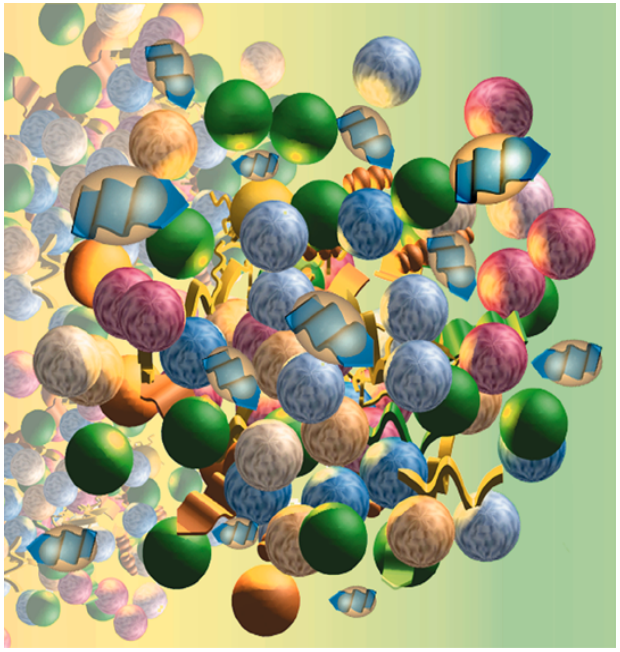
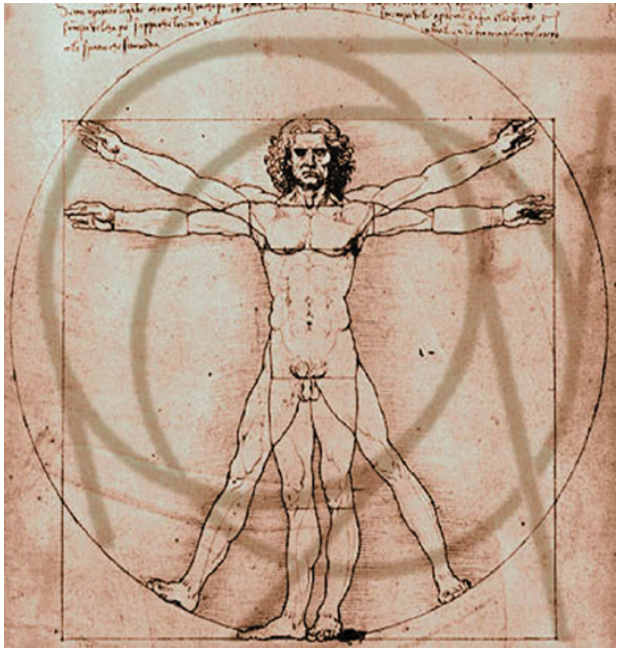
Big [unanswered] questions

... but hopefully not for long





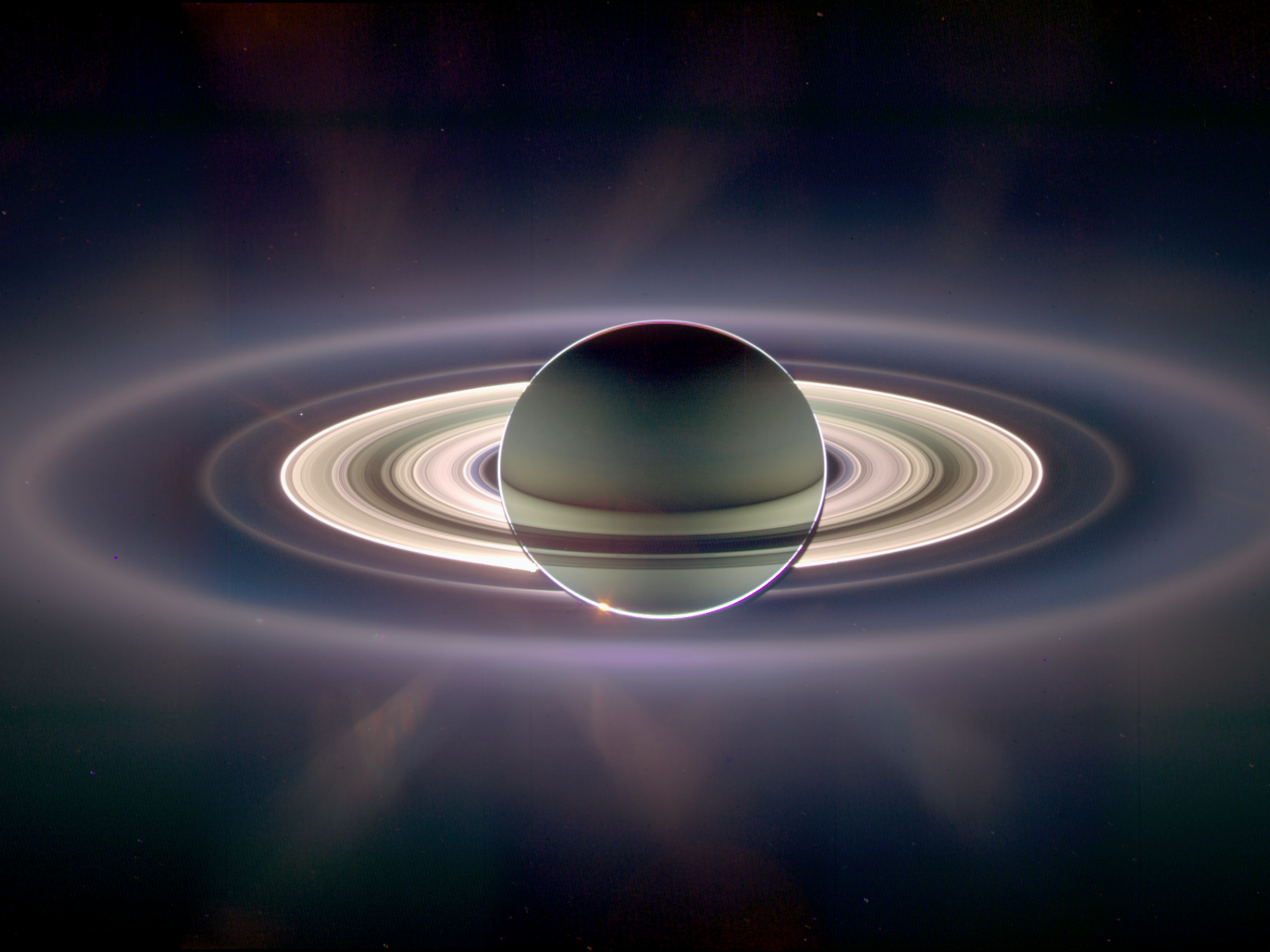
2nd Thematic CERN School of Computing
Split, 15 – 20 June 2014

Ivica Puljak
FESB – Split

Do we know anything?

- “We can know only that we know nothing. And that is the highest degree of human wisdom.”
  — Leo Tolstoy, *War and Peace*
- Is it really like that?


Earth as seen from Mars

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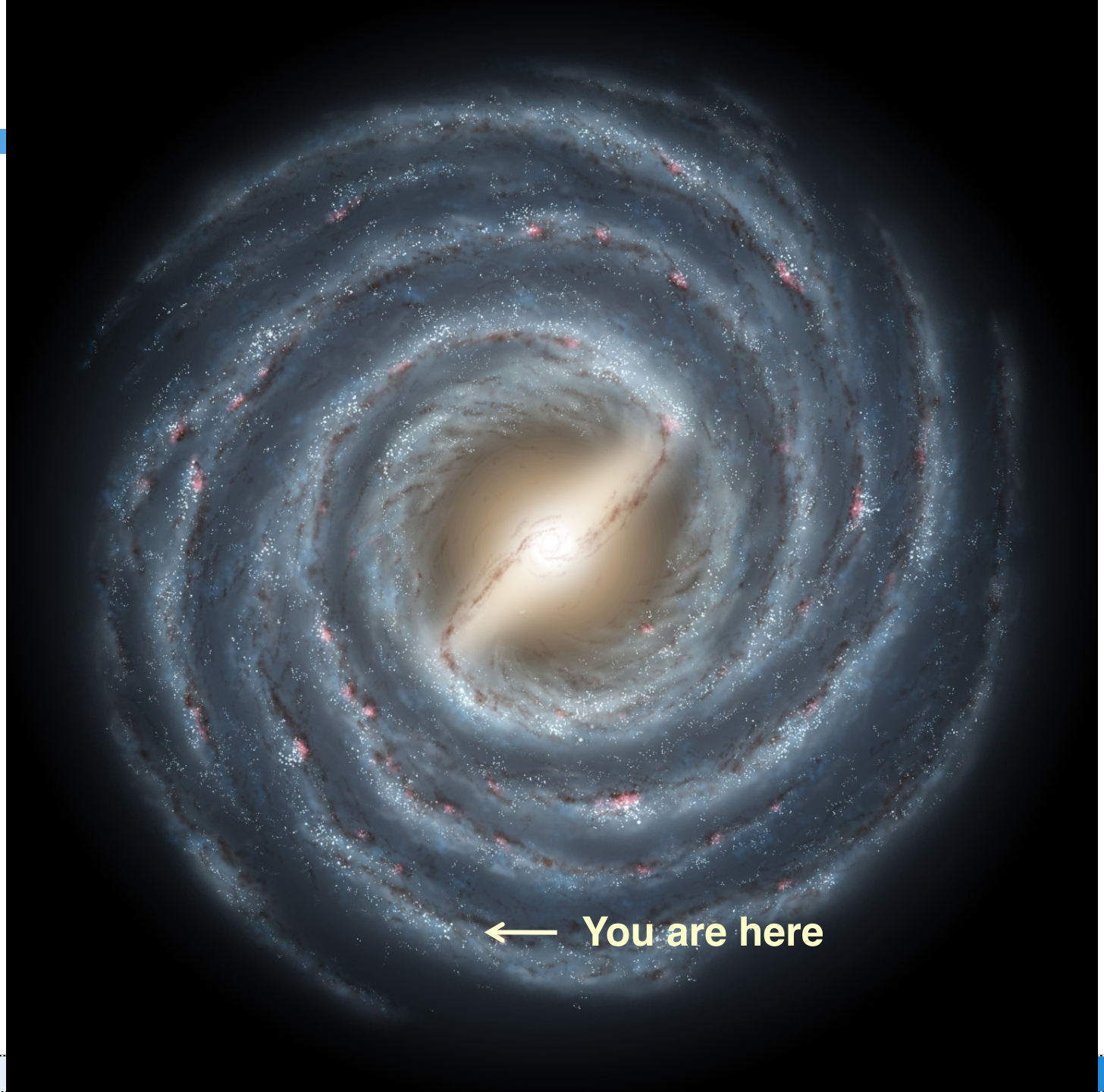
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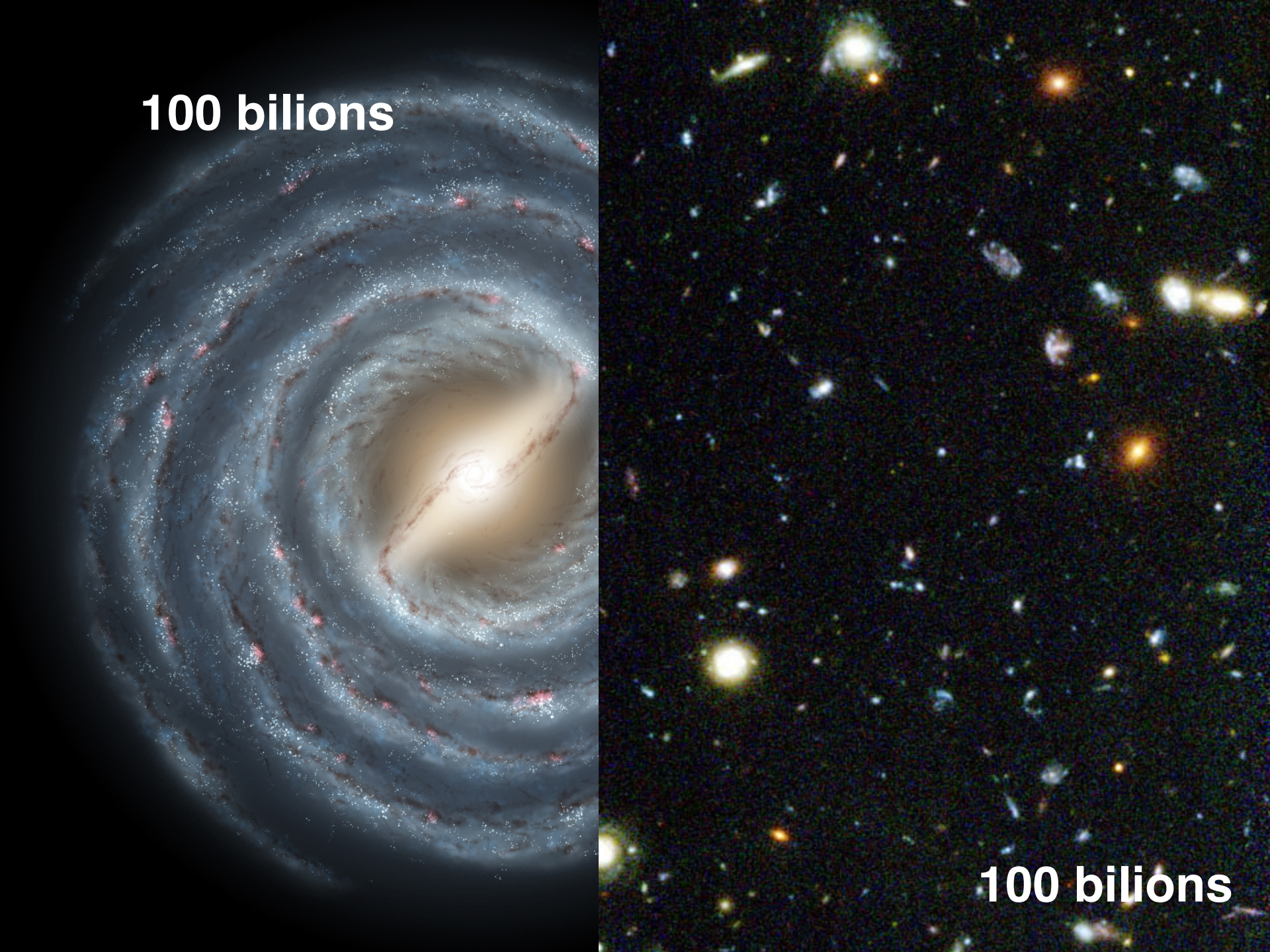
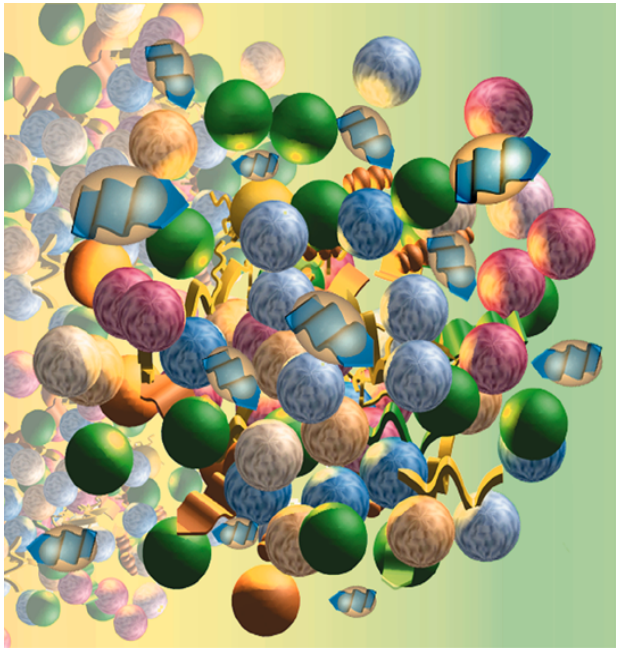
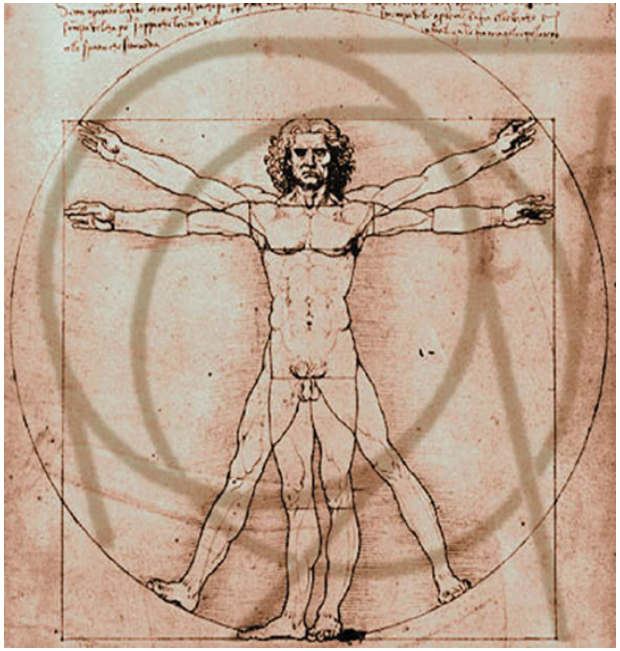

100 bilions
100 bilions

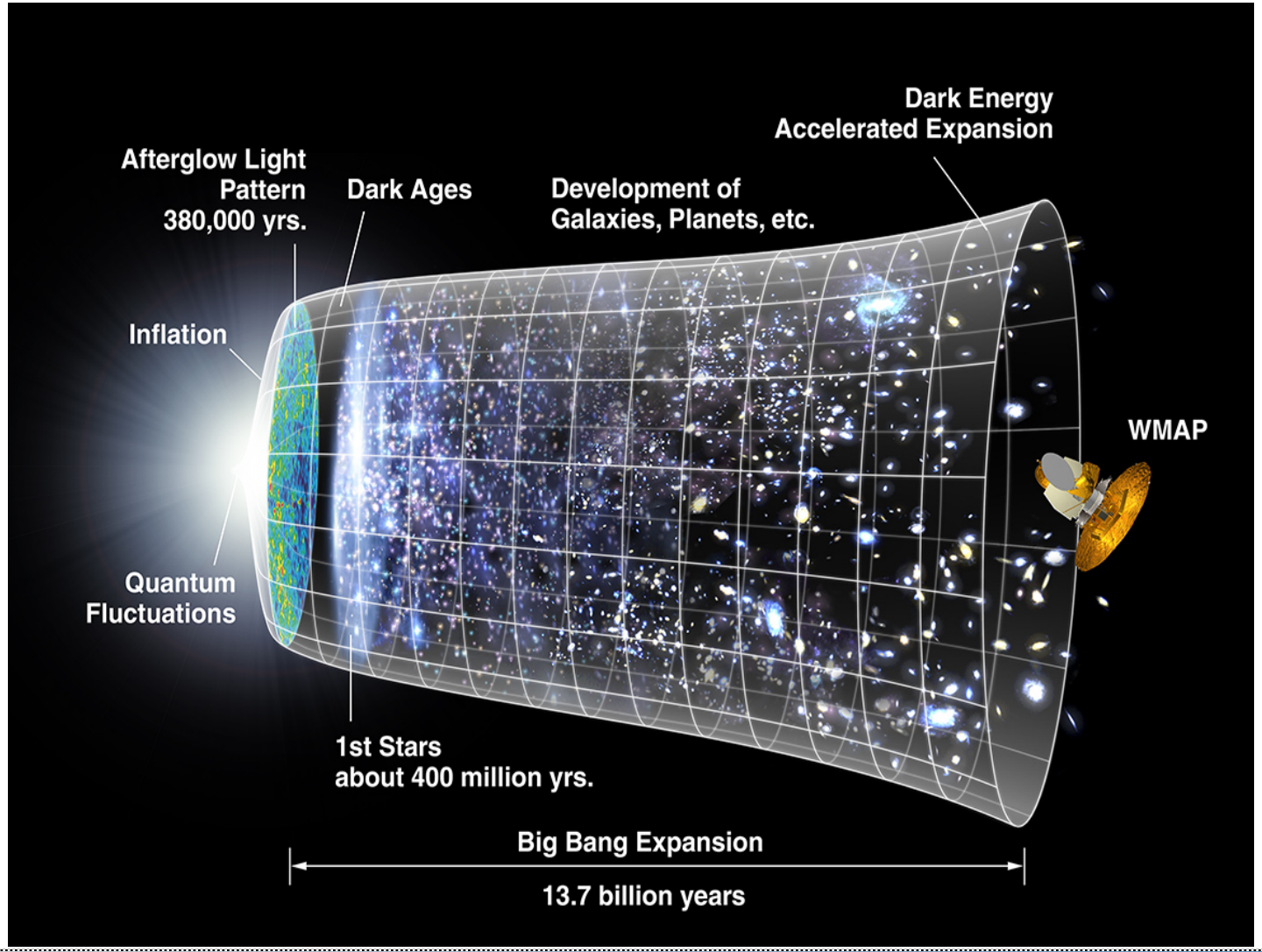





Hubble
Heritage

What do we know?

- Evolution of the Universe



What do we know?

- Standard Model of particles and their interactions

Leptons

Electric Charge

Tau	-1	0	Tau Neutrino
Mion	-1	0	Mion Neutrino
Elektron	-1	0	Elektron Neutrino

Quarks

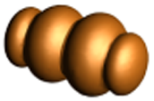
Električni naboj

Bottom	-1/3	2/3	Top
Strange	-1/3	2/3	Charm
Down	-1/3	2/3	Up

svaki kvark R, B, G 3 boje

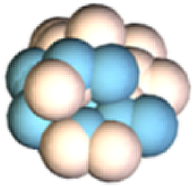
Strong

Gluoni (8)



Kvarkovi

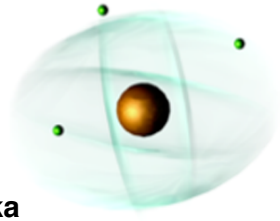
Mezoni
Barioni



Jezgre

Electromagnetic

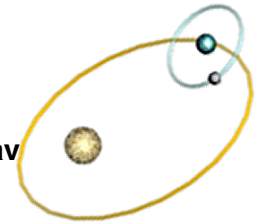
Foton



Atomi
Svjetlost
Kemija
Elektronika

Gravitation

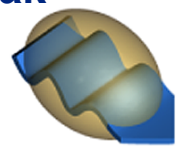
Graviton ?

