URI 2035

Imagine the Future

Our hope …

Informative

Stimulating

Fun

We also hope to identify a path to continue the futures dialog at URI beyond the Summit.

second breakout

Outline

- Imagining the future
  - Short-term vs long-term
  - Exponential growth
  - The Drivers
- The technologies
  - Nanotechnology
  - Biotech
  - Artificial Intelligence
- Recent Developments
- Concluding Remarks

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Amara's Law

We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.

Amara's Law

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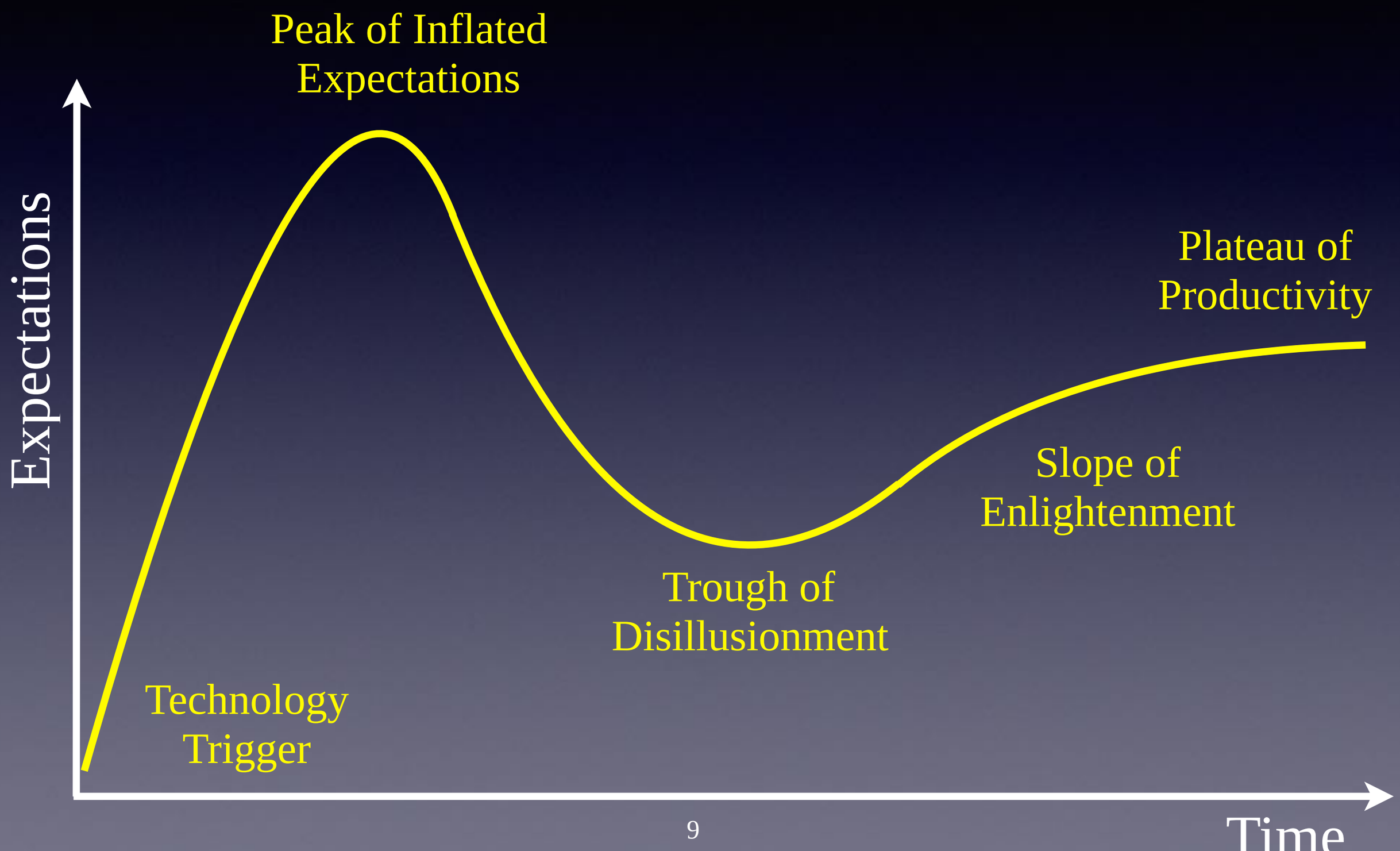
Short run < 5 years or so

Gartner Hype Cycle

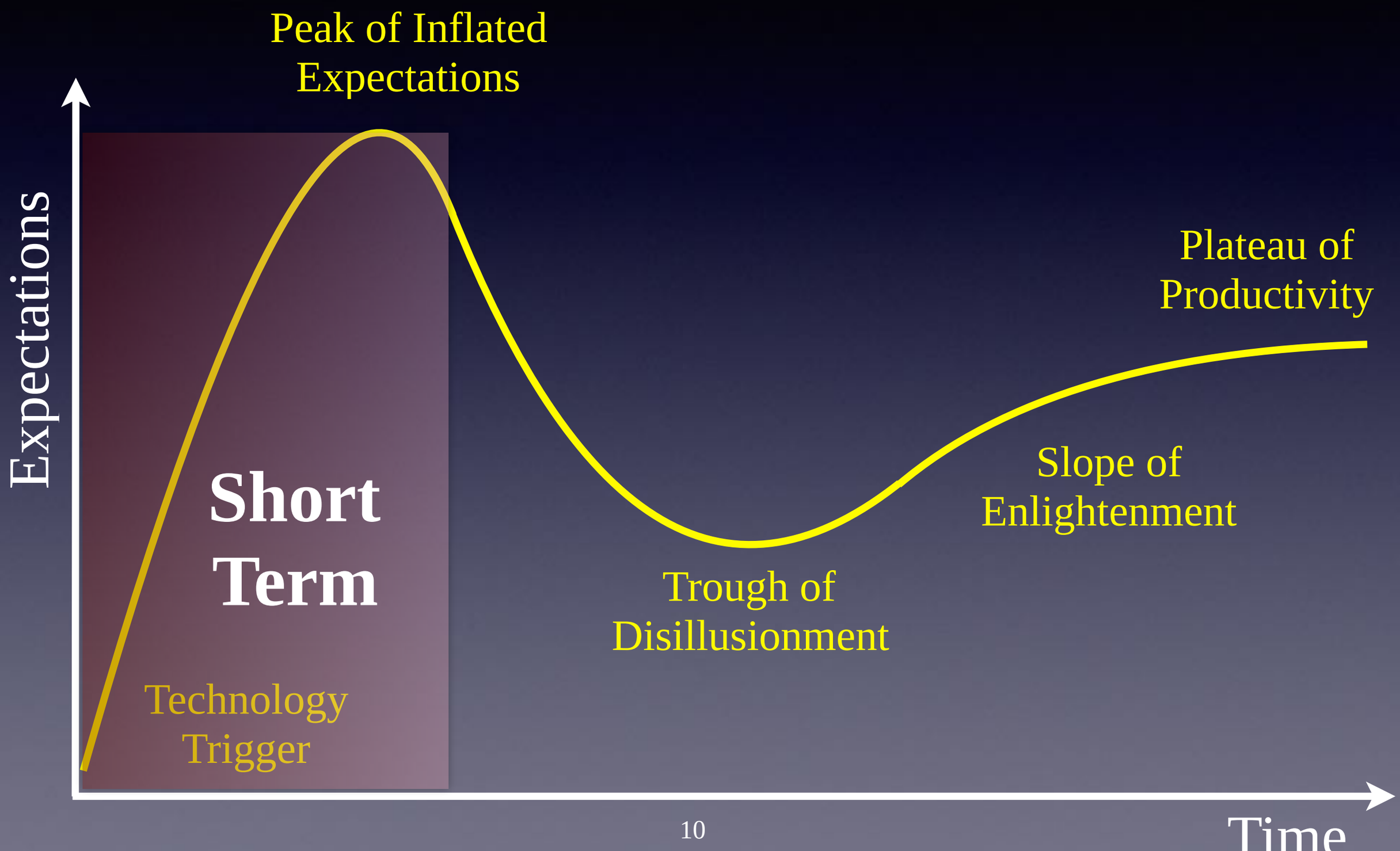
Provide a graphic representation of how a technology will evolve over time.

Hype Cycles are used to determine the promise of an emerging technology.

Gartner Hype Cycle



Gartner Hype Cycle



Amara's Law

We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.

Long run > 10 years or so

Clarke's Three Laws

1. When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong.

2.The only way of discovering the limits of the possible is to venture a little way past them into the impossible.

3. Any sufficiently advanced technology is indistinguishable from magic.

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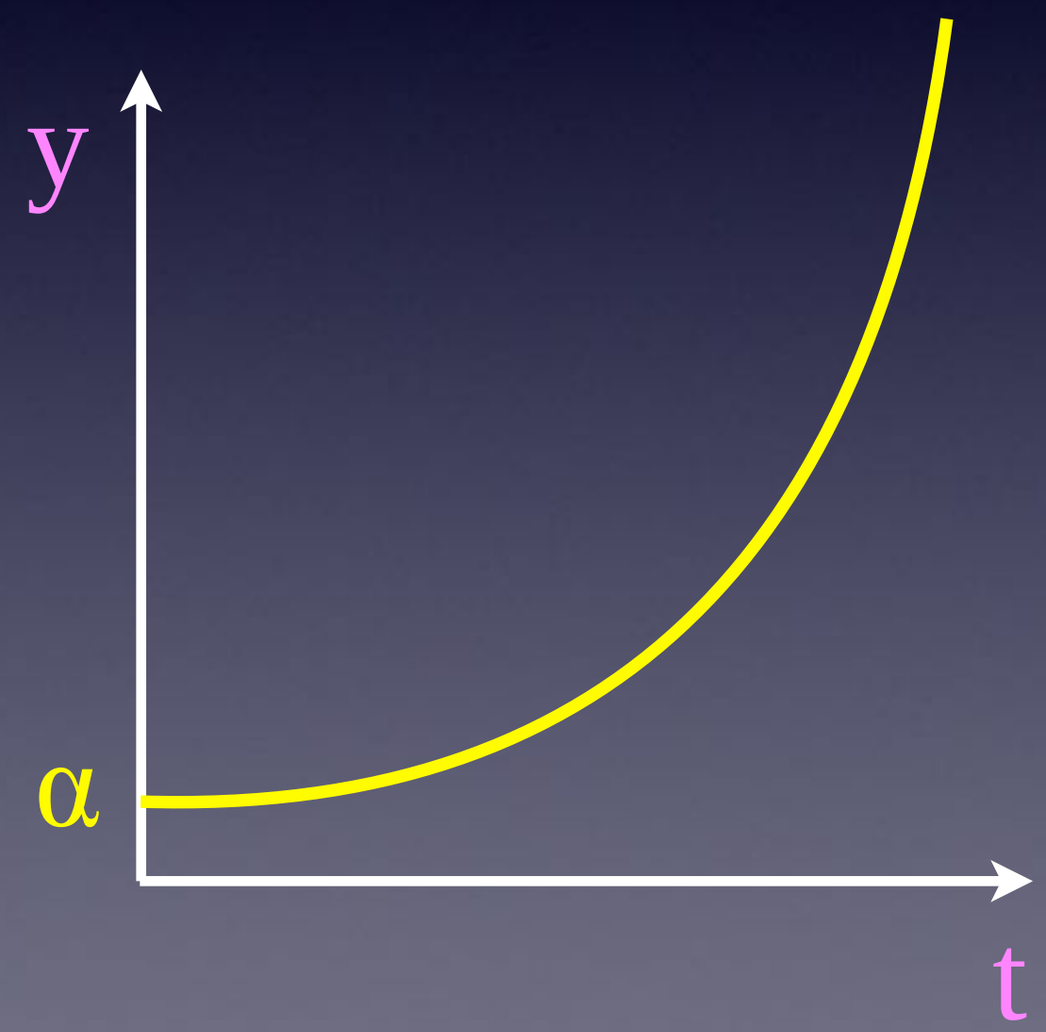
Many natural (and man made) systems grow exponentially

