

Those who have knowledge, don't predict.

Those who predict, don't have knowledge.

Lao Tzu (c.604 - 531 B.C.)

Prediction is very difficult, especially about the future.

Niels Bohr (1885 - 1962)

Predicting the Future

Wolfgang Bauer

Michigan State University

Predicting the Future



Johnny Carson, "Carnac the Magnificent"

- The Future of Energy
- The Future of Humans
- The Future of the Sun
- The Future of the Universe
- The Future of Eternity

Predicting the Future

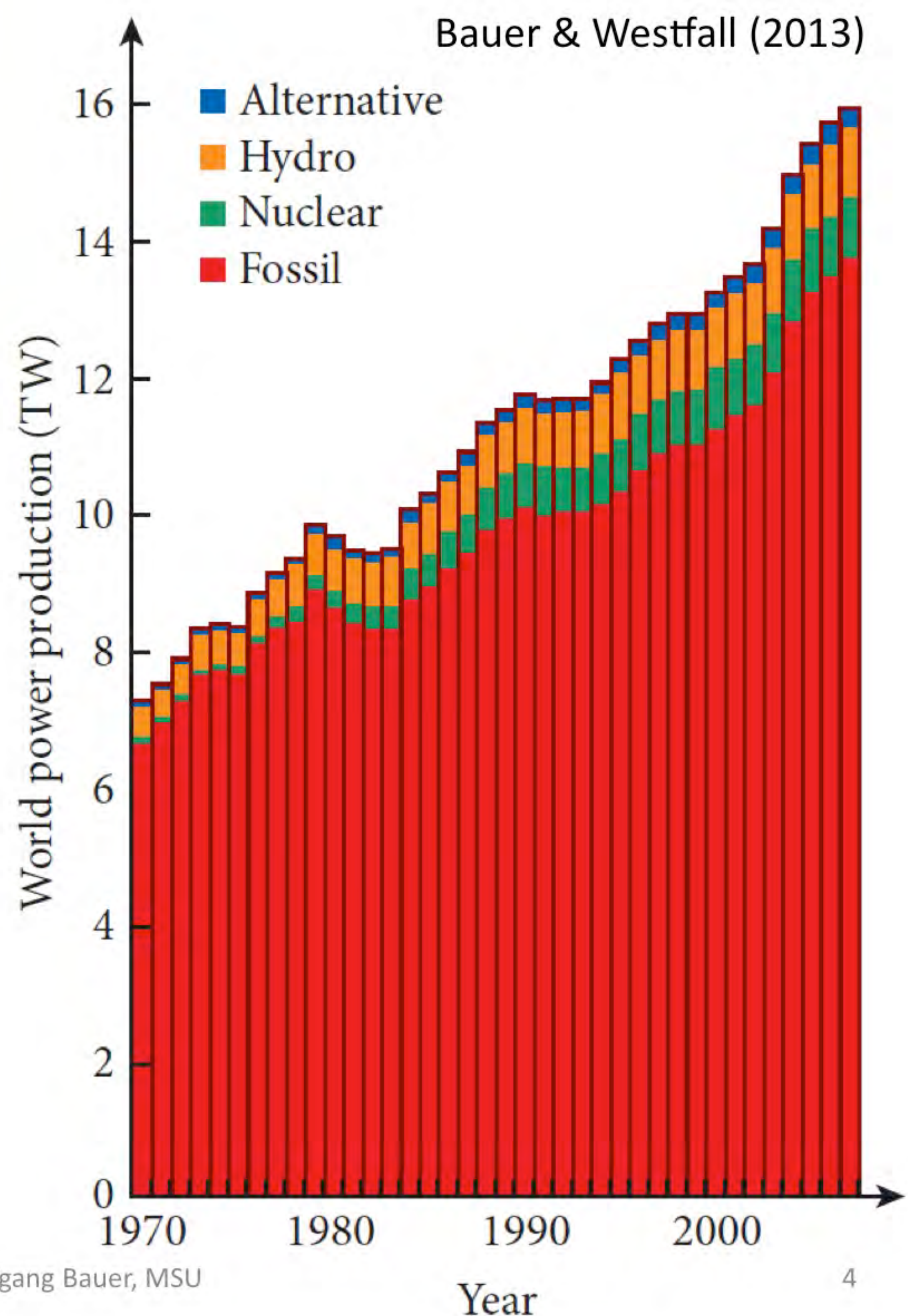


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World Power Consumption

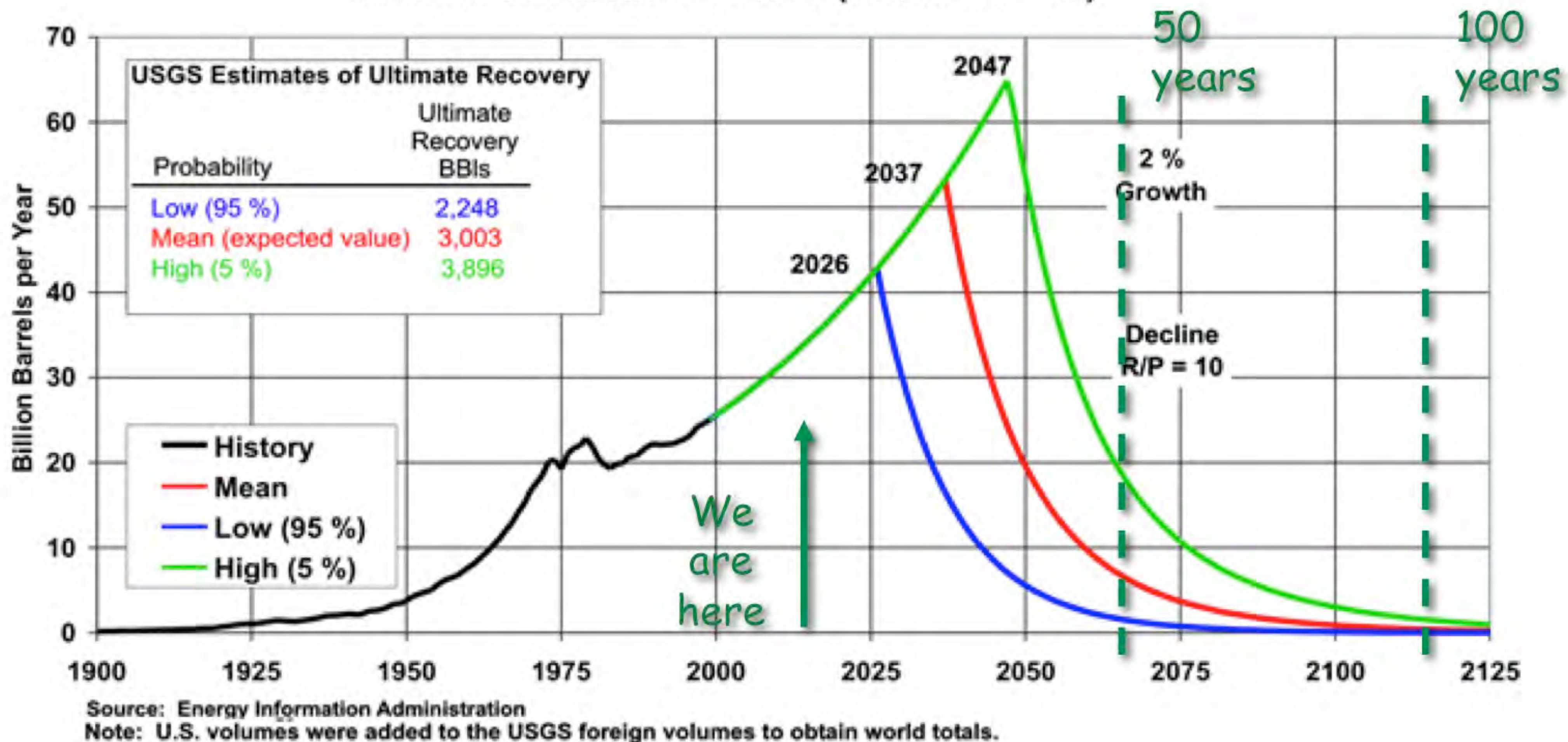
- Currently ~16 TW
- Increasing strongly with time
- Overwhelmingly satisfied with fossil fuels
- ~~Biggest Problem facing the World~~
- **Biggest Opportunity of our lifetime**



We are running out of oil!

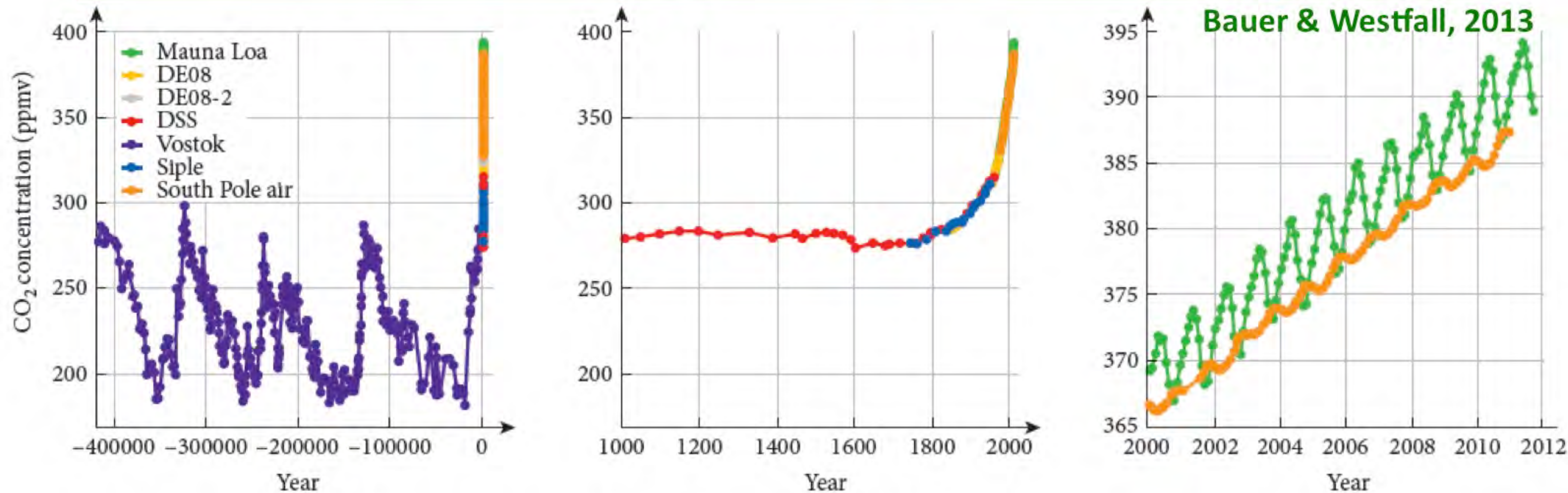
Fossil fuels from carboniferous period (360-300 My B.C.) are finite

Figure 2. Annual Production Scenarios with 2 Percent Growth Rates and Different Resource Levels (Decline R/P=10)



<http://www.eia.doe.gov/>
S.E. Koonin, BP

The Energy Problem: CO₂



- CO₂ rise from burning fossil fuels
 - Unsustainable
 - Man-made global warming
 - Worst climate change effects are yet to come: sea level rise, ocean acidification, droughts, ...

