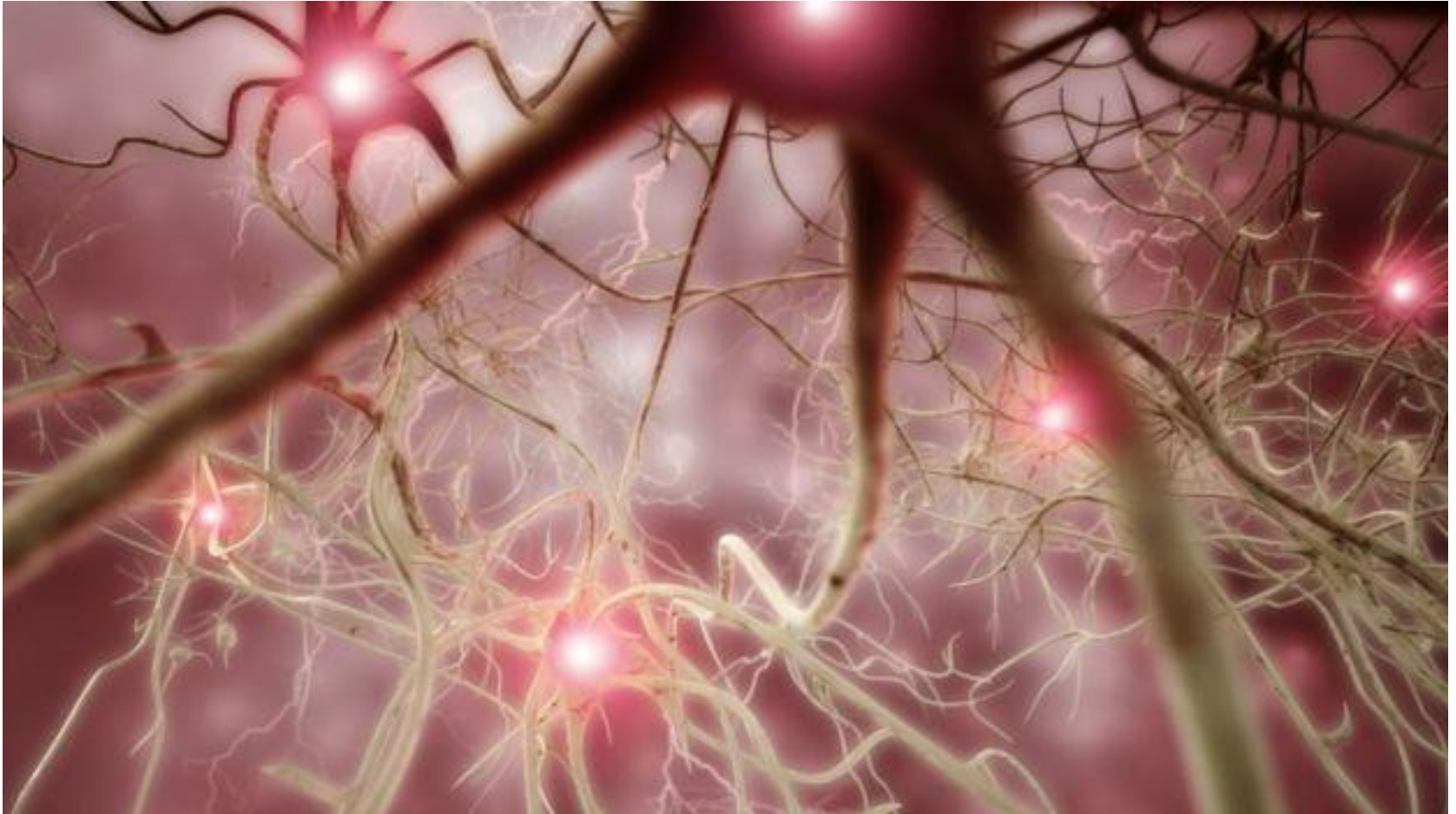
Man and Machine



2016

The robotic arm attaches to an implant that is inserted directly into the bone at the end of the remaining part of the limb, and prior nerve reassignment surgery gave way for brain signals to direct motion

Back-up brains: The era of digital immortality



A start-up **Nectome** claims it will one day allow people to back-up their brains as a computer simulation but admits it will come at the ultimate price: death.