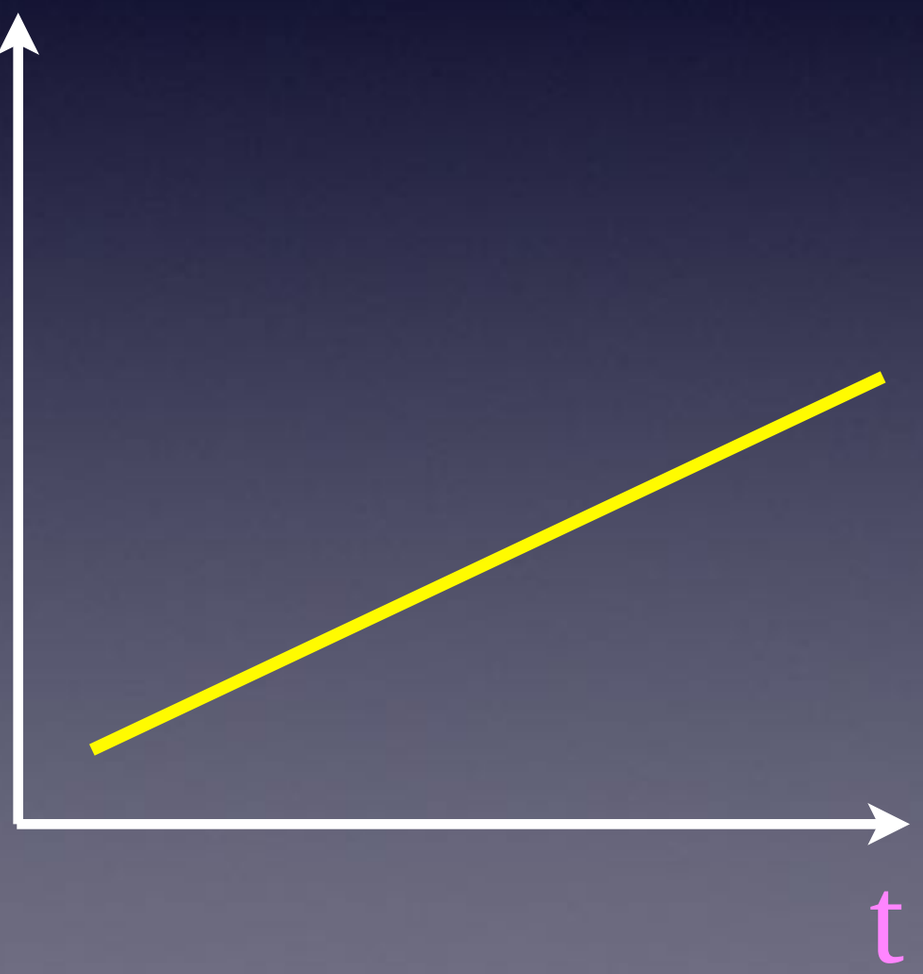
$$y = \alpha\, 2^{t/\tau}$$



Many natural (and man made) systems grow exponentially

$$y = \alpha\, 2^{t/\tau}$$

$$\log(y) = b + a\, t$$



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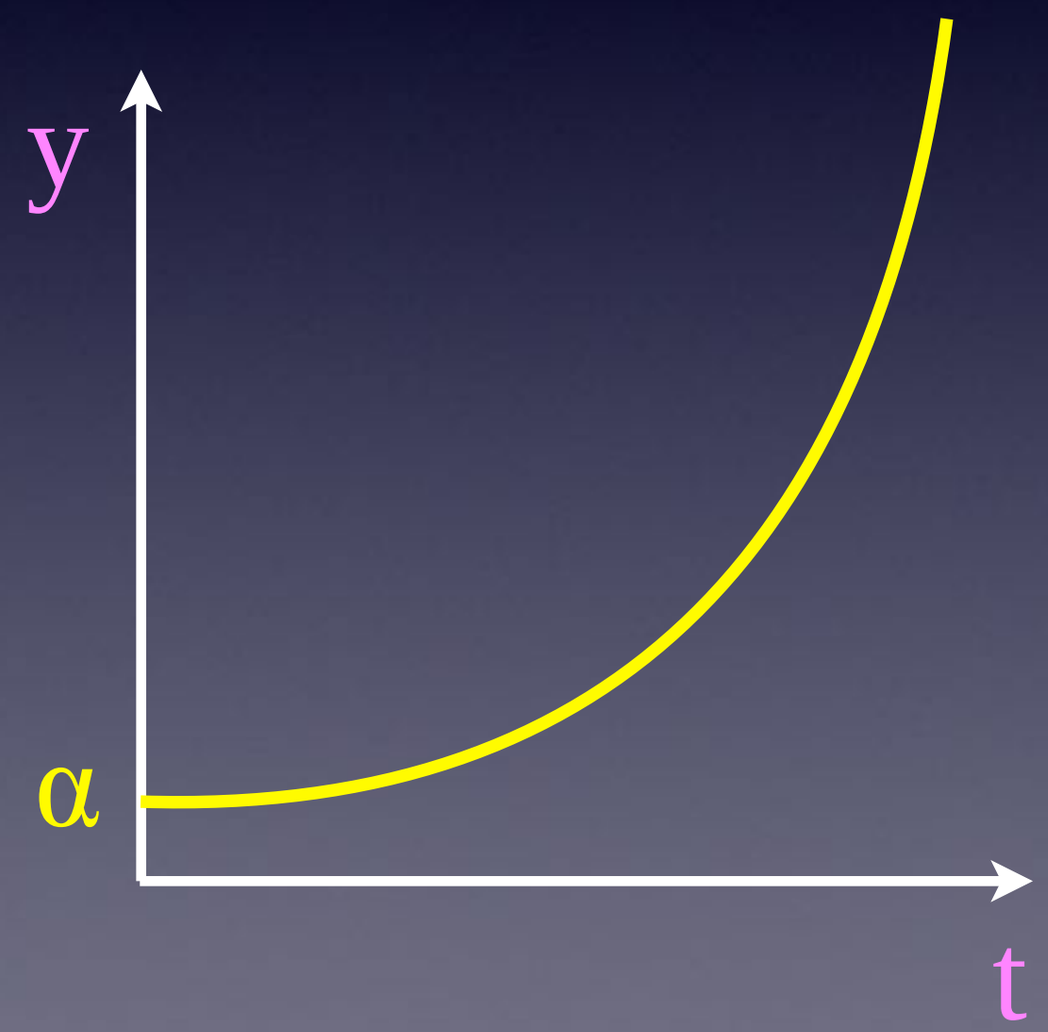


Nanotech Patents Issued by the US Patent Office

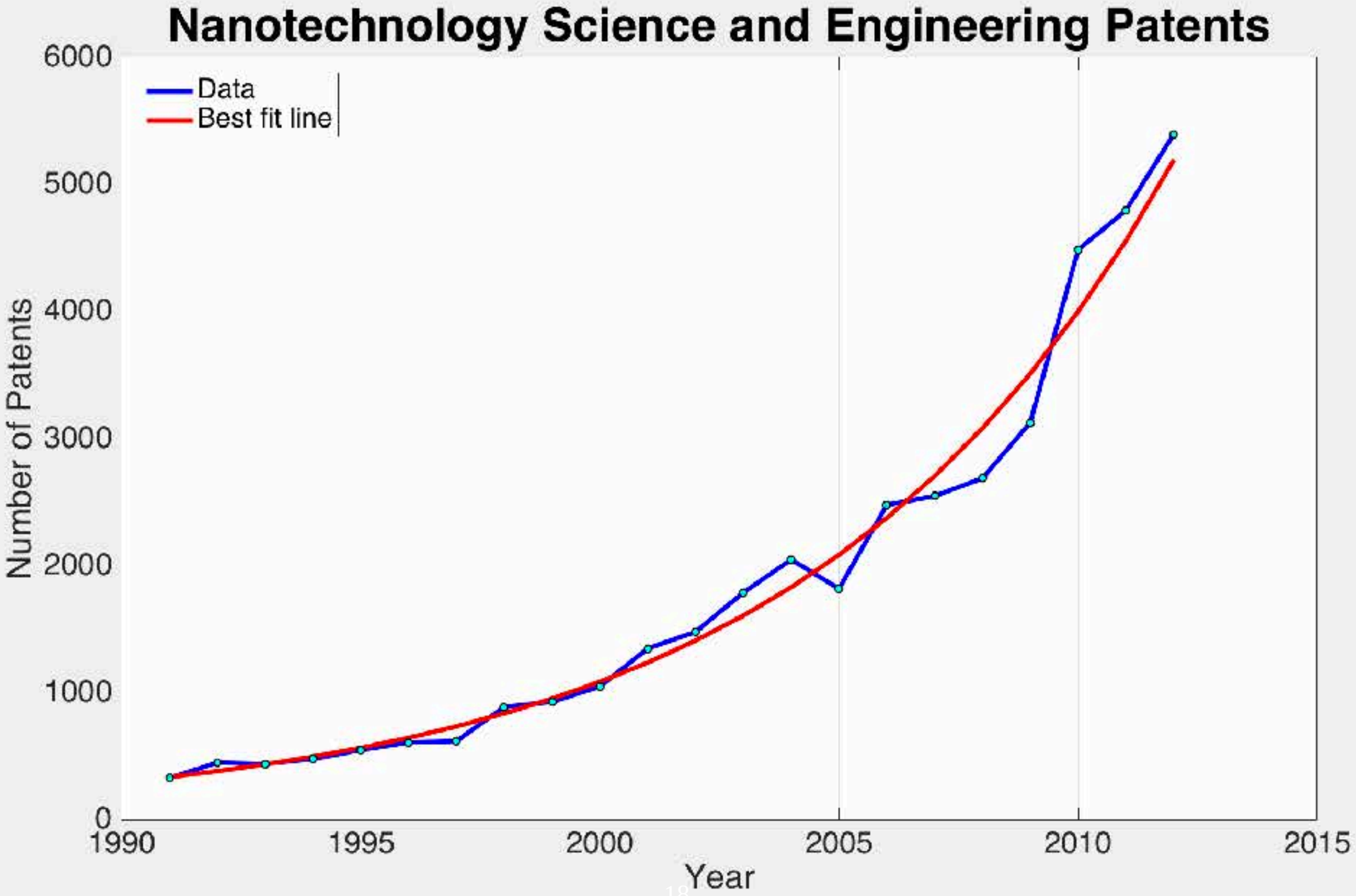
330 nano patents issued prior to 1991.

After the number doubled ~5 yrs.