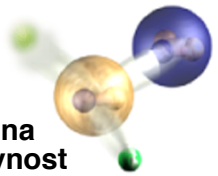


Sunčev sustav
Galaksije
Crne rupe

Weak

Bozoni
(W,Z)



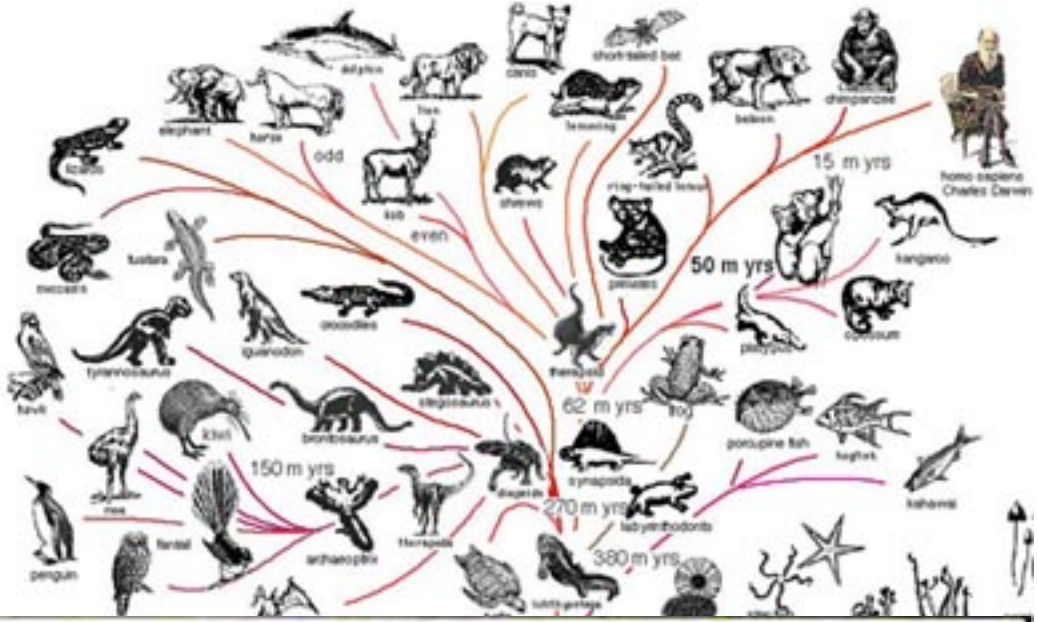


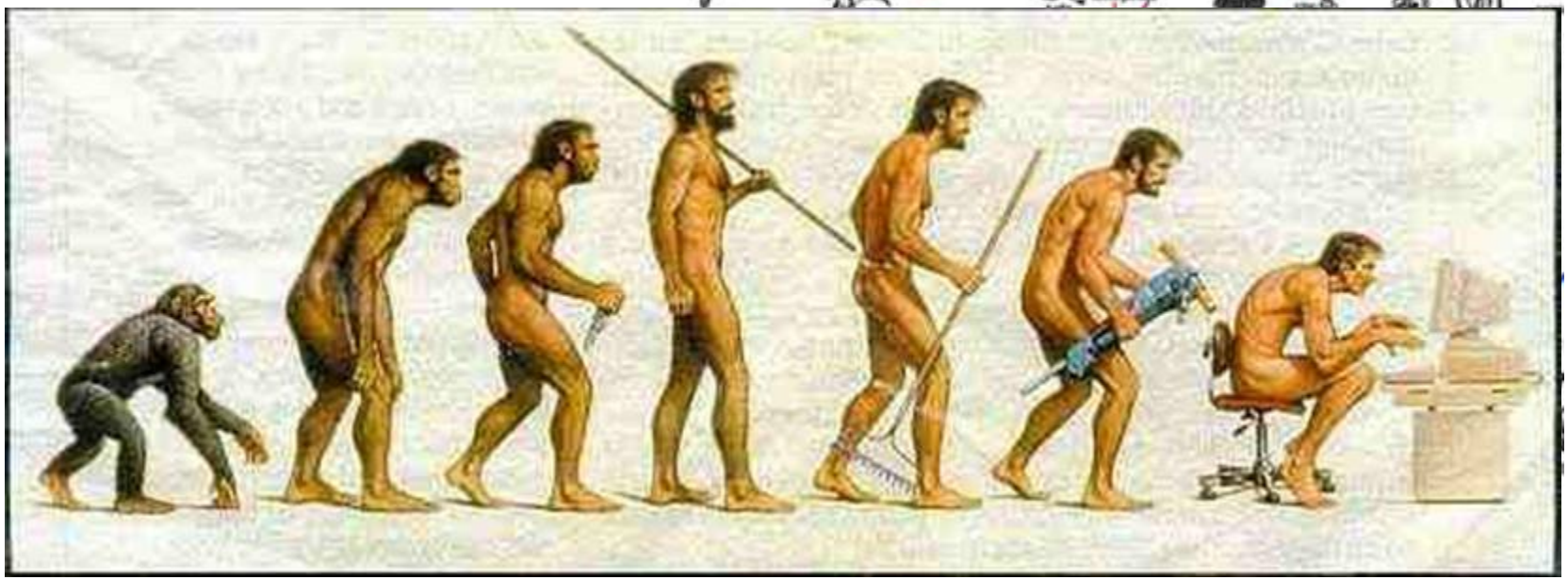
Raspad neutrona
Beta radioaktivnost
Interakcije neutrina
Izgaranja sunca

The particle drawings are simple artistic representations

What do we know?

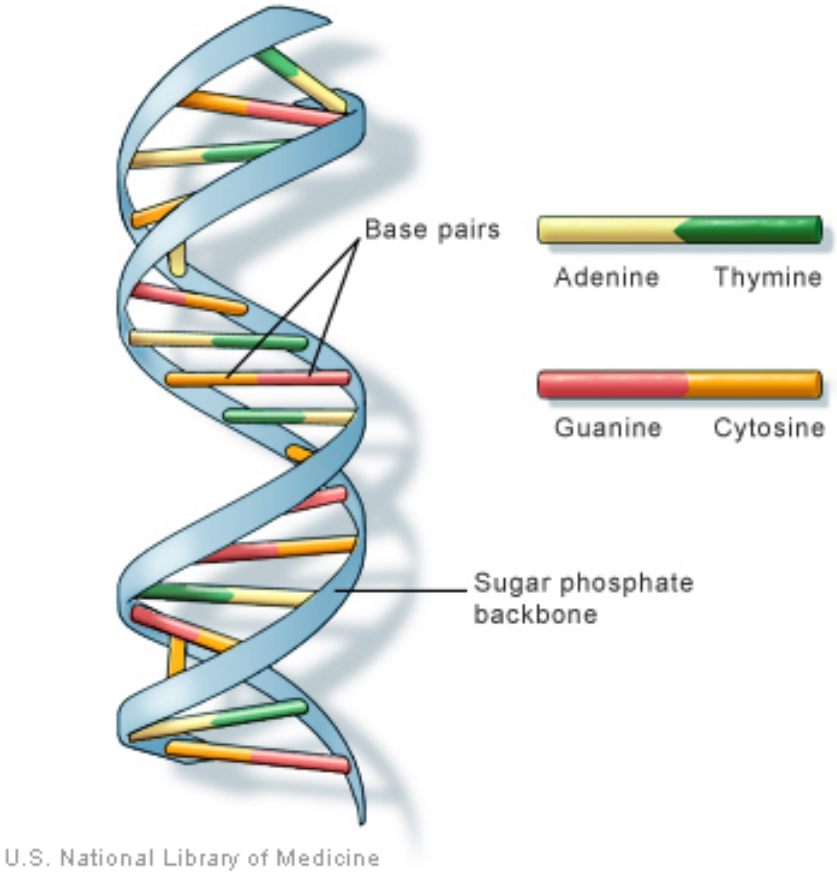
- Darwin's theory of natural selection

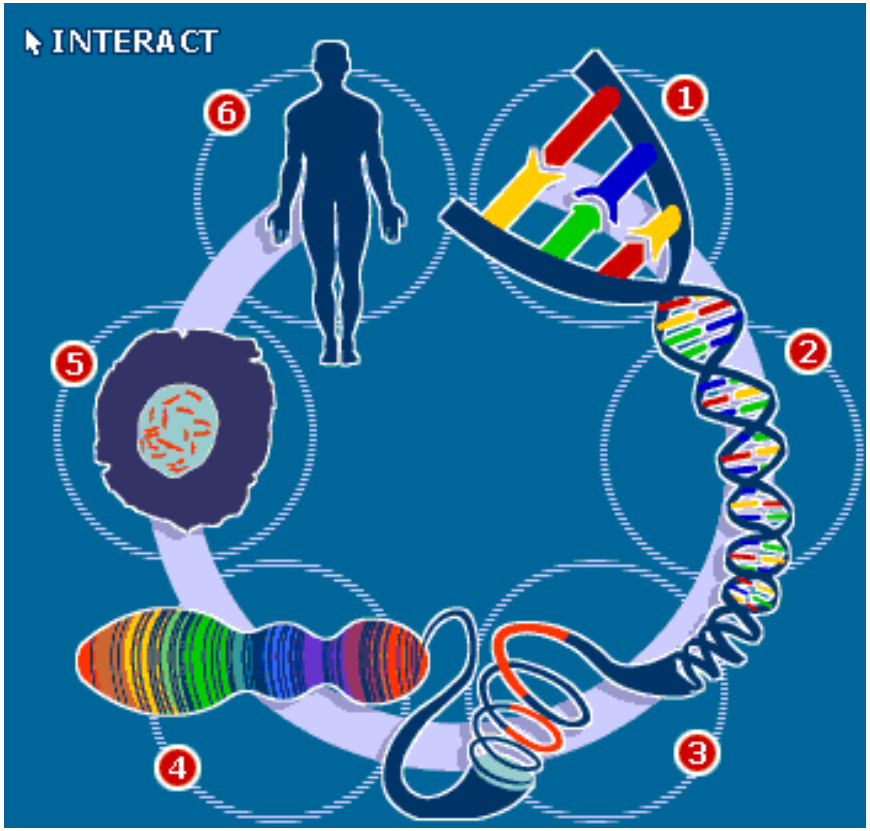


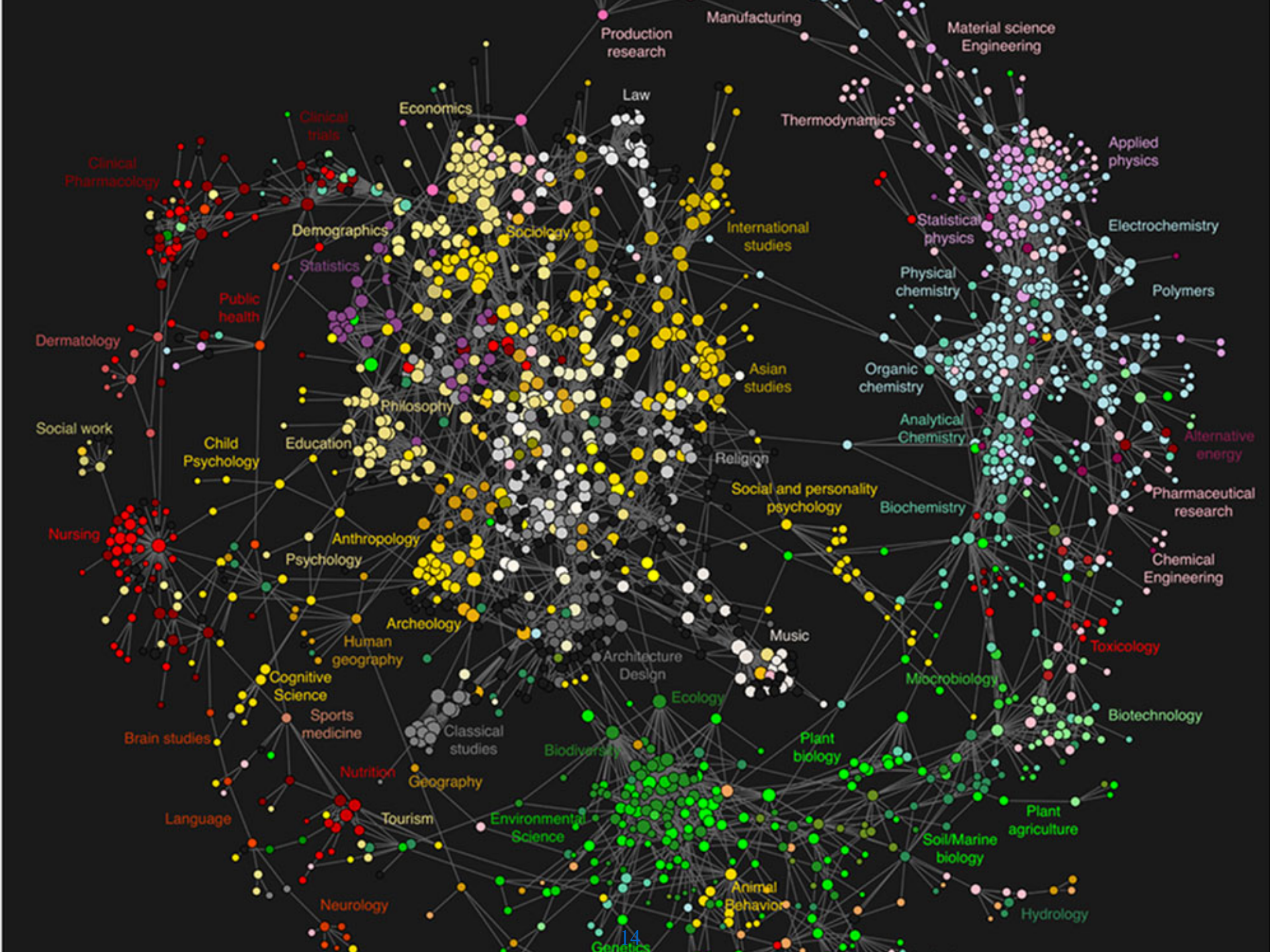


What do we know?

- DNA






Production research
Manufacturing
Material science Engineering
Law
Economics
Clinical trials
Thermodynamics
Applied physics
Clinical Pharmacology
Demographics
Sociology
International studies
Statistical physics
Electrochemistry
Statistics
Physical chemistry
Polymers
Public health
Dermatology
Asian studies
Organic chemistry
Philosophy
Social work
Analytical Chemistry
Alternative energy
Child Psychology
Education
Religion
Social and personality psychology
Biochemistry
Pharmaceutical research
Nursing
Anthropology
Psychology
Chemical Engineering
Archeology
Music
Human geography
Toxicology
Architecture
Design
Cognitive Science
Microbiology
Ecology
Biotechnology
Sports medicine
Brain studies
Classical studies
Biodiversity
Plant biology
Nutrition
Geography
Language
Tourism
Environmental Science
Plant agriculture
Soil/Marine biology
Animal Behavior
Neurology
Hydrology
Genetics

What don’t we know?

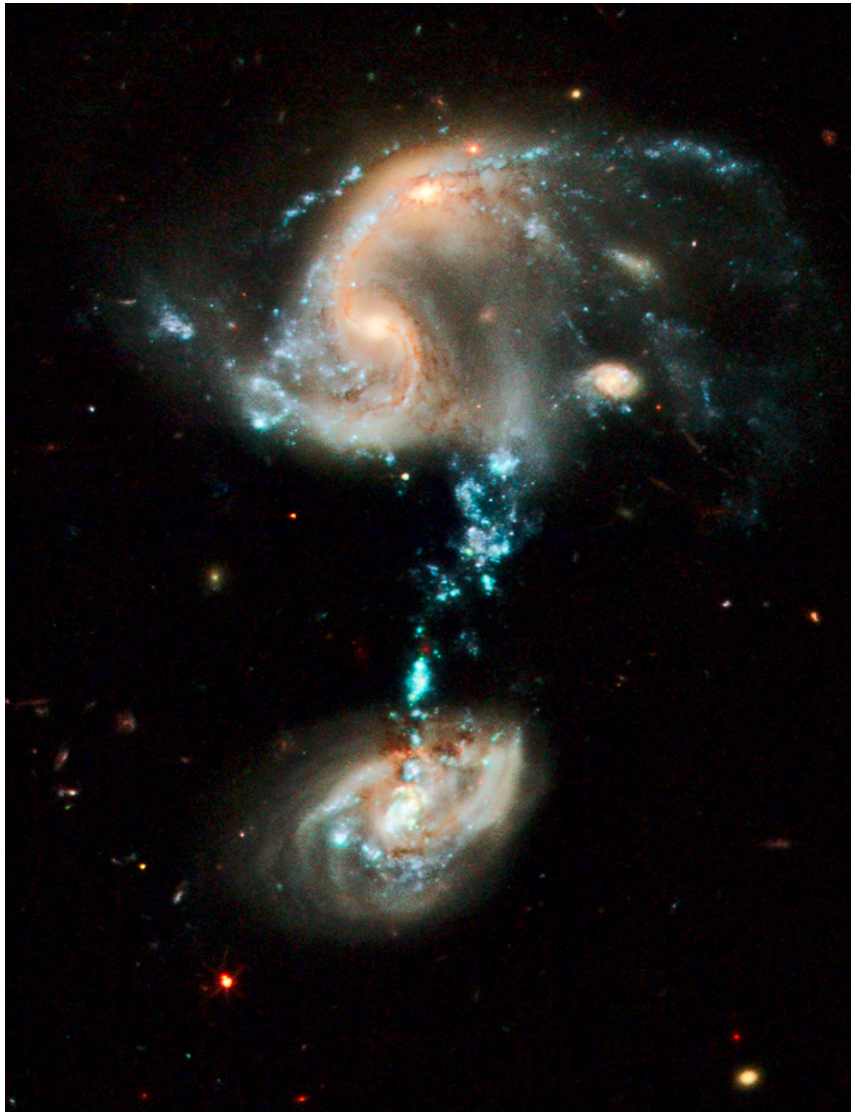
- What Is the Universe Made Of?
- What is the Biological Basis of Consciousness?
- Why Do Humans Have So Few Genes?
- To What Extent Are Genetic Variation and Personal Health Linked?
- Can the Laws of Physics Be Unified?
- How Much Can Human Life Span Be Extended?
- What Controls Organ Regeneration?
- How Can a Skin Cell Become a Nerve Cell?
- How Does a Single Somatic Cell Become a Whole Plant?
- How Does Earth's Interior Work?
- Are We Alone in the Universe?
- How and Where Did Life on Earth Arise?
- What Determines Species Diversity?
- What Genetic Changes Made Us Uniquely Human?

What don't we know?

- How Are Memories Stored and Retrieved?
- How Did Cooperative Behavior Evolve?
- How Will Big Pictures Emerge from a Sea of Biological Data?
- How Far Can We Push Chemical Self-Assembly?
- What Are the Limits of Conventional Computing?
- Can We Selectively Shut Off Immune Responses?
- Do Deeper Principles Underlie Quantum Uncertainty and Nonlocality?
- Is an Effective HIV Vaccine Feasible?
- How Hot Will the Greenhouse World Be?
- What Can Replace Cheap Oil -- and When?
- Will Malthus Continue to Be Wrong?
- Is Ours the Only Universe?
- What Drove Cosmic Inflation?
- When And How Did the First Stars and Galaxies Form?

From Guardian

What don't we know?

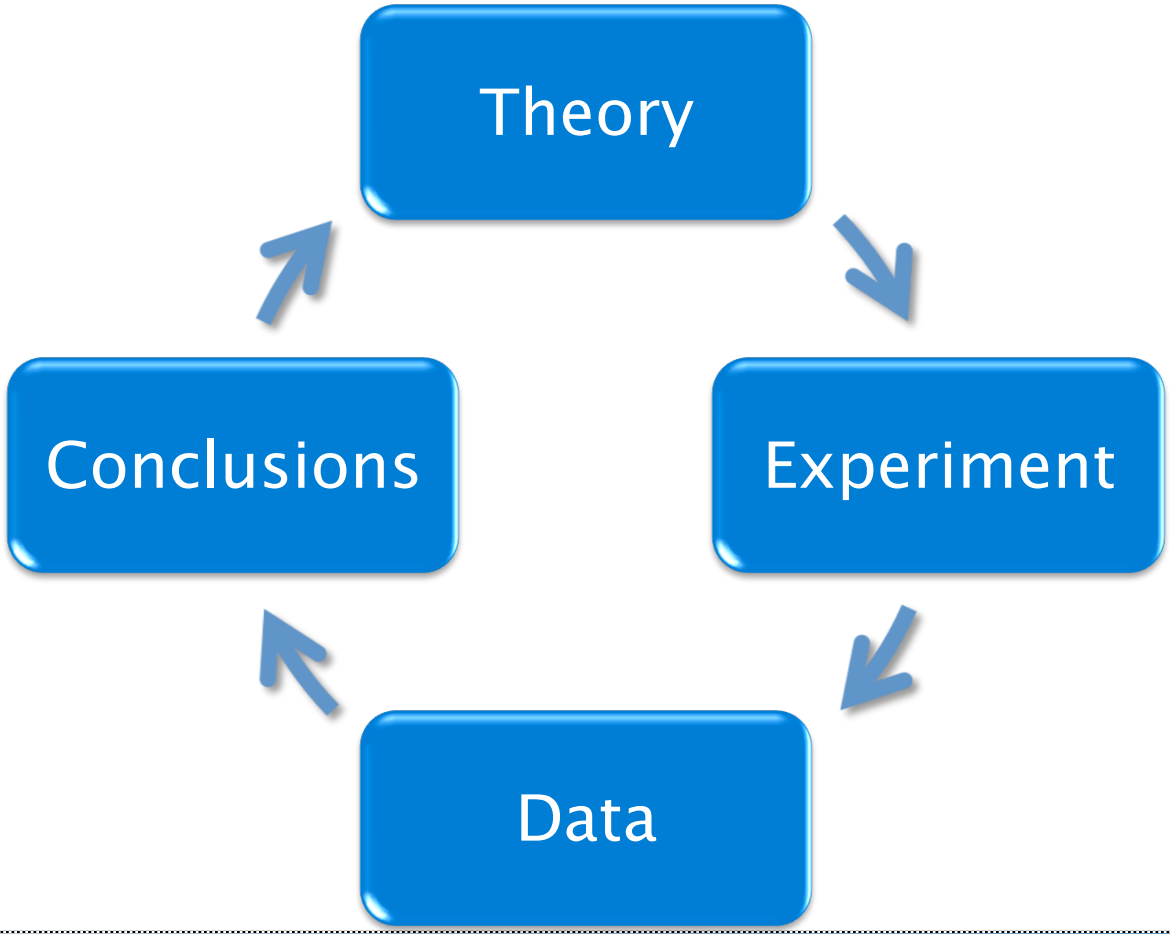


- What's so weird about prime numbers?
- How do we beat bacteria?
- Can computers keep getting faster?
- Will we ever cure cancer?
- When can I have a robot butler?
- What's at the bottom of the ocean?
- What's at the bottom of a black hole?
- How do we get more energy from the sun?
- How do we solve the population problem?
- Is time travel possible?
- Why do we dream?
- Why is there stuff?
- Are there other universes?
- Where do we put all the carbon?

What are we absolutely convinced about?