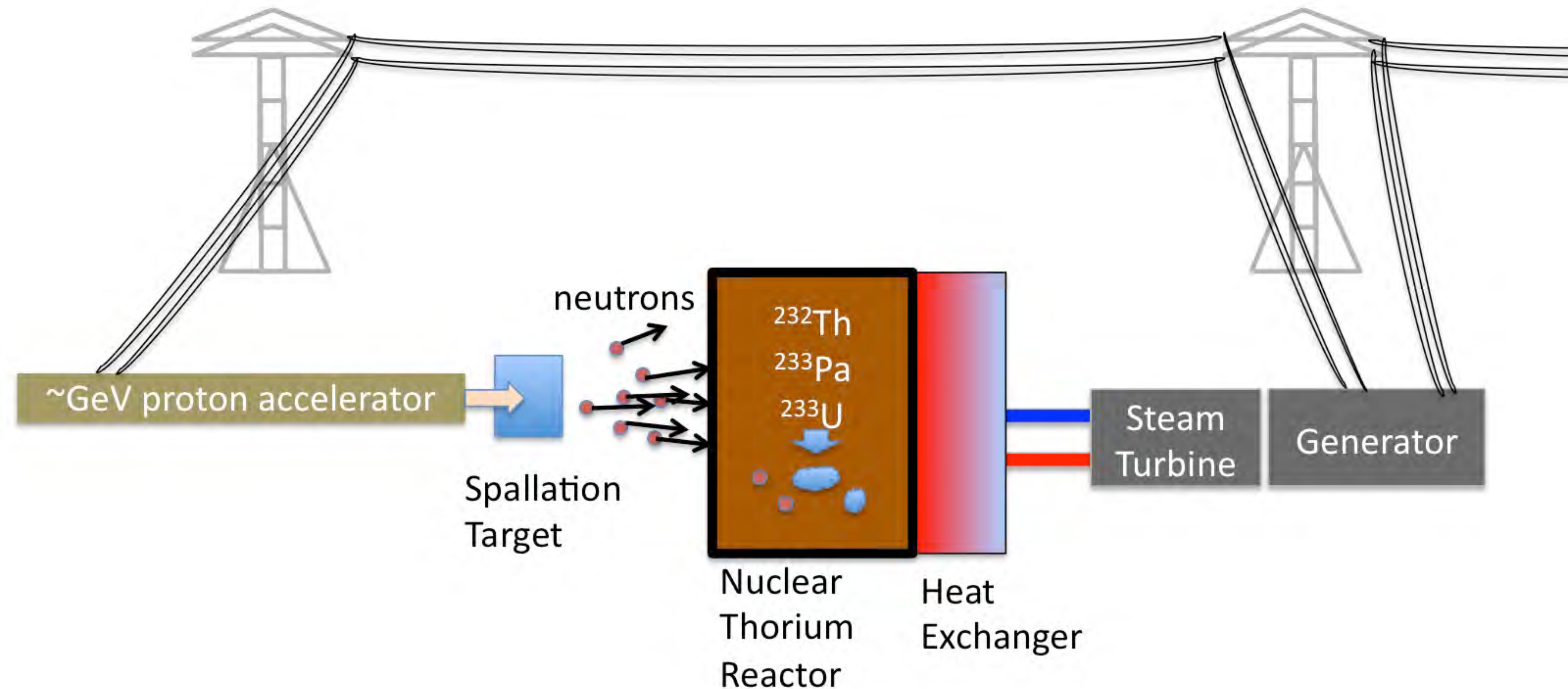
Latest CO₂ reading
October 12, 2014

395.52 ppm

Carbon dioxide concentration at Mauna Loa Observatory

<https://scripps.ucsd.edu/programs/keelingcurve/>

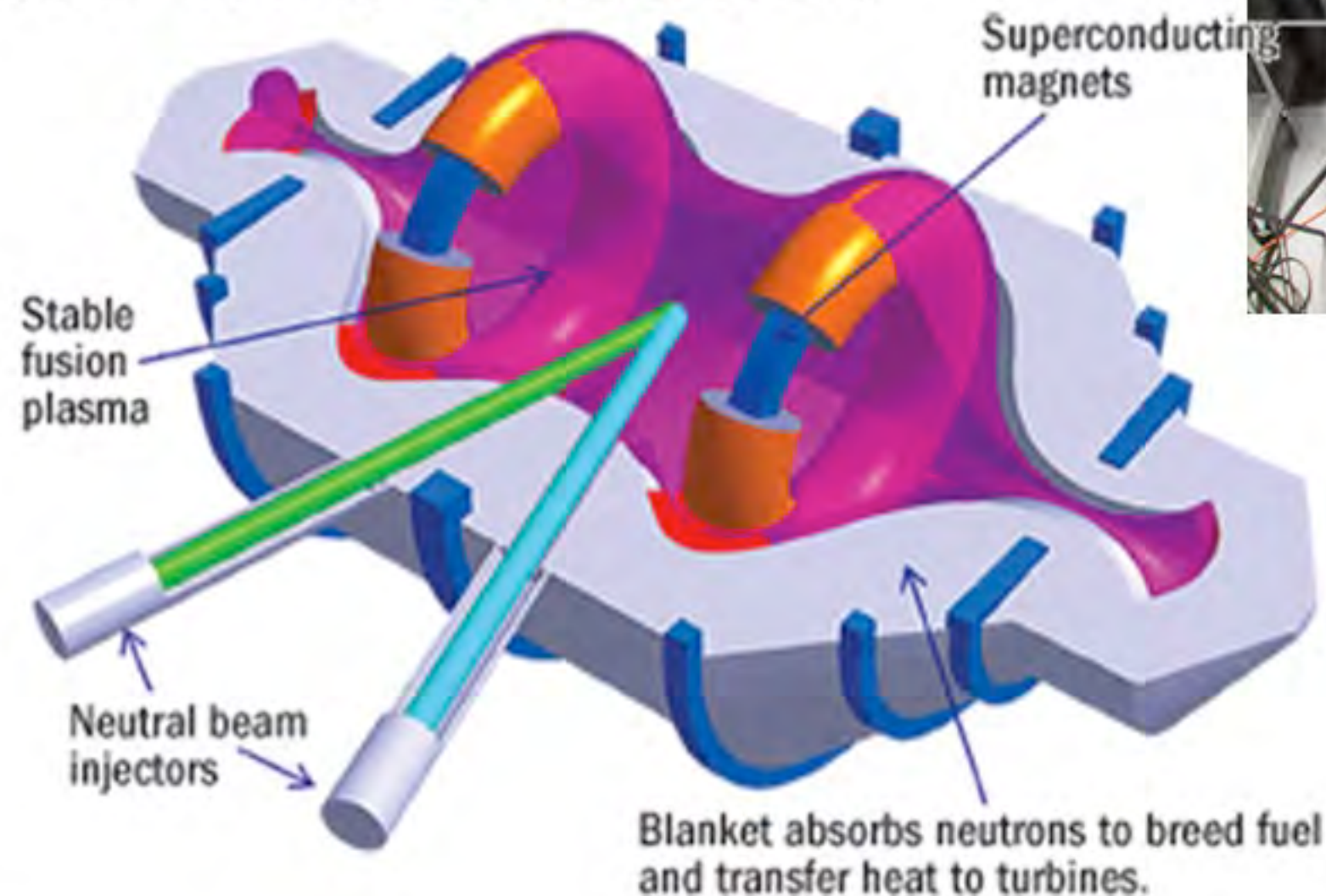
The Future of Nuclear Fission: Thorium



Energy for the next 10,000 years

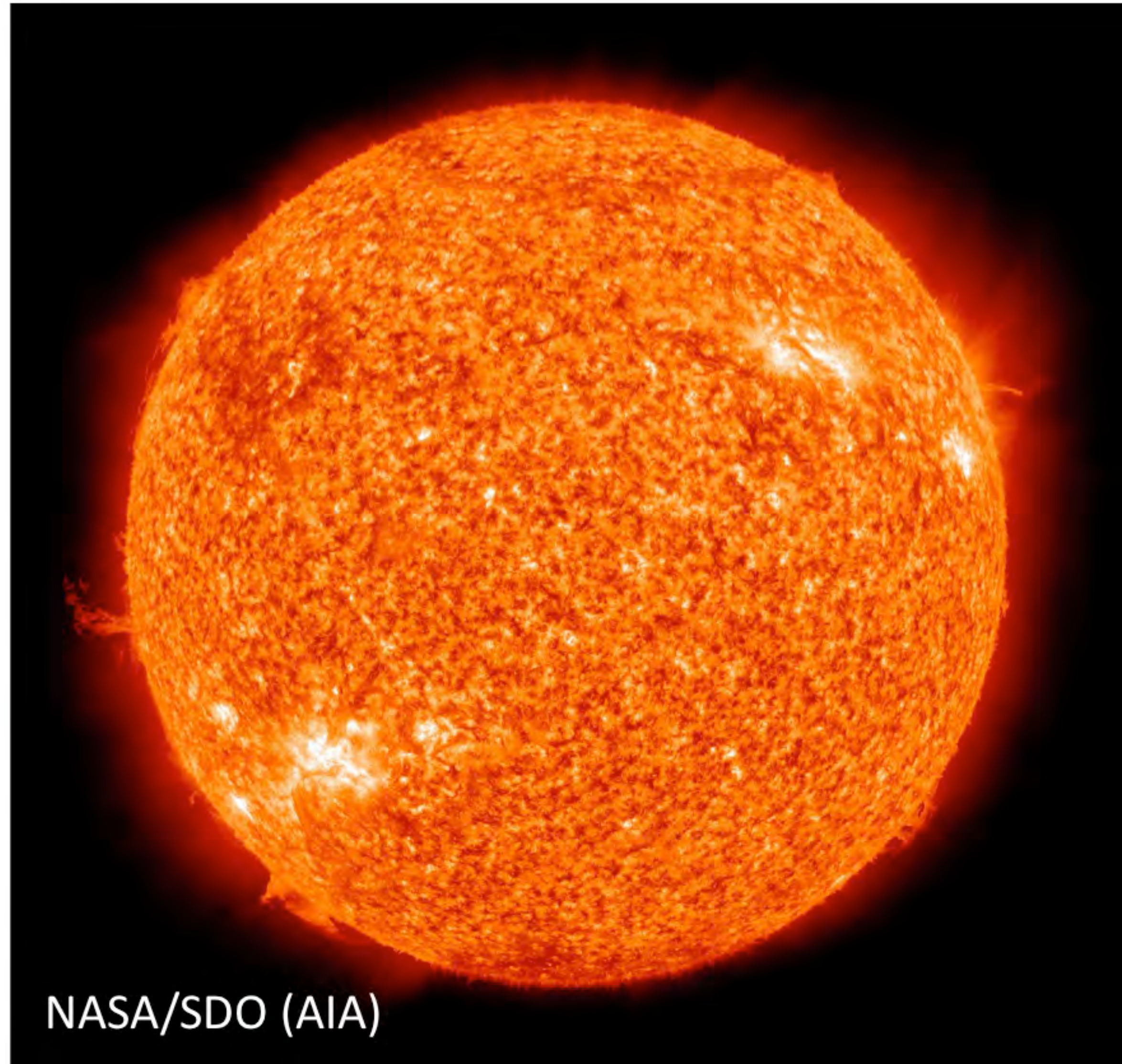
Nuclear Fusion

- ITER, NIF, Z-machine, ...:
always 30-50 years in the future
- Possible game changer?
 - Lockheed-Martin Skunk Works: “will have a commercial fusion reactor in a decade!”