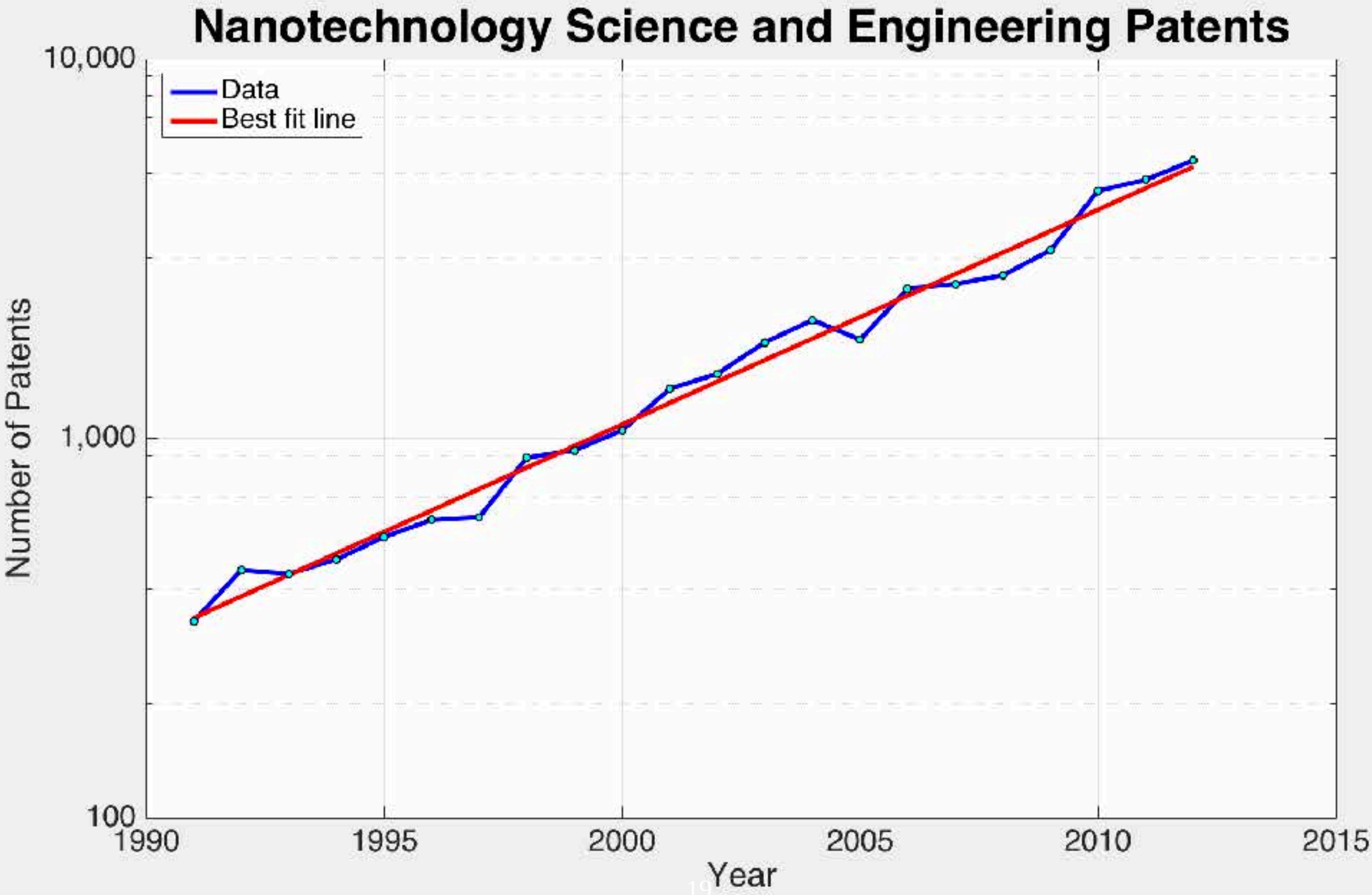
$$y = 330 \times 2^{t/5}$$

Years/5

Nano patents = 330 x 2



log(Nano patents) = log(330) + 0.06 Years

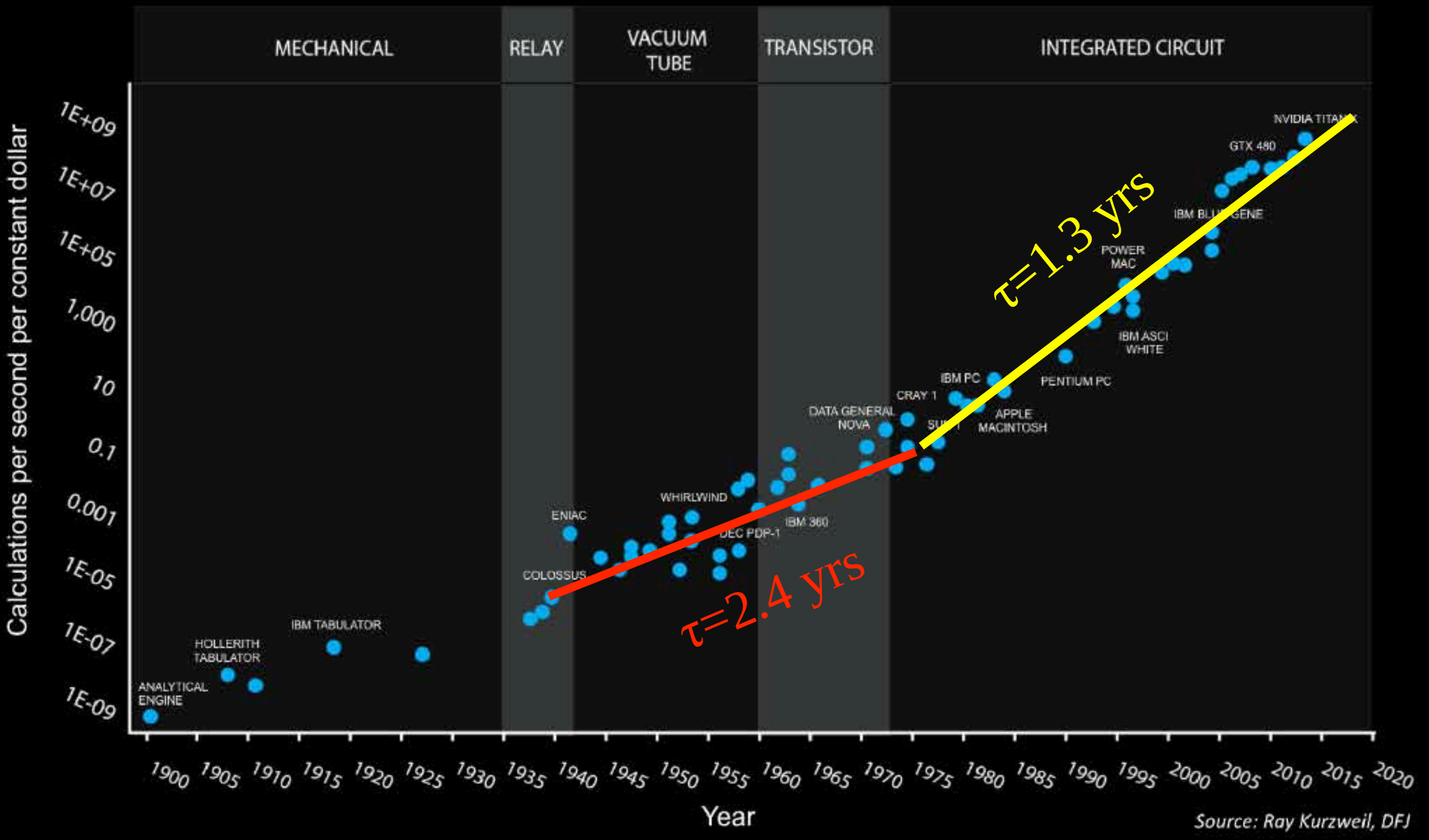


Moore's Law

Number of transistors per chip doubles every year.

A related number is the number of calculations/second per 2017 $

$$y(t) = \alpha\, 2^{t/\tau} \quad \text{with} \quad \tau = 1.3 \text{ yrs}$$


MECHANICAL
RELAY
VACUUM TUBE
TRANSISTOR
INTEGRATED CIRCUIT
Calculations per second per constant dollar
1E+09
1E+07
1E+05
1,000
10
0.1
0.001
1E-05
1E-07
1E-09
τ=1.3 yrs
τ=2.4 yrs
NVIDIA TITAN X
GTX 480
IBM BLUE GENE
POWER MAC
IBM ASCI WHITE
IBM PC
PENTIUM PC
CRAY 1
DATA GENERAL NOVA
APPLE MACINTOSH
WHIRLWIND
ENIAC
IBM 360
DEC PDP-1
COLOSSUS
IBM TABULATOR
HOLLERITH TABULATOR
ANALYTICAL ENGINE
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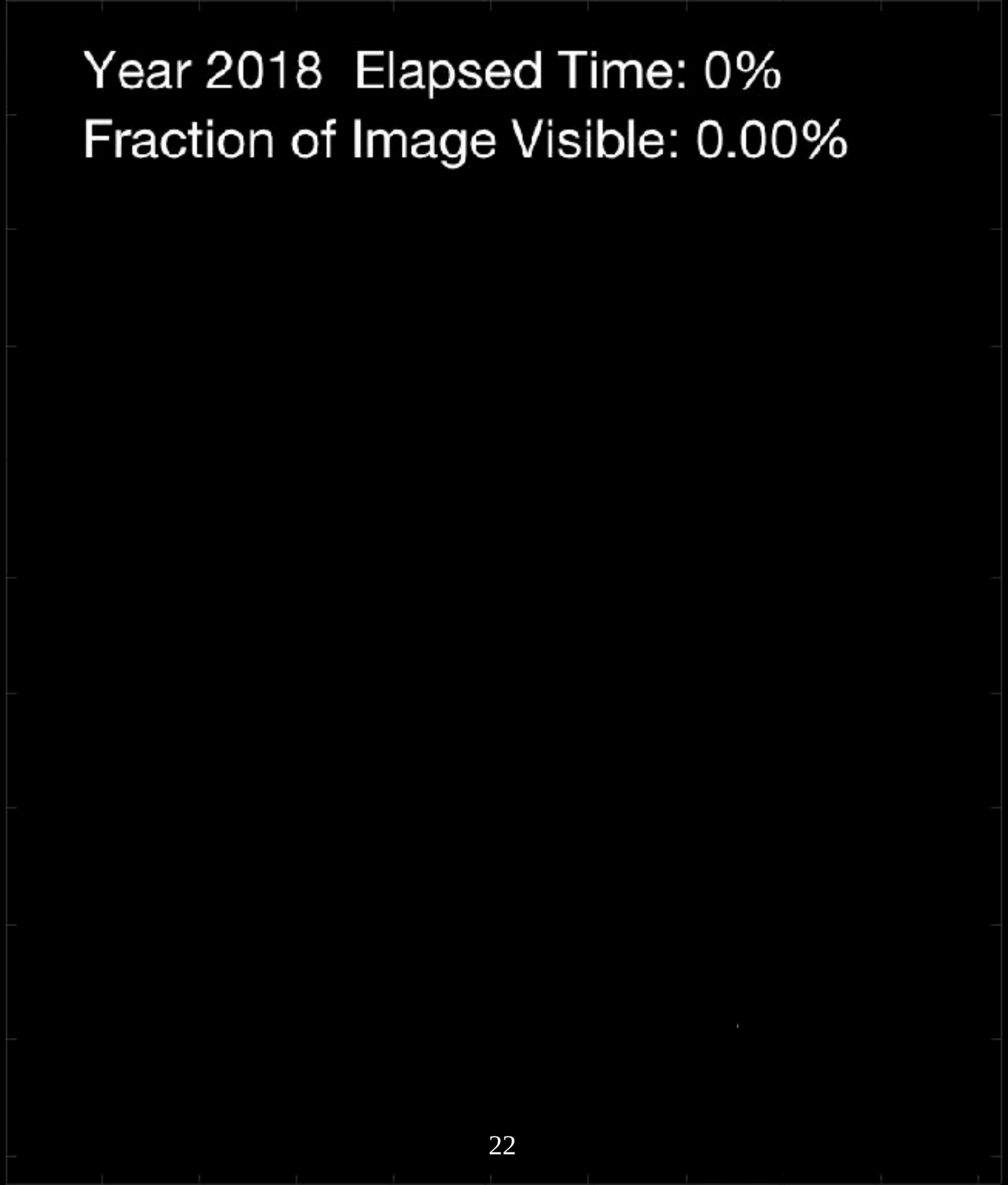
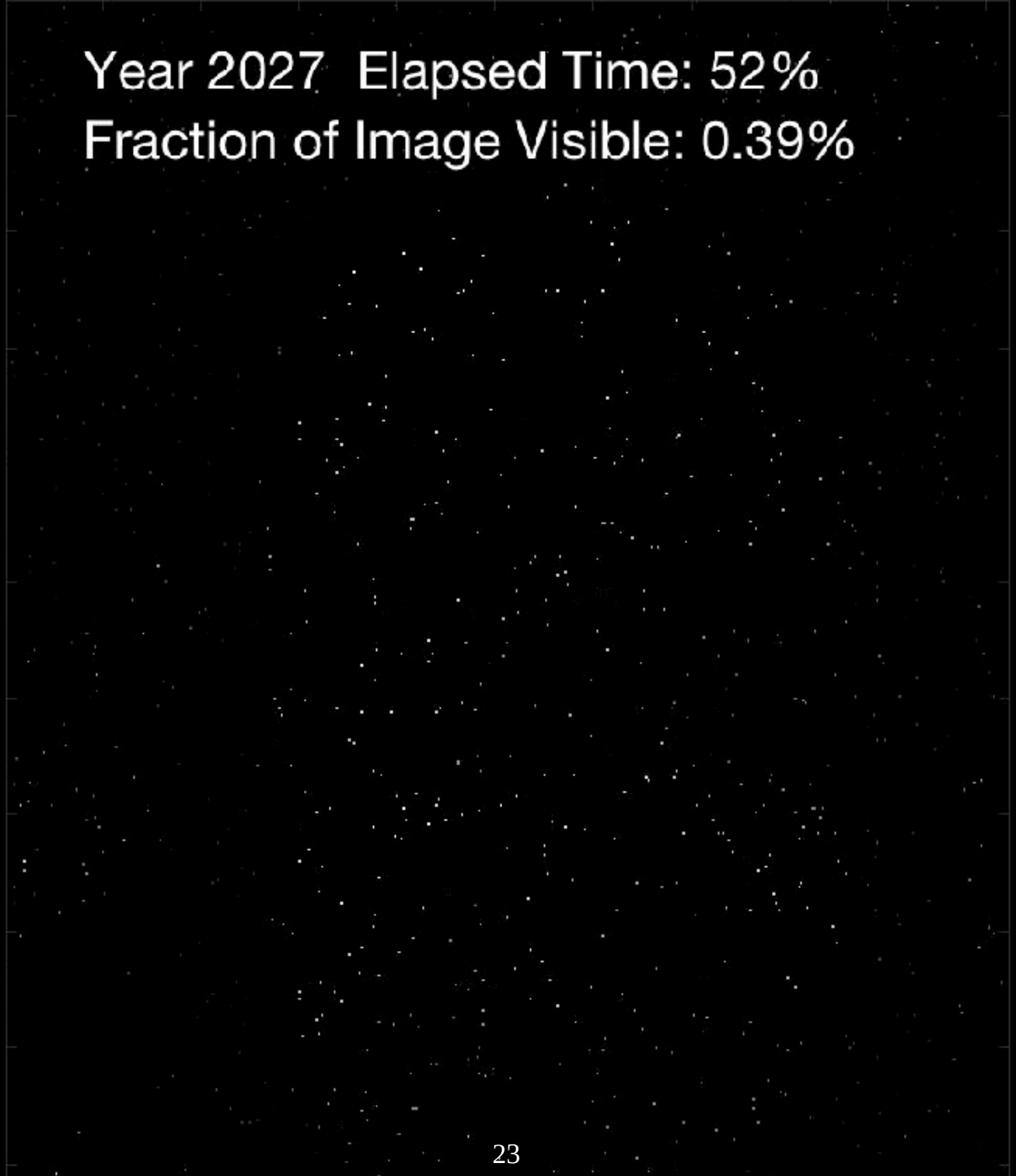
Year
Source: Ray Kurzweil, DFJ