- ... that the answer to these and many other questions will be found only by ...

THE SCIENTIFIC METHOD




SO YOU'RE TELLING ME
PEOPLE FROM YOUR COUNTRY THINK THAT FACEBOOK GIVES US FOOD FOR EVERY LIKE?
www.veryfunnypics.eu

What is the universe made of?

What do we know?

- Standard Model of particles and their interactions

Leptons

Electric Charge

Tau	-1	0	Tau Neutrino
Mion	-1	0	Mion Neutrino
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Električni naboj

Bottom	-1/3	2/3	Top
Strange	-1/3	2/3	Charm
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svaki kvark R, B, G 3 boje

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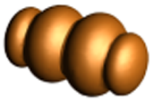

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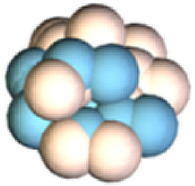

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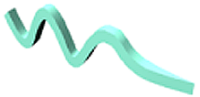

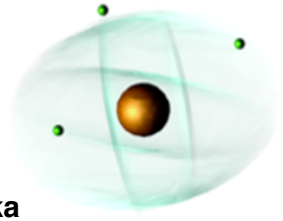

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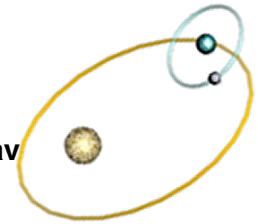

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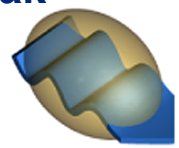

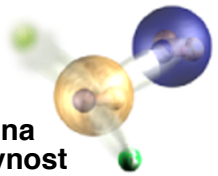

Raspad neutrona
Beta radioaktivnost
Interakcije neutrina
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The particle drawings are simple artistic representations

Particles

Leptoni

	Electric Charge		
Tau	-1	0	Tau Neutrino
Mion	-1	0	Mion Neutrino
Elektron	-1	0	Elektron Neutrino

Kvarkovi

	Električni naboj		
Dno	-1/3	2/3	Vrh
Strani	-1/3	2/3	Šarmantni
Dolje	-1/3	2/3	Gore

svaki kvark:R, B, G 3 boje

Antiparticles

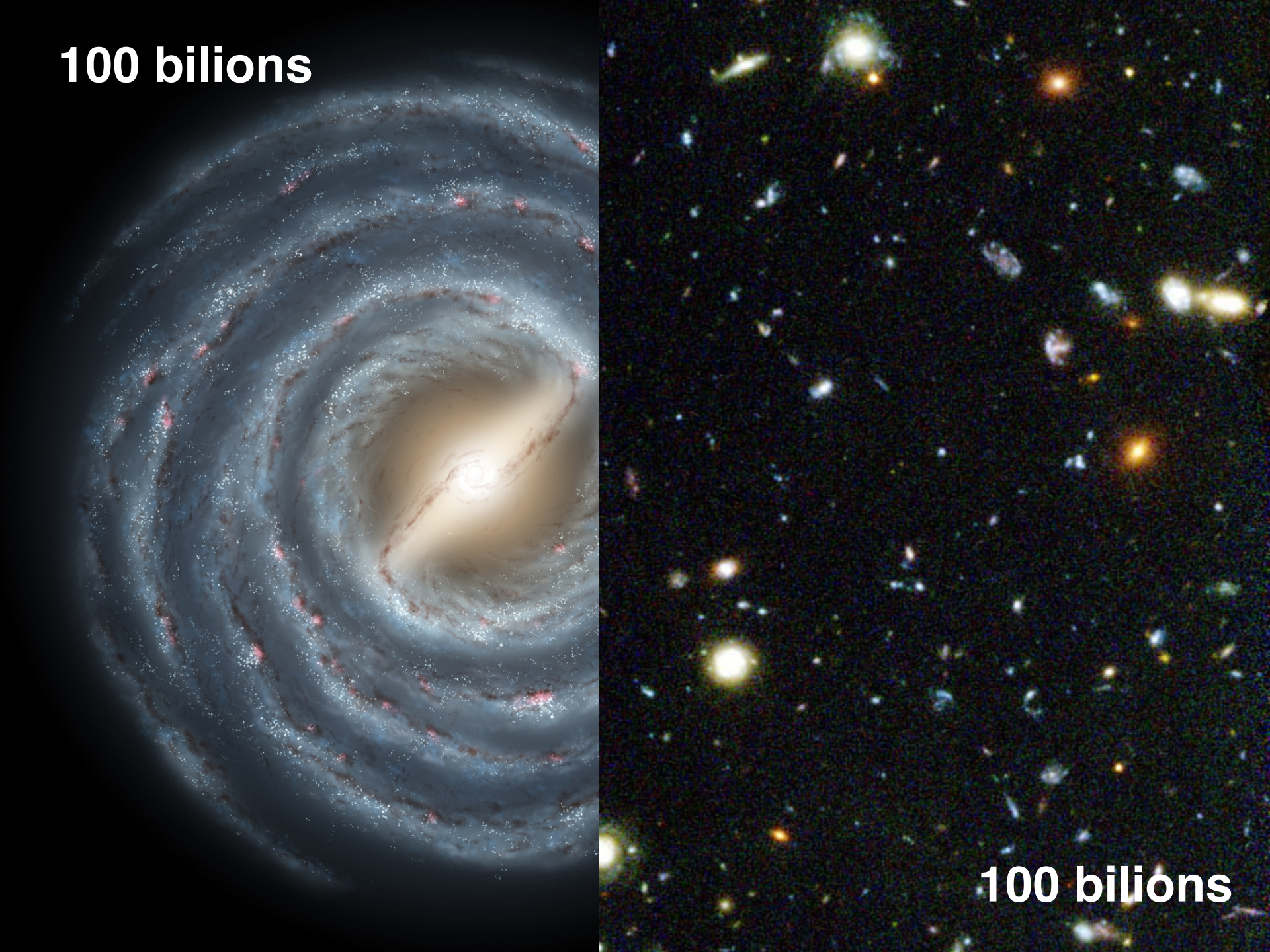
Antileptoni

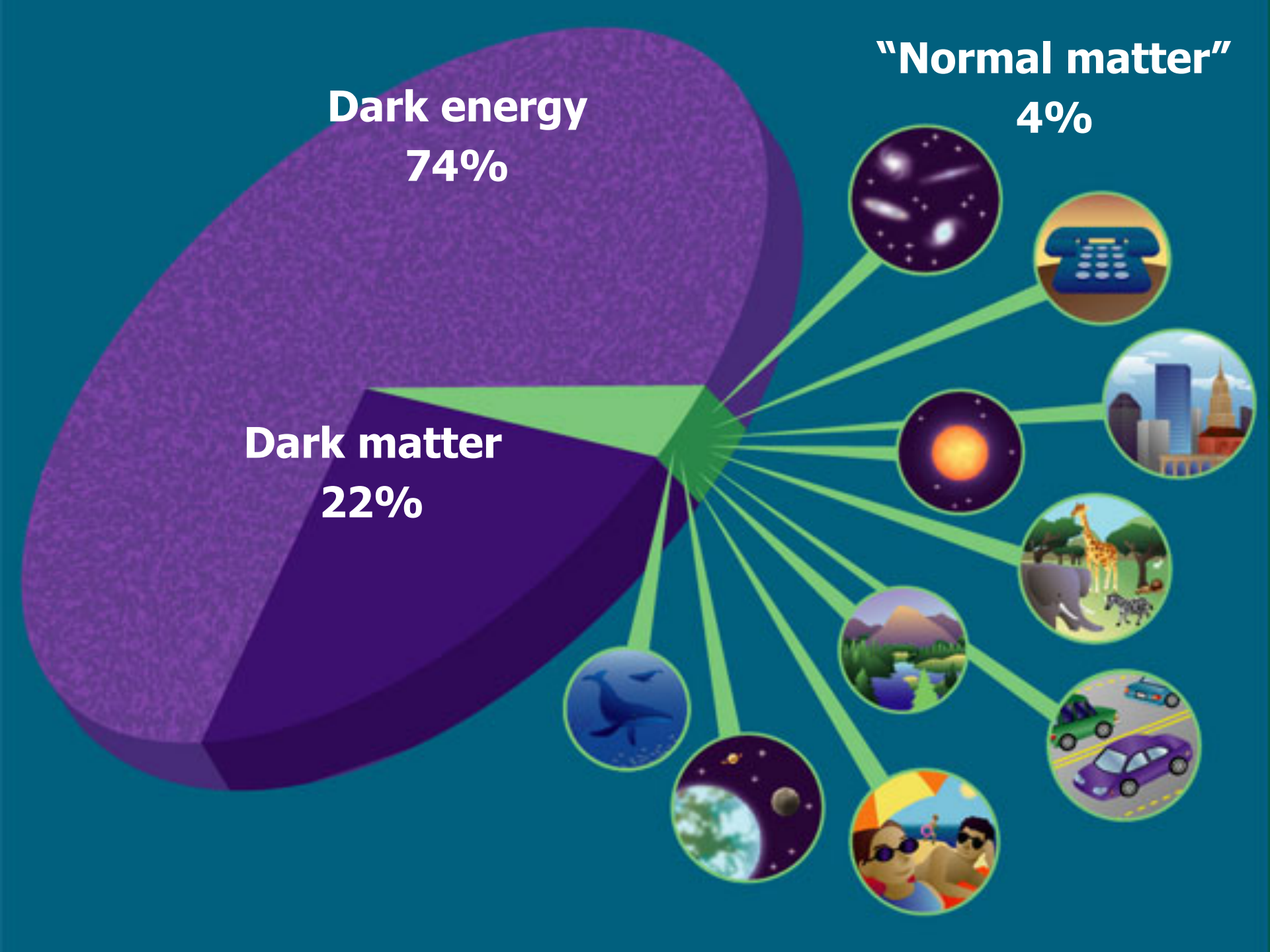
	Electric Charge		
Antitau	1	0	Antitau Neutrino
Antimion	1	0	Antimion Neutrino
Pozitron	1	0	Antielektron Neutrino

Antikvarkovi

	Električni naboj		
Antidno	1/3	-2/3	Antivrh
Antistrani	1/3	-2/3	Antišarmantni
Antidolje	1/3	-2/3	Antigore

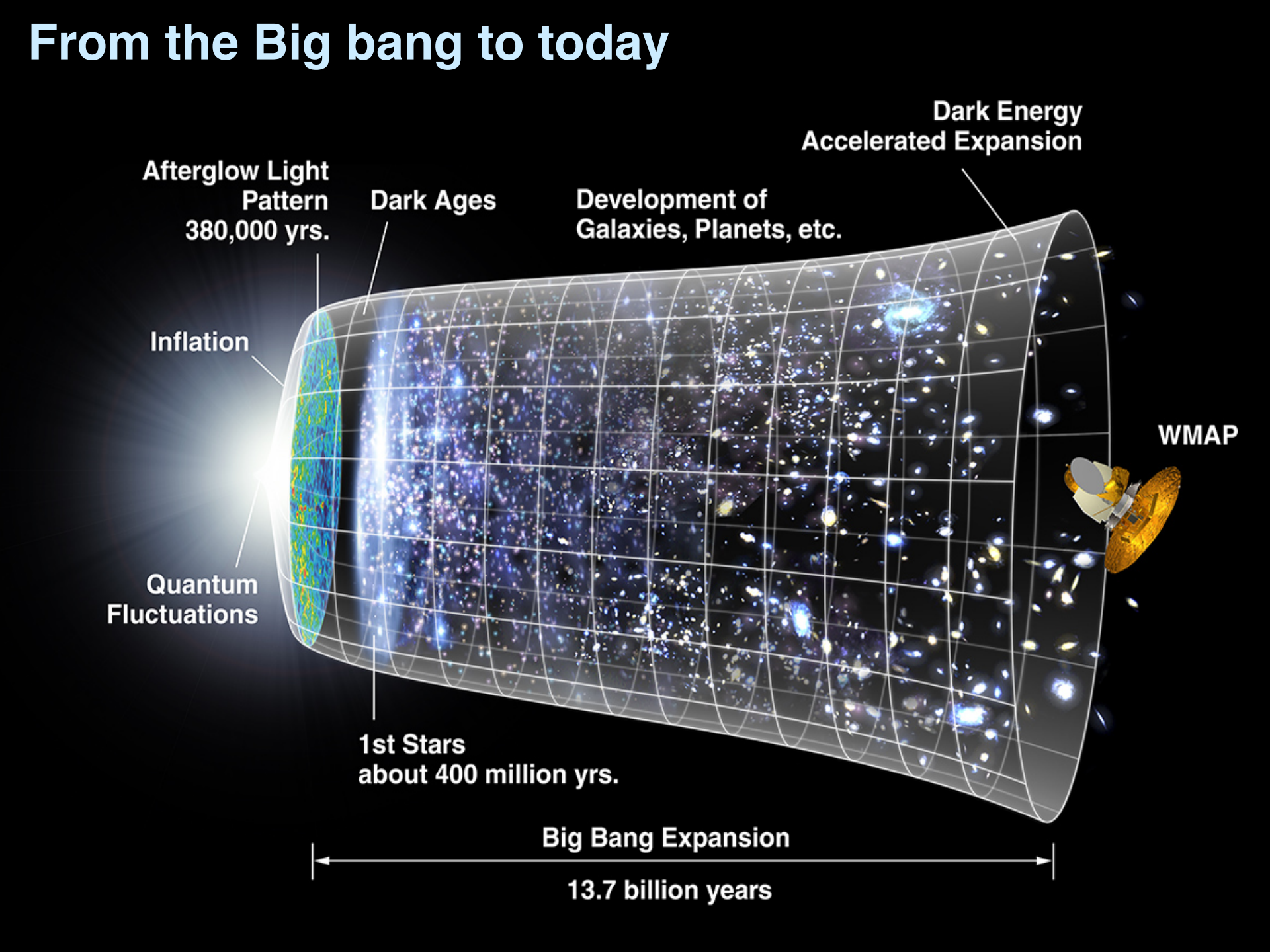
svaki antikvark:R, B, G 3 antiboje


100 bilions
100 bilions


Dark energy
74%
Dark matter
22%
"Normal matter"
4%

How do we know that?

From the Big bang to today



10^{-43}s Quantum gravitation era

t < 10^{-43} s : The Big Bang

The universe is considered to have expanded from a single point with an infinitely high energy density (infinite temperature). Is there a meaning to the question what existed before the big bang?

t - 10^{-43} s, 10^{32} K (10^{19} GeV, 10^{-34} m) : Gravity –freezes“ out

All particle types (quarks, leptons, gauge bosons, and undiscovered particles e.g.Higgs, sparticles, gravitons) and their anti-particles are in a thermal equilibrium (being created and annihilated at equal rate). These coexist with photons (radiation).

Through a phase transition gravity "froze" out and became distinct in its action from the weak, electromagnetic and strong forces. The other three forces could not be distinguished from one another in their action on quarks and leptons. This is the first instance of the breaking of symmetry amongst the forces.

10^{-35} s Grand unification era

t - 10^{-35} s, 10^{27} K (10^{16} GeV, 10^{32} m) : Inflation

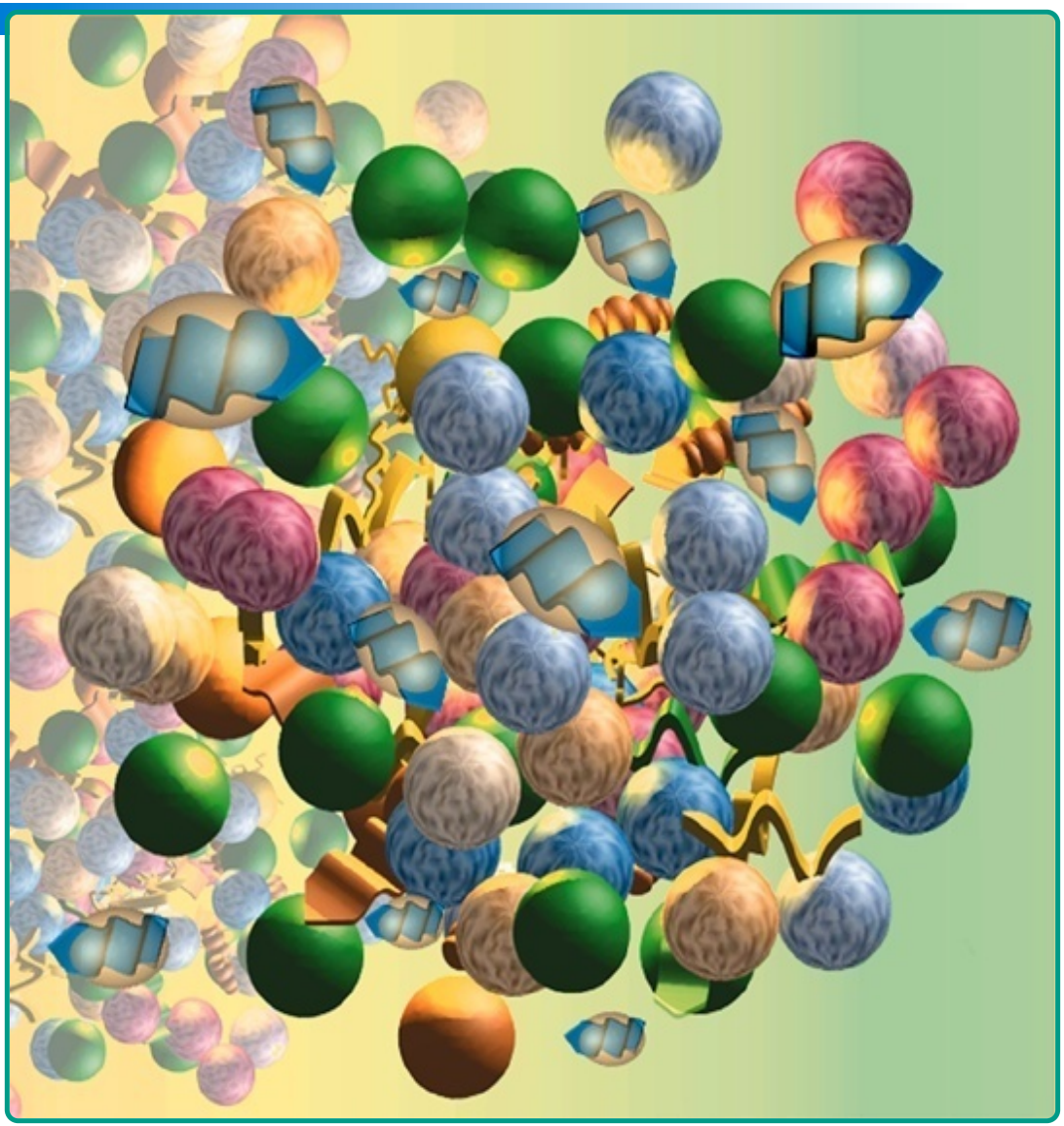
The rate of expansion increases exponentially for a short period. The universe doubled in size every 10^{-34} s. Inflation stopped at around 10^{-32} s. The universe increased in size by a factor of 10^{25}. This is equivalent to an object the size of a proton swelling to 10^{9} light years across.

However the presently visible universe was only 3 m in size after inflation. This solves the problems of 'horizon' (how is it possible for two opposing parts of the present universe to be at the same temperature when they cannot have interacted with each other before recombination) and 'flatness' (density of matter is close to the critical density).

t - 10^{-32} s : Strong forces freezes out

Through another phase transition the strong force "freezes" out and a slight excess of matter over anti-matter develops. This excess, at a level of 1 part in a billion, is sufficient to give the presently observed predominance of matter over anti-matter. The temperature is too high for quarks to remain clumped to form neutrons or protons and so exist in the form of a quark gluon plasma. The LHC can study this by colliding together high energy nuclei.

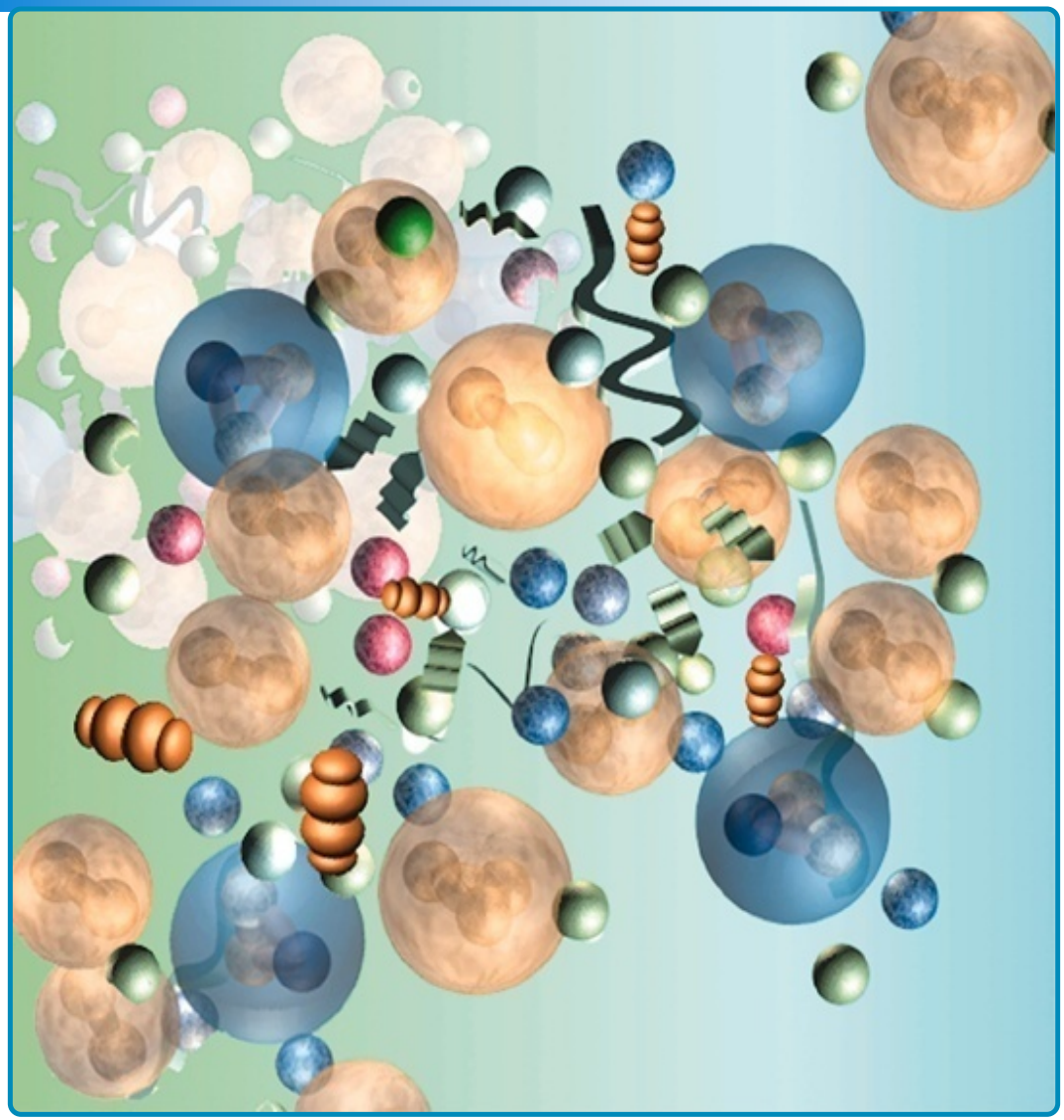
10^{-10} s Elektroweak era



t - 10^{-10} s, 10^{15} K (100 GeV, 10^{-18} m) : Electromagnetic and Weak Forces separate

The energy density corresponds to that at LEP. As the temperature fell the weak force "freezes" out and all four forces become distinct in their actions. The antiquarks annihilate with the quarks leaving a residual excess of matter. W and Z bosons decay. In general unstable massive particles disappear when the temperture falls to a value at which photons from the black-body radiation do not have sufficient energy to create a particle-antiparticle pair.