Upper Limit of Power

- Long-time upper limit of power consumption of Earth: solar radiation
 - 175 PW total
 - ~10,000 times current world consumption



NASA/SDO (AIA)

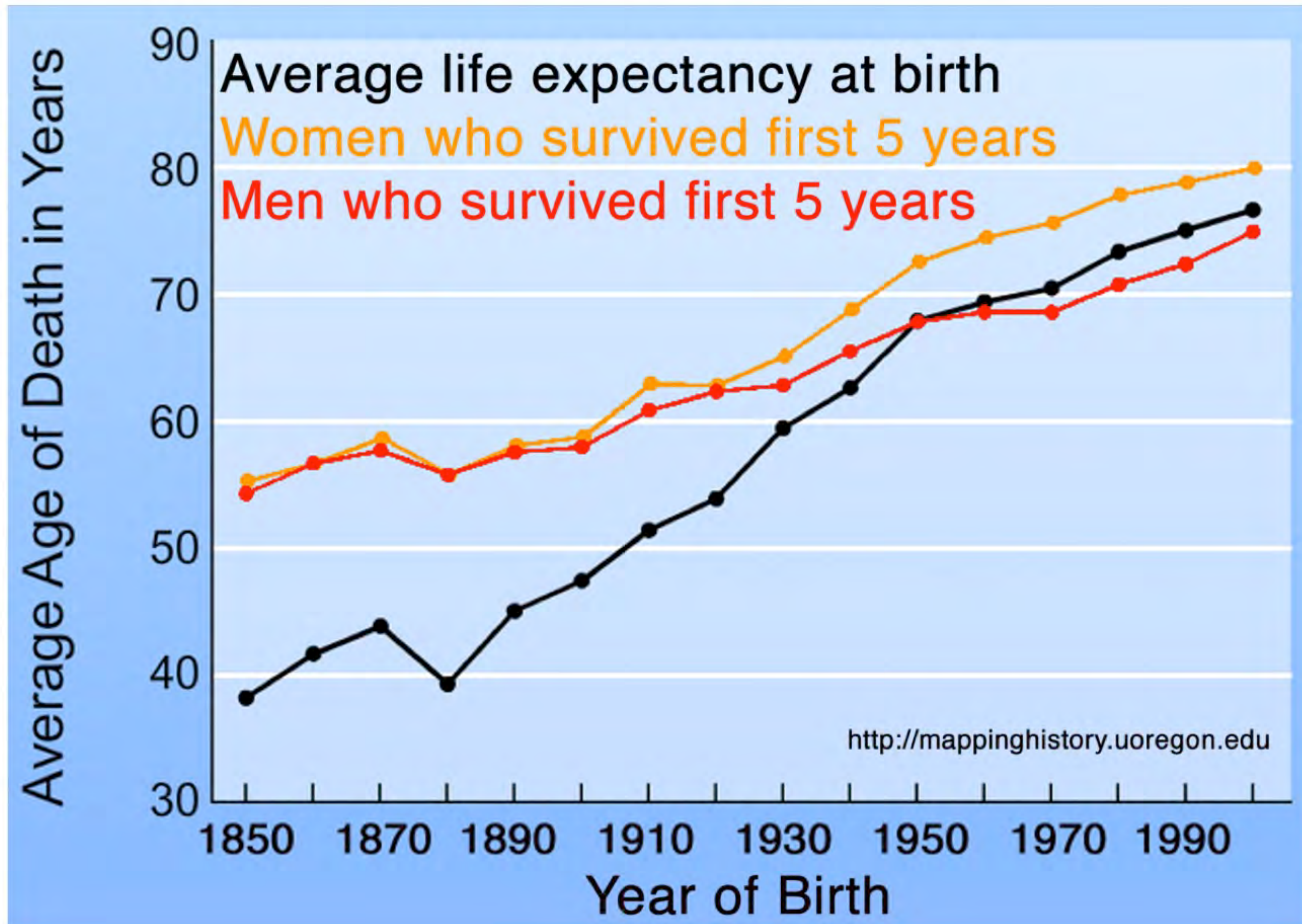
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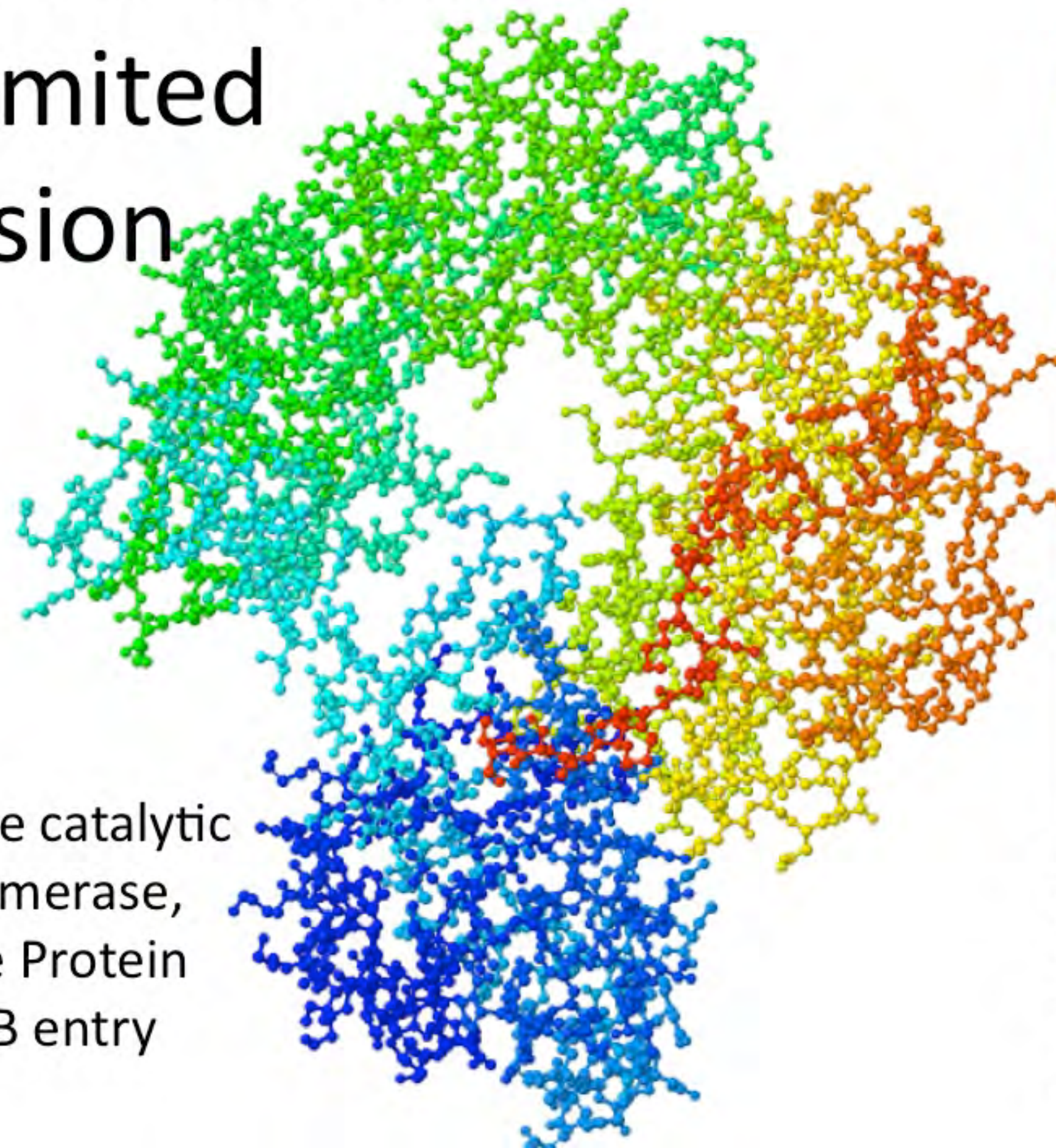
Life Expectancy



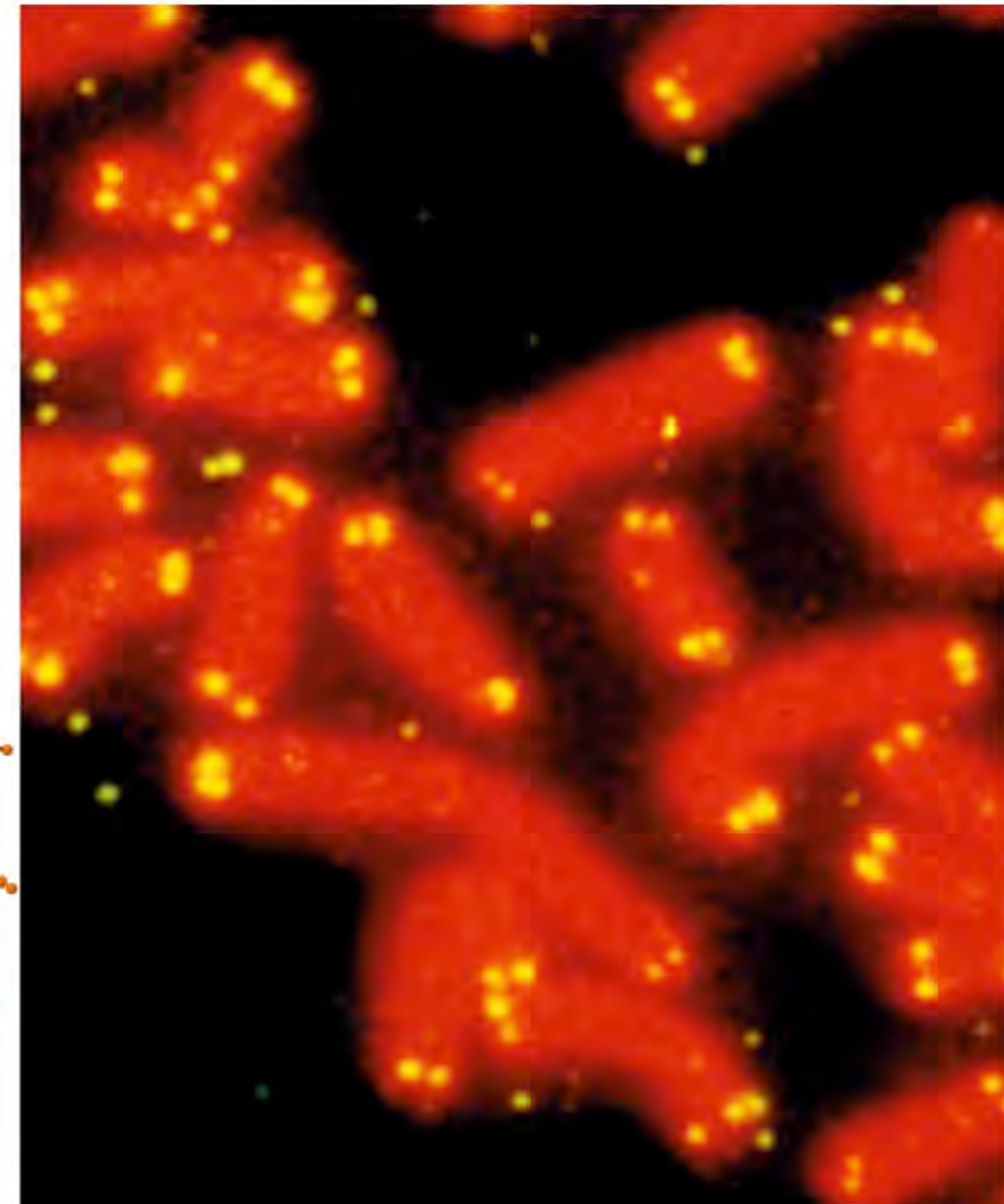
Nano-Medicine of the Near Future

- Next century: On-demand DNA repair to fix illnesses and aging
- Example: Telomere replacement to allow for unlimited cell division

TTAGGG
|||
AATCCC



Structure of the catalytic subunit of telomerase, TERT. From the Protein Data Bank (PDB entry 3DU5)