Year 2018 Elapsed Time: 0%
Fraction of Image Visible: 0.00%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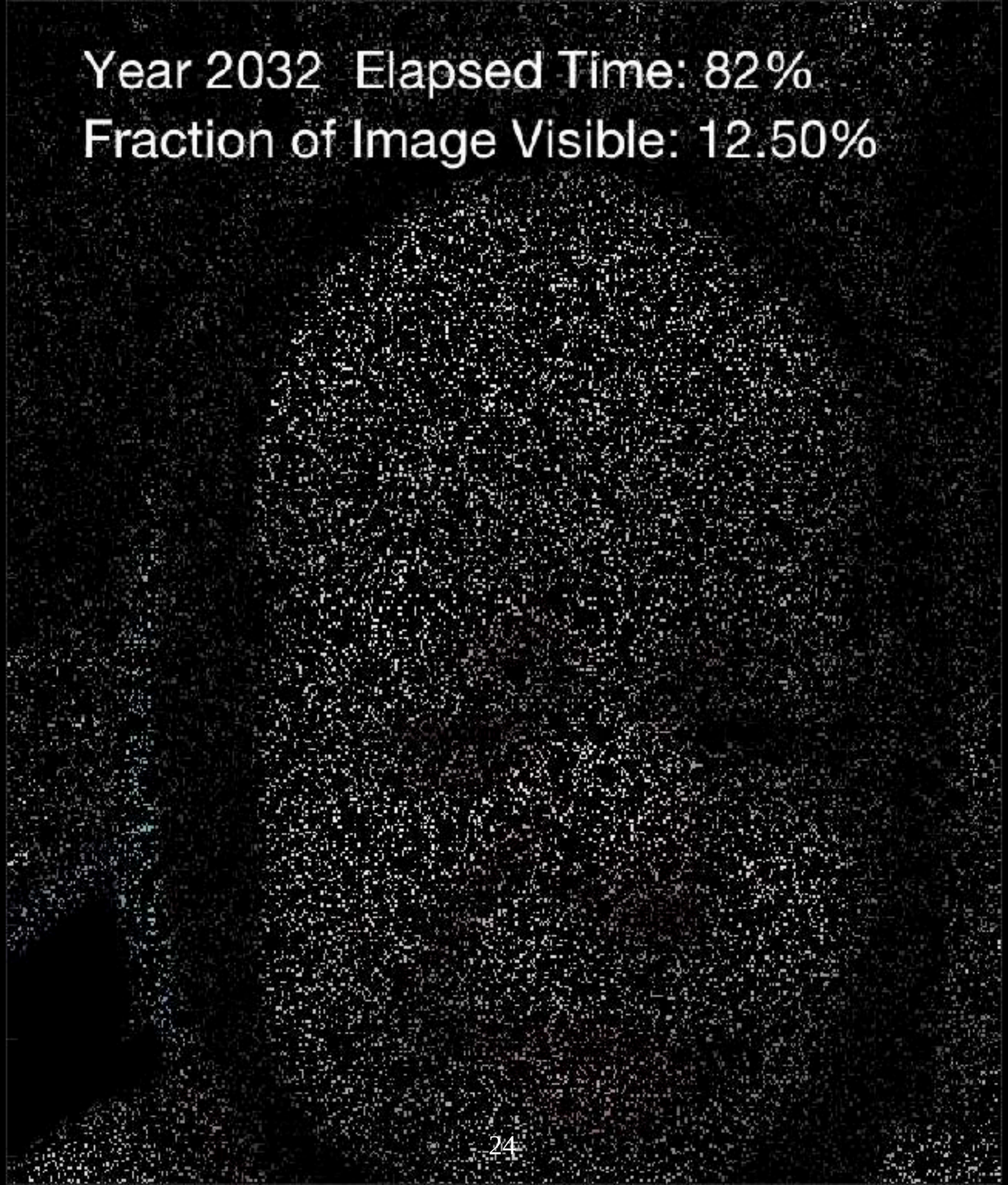
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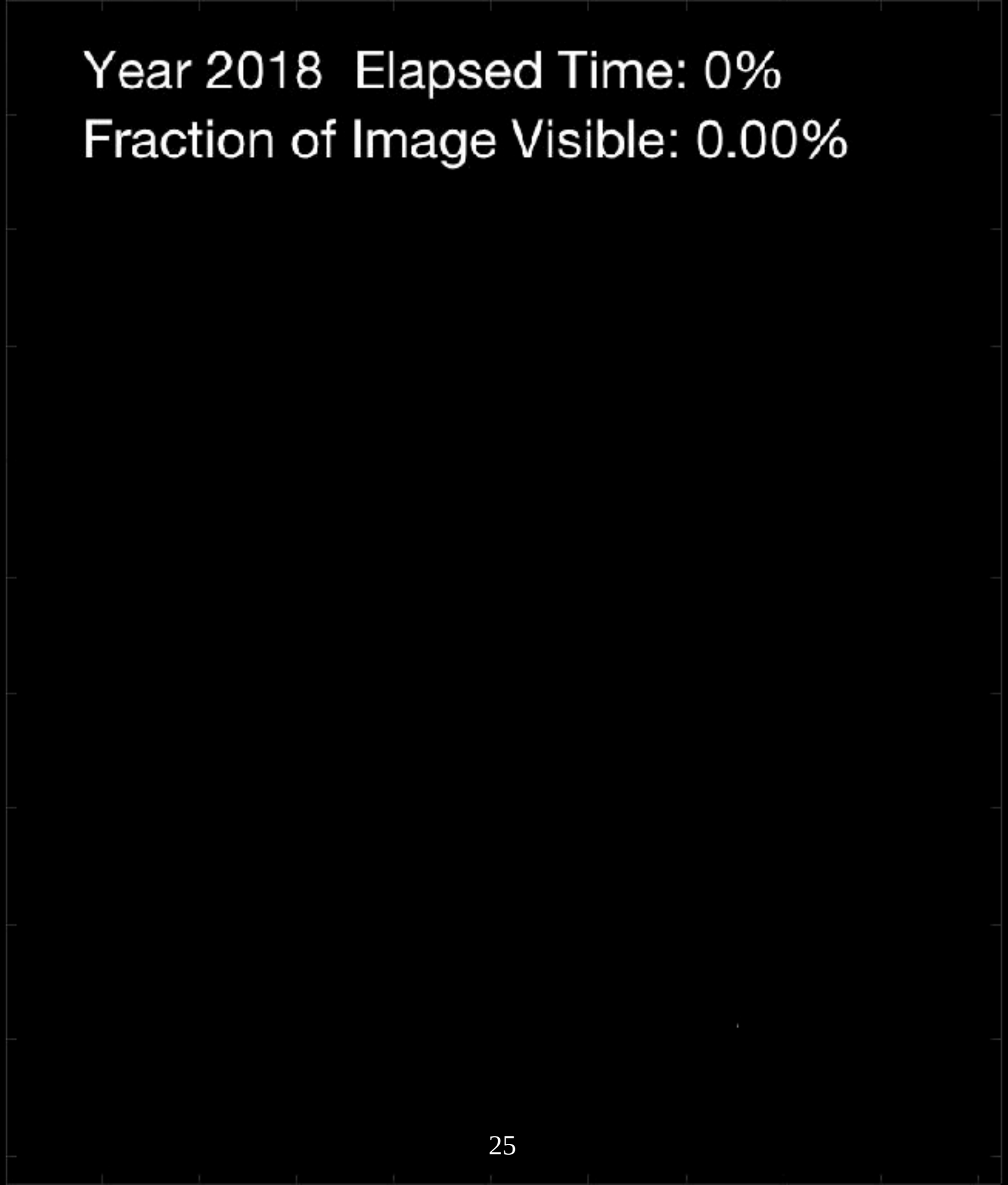
Year 2018 Elapsed Time: 0%
Fraction of Image Visible: 0.00%

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Imagining technologies of the future requires an examination of the drivers.

- Gaming
- Military
- Health care
- Elderly
- Environment
- Quality of life
- Safety

In 2010, gaming surpassed the military as the major driver for tech change

Volume is especially good at spurring the creation of new applications.