10^{-4} s Making protons and neutrons



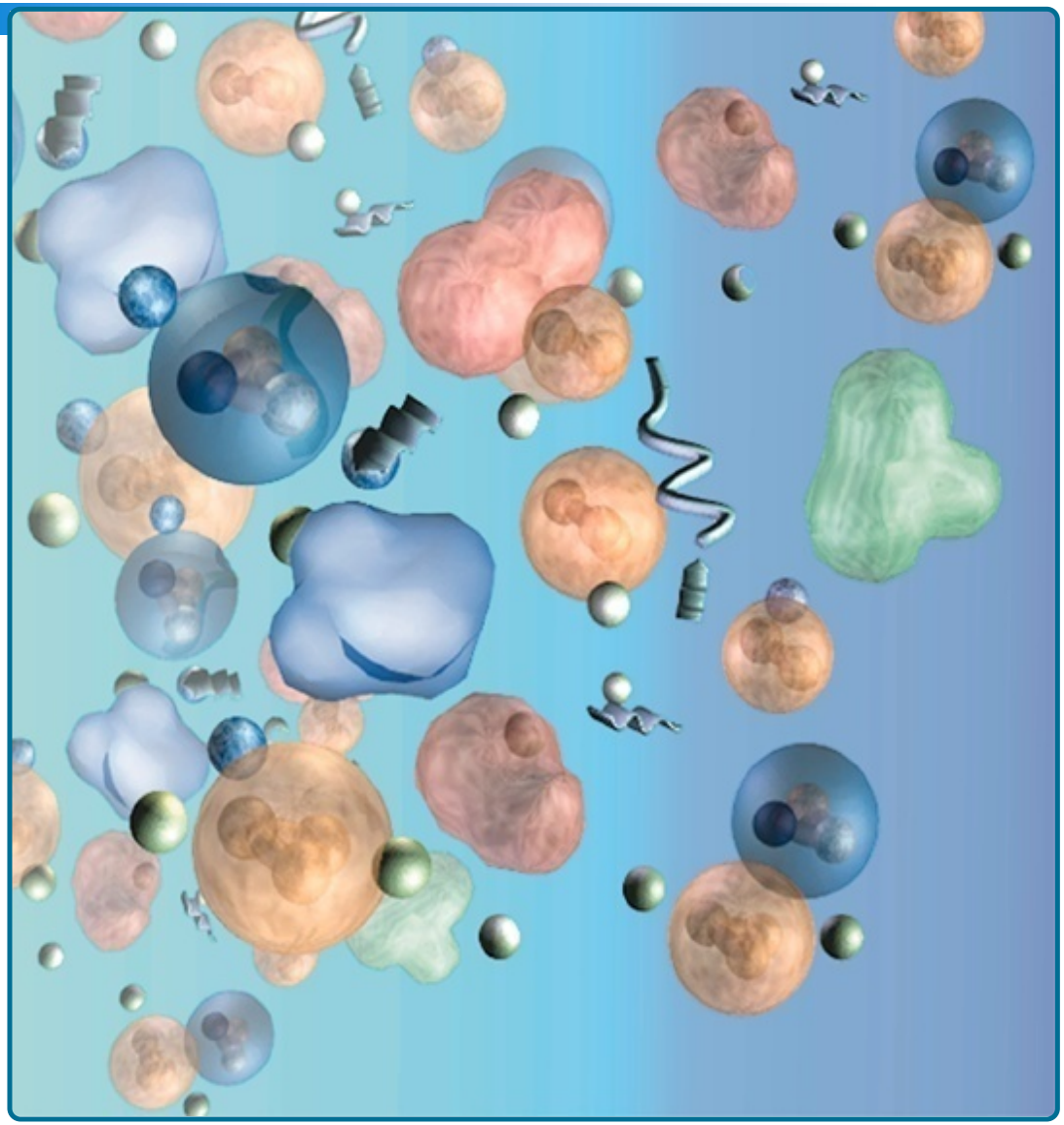
t - 10^{-4} s, 10^{13} K (1 GeV, 10^{-16} m) : Protons and Neutrons form

The universe has grown to the size of our solar system. As the temperature drops quark-antiquark annihilation stops and the remaining quarks combine to make protons and neutrons.

t = 1 s, 10^{10} K (1 MeV, 10^{-15} m) : Neutrinos decouple

The neutrinos become inactive (essentially do not participate further in interactions). The electrons and positrons annihilate and are not recreated. An excess of electrons is left. The neutron-proton ratio shifts from 50:50 to 25:75.

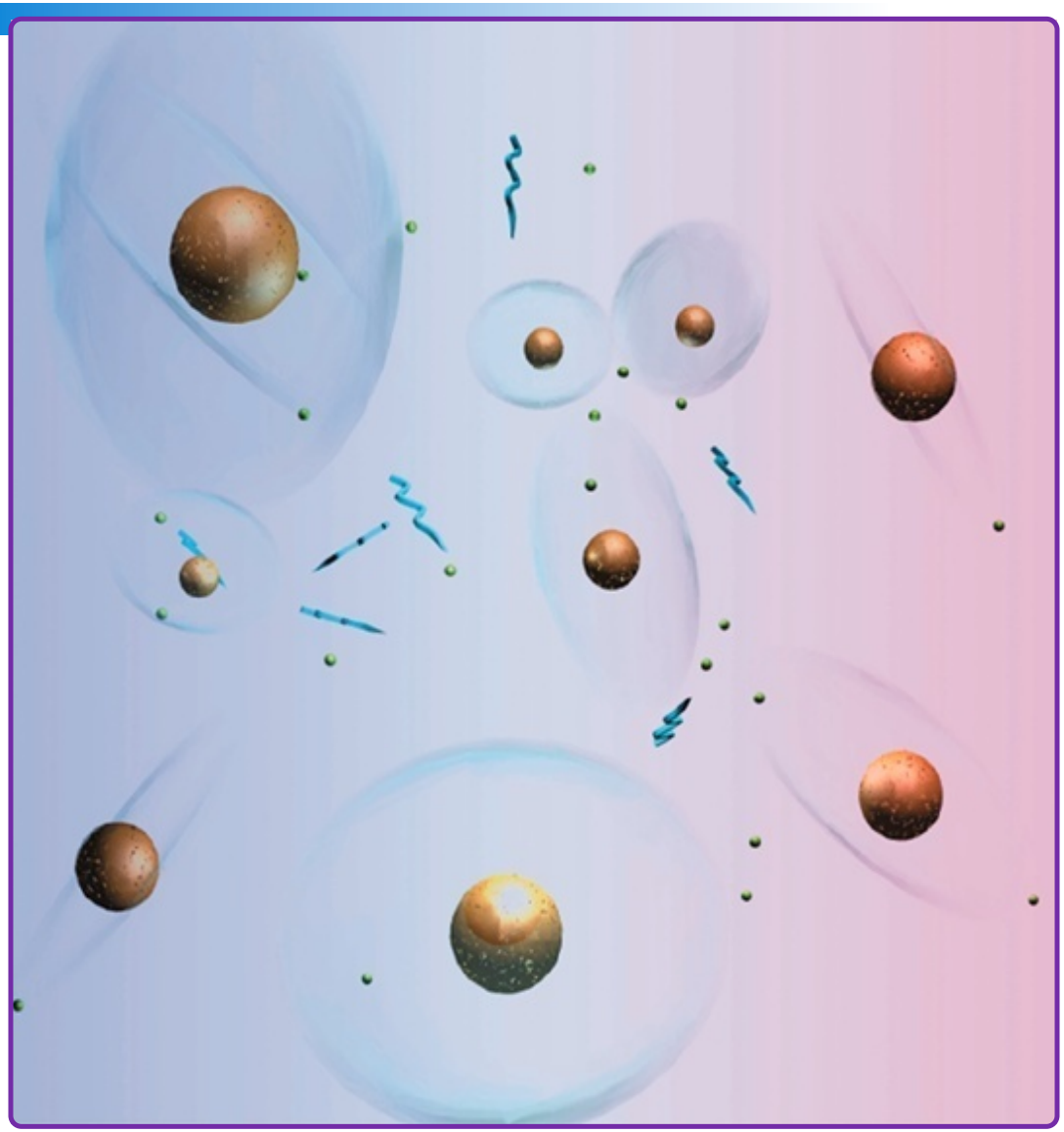
100 s Making nuclei



t = 3 minutes, 10^9 K (0.1 MeV, 10^{-12} m) : Nuclei are formed

The temperature is low enough to allow nuclei to be formed. Conditions are similar to those that exist in stars today or in thermonuclear bombs. Heavier nuclei such as deuterium, helium and lithium soak up the neutrons that are present. Any remaining neutrons decay with a time constant of ~ 1000 seconds. The neutron-proton ratio is now 13:87. The bulk constitution of the universe is now in place consisting essentially of protons (75%) and helium nuclei. The temperature is still too high to form any atoms and electrons form a gas of free particles.

300000 years Atoms and light era



t = 300 000 years, 6000 K (0.5 eV, 10^{-10} m) : Atoms are created

Electrons begin to stick to nuclei. Atoms of hydrogen, helium and lithium are created. Radiation is no longer energetic enough to break atoms. The universe becomes transparent. Matter density dominates. Astronomy can study the evolution of the Universe back to this time.

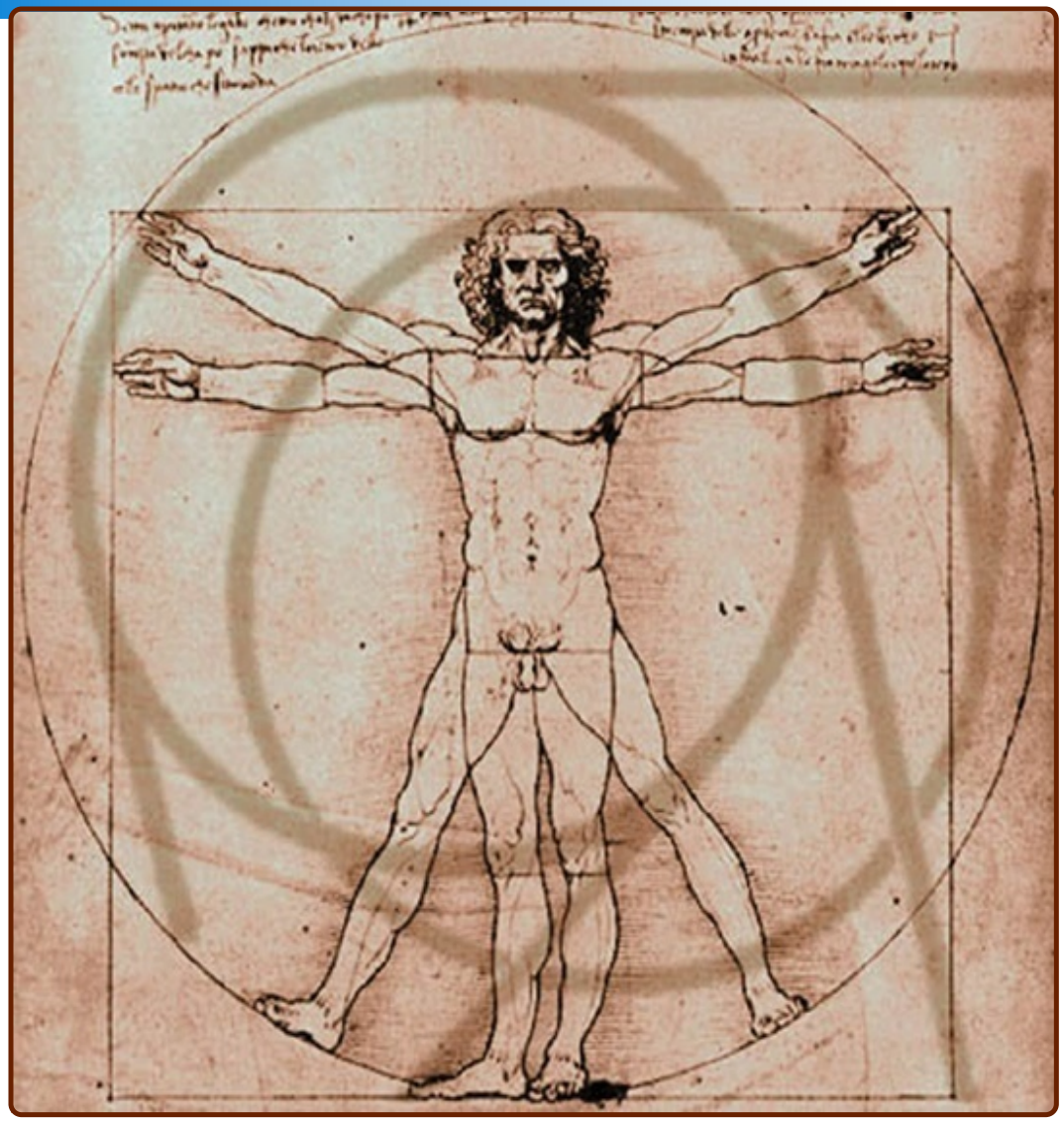
1000 M years

Making galaxies

t = 10^9 years, 18 K : Galaxy Formation

Local mass density fluctuations act as seeds for stellar and galaxy formation. The exact mechanism is still not understood. Nucleosynthesis, synthesis of heavier nuclei such as carbon up to iron, starts occurring in the thermonuclear reactors that are stars. Even heavier elements are synthesized and dispersed in the brief moment during which stellar collapse and supernovae explosions occur.

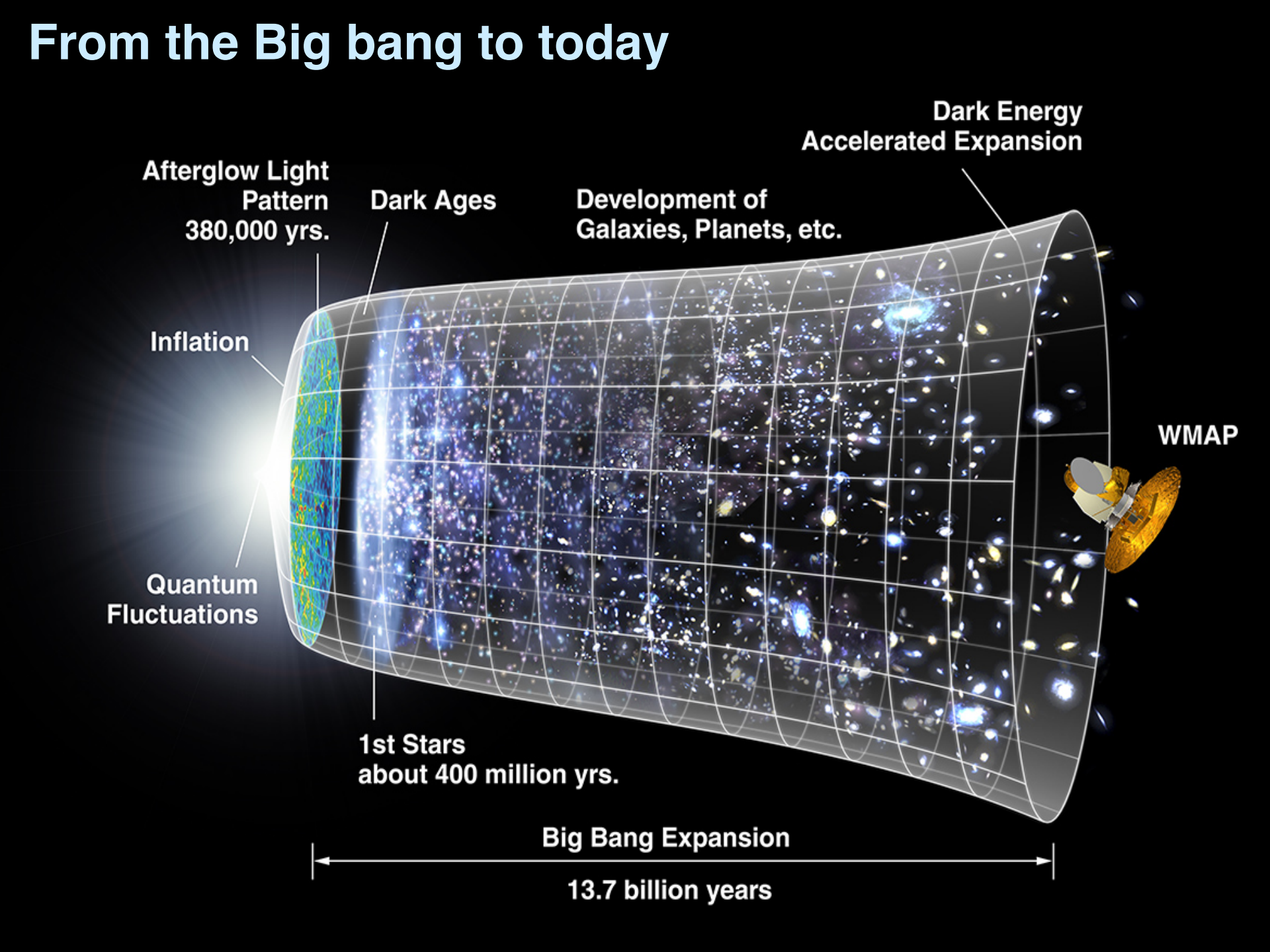
15000 M years Today



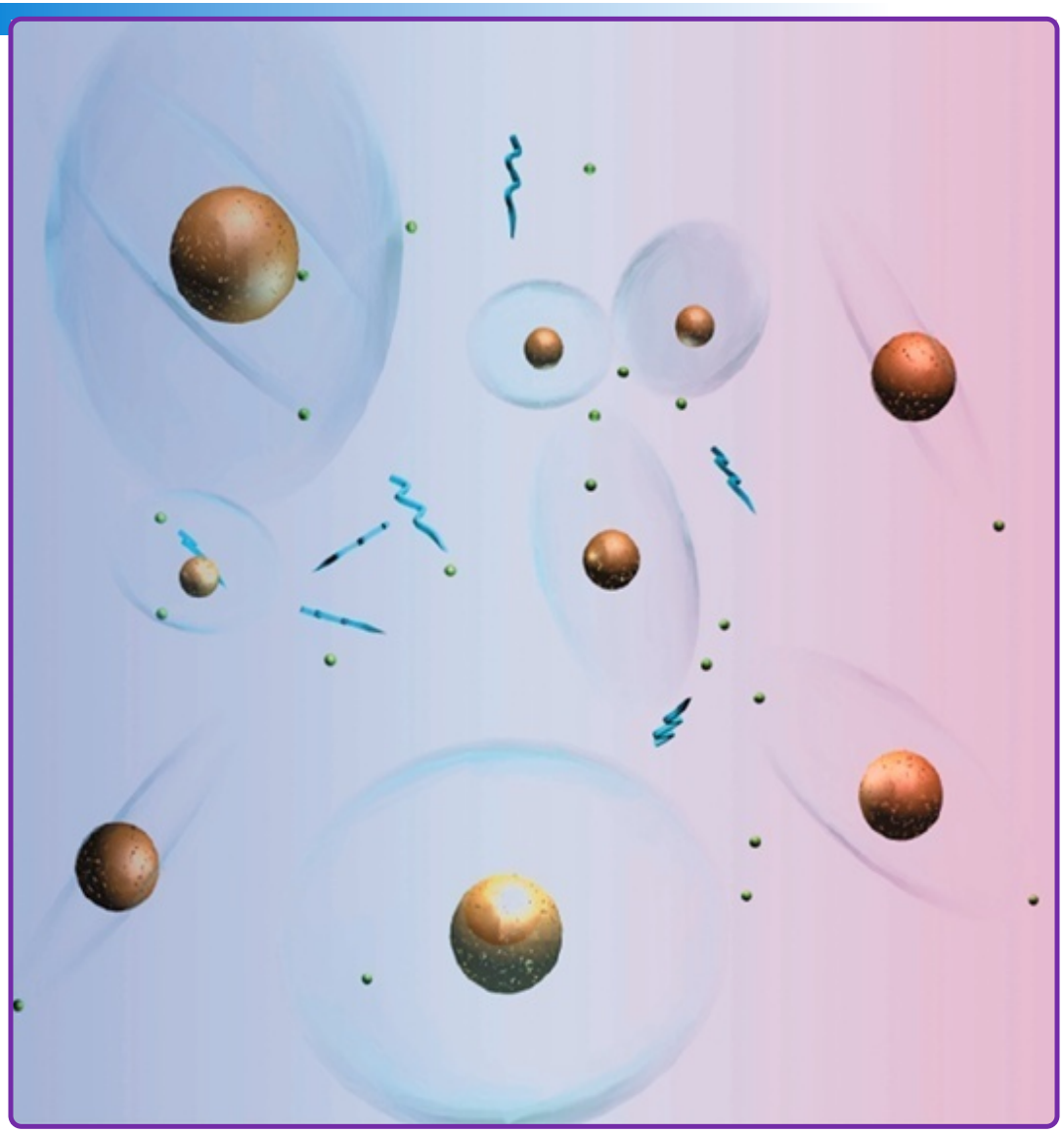
t = 15 x 10^9 years, 3 K : Humans

The present day. Chemical processes have linked atoms to form molecules. From the dust of stars and through coded messages (DNA) humans emerge to observe the universe around them.