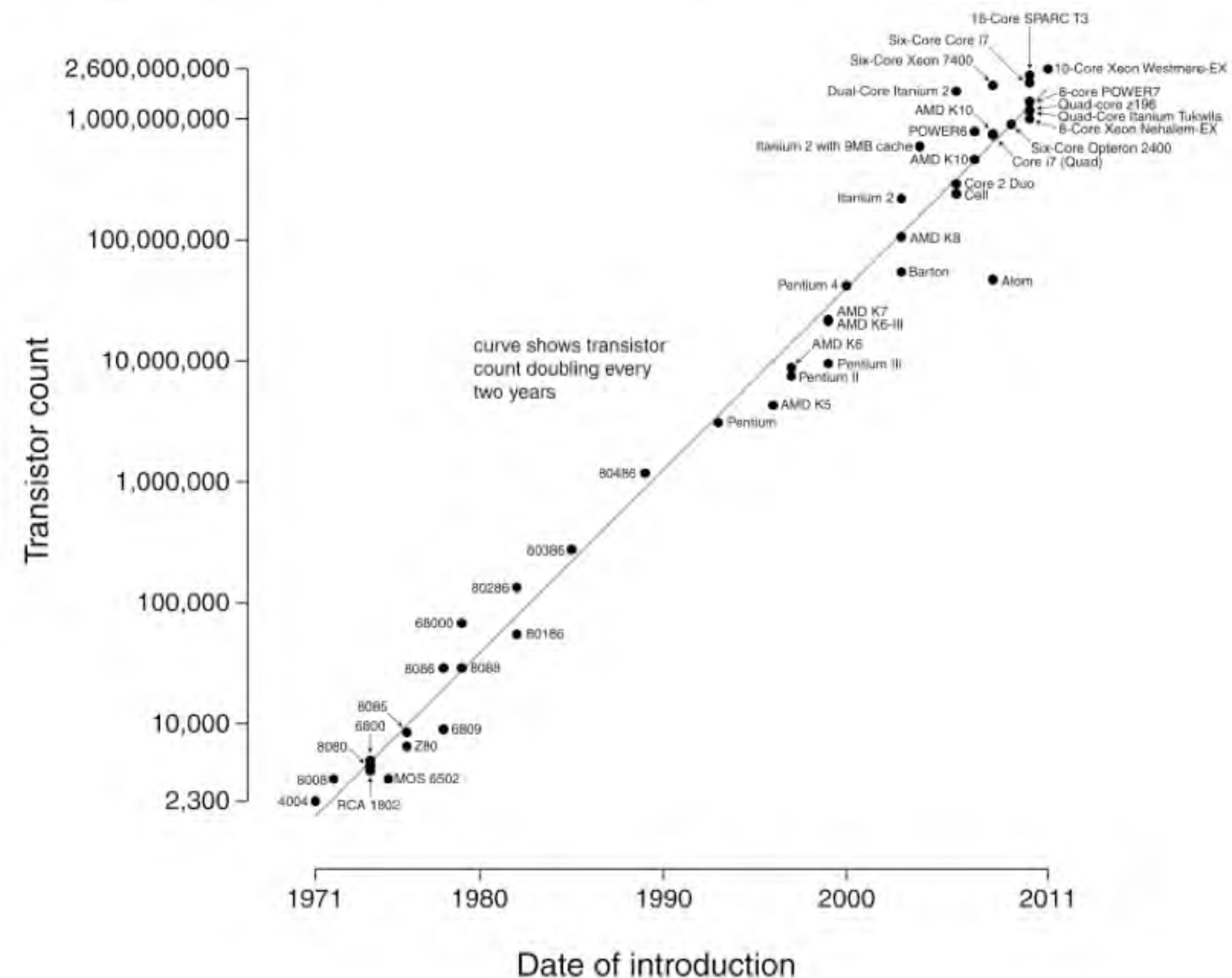


Fluorescence-stained chromosomes (red); telomeres (yellow) sit at the ends of each chromosome. Robert Moyzis, UC Irvine, US Human Genome Program

The Competition: Cyber Life

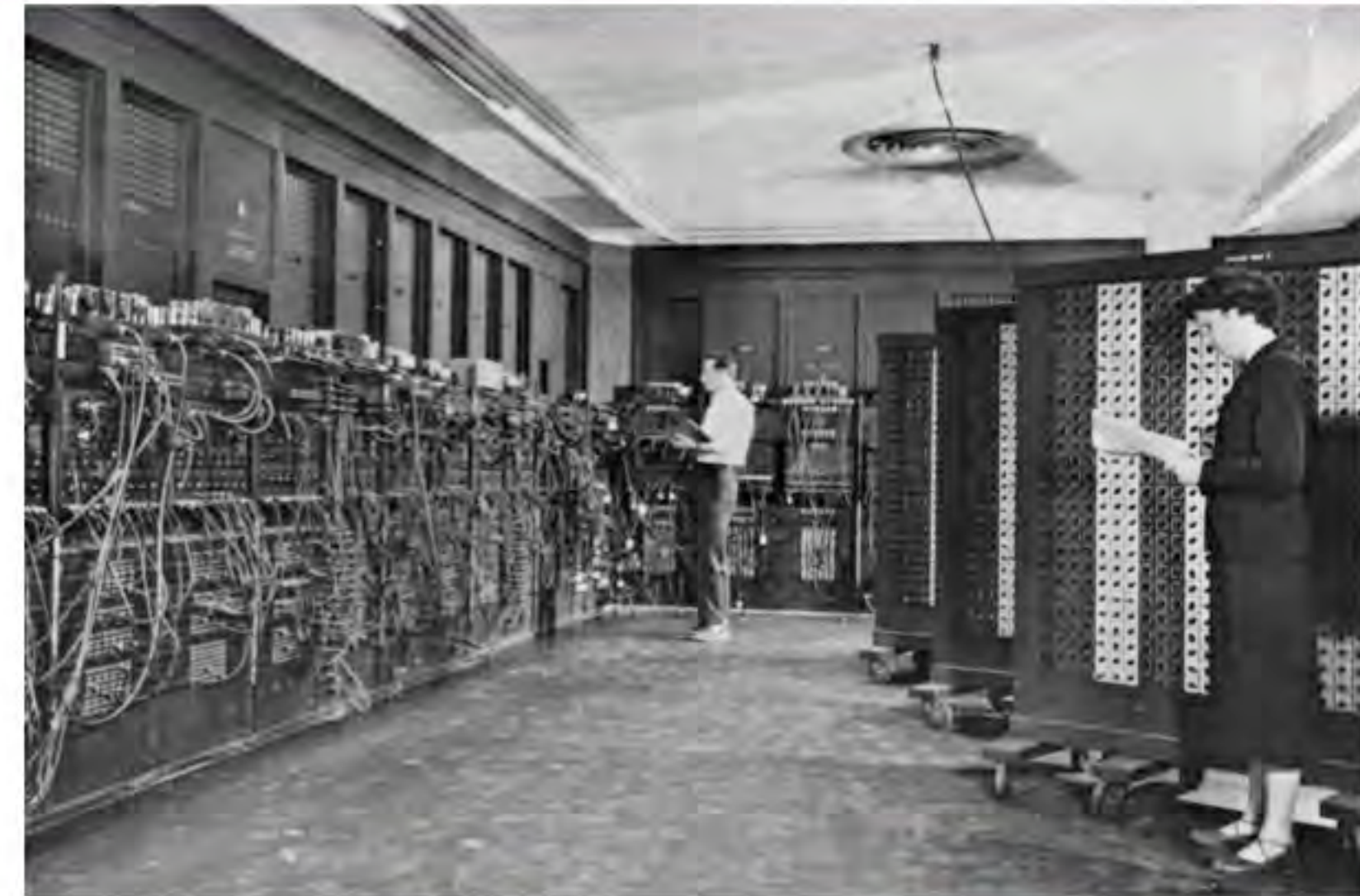
- Computer speed doubles every 18 months (**Moore's Law**)
- Data storage doubles every 12 months
- Network speed doubles every 9 months
- Inventions in last two decades:
GPS, cell phones, laptops, iPods,
DVD, BluRay, HDTV, 3d-TV, ...
- Physics limits not to be reached for another decade or more

Microprocessor Transistor Counts 1971-2011 & Moore's Law



Supercomputers

- 1946-55: ENIAC
 - 150 kW
 - 5 kFLOPs
 - 0.03 FLOPs/W
- 2014: L-CSC
 - 5.27 GFLOPs/W
- Factor 10^{11} improvement
 - ENIAC architecture scaled up to L-CSC performance would require ~20 PW of power, a factor of 1000 more than presently consumed by all people on the planet

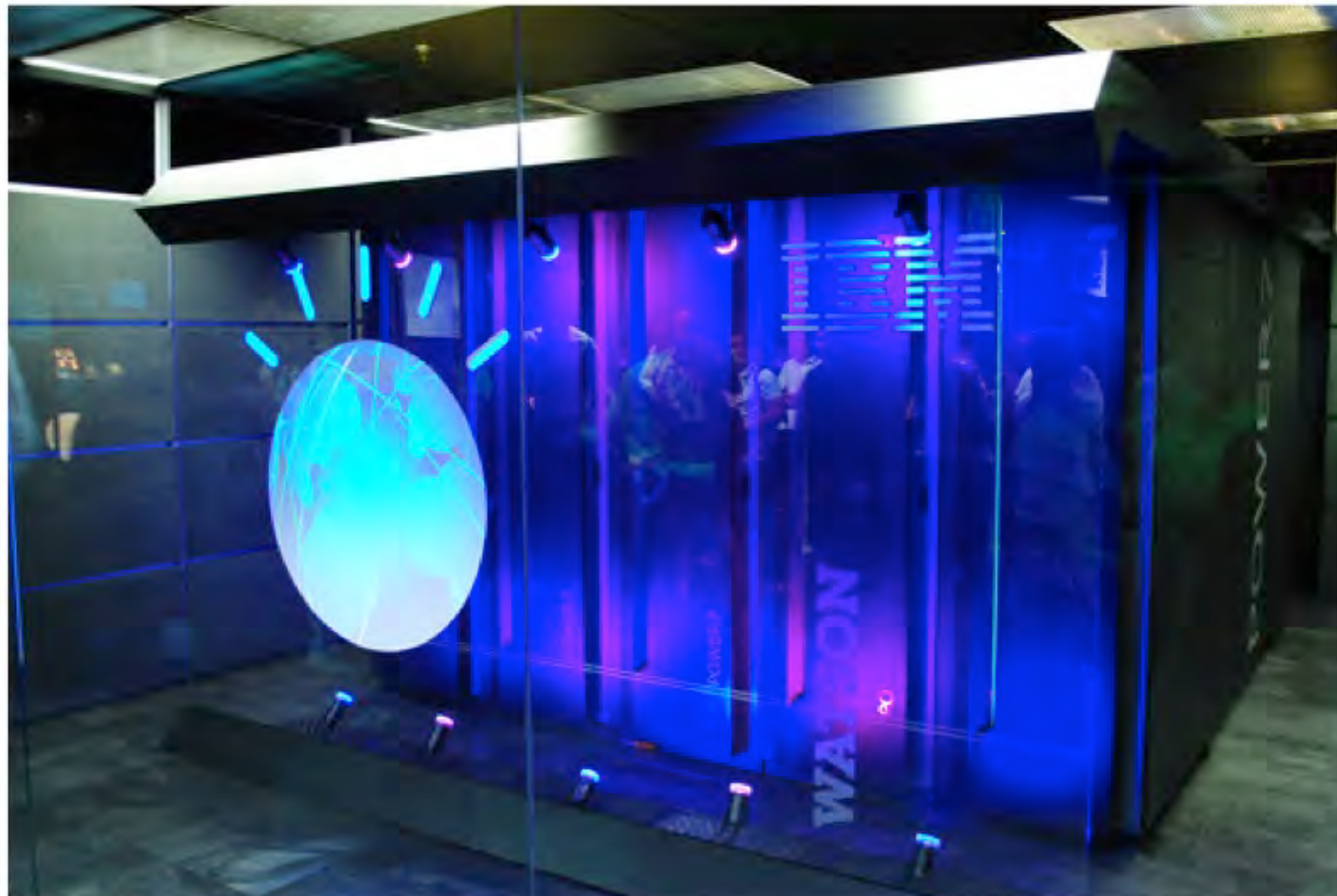


The Competition: Cyber Life

- True AI within reach in the next two decades
- Example: IBM Watson



Ken Jennings, Watson and Brad Rutter on Jeopardy. Photo Credit: IBM.