Some technologies attributed to/enhanced by gaming

- Color LCD displays
- Joy stick
- Graphics Processing Units (GPUs)
- **Virtual/augmented reality**

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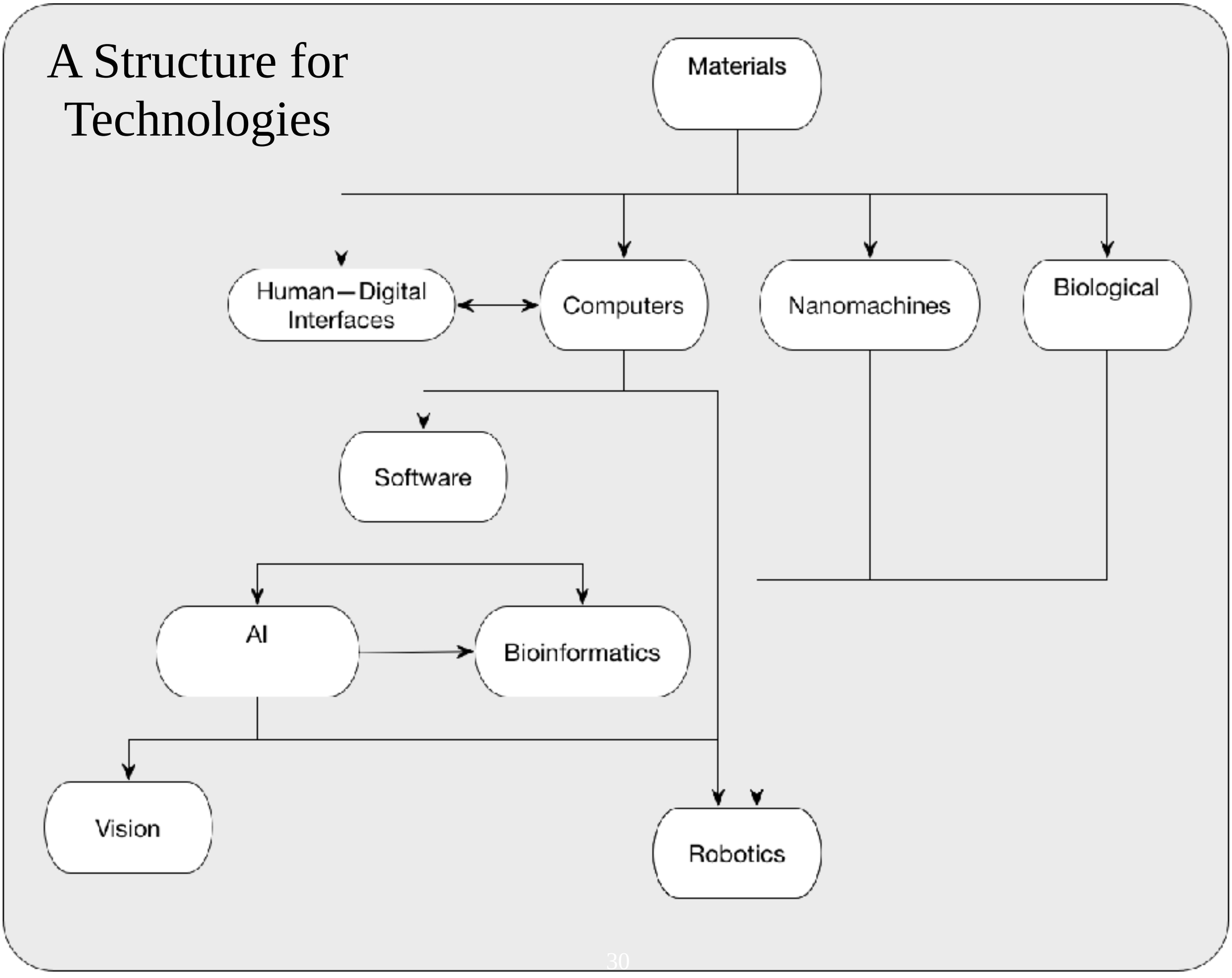
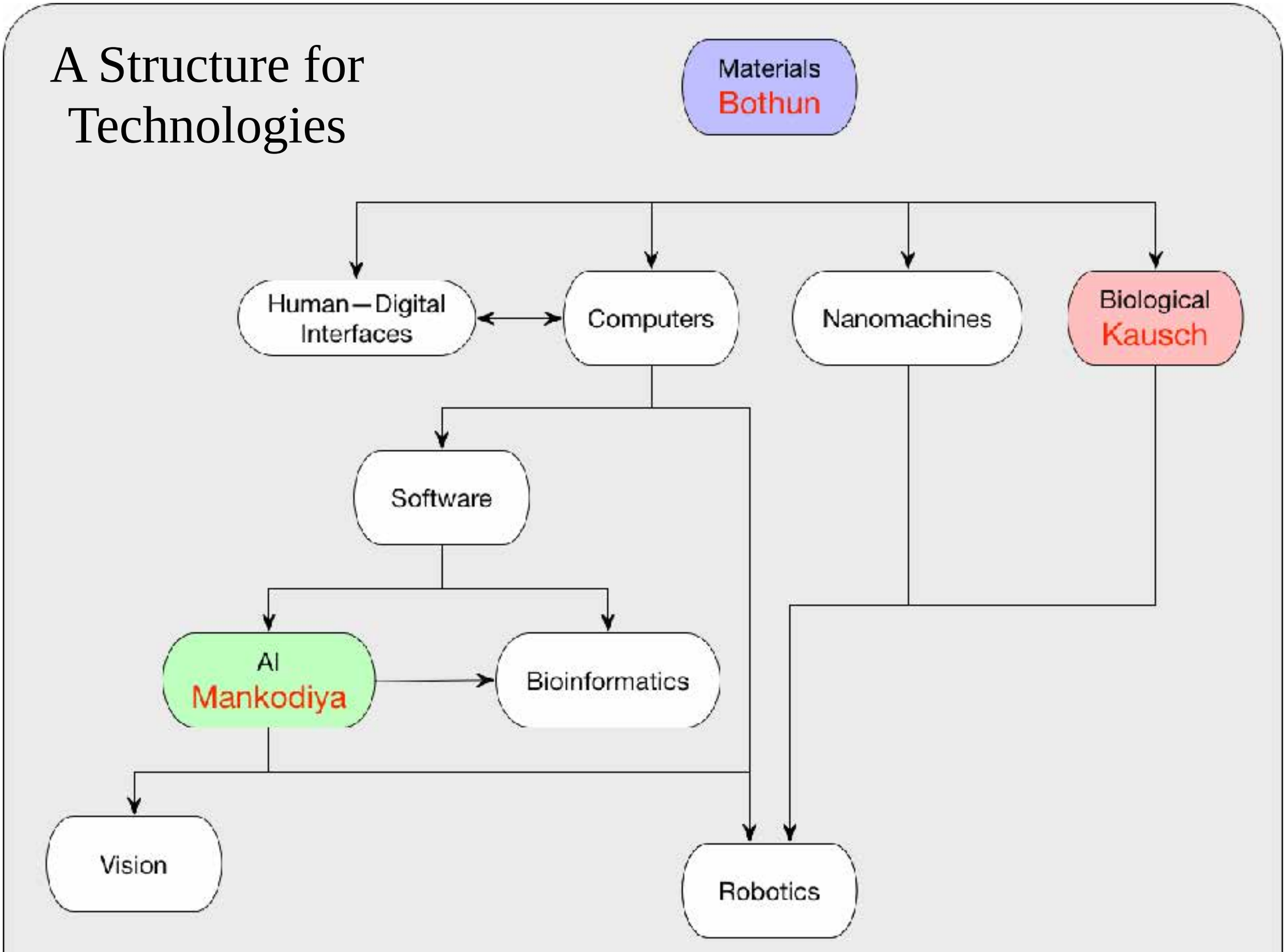
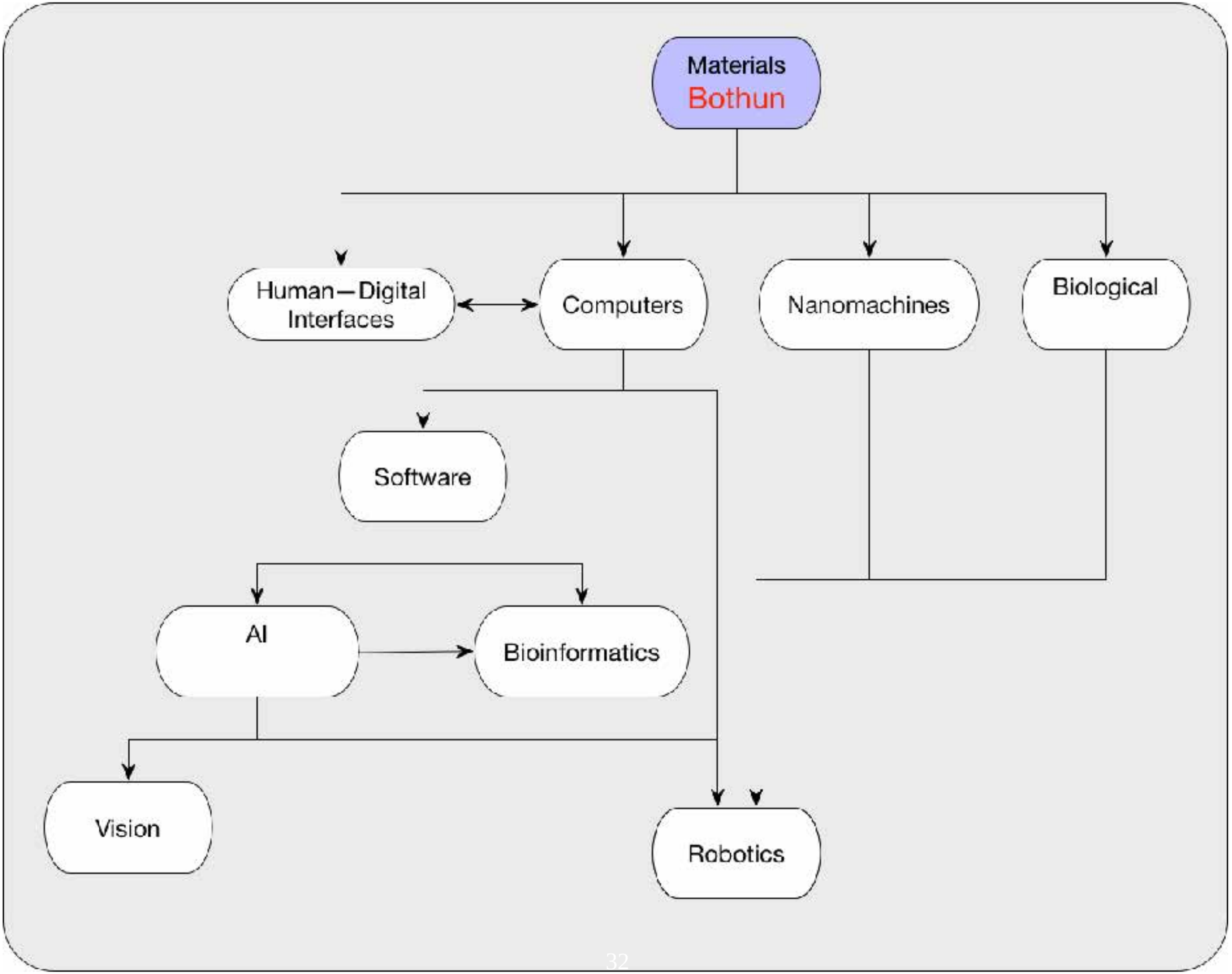
A Structure for Technologies



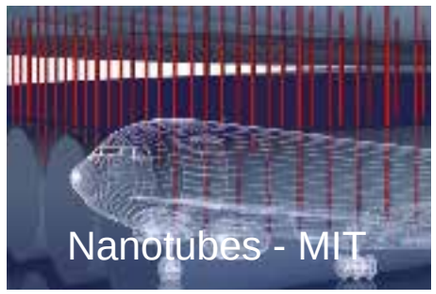
A Structure for Technologies

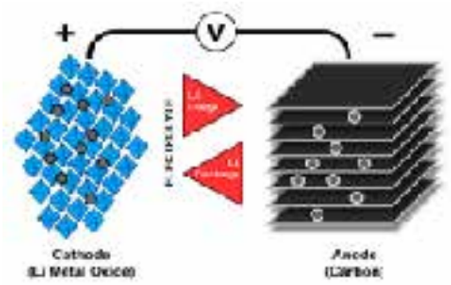



Materials
Bothun
Human—Digital Interfaces
Computers
Nanomachines
Biological
Software
AI
Bioinformatics
Vision
Robotics

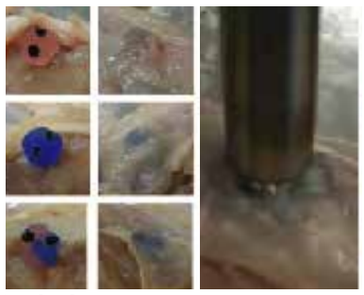
Enabling the Advanced Materials revolution