คุณธรรม สำคัญกว่า ความรู้ความสามารถ

การมีความรู้ความสามารถเป็นเหมือนการมีเครื่องมือ เช่น ขวาน ไว้ในมือ
คนถือขวานต้องมีคุณธรรมเป็นเครื่องกำกับใจให้ใช้ขวานไปในทางที่ชอบ



NUCLEAR BOMB



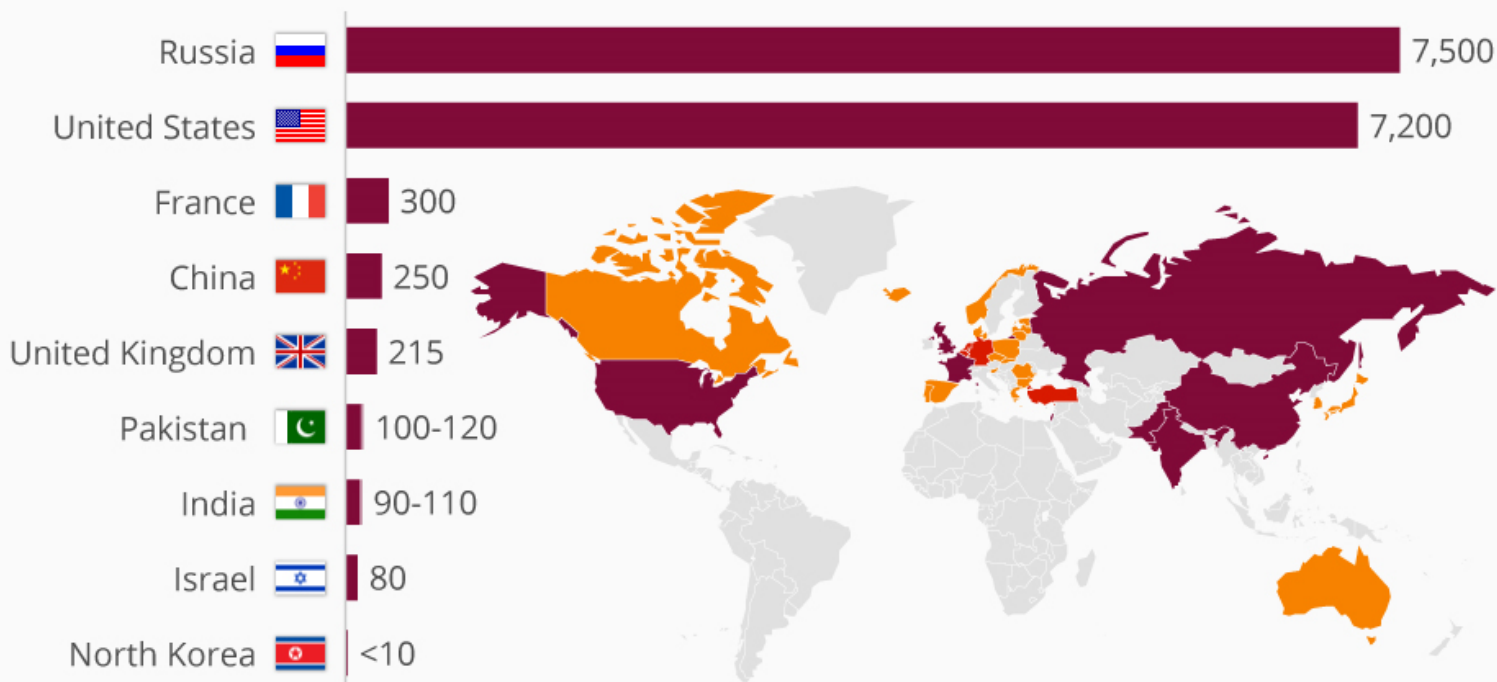
Ruins of the Hiroshima Prefectural Industrial Promotion Hall
on August 6, 1945.