The Competition: Cyber Life

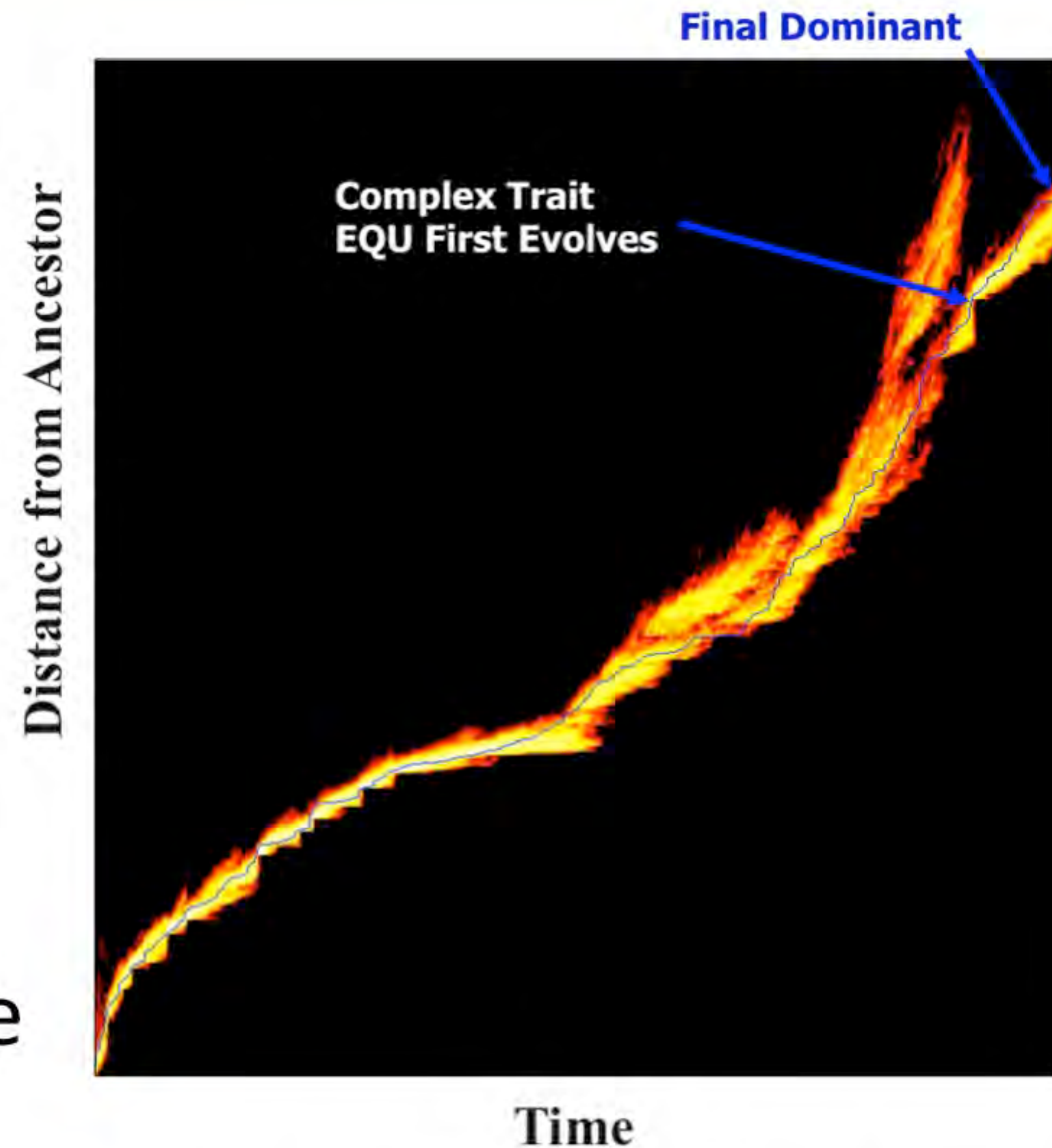
- 3d color multi-materials printing will enable computers to build new computers and robots much faster than we can design them



Example: Mcor Technologies Iris
3D True Color Printer

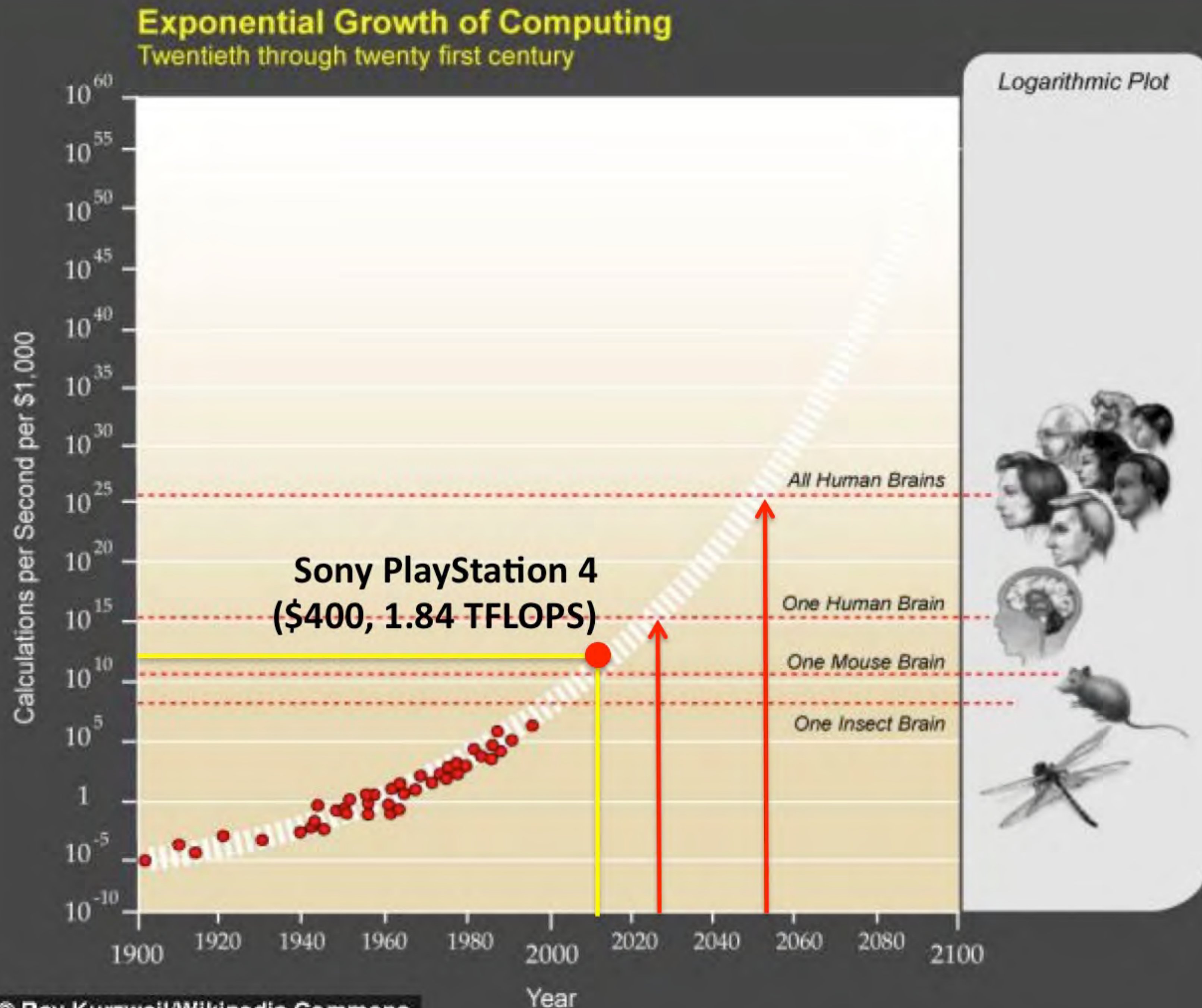
The Competition: Cyber Life

- Evolution of algorithms and cyber-life forms (Adami-Lenski-Ofria-Pennock, BEACON@MSU)
- Possible future: Bio-Cyber convergence
- 100+ year horizon: Transfer of human conscience to more sustainable artificial life forms (with backup!)



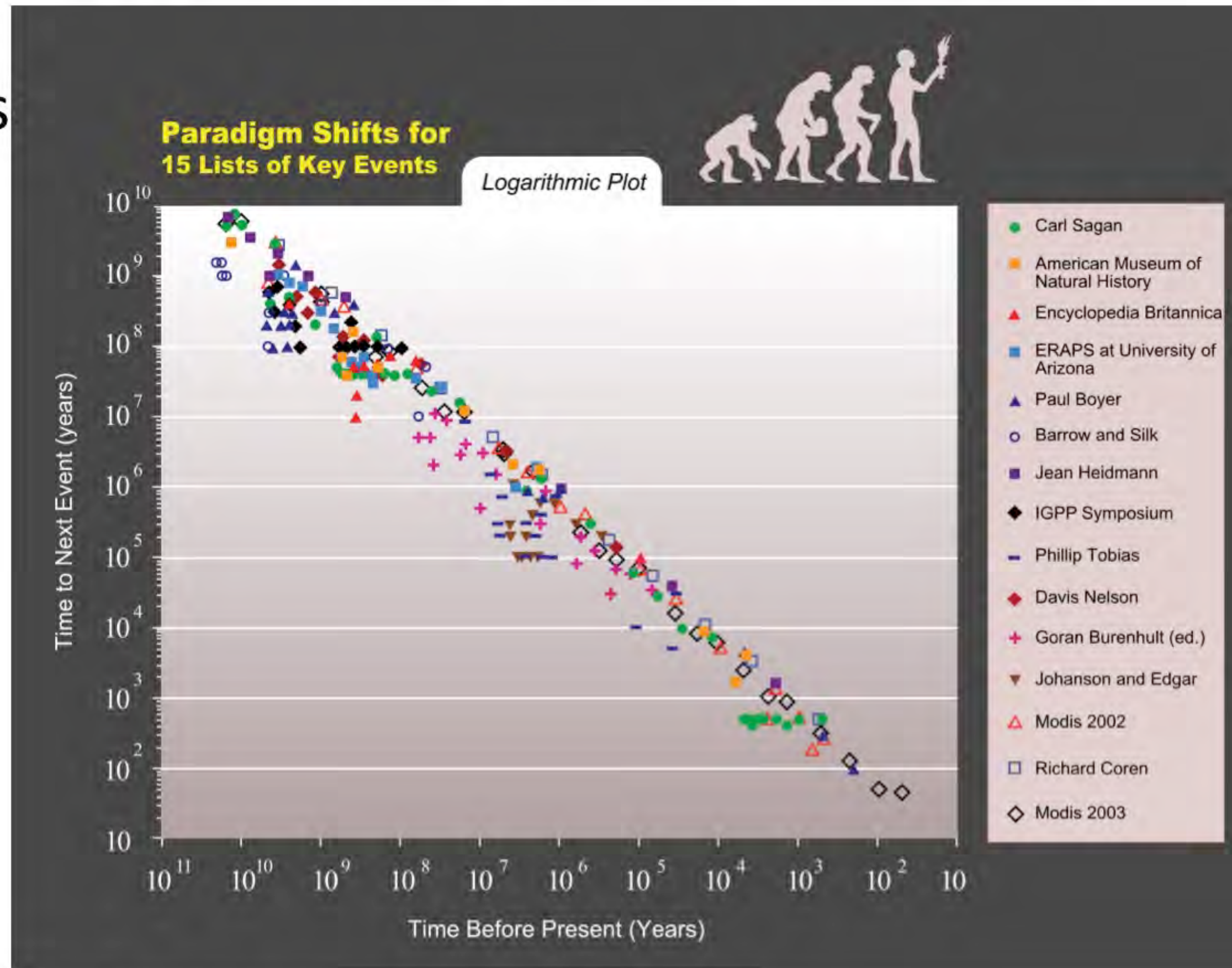
Adapted from: Lenski RE, Ofria C, Pennock RT, and Adami C (2003) The Evolutionary Origin of Complex Features, *Nature*, 423:139-144.