- Materials with improved performance or new functionalities

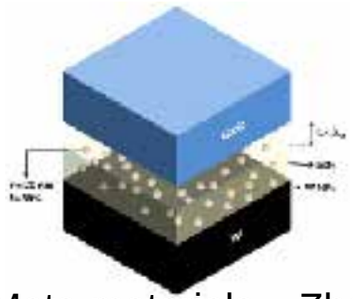




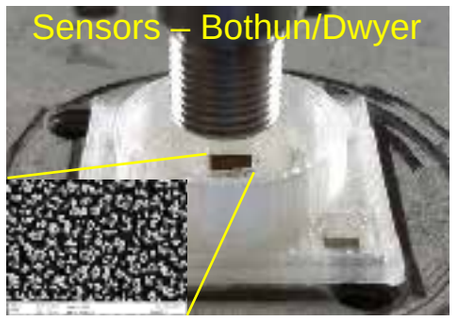
Electrodes – Bose/Lucht



Gel therapy – Kennedy



Meta-materials – Zheng



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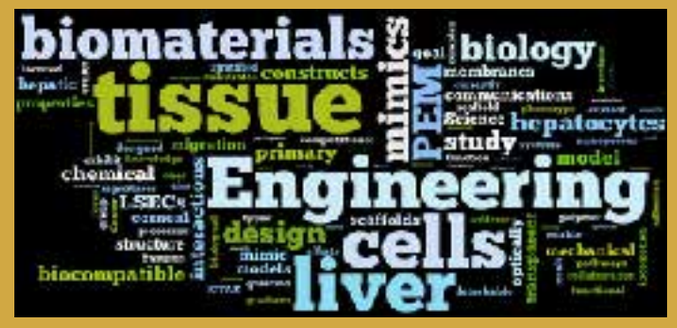
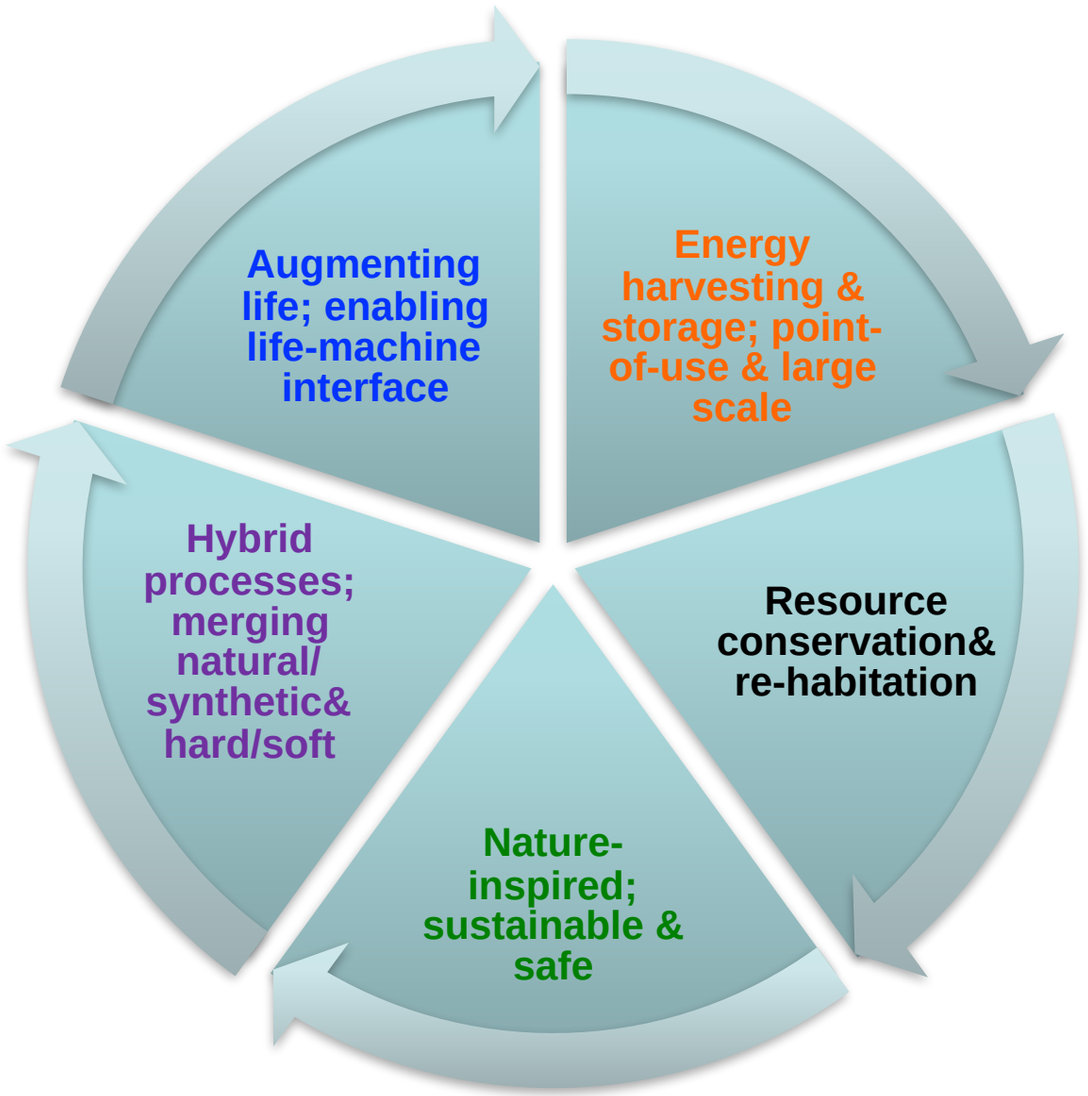
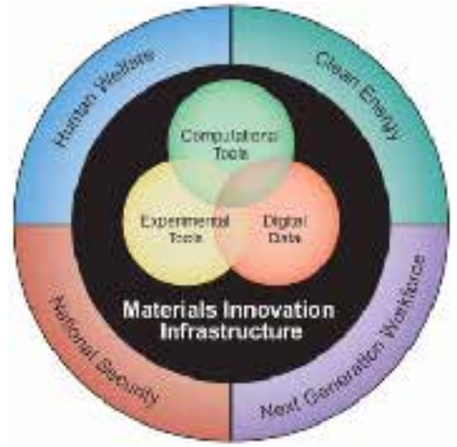


THINK BIG WE DO℠

Enabling the Advanced Materials revolution

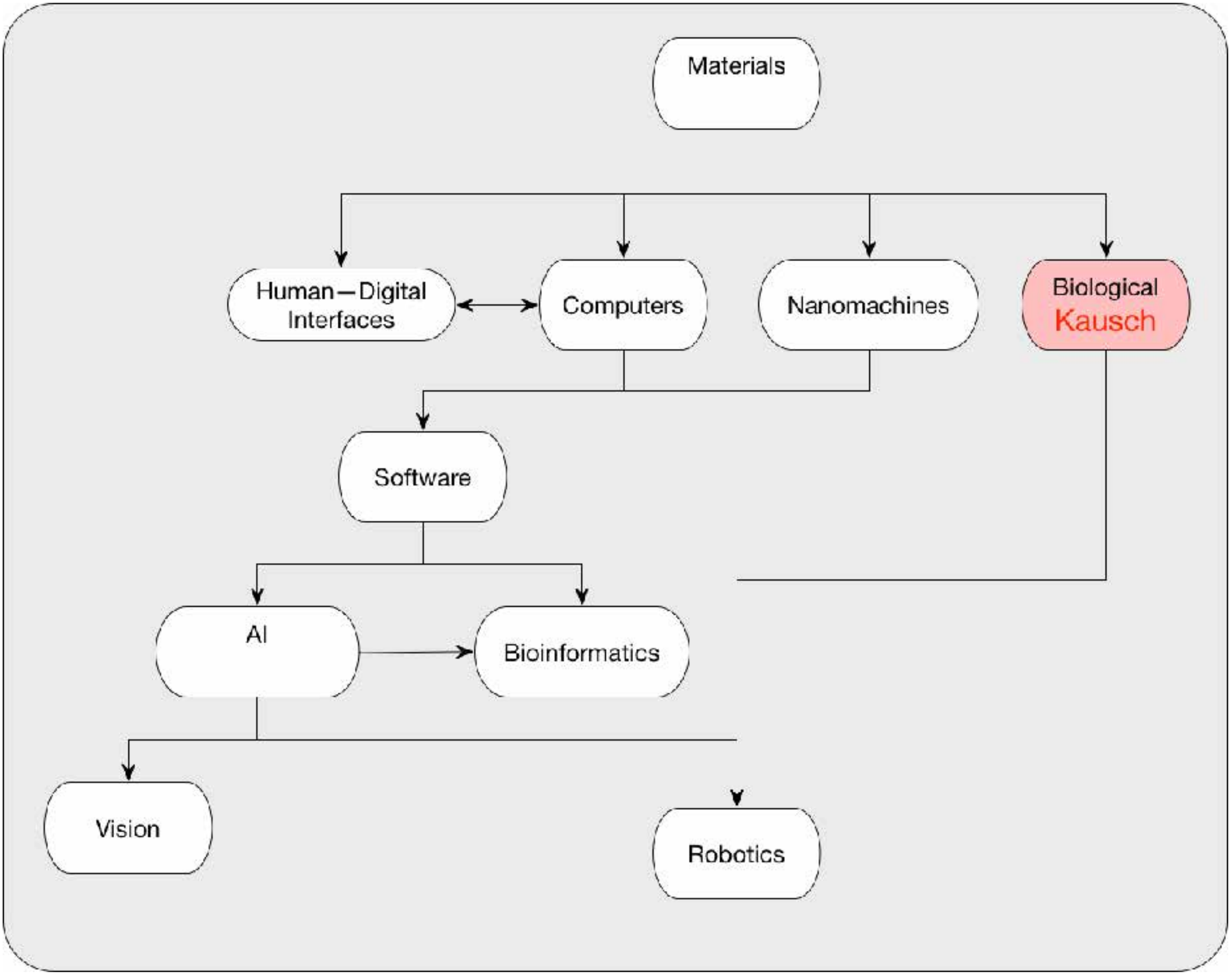


Materials Genome Initiative



Scholars & students with:

- Ability to integrate experiment, theory, & computation & employ new “tools”
- Understanding of life-cycle analysis, barriers to commercialization
- Ability to access & utilize data for structure/function, to guide design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Nanomachines
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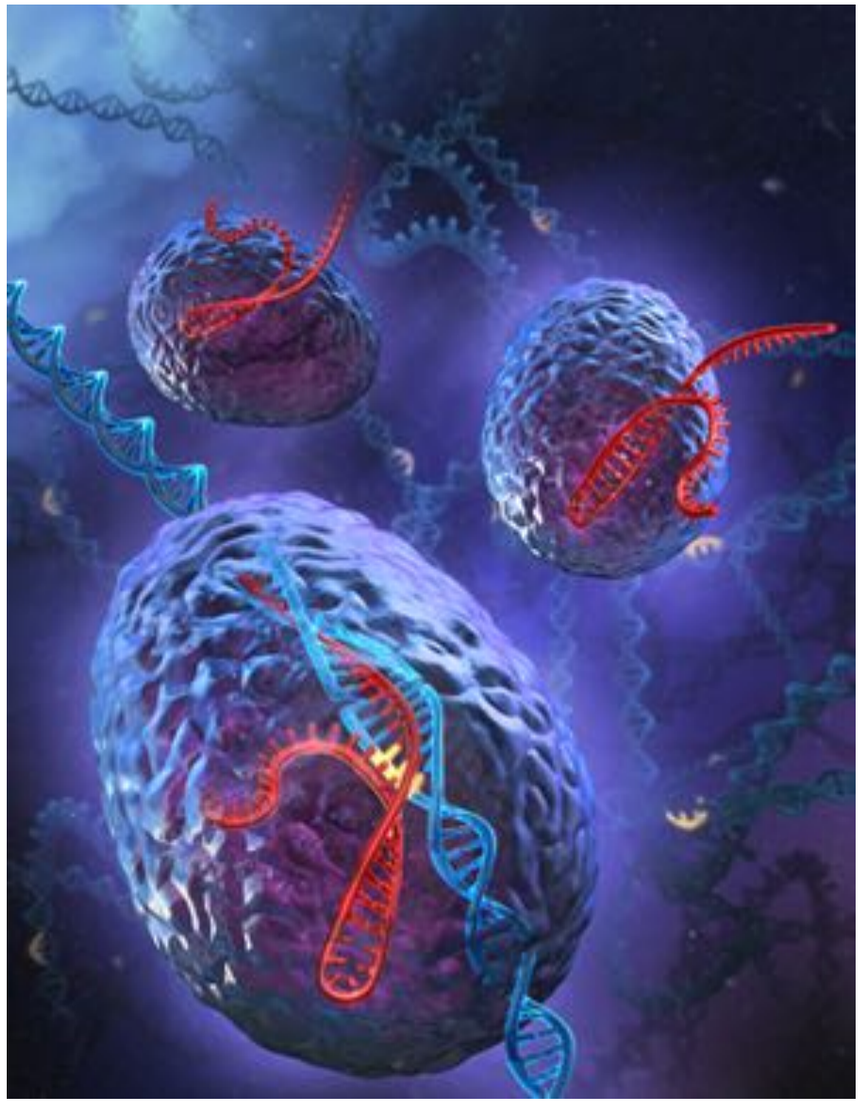
Robotics