From the Big bang to today



300000 years Atomi i era svjetla

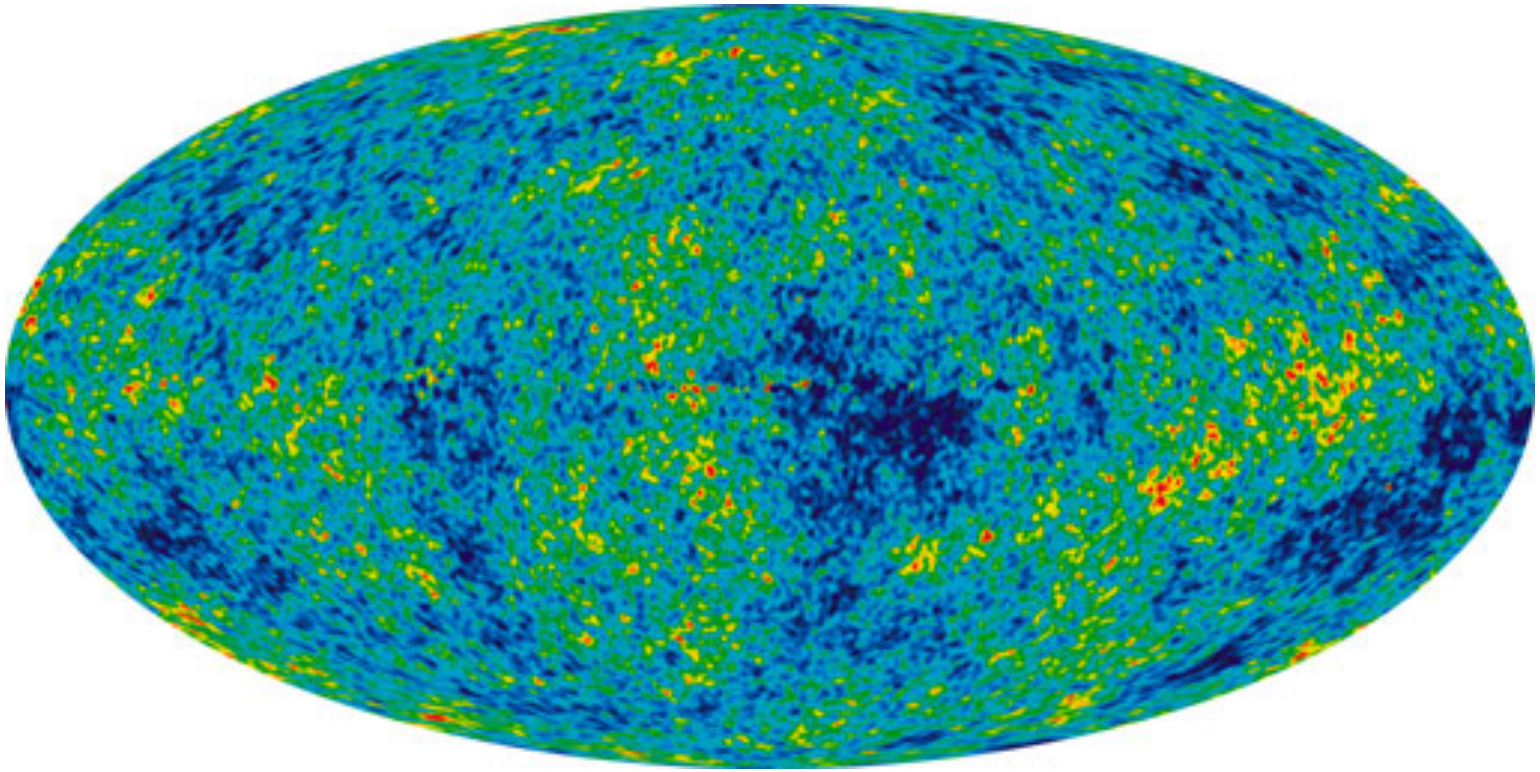


t = 300 000 years, 6000 K (0.5 eV, 10^{-10} m) : Atoms are created

Electrons begin to stick to nuclei. Atoms of hydrogen, helium and lithium are created. Radiation is no longer energetic enough to break atoms. The universe becomes transparent. Matter density dominates. Astronomy can study the evolution of the Universe back to this time.

Wilkinson Microwave Anisotropy Probe

WMAP



Particles

Leptoni

	Electric Charge		
Tau	-1	0	Tau Neutrino
Mion	-1	0	Mion Neutrino
Elektron	-1	0	Elektron Neutrino

Kvarkovi

	Električni naboj		
Dno	-1/3	2/3	Vrh
Strani	-1/3	2/3	Šarmantni
Dolje	-1/3	2/3	Gore

svaki kvark:R, B, G 3 boje

Antiparticles

Antileptoni

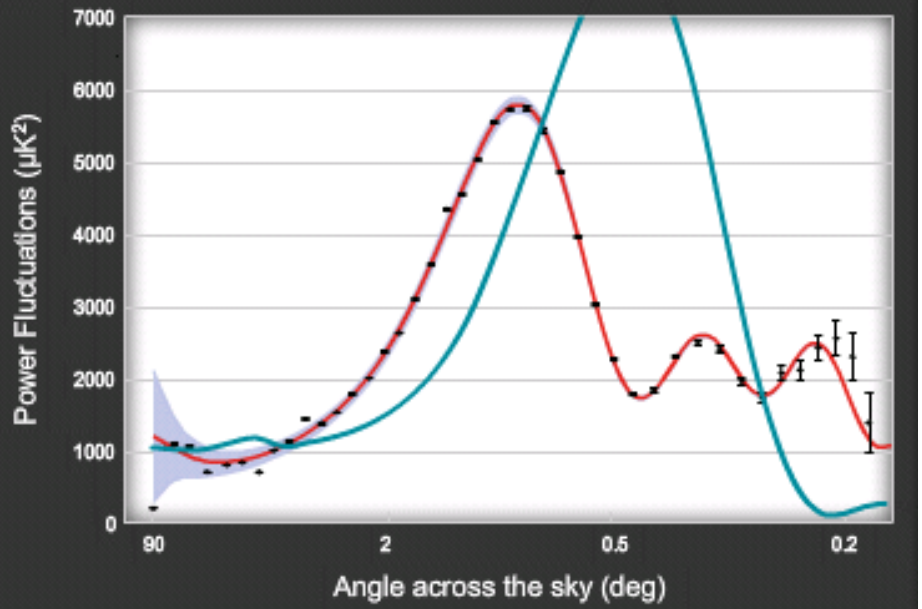
	Electric Charge		
Antitau	1	0	Antitau Neutrino
Antimion	1	0	Antimion Neutrino
Pozitron	1	0	Antielektron Neutrino

Antikvarkovi

	Električni naboj		
Antidno	1/3	-2/3	Antivrh
Antistrani	1/3	-2/3	Antišarmantni
Antidolje	1/3	-2/3	Antigore

svaki antikvark:R, B, G 3 antiboje

WMAP CMB Analyzer



Age: 9.1 billion years **Flatness:** 1.00

Power Spectrum Plot: This plot shows how temperature varies with the angular size of patches on the sky. This reveals the energy emitted by different size ripples of sound traveling through the early universe.

- Red line = analyzed sky / universe signal.
- Blue line = your simulated sky / universe signal.
- Black points with error bars = 'binned' (grouped) data to analyze data accuracy.
- Light blue area = likelihood of results being caused by random chance- only a concern at large scale (left).

ANSWER RESET

WMAP CMB Analyzer

Universe Content

Atoms 74 %

Cold Dark Matter 22 %

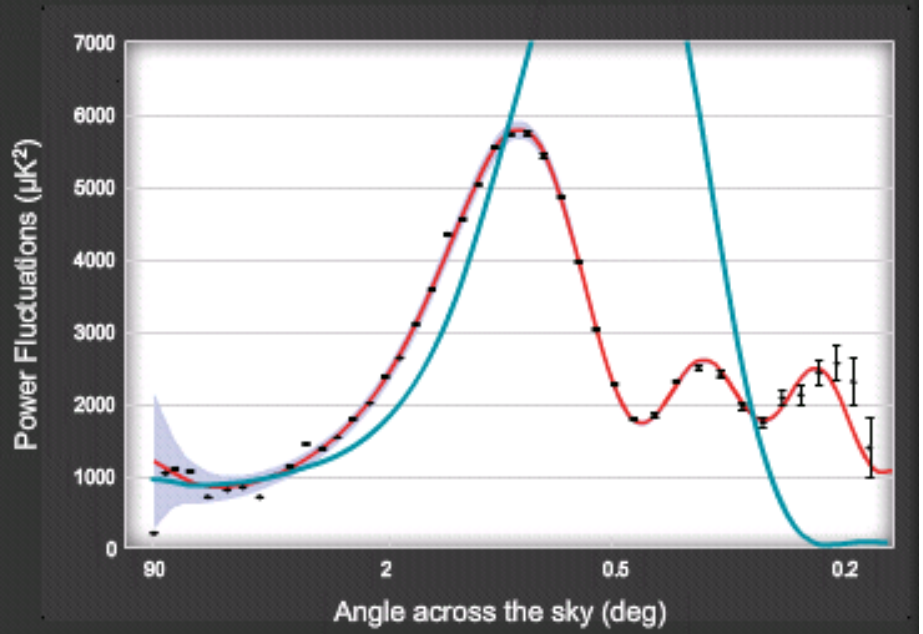
Dark Energy 4 %

Additional Properties

Hubble Constant 73

Reionization redshift 11

Spectral Index 0.95



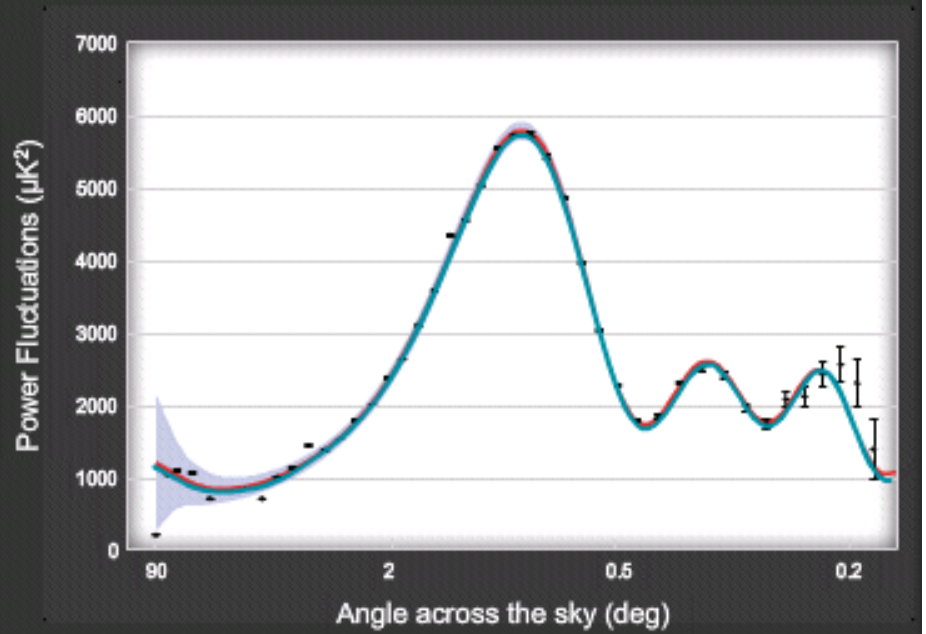
Age: 9.2 billion years **Flatness:** 1.00

Pie Chart: Graphically shows the composition of your universe. The wedges compare the amount of each component; the size of the pie compares the total composition (matter + dark matter + dark energy) with the critical density (black circle).

- A universe at critical density is geometrically flat and probably infinite.
- A universe can have more or less than the critical density.
- Flatness - the term we use for closeness to critical density.

ANSWER RESET

WMAP CMB Analyzer

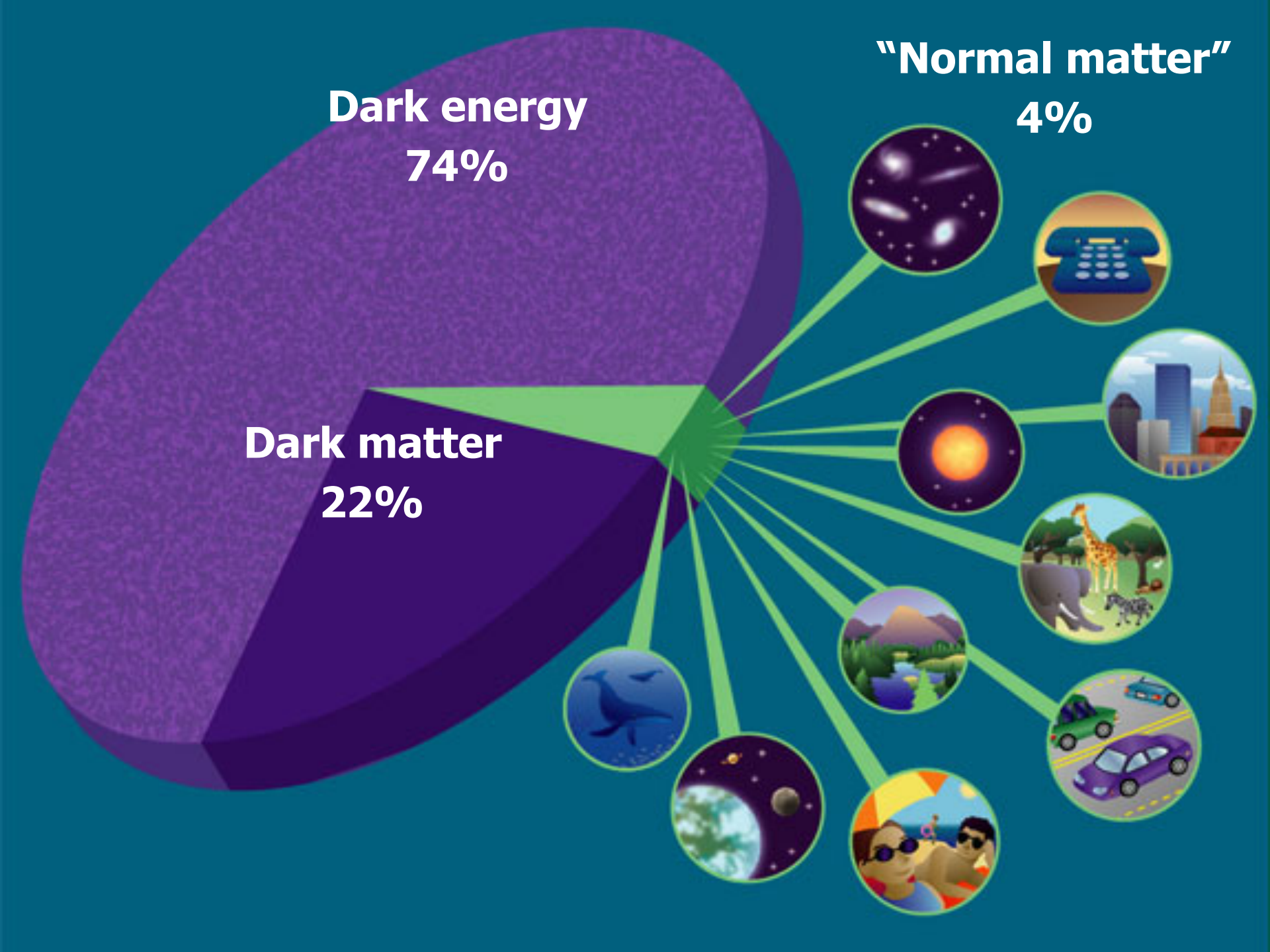


Age: 13.7 billion years **Flatness:** 1.00

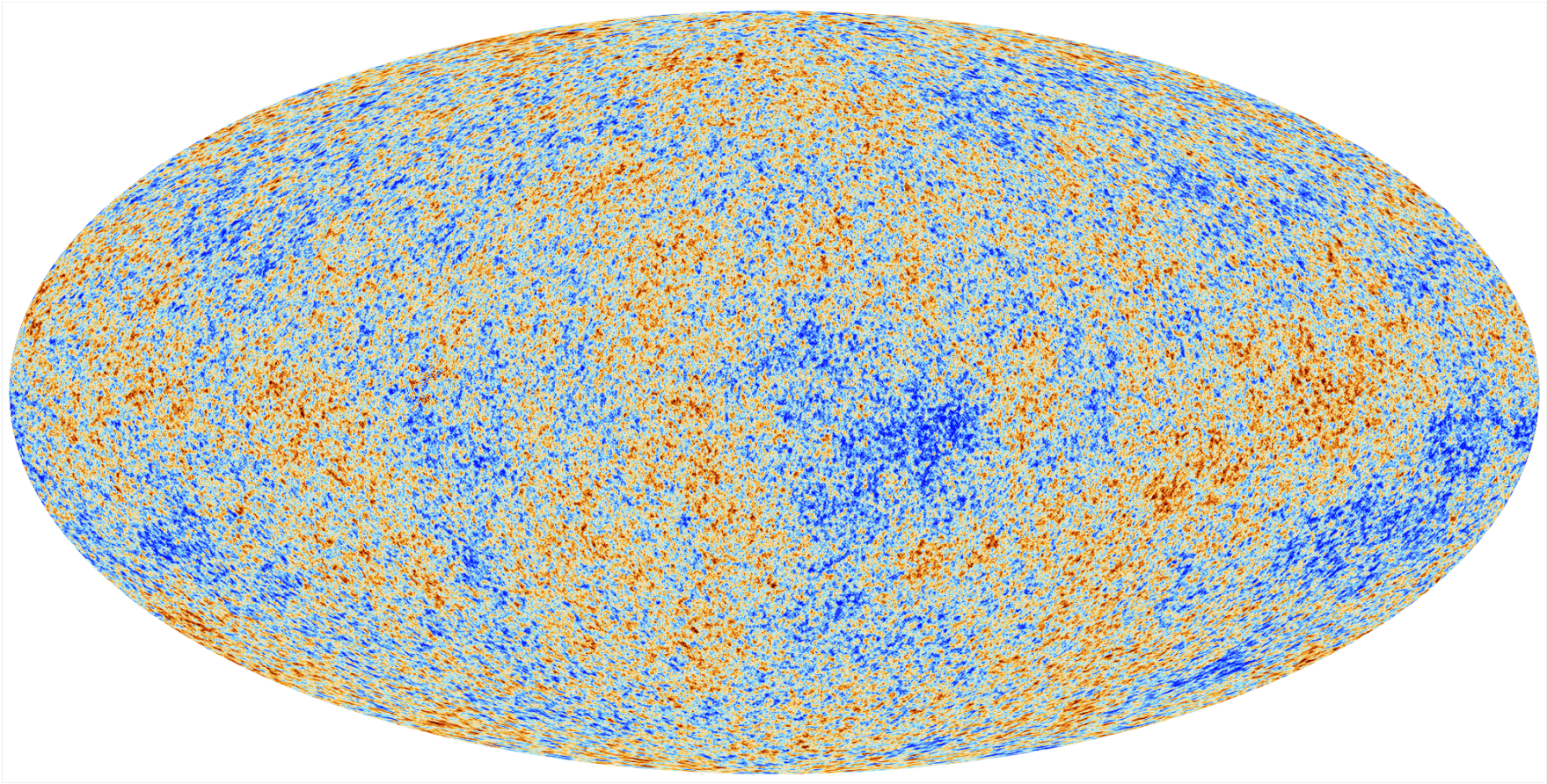
Pie Chart: Graphically shows the composition of your universe. The wedges compare the amount of each component; the size of the pie compares the total composition (matter + dark matter + dark energy) with the critical density (black circle).

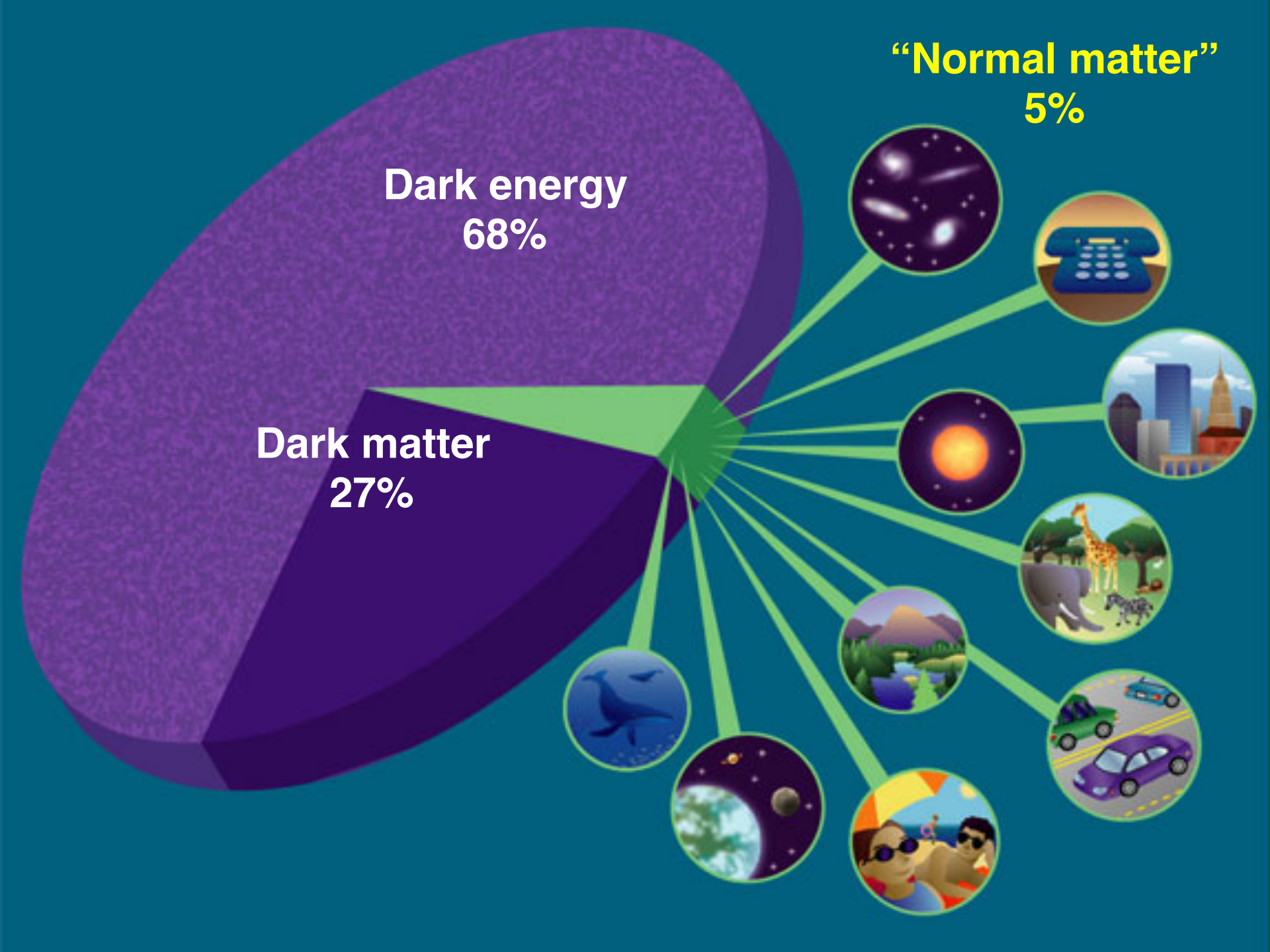
- A universe at critical density is geometrically flat and probably infinite.
- A universe can have more or less than the critical density.
- Flatness - the term we use for closeness to critical density.