Kurzweil Singularity



Kurzweil Singularity

- Observation: Paradigm shifts happen faster and faster
- Time between paradigm shifts approaches 0 around the year 2045



Predicting the Future

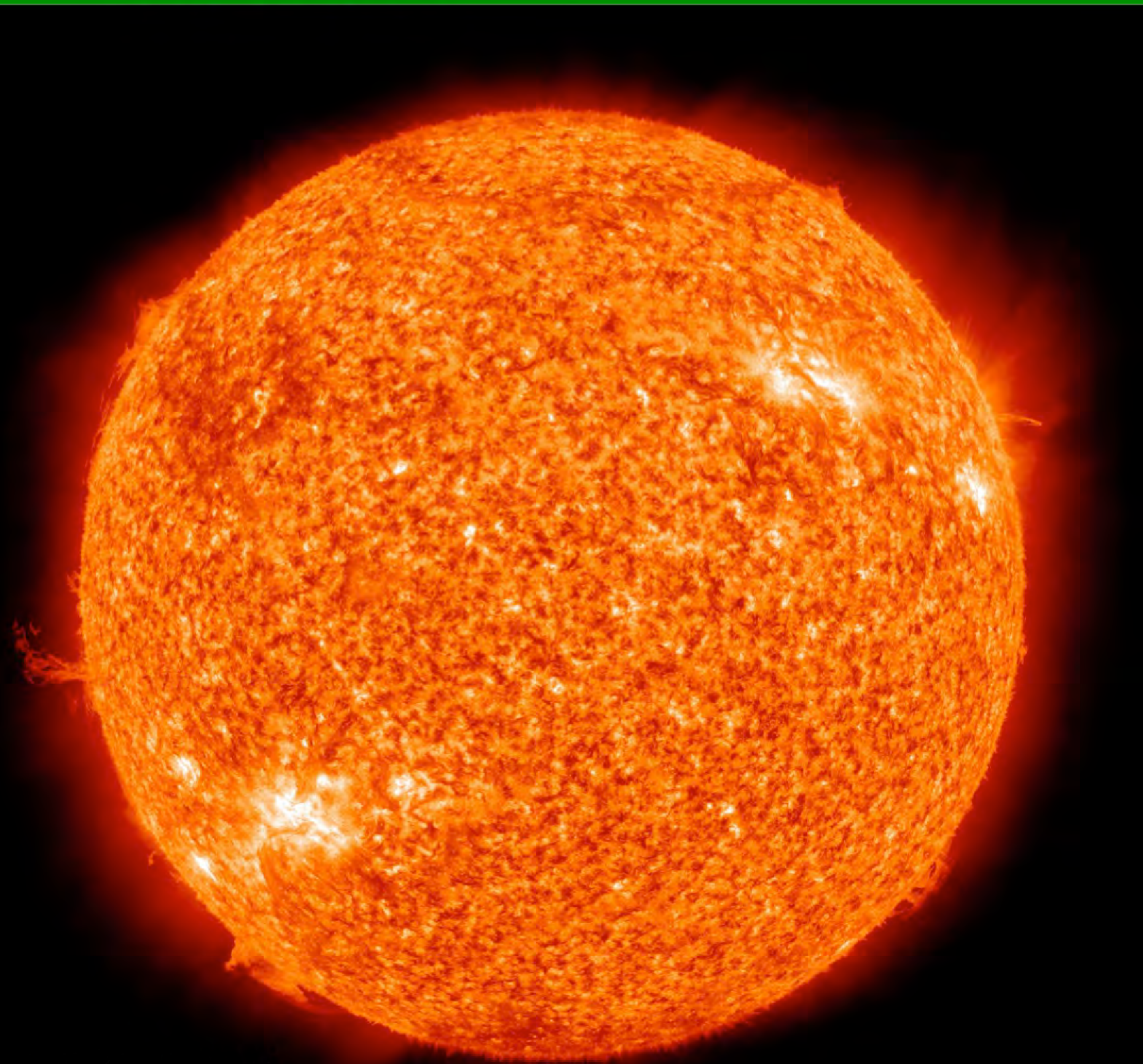


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The Sun

- Age 4.57 billion years
- Diam. = $109 d_{\text{Earth}}$
- Mass = $330,000 m_{\text{Earth}}$
- Composition
74.9% H
23.8% He
- Nuclear Fusion
 $4\text{H} \rightarrow \text{He} + 2e^+ (+\nu_e + \gamma)$
uses 620 M tons of H
each second
- Total power product.
 $3.85 \cdot 10^{26} \text{ W}$
- Total power delivered
to Earth: $1.75 \cdot 10^{17} \text{ W}$



NASA/SDO (AIA)

The Future of the Sun

- H – fusion will end in about **5 billion years**
- Fusion of core He into successively heavier elements, C, O, Ne, ..., Fe
- Collapse into brown dwarf or neutron star

Predicting the Future

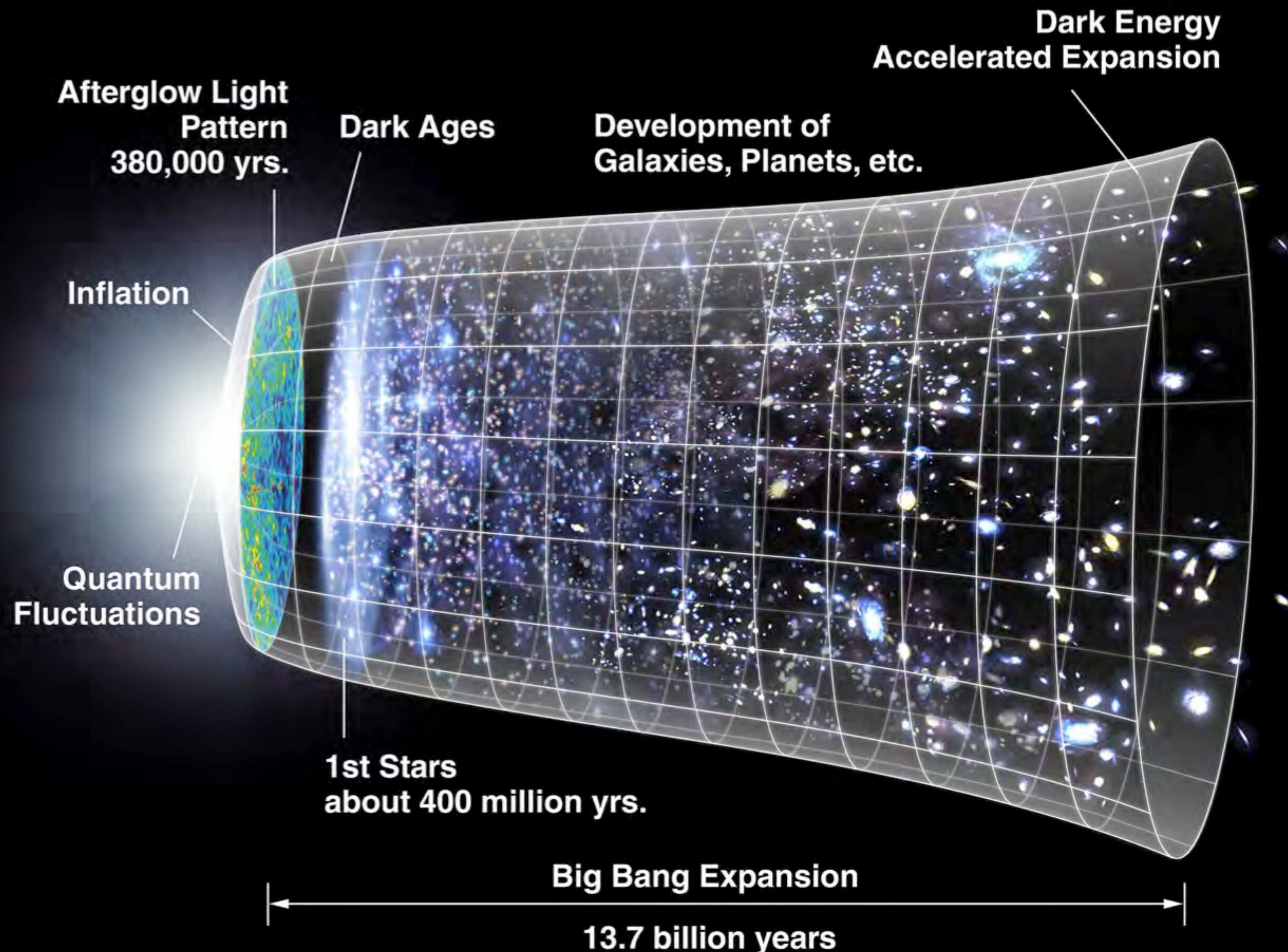


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And God said, "Let there be light," and there was light.
God saw that the light was good, and he separated the light from the darkness.
Genesis 1:3-4