NUCLEAR BOMB ARSENAL

The Countries With The Biggest Nuclear Arsenals

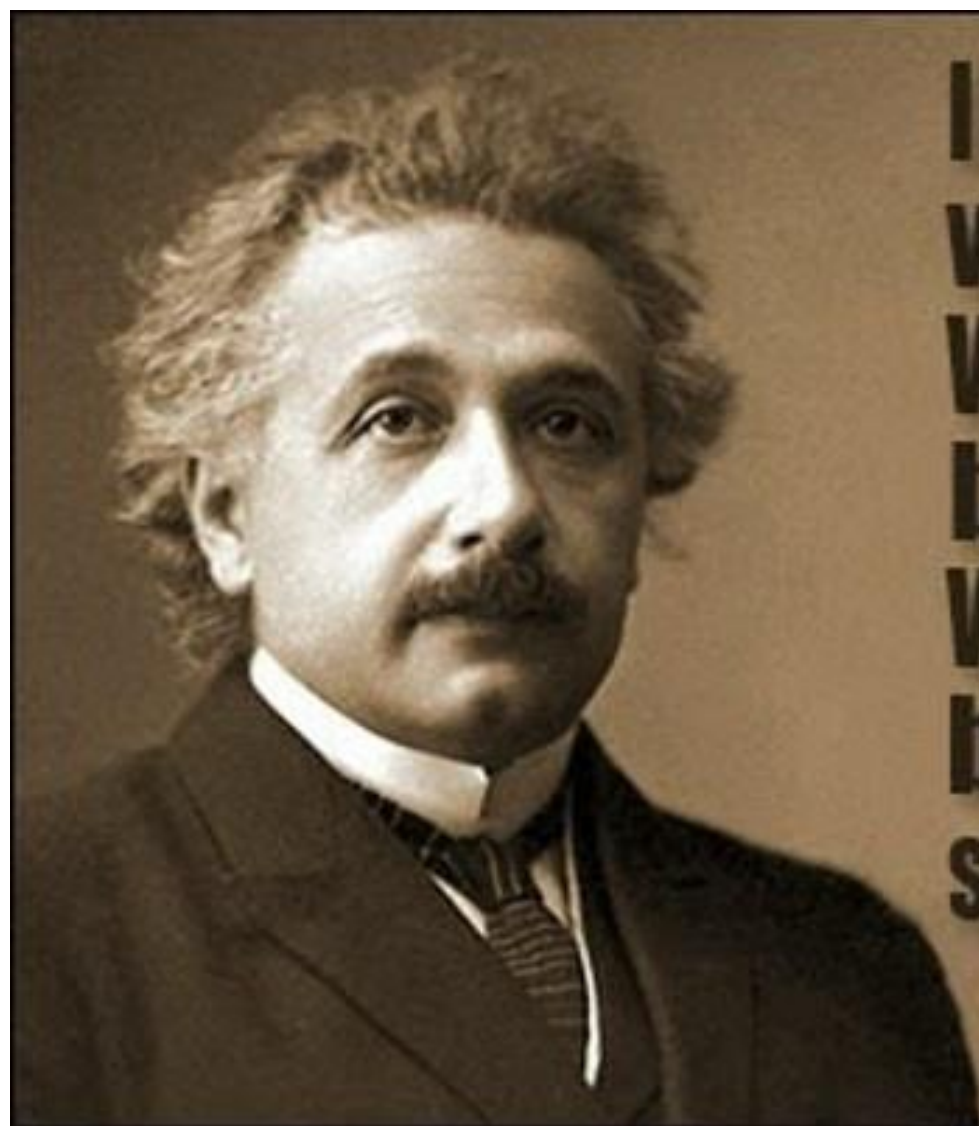
Number of nuclear warheads in countries worldwide in 2015

■ Nations with nuclear weapons ■ Nations hosting nuclear weapons
■ Nations in nuclear alliances



@StatistaCharts Source: ican



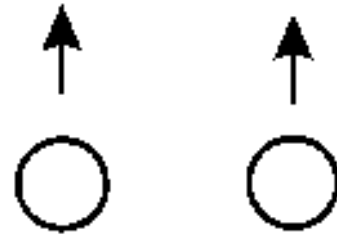
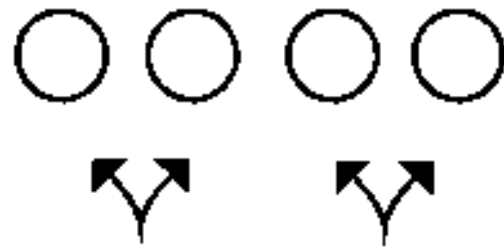


**I do not know with
what weapons
World War III will
be fought, but
World War IV will
be fought with
sticks and stones.**

--ALBERT EINSTEIN

The Exponential Minds

Mature Minds



Mature Minds



...



“ขอให้ถือผลประโยชน์ส่วนตัวเป็นที่สอง
 ประโยชน์ของเพื่อนมนุษย์เป็นกิจที่หนึ่ง
 ลาภทรัพย์และเกียรติยศจะตกมาแก่ท่านเอง
 ถ้าท่านทรงธรรมะแห่งอาชีพไว้ให้บริสุทธิ์”



คุณธรรม

Walailak University: Land of Glory



ขอบคุณครับ