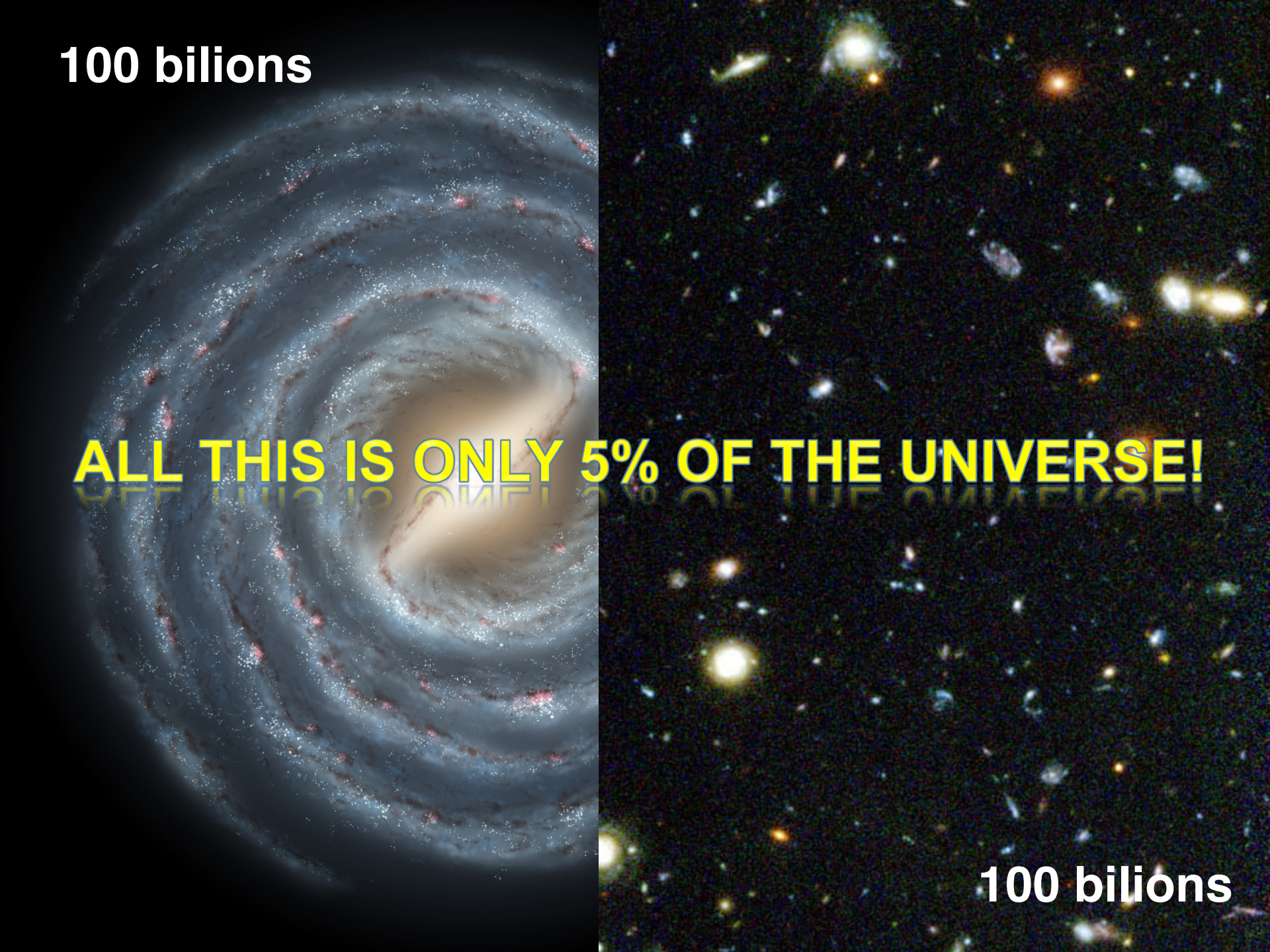
ANSWER RESET


Dark energy
74%
Dark matter
22%
"Normal matter"
4%

Breaking news: Planck satelite

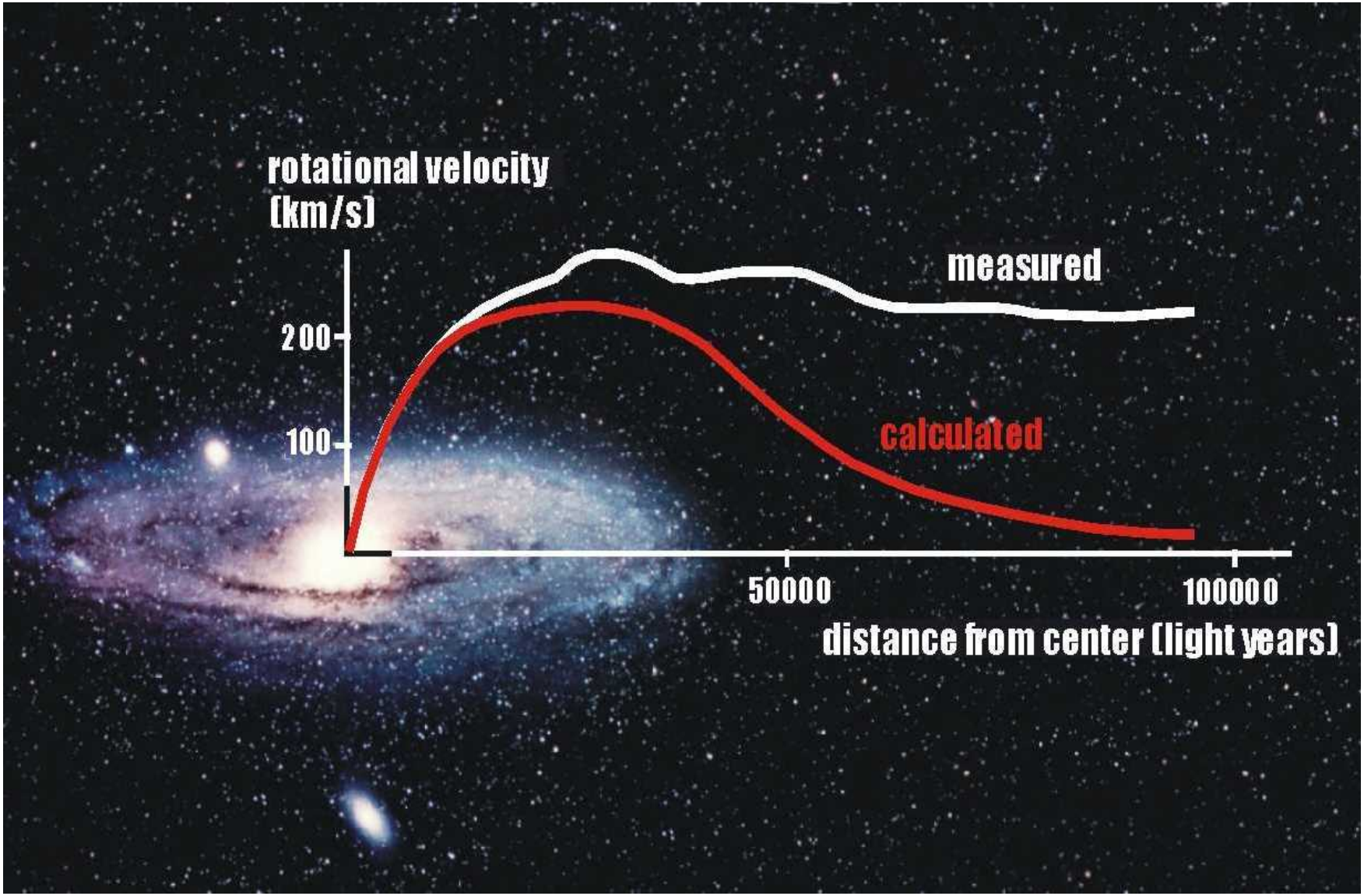



“Normal matter”
5%
Dark energy
68%
Dark matter
27%

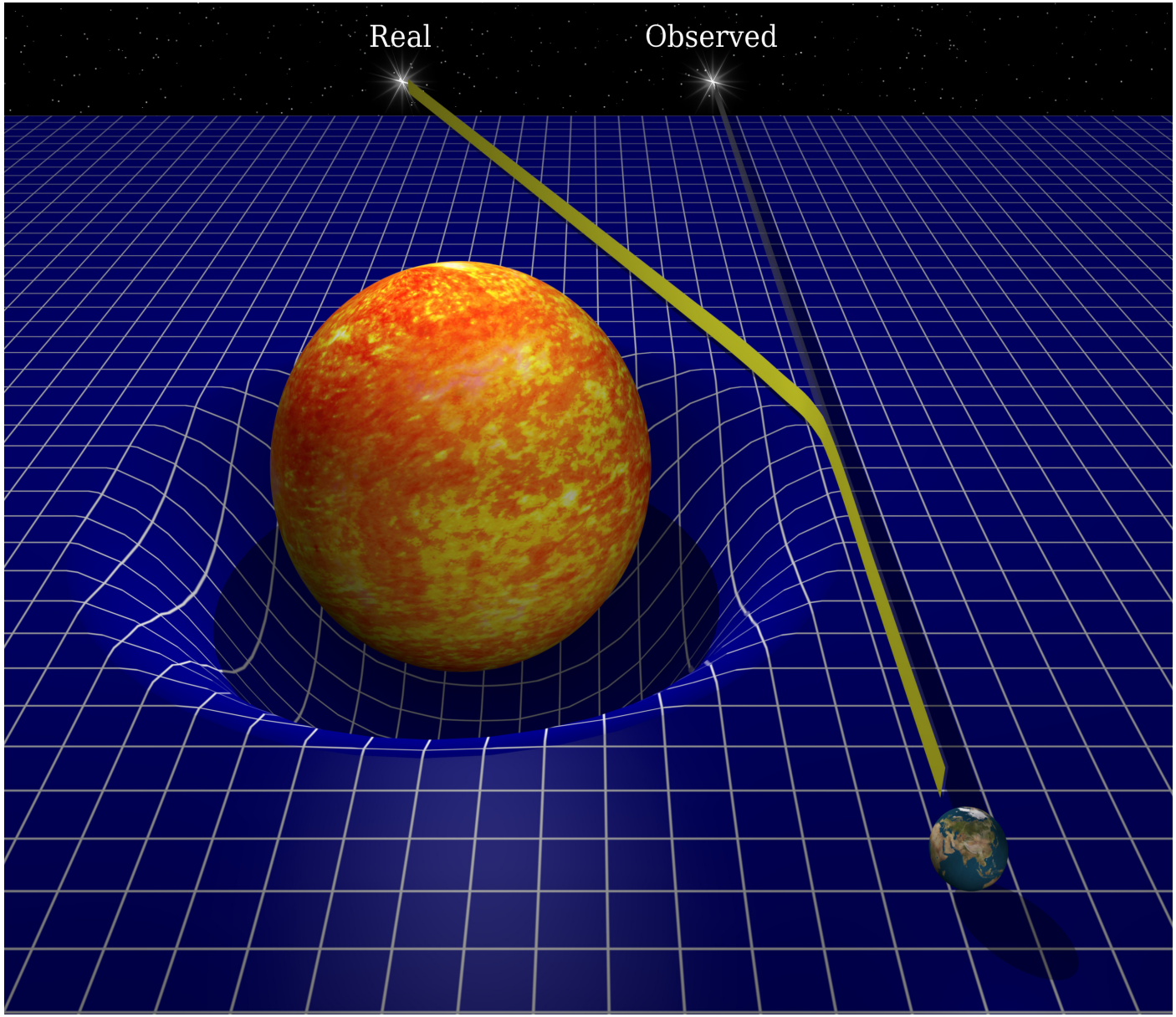

100 bilions
ALL THIS IS ONLY 5% OF THE UNIVERSE!
100 bilions

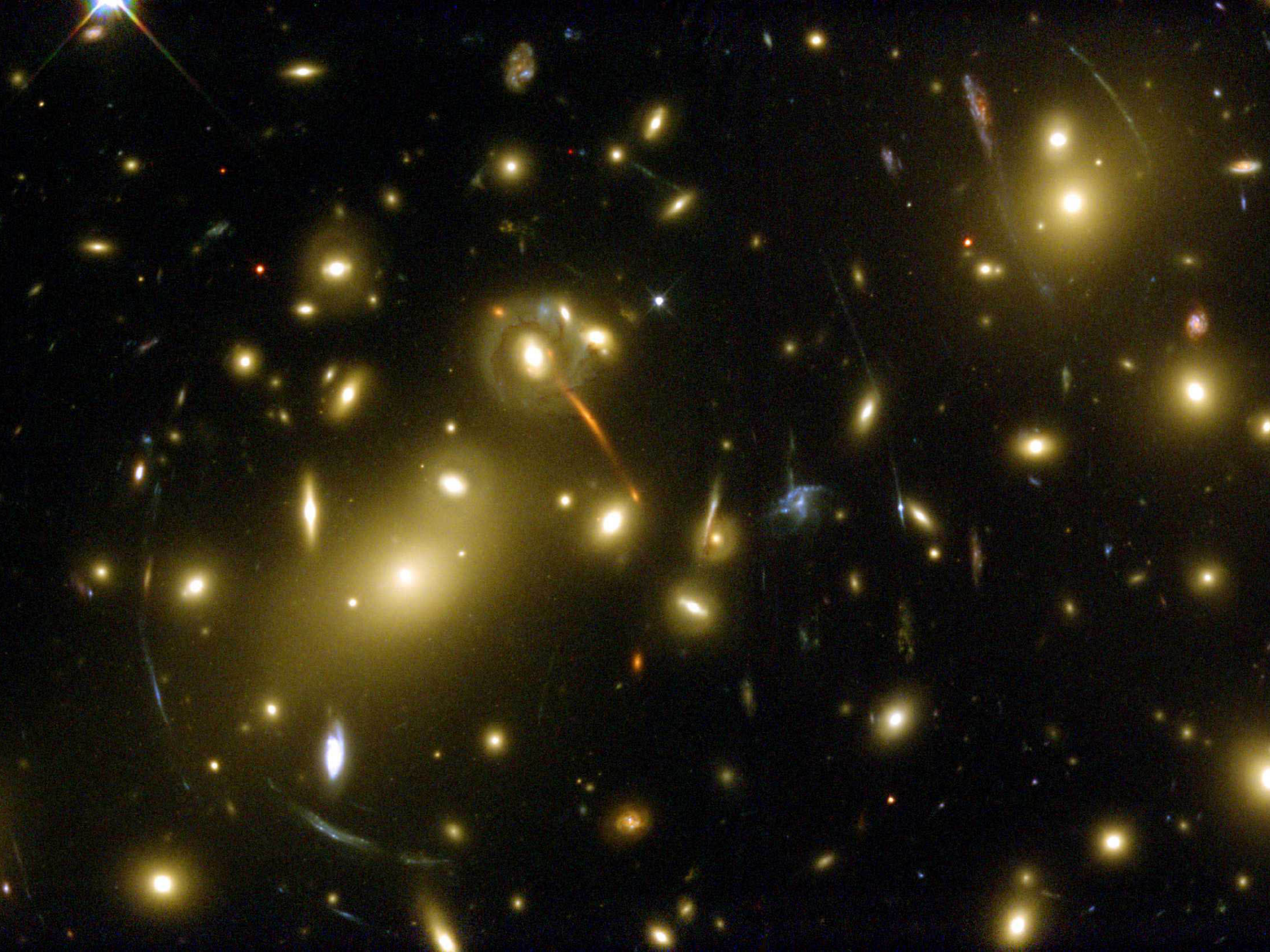

I am
the
center
of the
universe

Dark matter: rotational velocity of stars in galaxies

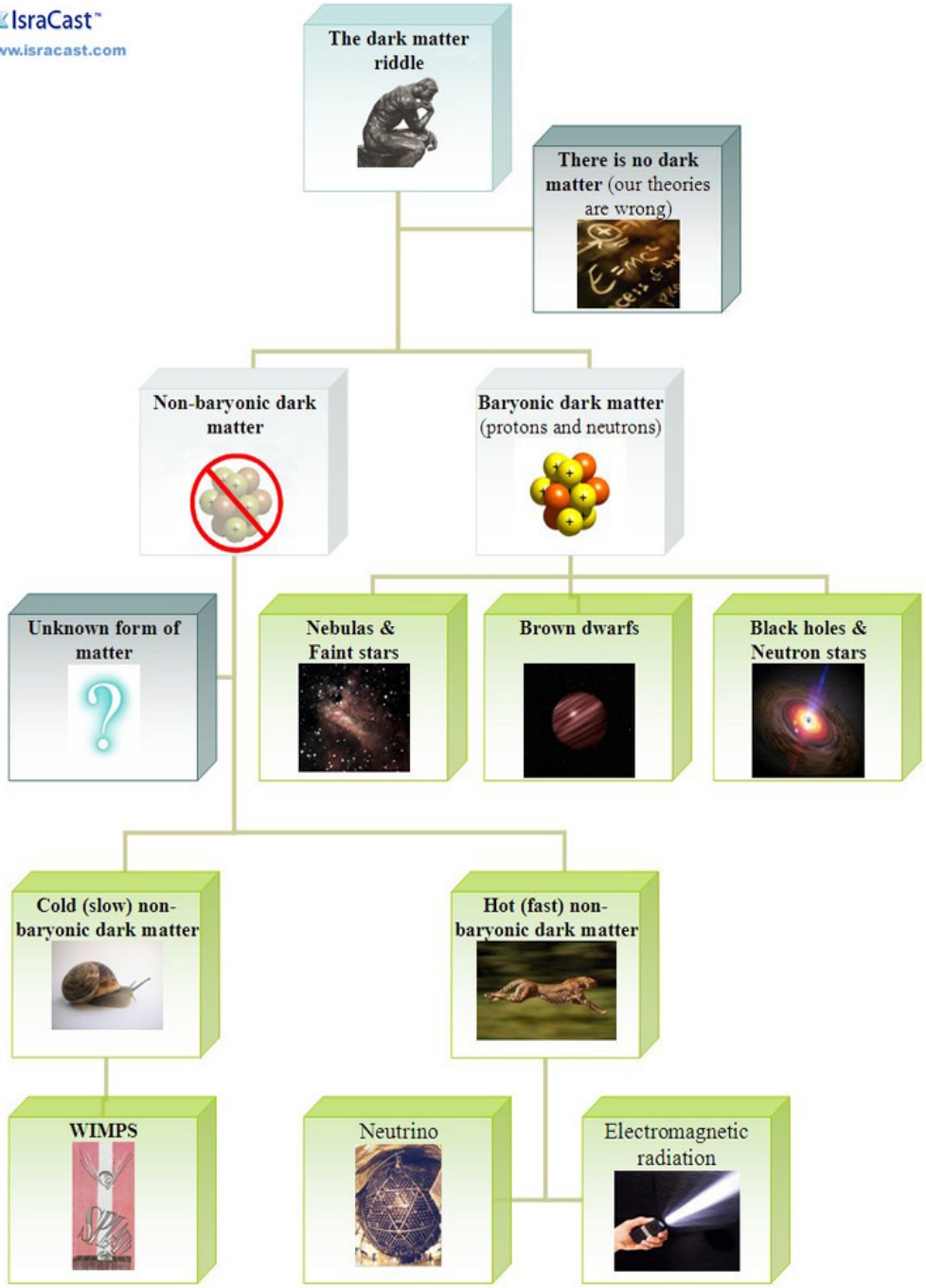


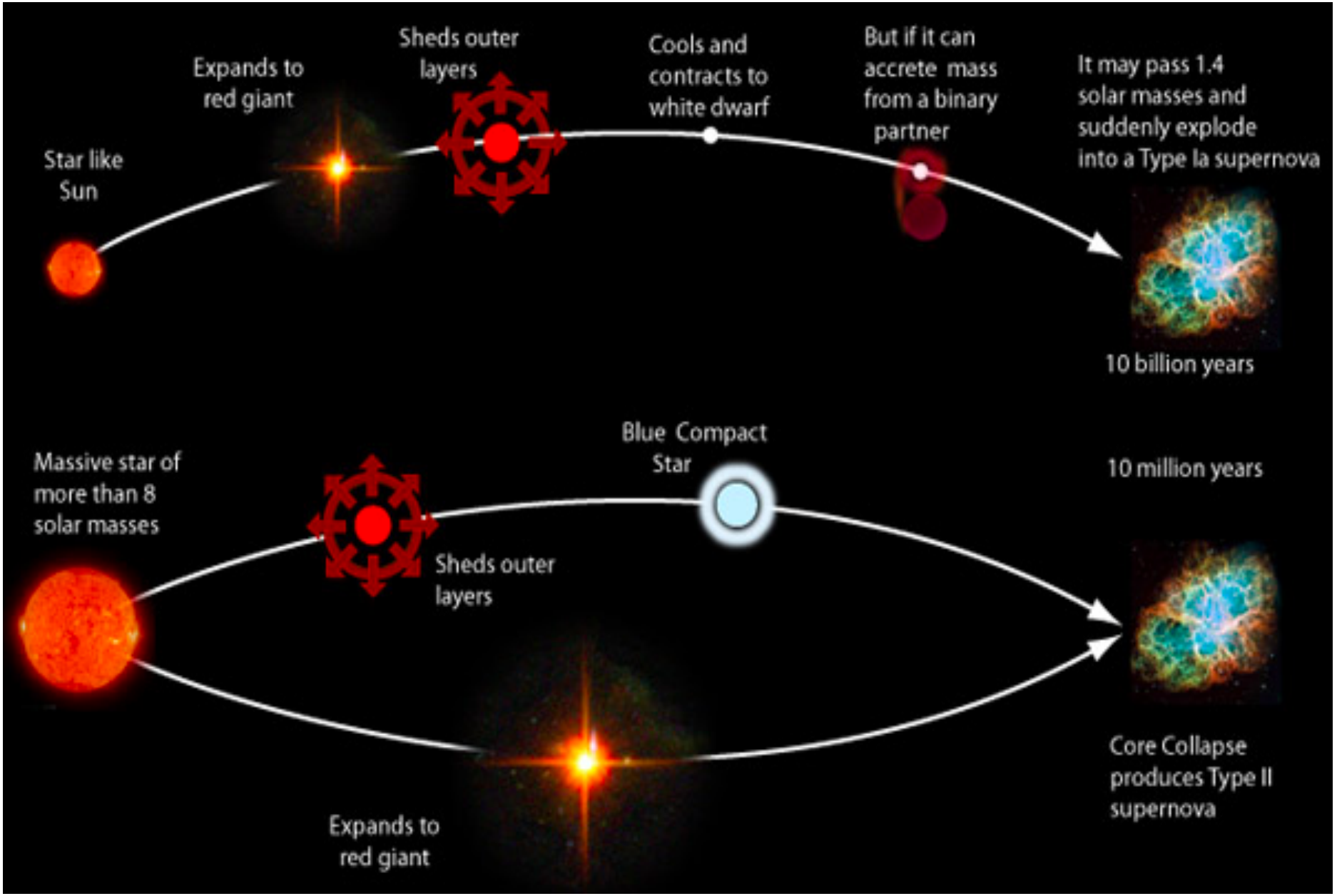
Dark matter: gravitational lensing

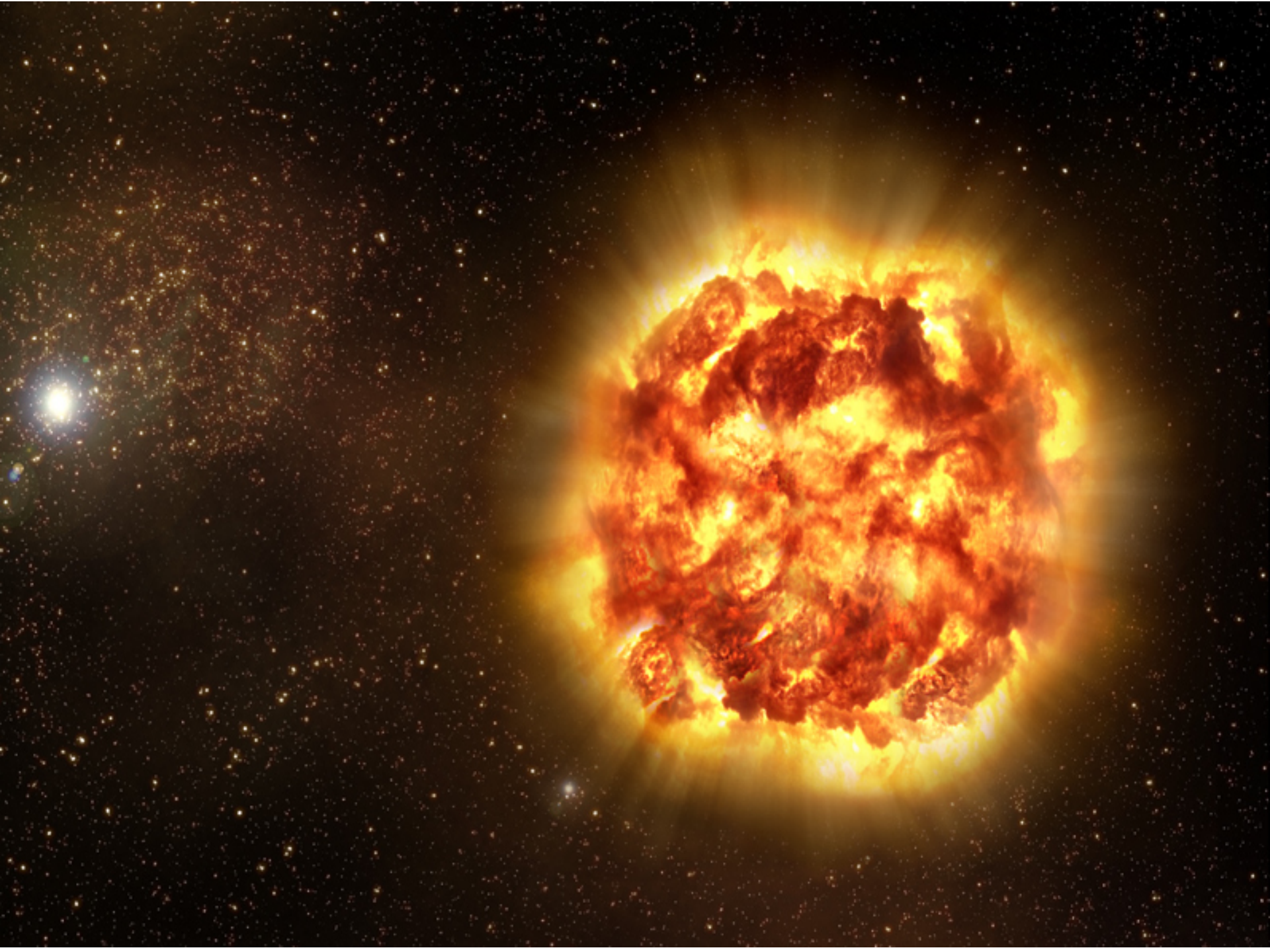




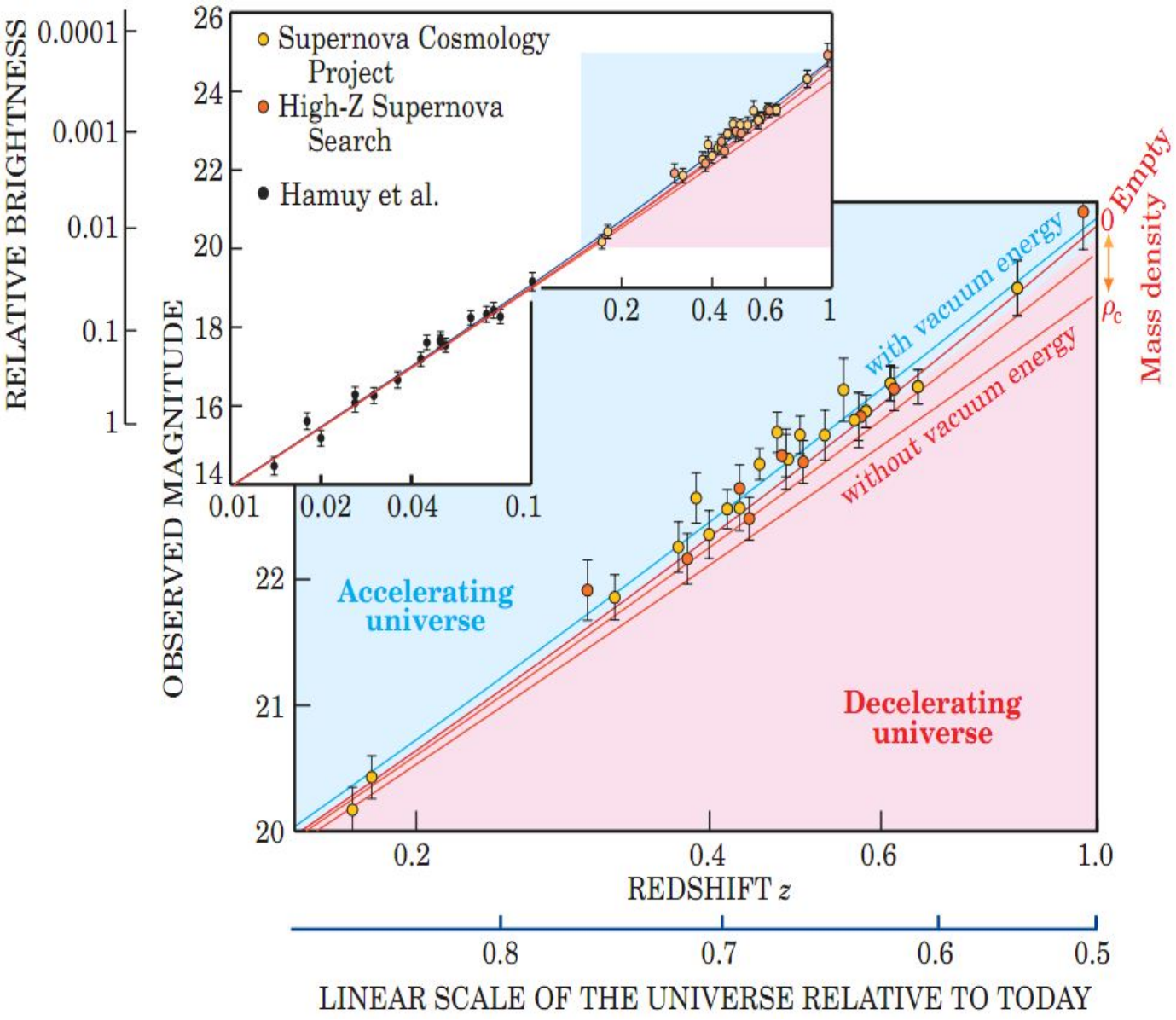
IsraCast™
www.isracast.com

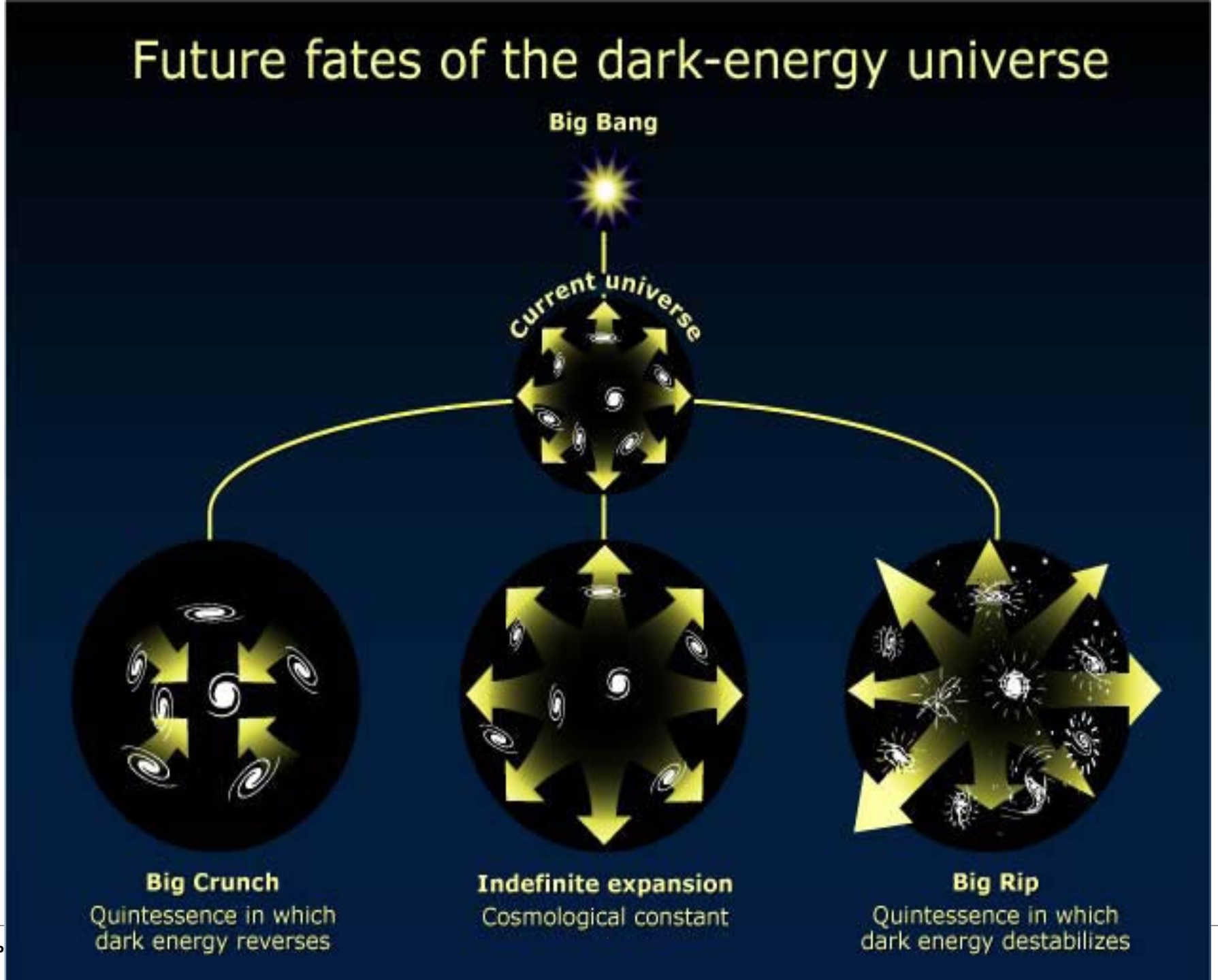


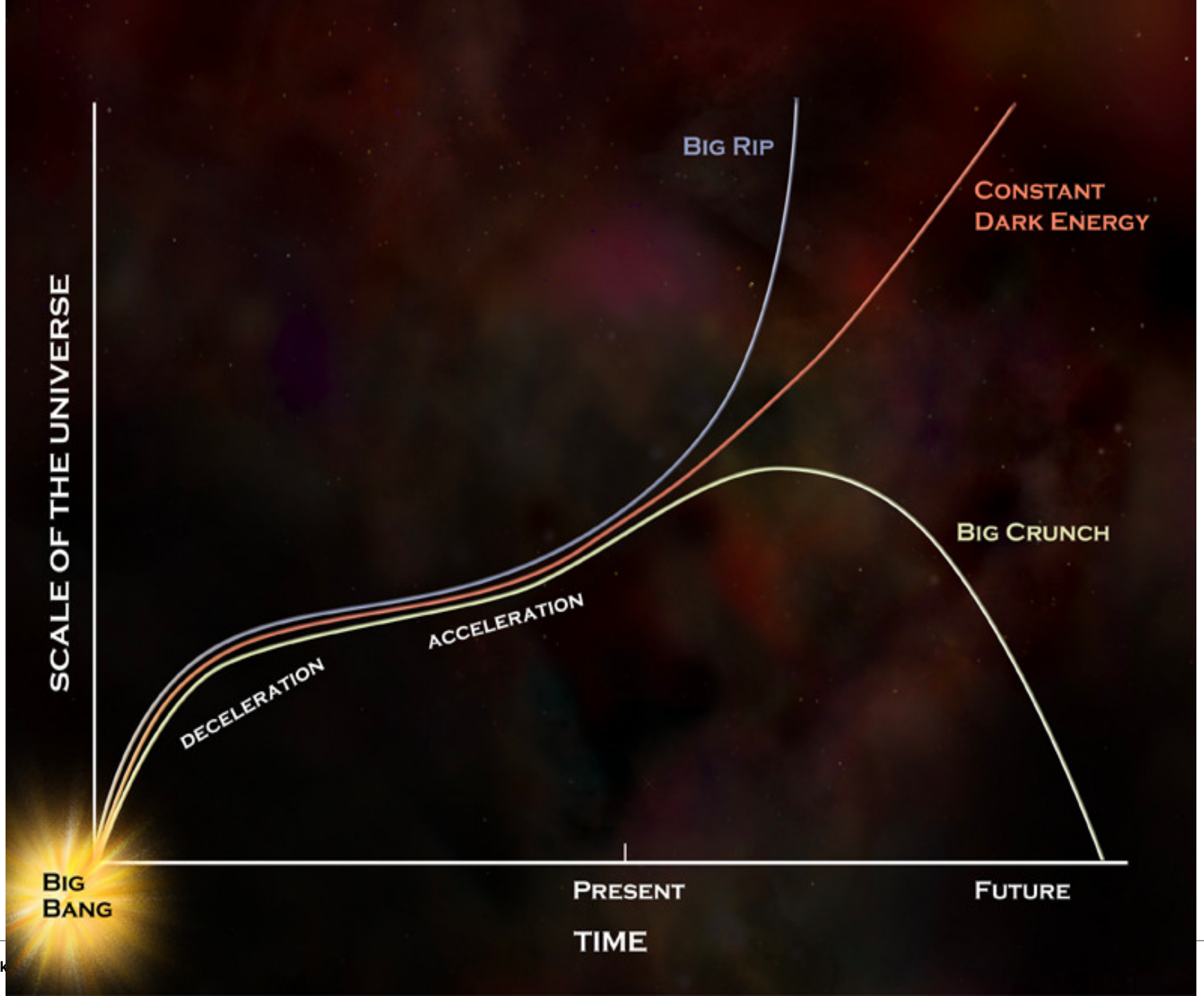

Star like Sun
Expands to red giant