The Beginning of the Universe



Dark Matter / Dark Energy

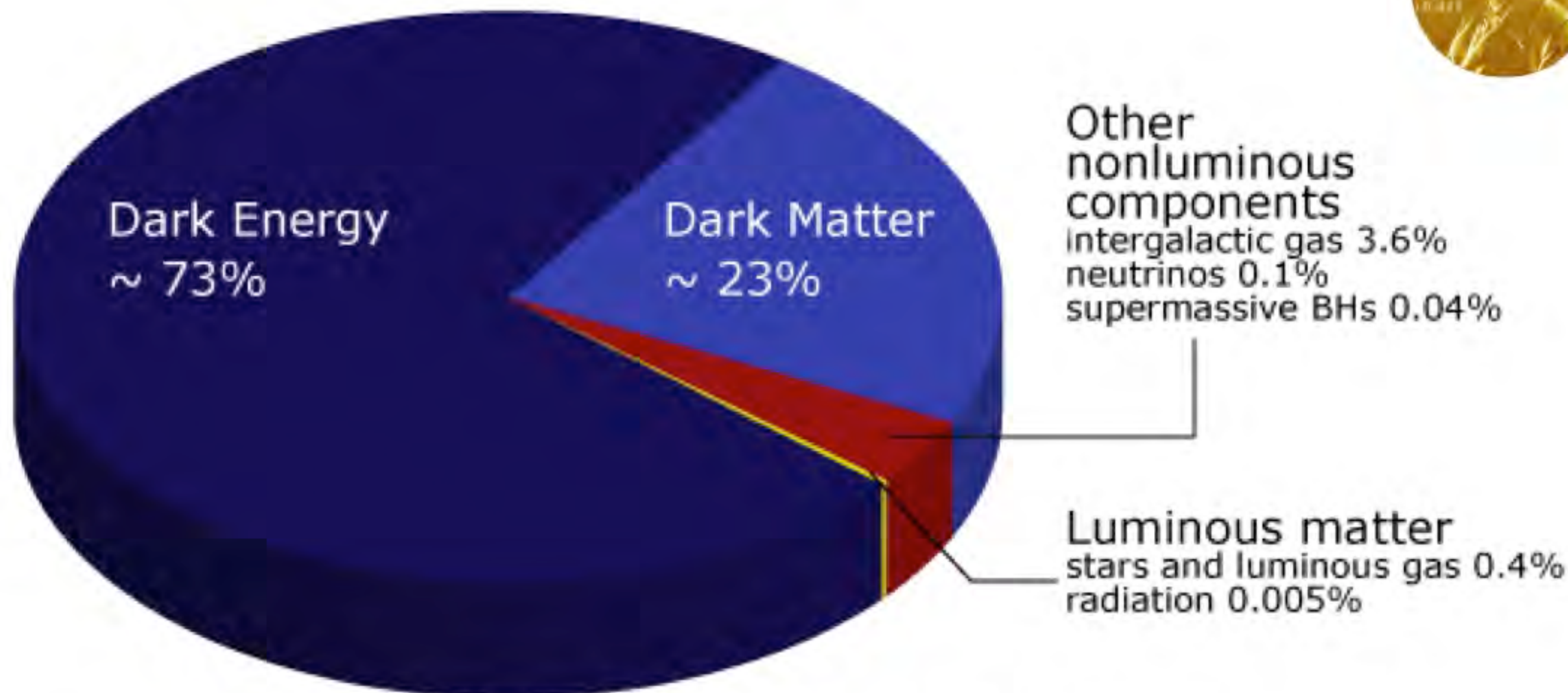


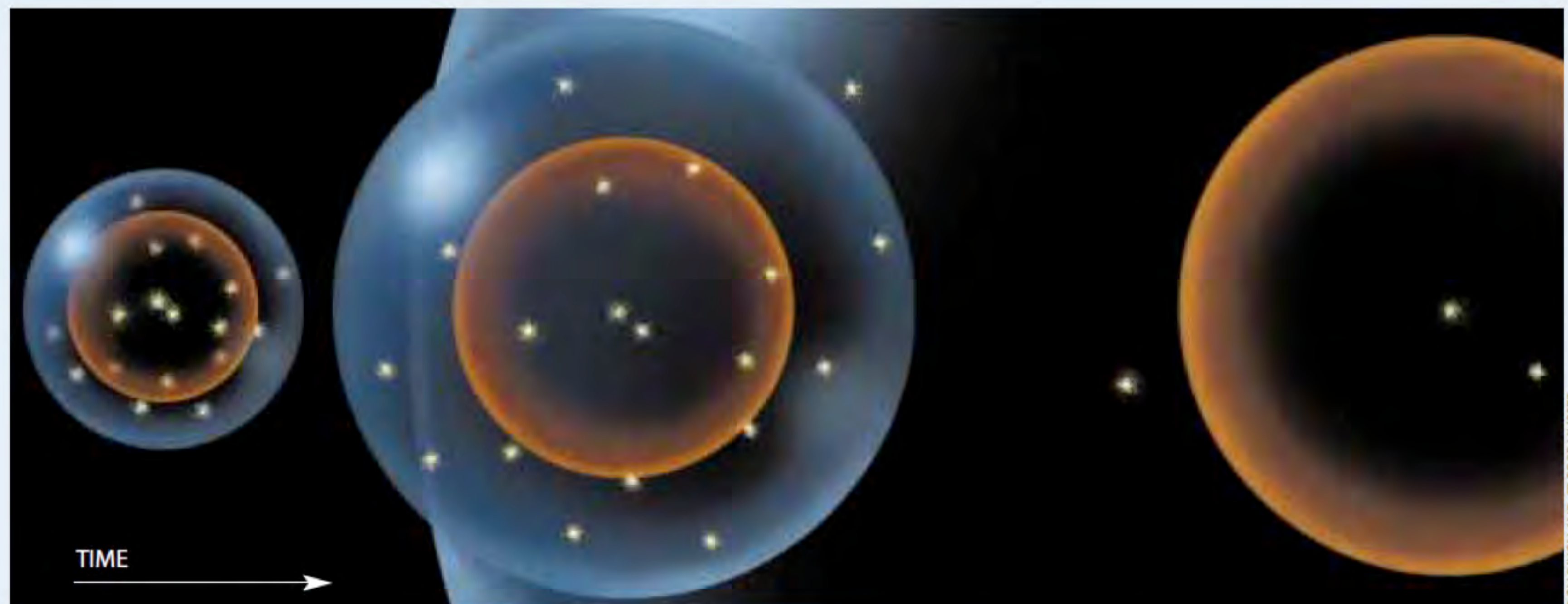
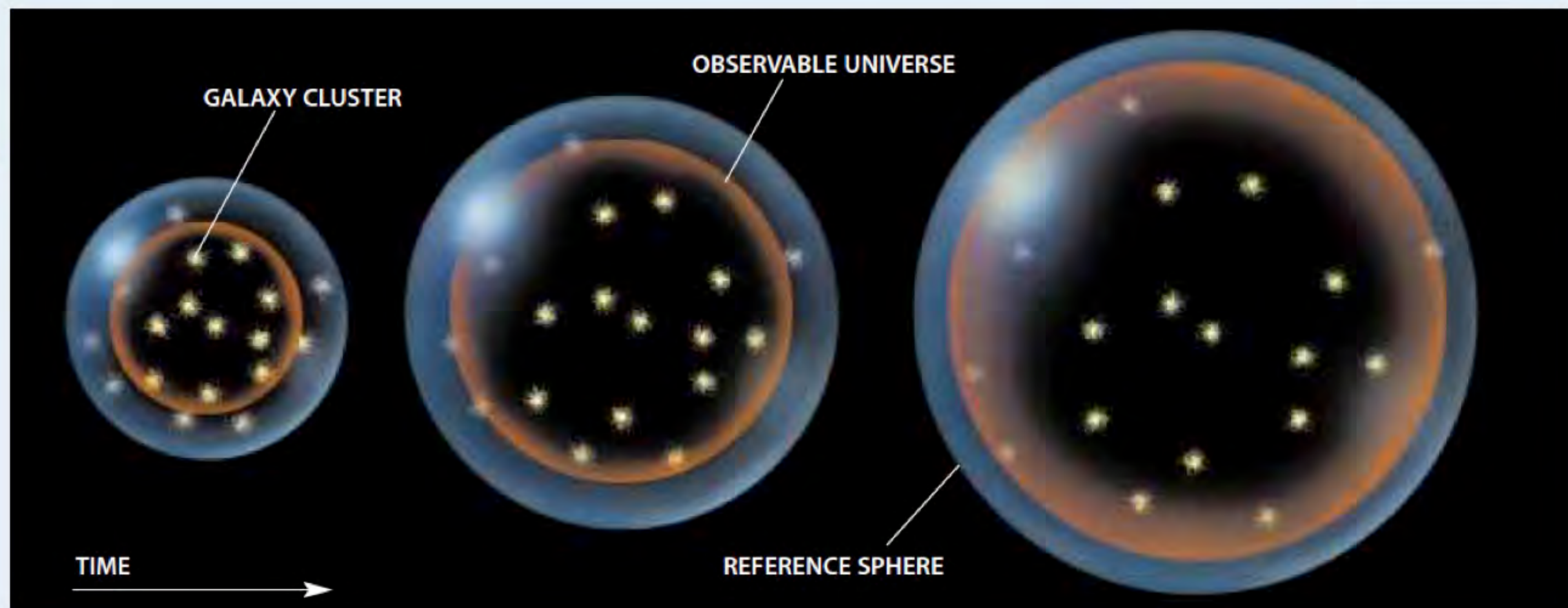
KUNGL.
VETENSKAPS-
AKADEMIEN

THE ROYAL SWEDISH ACADEMY OF SCIENCES

4 OCTOBER 2011

Saul Perlmutter, Brian P. Schmidt, Adam G. Riess
“for the discovery of the accelerating expansion
of the Universe through observations of
distant supernovae”





DON DIXON AND GEORGE MUSSER

EXPANDING UNIVERSE looks dramatically different depending on whether the growth is decelerating (*upper sequence*) or accelerating (*lower sequence*). In both cases, the universe is infinite, but any patch of space—demarcated by a reference sphere that represents the distance to particular galaxies—enlarges (*blue sphere*). We can see

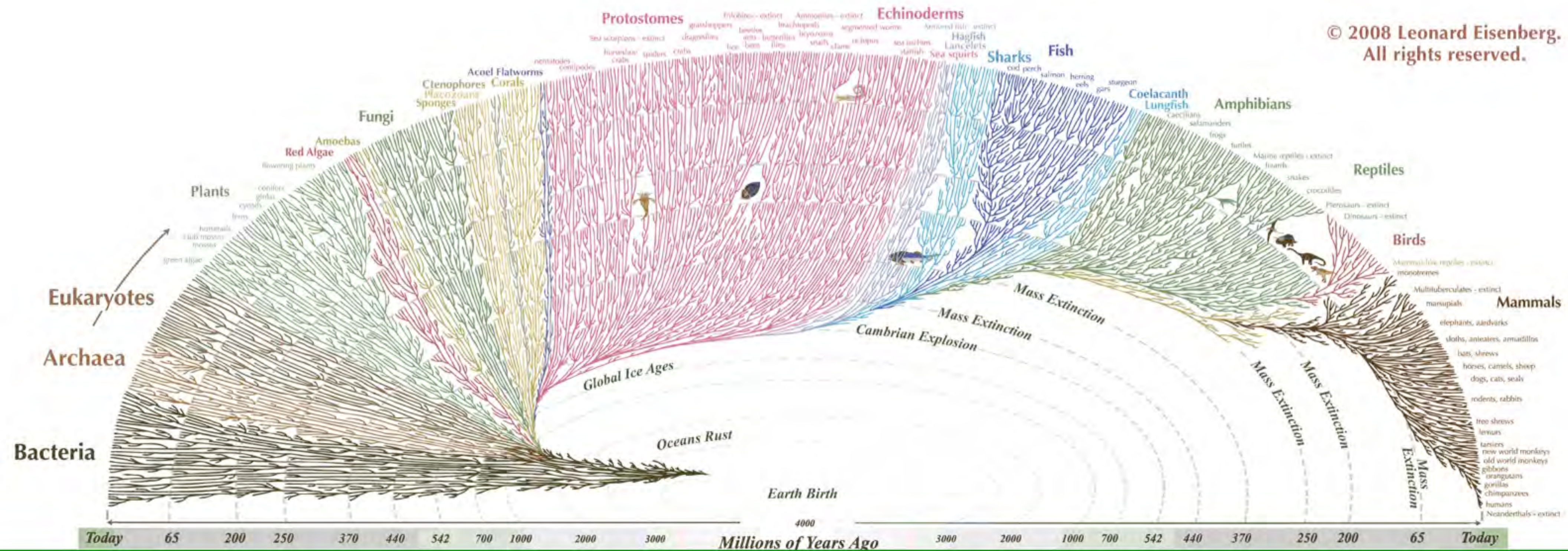
only a limited volume, which grows steadily as light signals have time to propagate (*red sphere*). If expansion is decelerating, we can see an increasing fraction of the cosmos. More and more galaxies fill the sky. But if expansion is accelerating, we can see a decreasing fraction of the cosmos. Space seems to empty out.

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Immortality

- From the first self-replicating single cell organism in the primordial muck ...
- ... to each of us
- An unbroken chain!
- 4 billion years of evolution!

“As all the living forms of life are the lineal descendants of those which lived before the Cambrian epoch, we may feel certain that the ordinary succession by generation has never once been broken. . . . Hence we may look with some confidence to a secure future of great length.”