Biotechnology



CRISPR

Medical

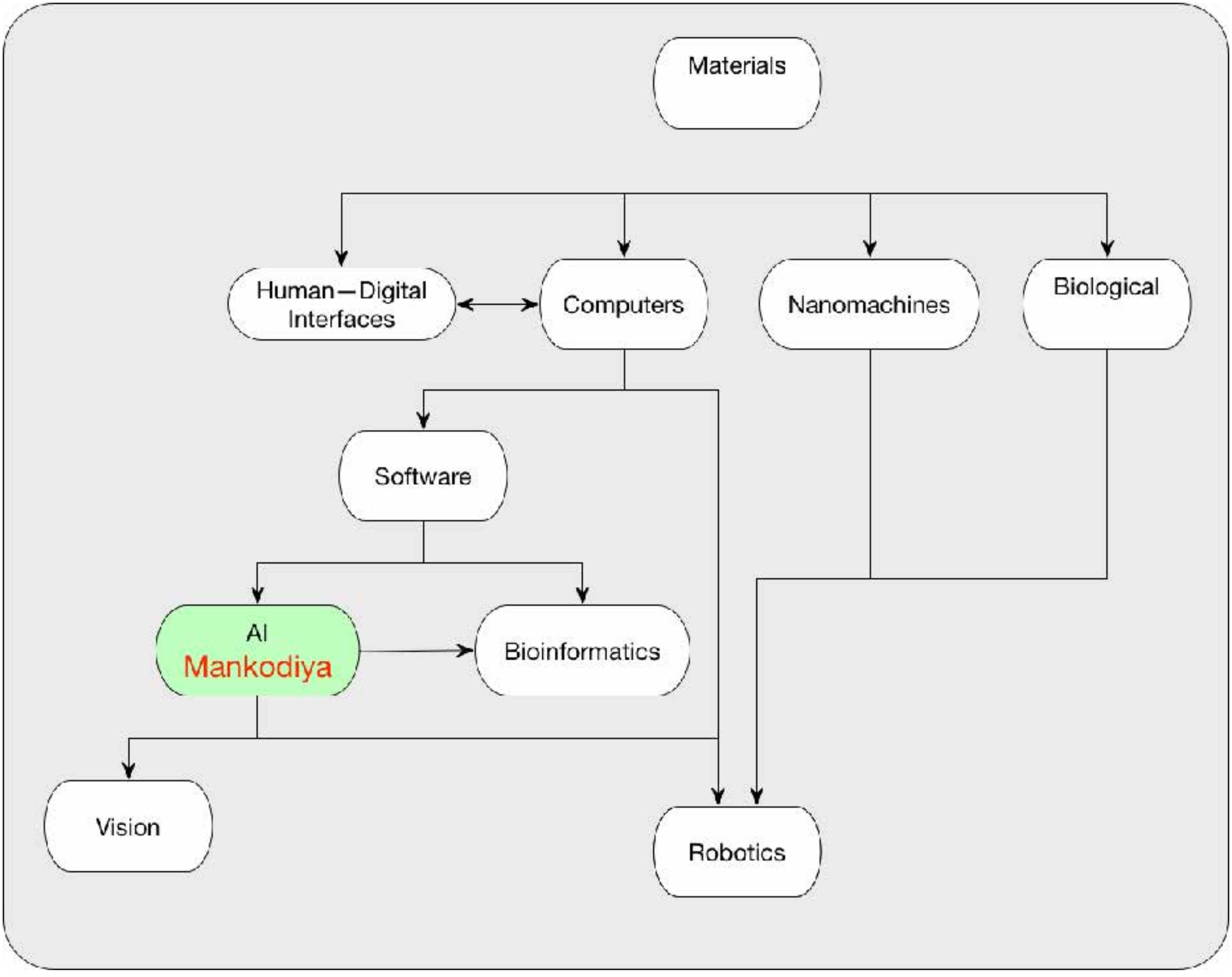
Stem Cells
Regenerative Medicine
Genomics
Prosthetics

Pharmaceutical

Precision Medicine
Gene Therapy
Immuno-therapy
Antibody Drugs

Agricultural

Advanced Breeding
Yield Improvement
Gene Editing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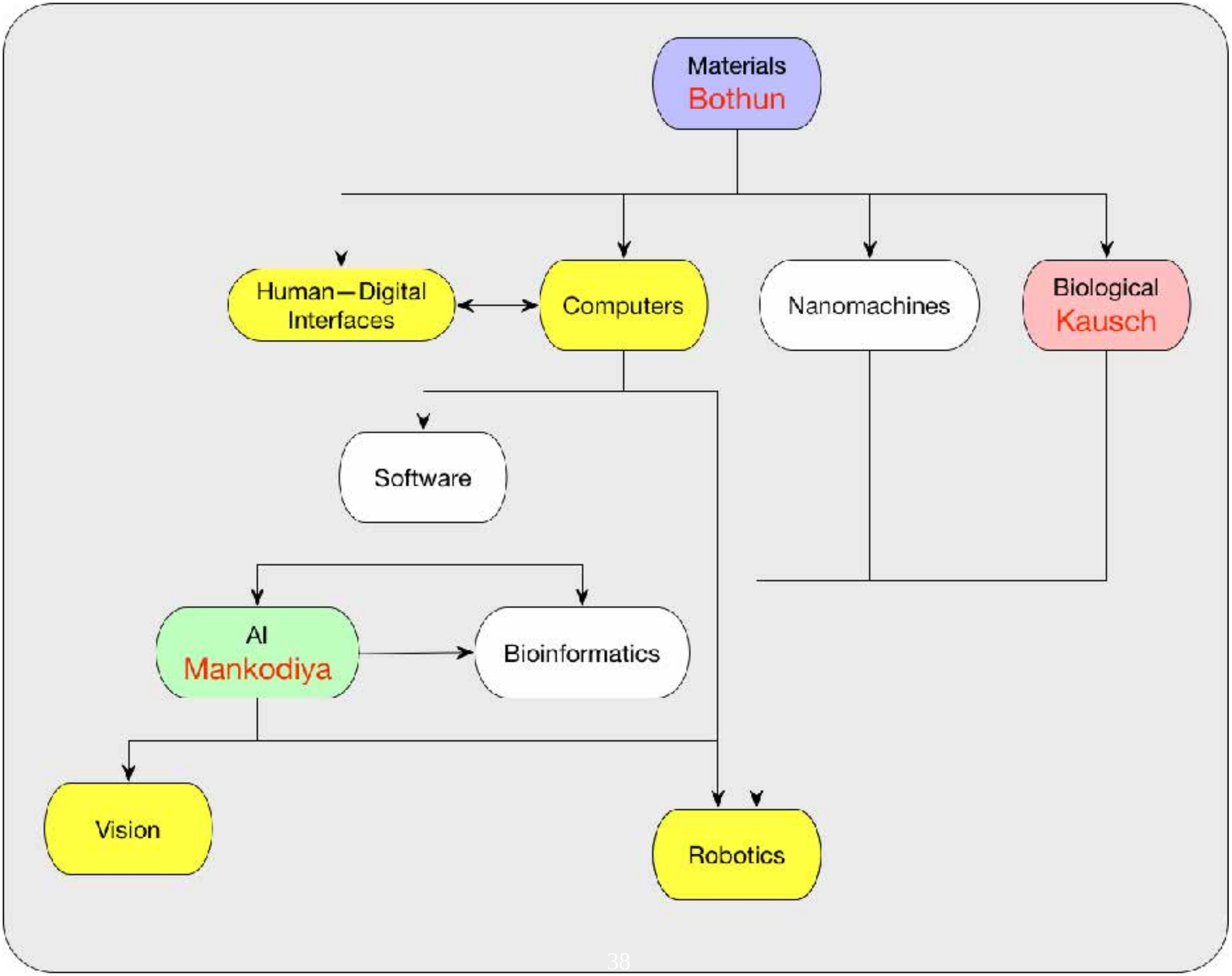
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Example of the Growth of Artificial Intelligence Software

A constant refrain: computers are only as creative as the people who program them.

AlphaGo-Lee beat Lee Sedol in 4 of 5 games of Go in March 2016.

Over several months AlphaGo-Lee trained on thousands of amateur and professional games.

Example of the Growth of Artificial Intelligence Software

AlphaGo-Zero, the next gen Go playing game, beat AlphaGo-Lee in 100 of 100 games in October 2017.

And it did so with 1/10 processing power.

Given rules of Go, AlphaGo-Zero trained for ~3 days with **no** human input.

AlphaZero, most recent version, achieved superhuman skill in Go, **chess and other game types** knowing only their rules.

Think about it

In days, AlphaZero discovered new knowledge, developing unconventional strategies and creative new moves.

And it did so in a variety of games.

It accumulated 1000s of years of human knowledge in just a few days.

And ~3 years ago most experts predicted machines would not achieve superhuman capability in Go for >10 years

But Go and chess are games

Doesn’t mean AI will function effectively in unstructured human environments.

Agreed - today, AI does not deal well in such environments.

But it will, the question is when?

And when it does, what are the consequences

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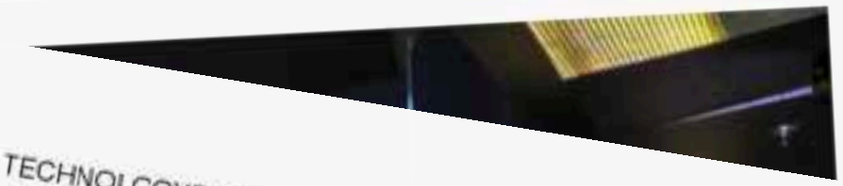
Artificial Intelligence

BUSINESS DAY

A.I. Has Arrived in Investing. Humans Are Still Dominating.