Sheds outer layers
Cools and contracts to white dwarf
But if it can accrete mass from a binary partner
It may pass 1.4 solar masses and suddenly explode into a Type Ia supernova
10 billion years
Massive star of more than 8 solar masses
Blue Compact Star
10 million years
Sheds outer layers
Core Collapse produces Type II supernova
Expands to red giant



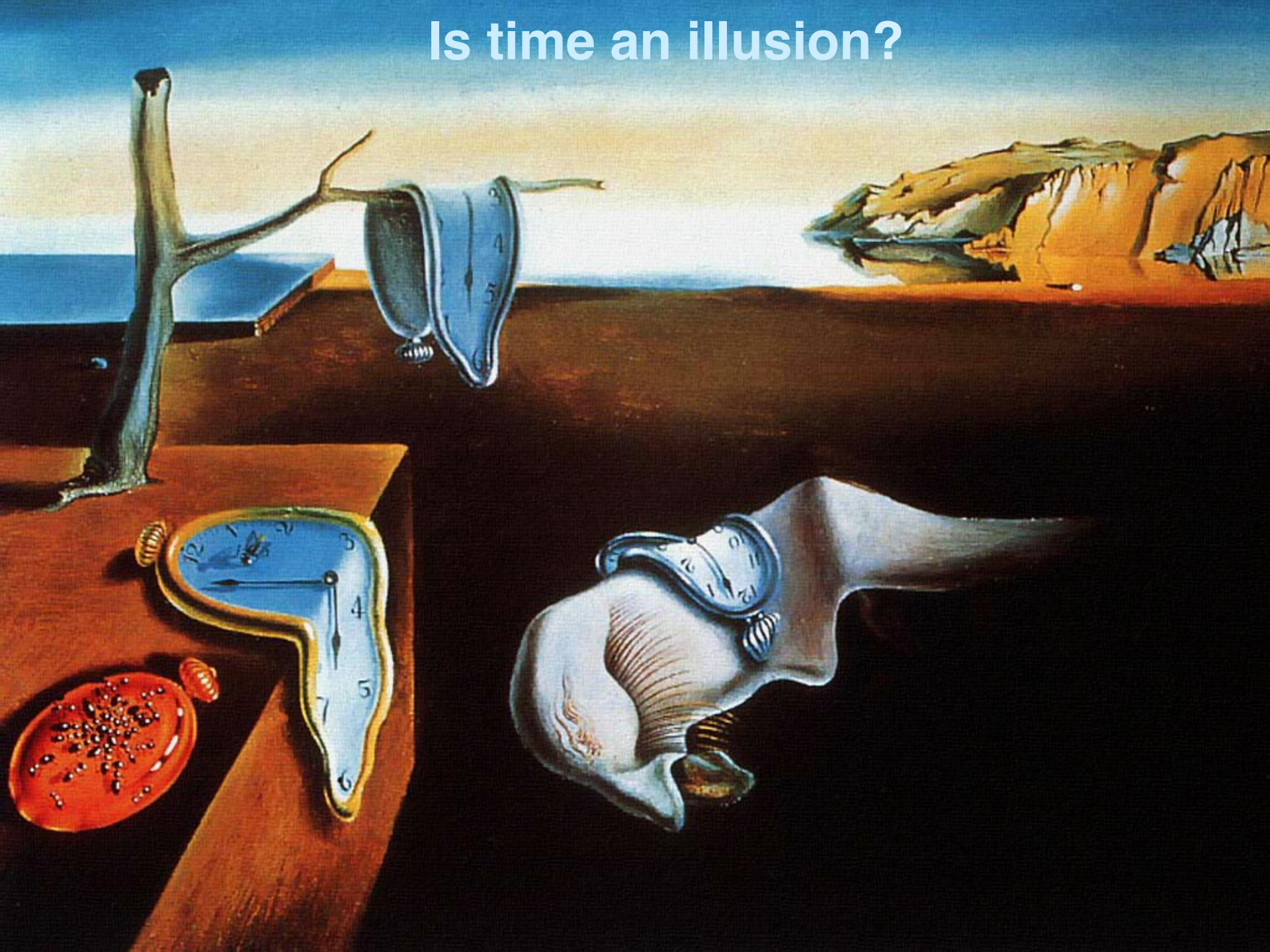
Dark energy from supernovas




Future fates of the dark-energy universe
Big Bang
Current universe
Big Crunch
Quintessence in which dark energy reverses
Indefinite expansion
Cosmological constant
Big Rip
Quintessence in which dark energy destabilizes


SCALE OF THE UNIVERSE
BIG RIP
CONSTANT
DARK ENERGY
BIG CRUNCH
ACCELERATION
DECELERATION
BIG
BANG
PRESENT
FUTURE
TIME

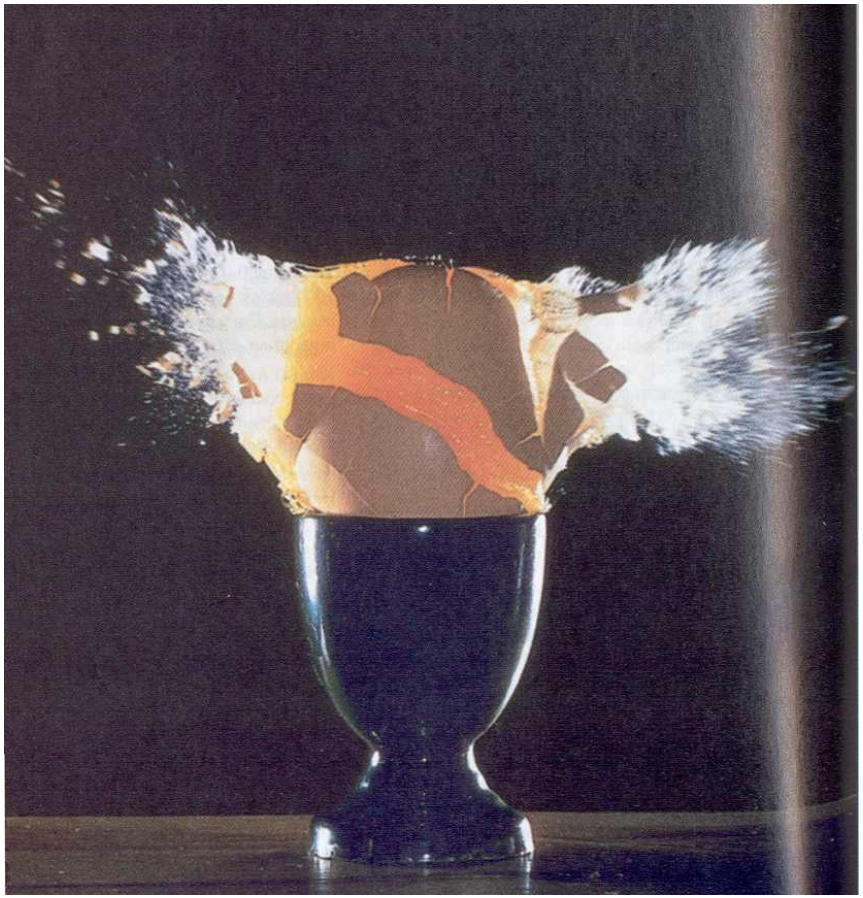
Is time an illusion?