Charles Darwin (1809–1882), Origin of Species

Individual Immortality & Eternity

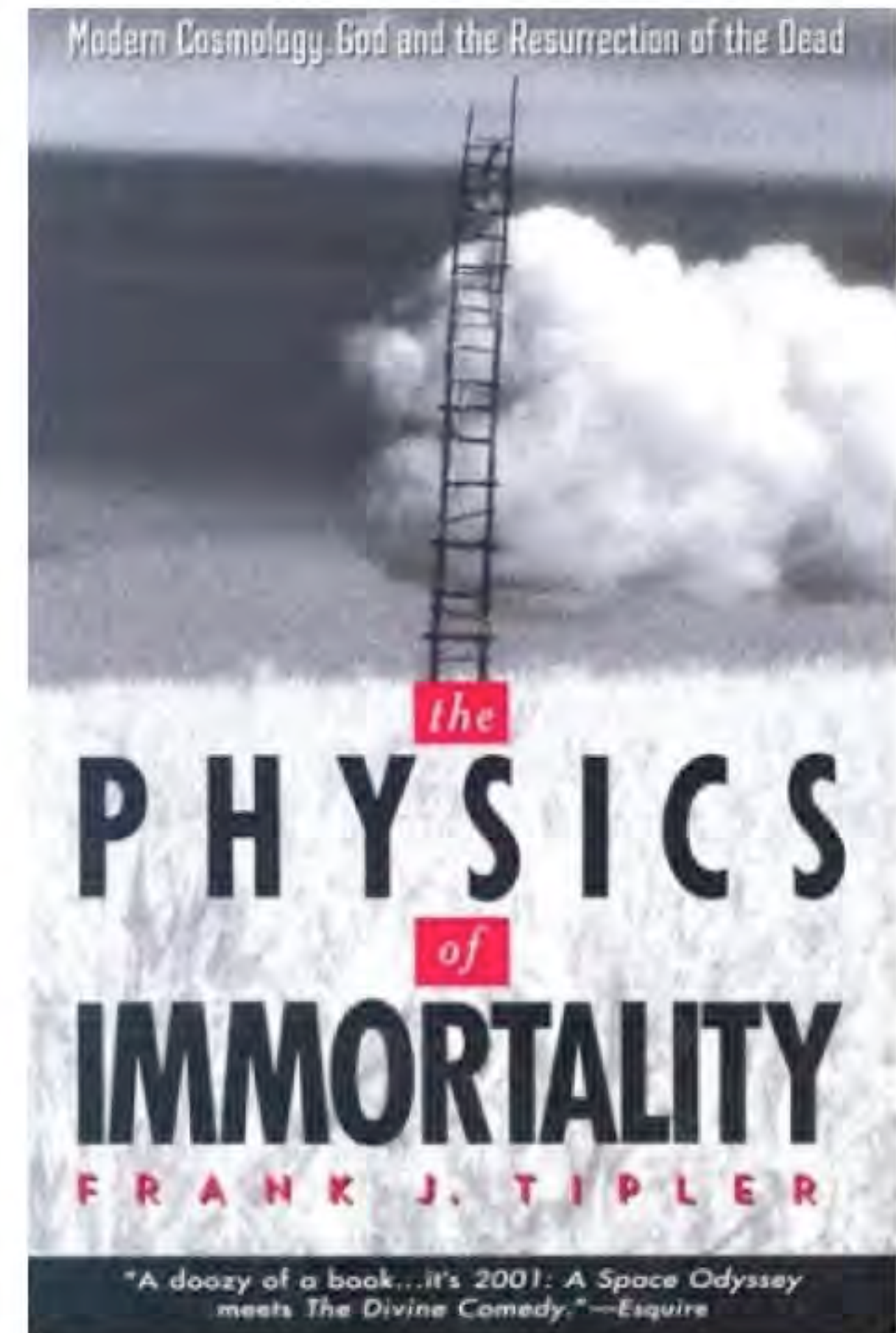
- Afterlife
- One time reincarnation, eternal life
 - Western monotheistic religions: Heaven / Hell
 - Also part of European pantheistic religions
 - Germanic religions: Valhalla
 - Greek, Roman: Elysium (good) / Asphodel (ok) / Tartarus (bad)
- Endless cycle of reincarnations
 - Buddhism, Hinduism, Jainism, Sikhism
 - Nirvana: final liberation from the endless cycle of birth, life, and death



Paradise by [Jan Bruegel](#)

The Physics of Immortality

- Mankind creates evermore powerful artificial intelligence
- Machines colonize universe at $\sim$ speed of light
- Machines remember us fondly as their creators and reconstruct us in the quantum wave function of the universe
- Machines cause 2d collapse of universe to take advantage of general relativity and time dilation to make themselves (and us!) live forever



THE FATE OF LIFE IN THE UNIVERSE

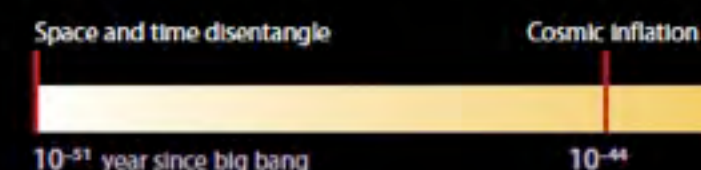
Billions of years ago the universe was too hot for life to exist. Countless eons hence, it will become so cold and empty that life, no matter how ingenious, will perish

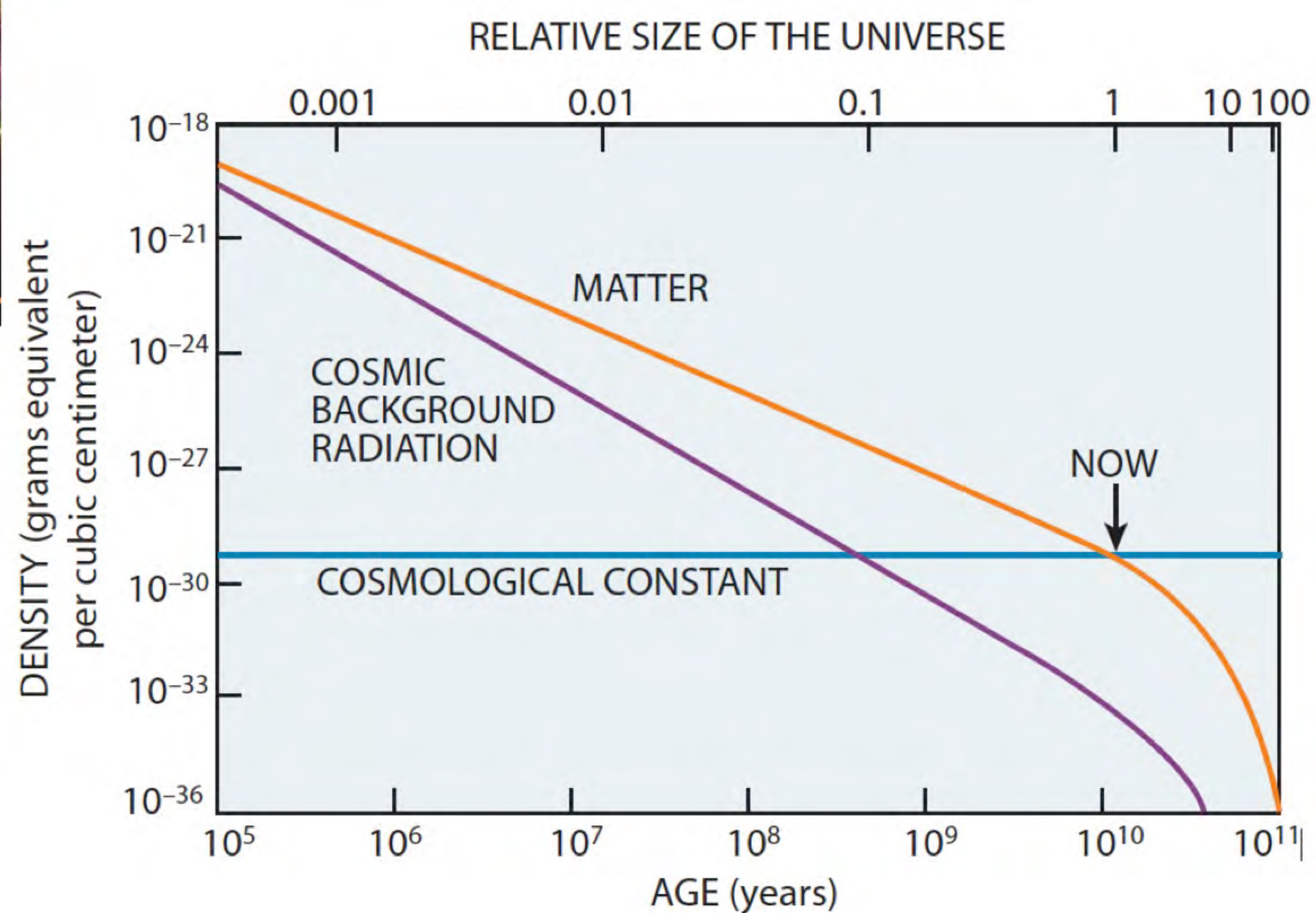
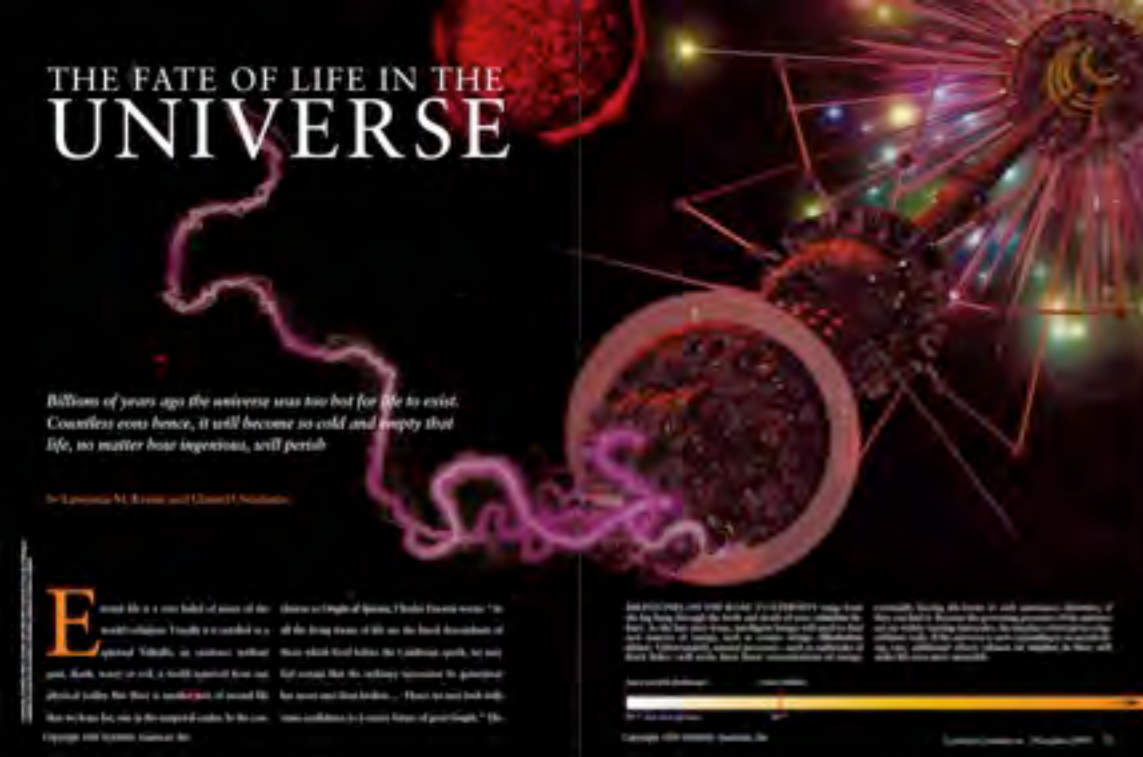
by Lawrence M. Krauss and Glenn D. Starkman

Eternal life is a core belief of many of the world's religions. Usually it is extolled as a spiritual Valhalla, an existence without pain, death, worry or evil, a world removed from our physical reality. But there is another sort of eternal life that we hope for, one in the temporal realm. In the conclusion to *Origin of Species*, Charles Darwin wrote: "As all the living forms of life are the lineal descendants of those which lived before the Cambrian epoch, we may feel certain that the ordinary succession by generation has never once been broken.... Hence we may look with some confidence to a secure future of great length." The

MILESTONES ON THE ROAD TO ETERNITY range from the big bang through the birth and death of stars (*timeline below*). As the last stars wane, intelligent beings will need to find new sources of energy, such as cosmic strings (*illustration above*). Unfortunately, natural processes—such as outbreaks of black holes—will erode these linear concentrations of energy,

eventually forcing life-forms to seek sustenance elsewhere, if they can find it. Because the governing processes of the universe act on widely varying timescales, the timeline is best given a logarithmic scale. If the universe is now expanding at an accelerating rate, additional effects (*shown on timeline in blue*) will make life even more miserable.





DILUTION of the cosmos by the expansion of space affects different forms of energy in different ways. Ordinary matter (*orange*) thins out in direct proportion to volume, whereas the cosmic background radiation (*purple*) weakens even faster as it is stretched from light into microwaves and beyond. The energy density represented by a cosmological constant (*blue*) does not change, at least according to present theories.

> 10^{18} years

Not enough energy density

- to sustain any stars or planets
- to sustain black holes
- to sustain any finite volume of space at a temperature significantly above a temperature of 0 K
- to process any information
- to sustain any life form

In Conclusion

... the very long term future