JAN. 12, 2018



TECHNOLCGYREVIEW.COM

RELATED COVERAGE

MIT TECHNOLOGY REVIEW
VOL. 121 | NO. 1

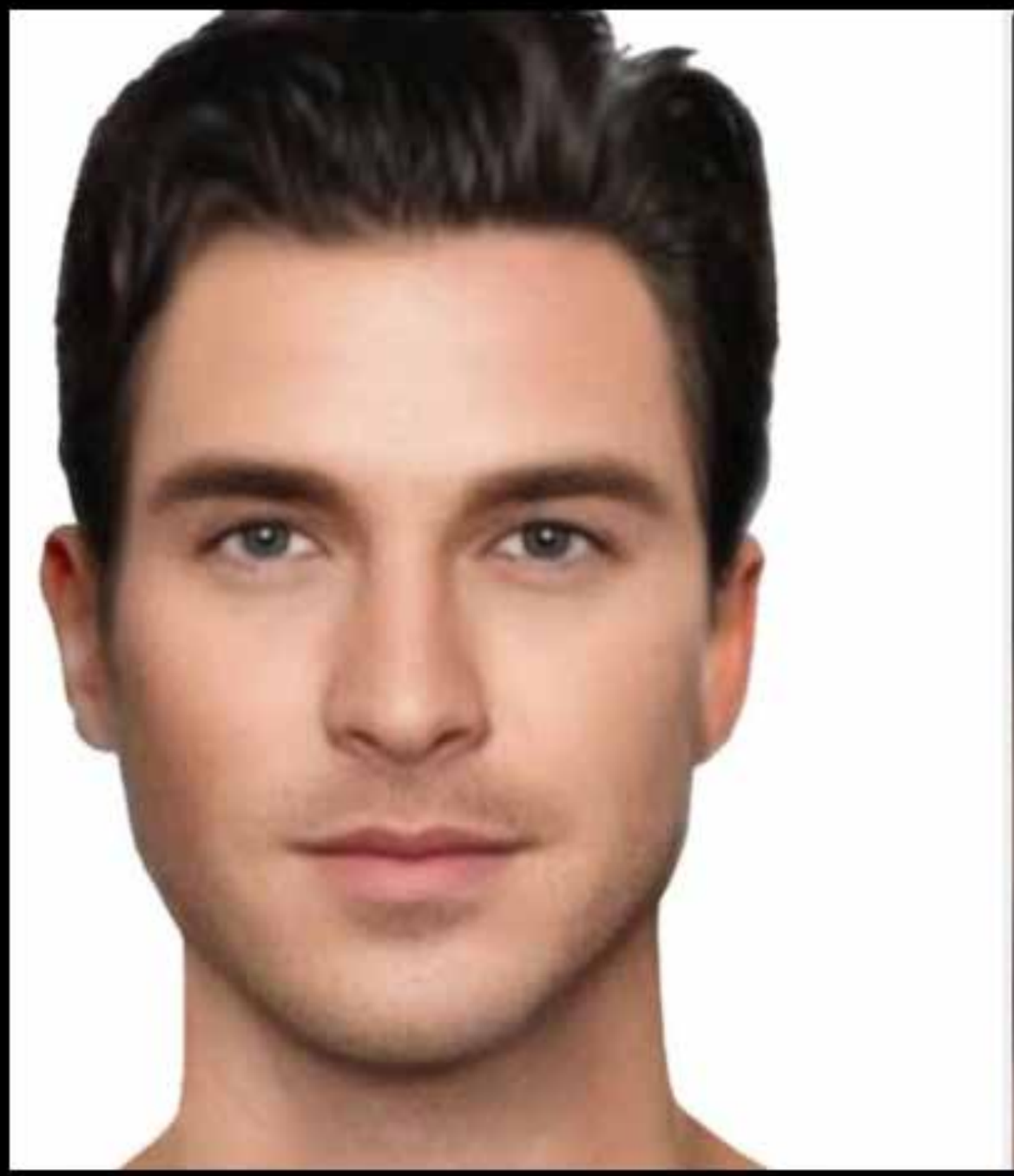
Andrew Ng Has a Chatbot That Can Help with Depression

Woebot combines cognitive behavioral therapy with advances in natural language to create a virtual counselor.

I mostly used predefined answers that it offered me, but even when I strayed from the script a little, it didn't get tripped up.

You are guided through conversations with Woebot, but the system is able to understand a pretty wide range of answers. It checks in with you every

Computer Generated Face(s)?



Computers

Science News

from research organizations

Memristors power quick-learning neural network

Date: December 22, 2017

Source: University of Michigan

Summary: A new type of neural network made with memristors can dramatically improve the efficiency of teaching machines to think like humans. The network, called a reservoir computing system, ...dict words before they are said during conversation, and help predict future outcomes

Science News

from research organizations

Making the internet of things possible with a new breed of 'memristors'

Easily printable, organic thin films can retain data for more than 10 years ... power, work with low voltages -- and become the building block of ... ers that mimic the human brain

Date: January 10, 2018

Source: Aalto University

Biotech

ROBBIE GONZALEZ SCIENCE 01.09.18 05:00 AM

SCIENTISTS FIGURE OUT HOW TO MAKE MUSCLES FROM SCRATCH

Science News *from research organizations*

Scientists make cells that enable the sense of touch

Researchers are the first to create sensory interneurons from stem cells

Date: January 11, 2018

Source: University of California - Los Angeles Health Sciences

Summary: Researchers have, for the first time, coaxed human stem cells to become sensory interneurons [illegible] give us our sense of touch. The new protocol could be a step toward stem cell- [illegible]tion in paralyzed people who have lost feeling in parts of their

Science News *from research organizations*

CRISPR treatment prevents hearing loss in mice

Date: December 20, 2017

Source: Howard Hughes Medical Institute

Summary: A single treatment of a genome editing agent partially preserved hearing in mice with genetic deafness. The work could one day help scientists treat certain forms of genetic hearing [illegible] humans.

Optics

Science News

from research organizations

Single metalens focuses all colors of the rainbow in one point

Lens opens new possibilities in virtual and augmented reality

Date: January 1, 2018

Source: Harvard John A. Paulson School of Engineering and Applied Sciences

Summary: Metalenses -- flat surfaces that use nanostructures to focus light -- promise to revolutionize optics by replacing the bulky, curved lenses currently used in optical devices with a simple, flat ... these metalenses have remained limited in the spectrum of light they can focus ...rchers has developed the first single lens that can focus the entire visite light -- in the same spot and in high resolution.

Science News

from research organizations

Now entering, lithium niobate valley

Researchers demonstrate high-quality optical microstructures using lithium niobate

Date: December 21, 2017

Source: Harvard John A. Paulson School of Engineering and Applied Sciences

Summary: Lithium niobate is already one of the most widely used optical materials, well-known for its electro-optic properties but it is notoriously difficult to fabricate high-quality devices on a small scale using lithium niobate, an obstacle that has so far ruled out practical integrated, on-chip applications. Now, researchers have developed a technique to fabricate high-performance optical microstructures using lithium niobate, opening the door to ultra-efficient integrated photonic circuits, quantum photonics, microwave-to-optical

Robotics

ALEX DAVIES TRANSPORTATION 01.12.18 12:01 AM

GM WILL LAUNCH ROBOCARS WITHOUT STEERING WHEELS NEXT YEAR

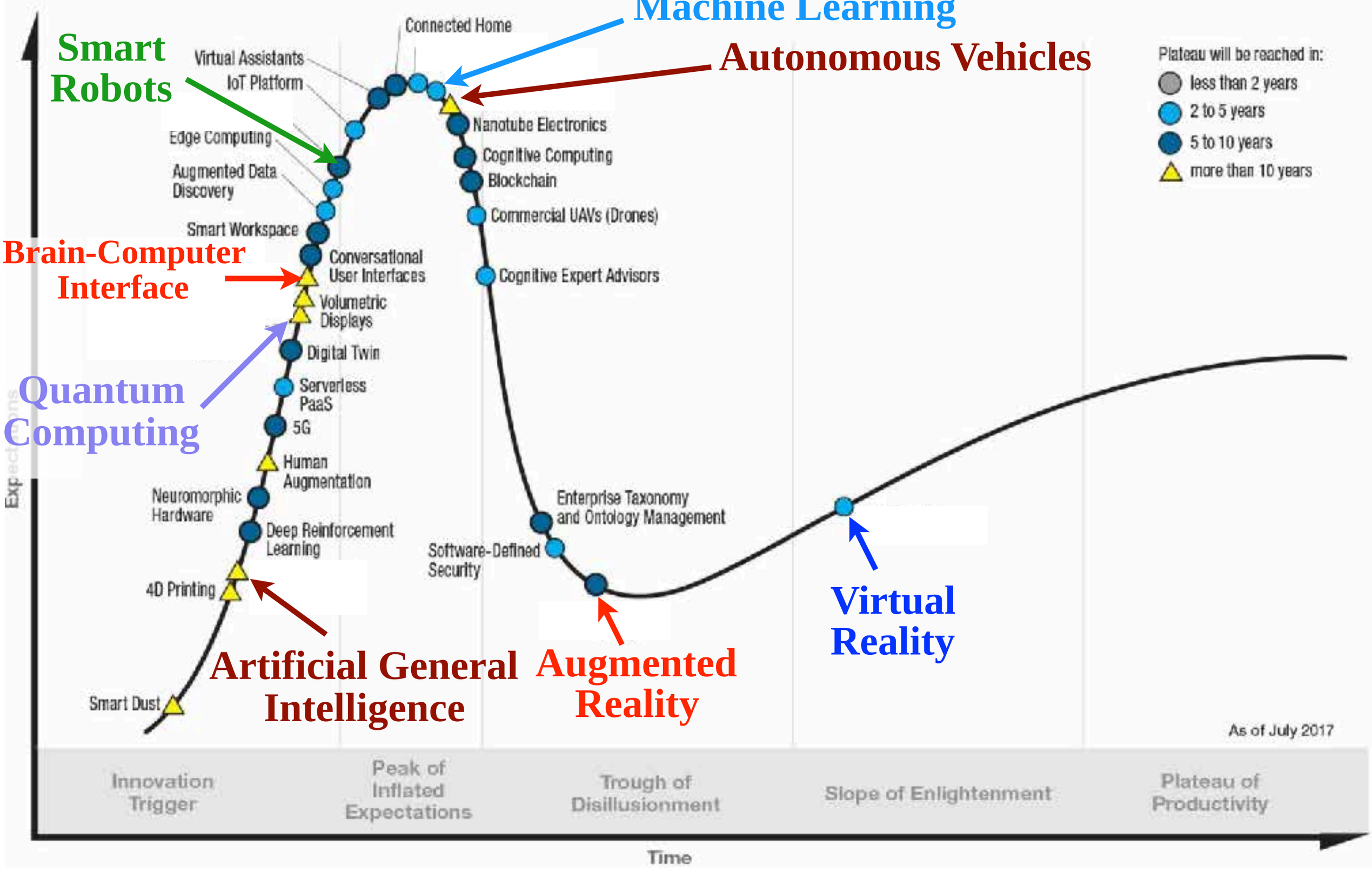
Wandelbots wants to reinvent the way we program robots

Posted Dec 4, 2017 by Darrell Etherington (@etherington)

Researchers train robots to see into the future

Posted Dec 8, 2017 by John Biggs (@johnbiggs)

Gartner Hype Cycle for Emerging Technologies, 2017



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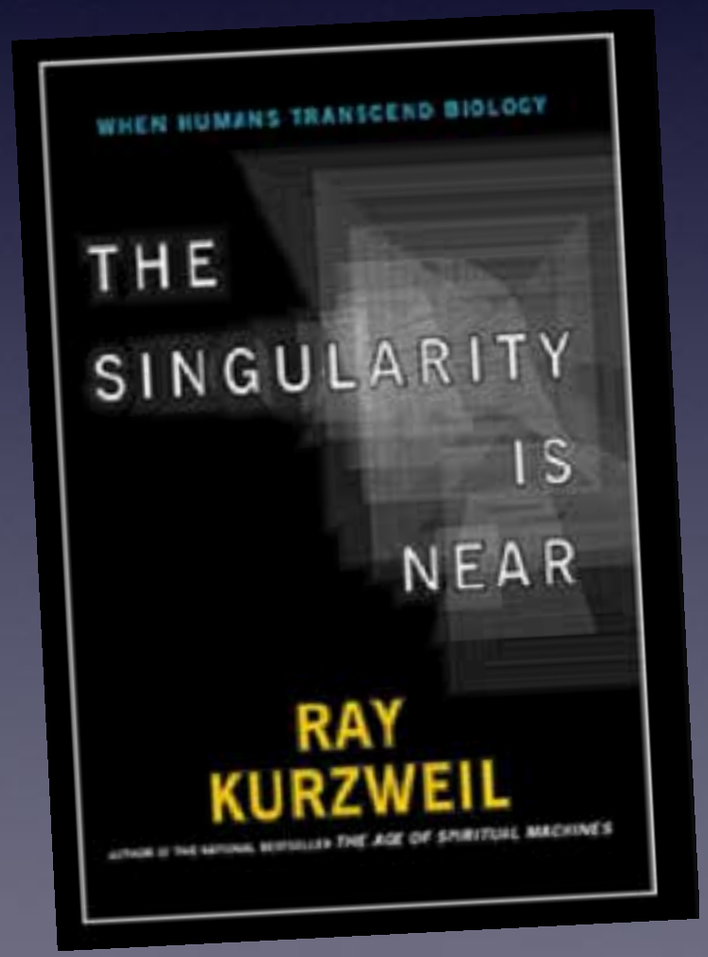
Technologies double at different rates.

You're only at the 1/2 way point immediately prior to the final doubling.

Remember when envisioning the future, all aspects of it are evolving.

Thinking about the future can be fun, exciting and enlightening!



That's all Folks!