Is time an illusion?

“Time is God's way of keeping everything from happening at once”

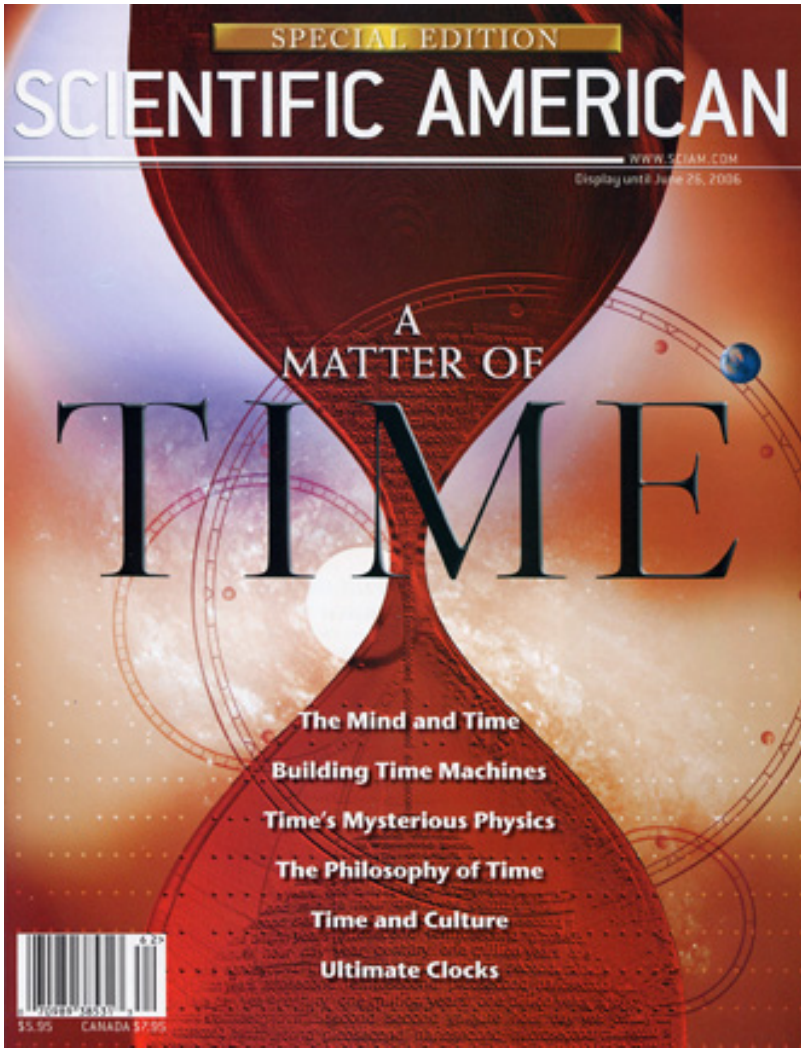
Uknown



Is time an illusion?

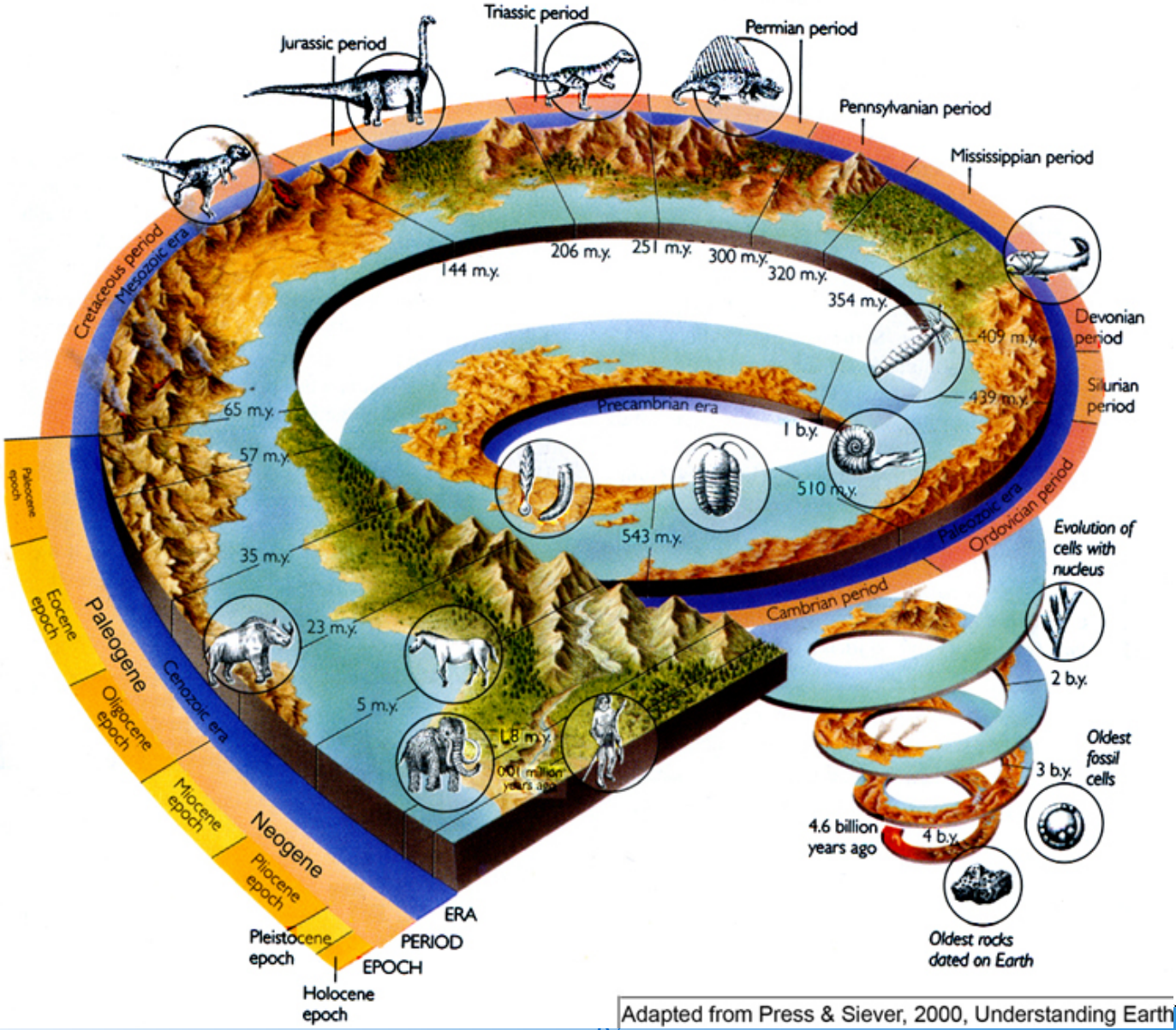
- "Our senses tell us that time flows: namely, that the past is fixed, the future undetermined, and reality lives in the present. Yet various physical and philosophical arguments suggest otherwise."
- "The passage of time is probably an illusion. Consciousness may involve thermodynamic or quantum processes that lend the impression of living moment by moment."
- "TO BE PERFECTLY HONEST, neither scientists nor philosophers really know what time is or why it exists. The best thing they can say is that time is an extra dimension akin (but not identical) to space. For example, the two-dimensional orbit of the moon through space can be thought of as a three-dimensional corkscrew through spacetime. "

P. Davies



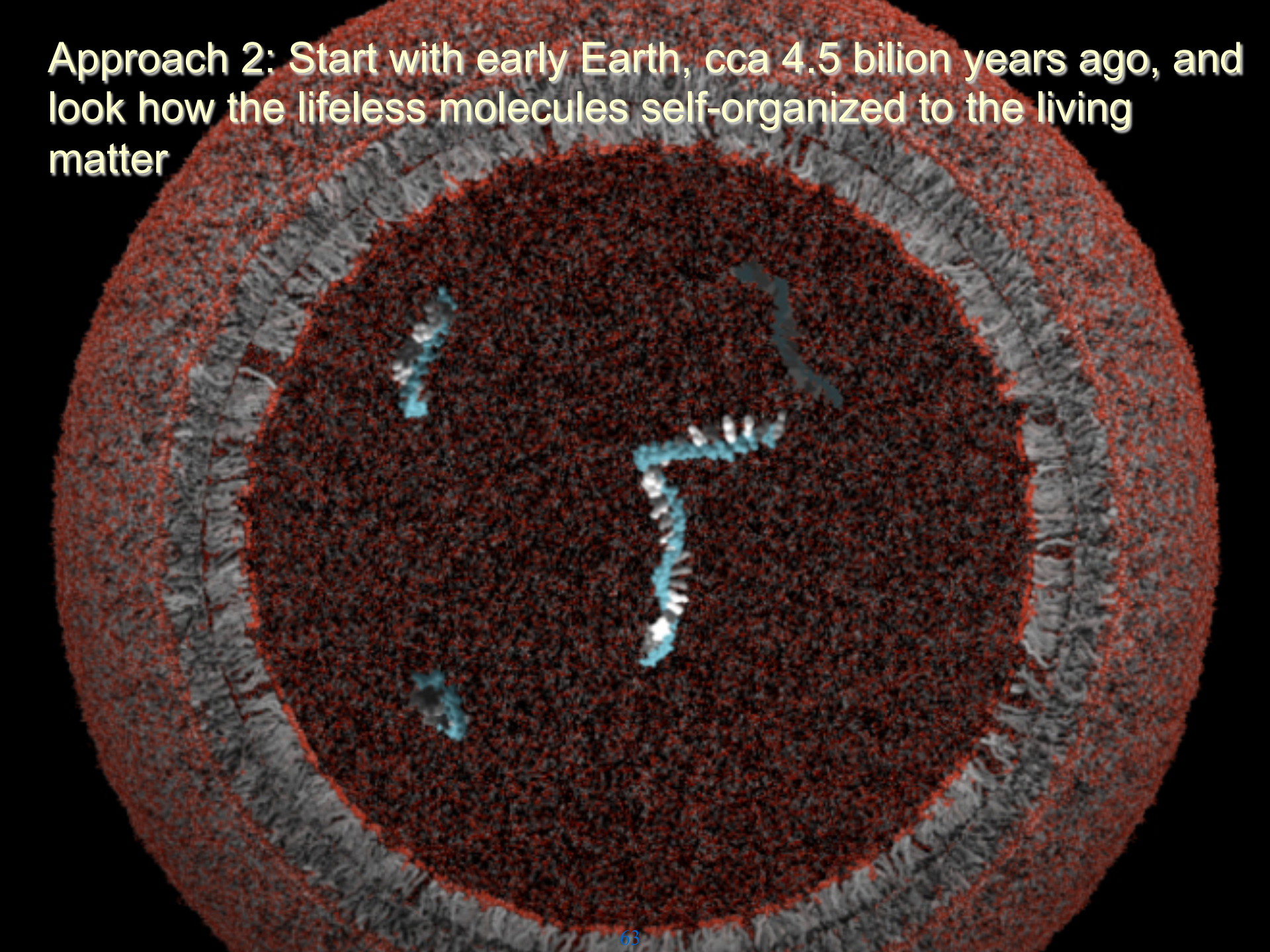
When and how did life appear on Earth?

Approach 1: from today back ...



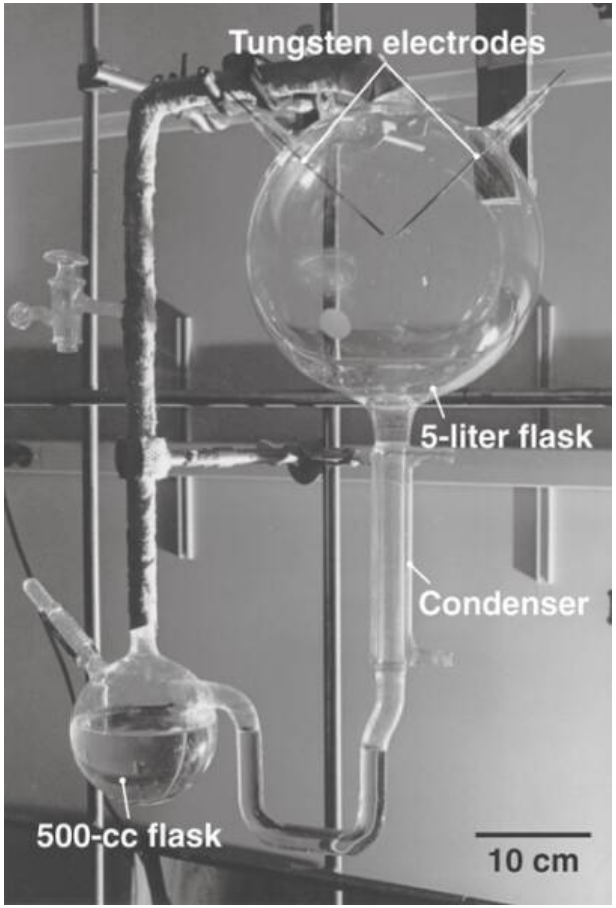
Adapted from Press & Siever, 2000, Understanding Earth

Approach 2: Start with early Earth, cca 4.5 bilion years ago, and look how the lifeless molecules self-organized to the living matter



[Some] results

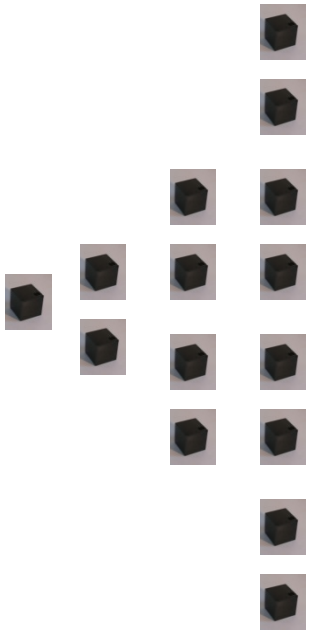
- Microbs fossils 3.4 bilion years old
- Chemical analysis of old rocks suggests that organisms with photosyntesis were widespread on Earth 3.7 bilion years ago
- All living organisms on Earth code their information in DNA and use protens as catalists for chemical reactions
- But what was before: proteins or DNA?
  - Experiments suggest: the first was RNA
  - The life first has its “RNA phase” and then transformed to the form we see today
- 1953: Stanly Miller i Harold Urey, University of Chicago
  - Electric current through the mix of ammonia, methane, hydrogen and water wapor, simulating the early Earth atmosphere, produced amino acids and other building blocks of life



When and how did life appear on Earth?

How does a fertilized egg become a living being?

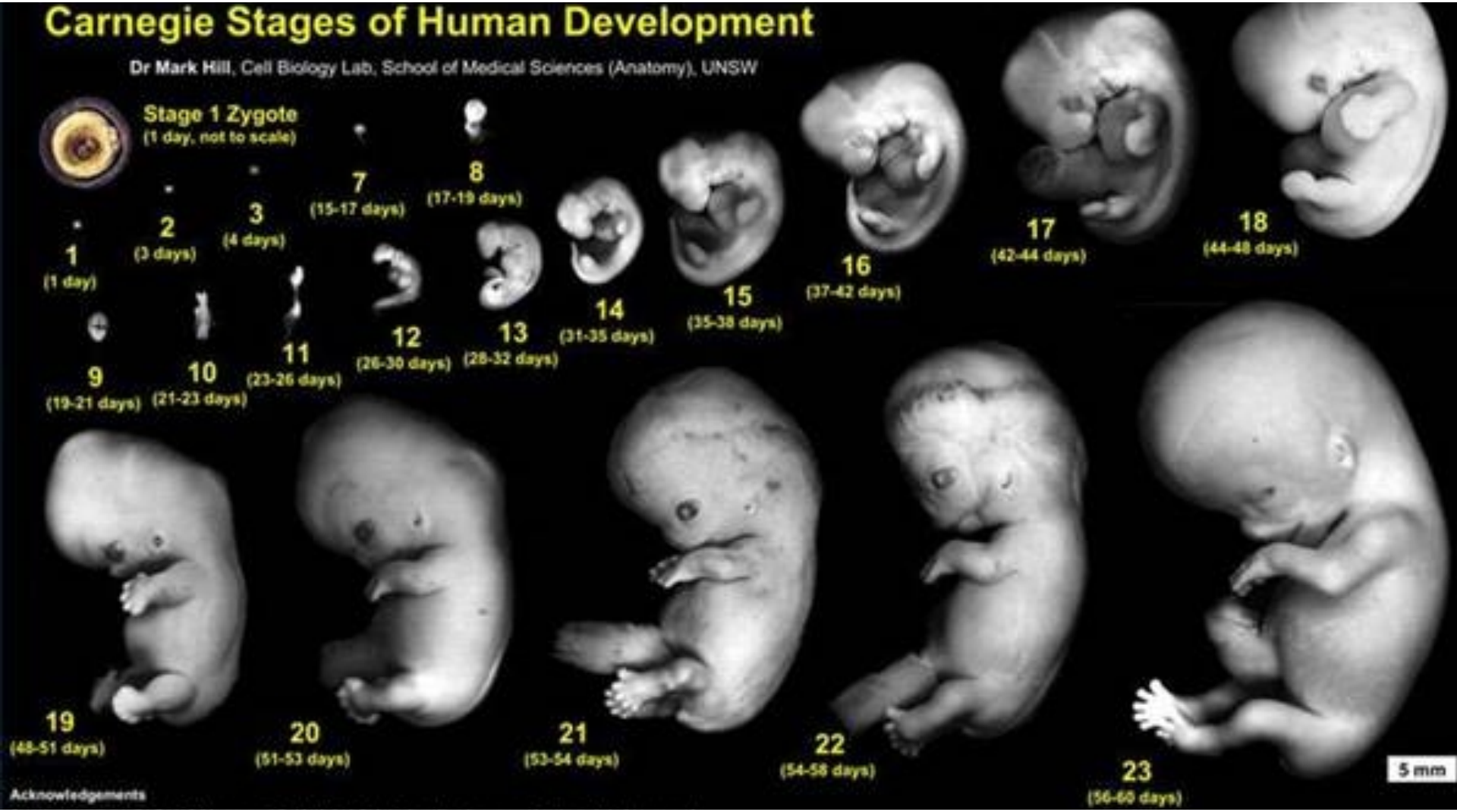
How does a fertilized egg become a living being?



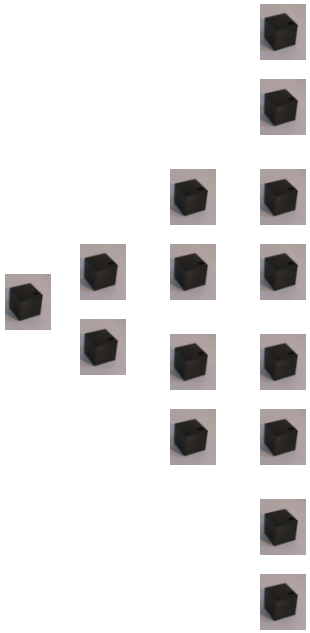
...

...

But this it the way nature creates us!



How does a fertilized egg become a living being?

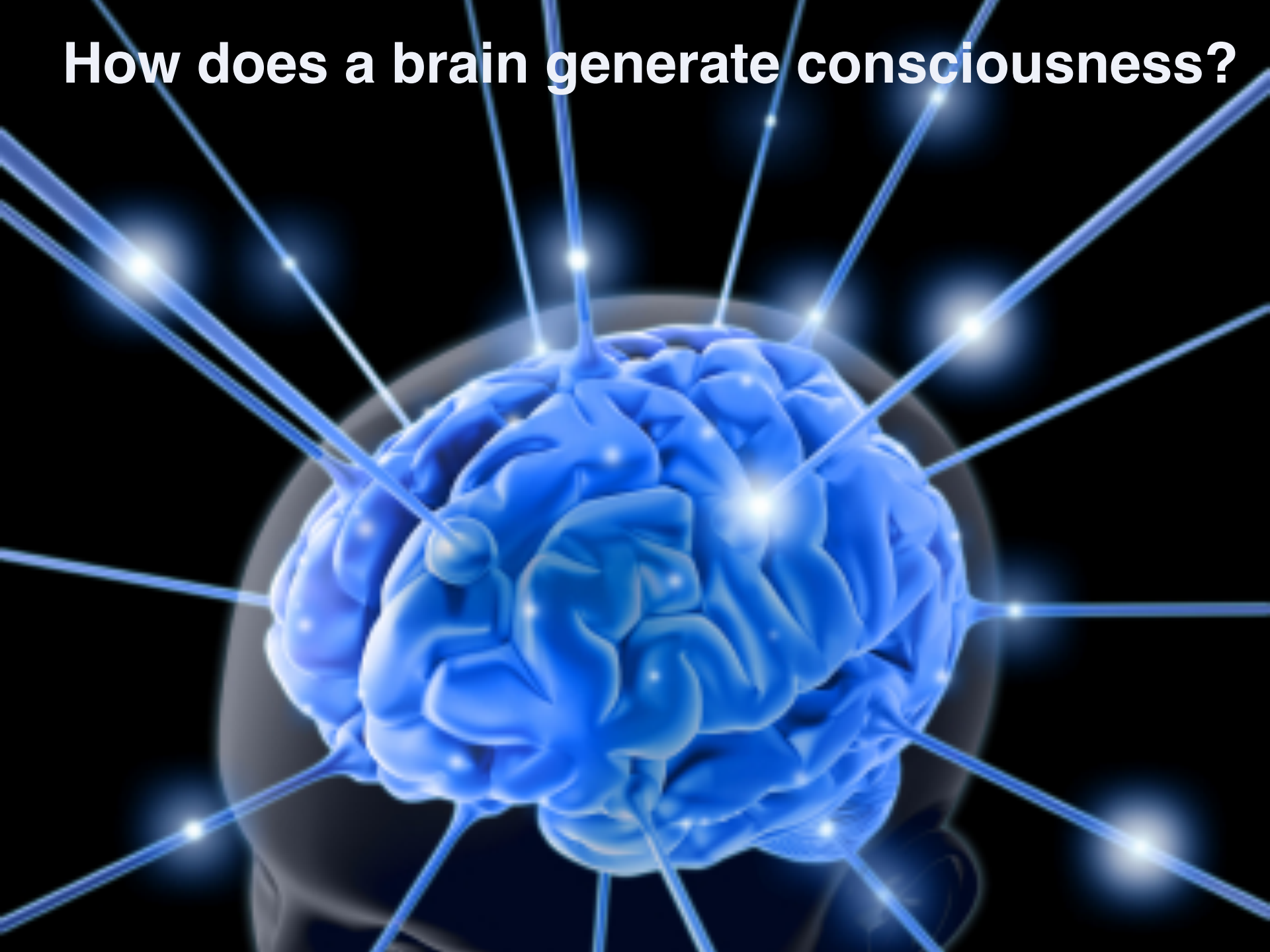


...

...

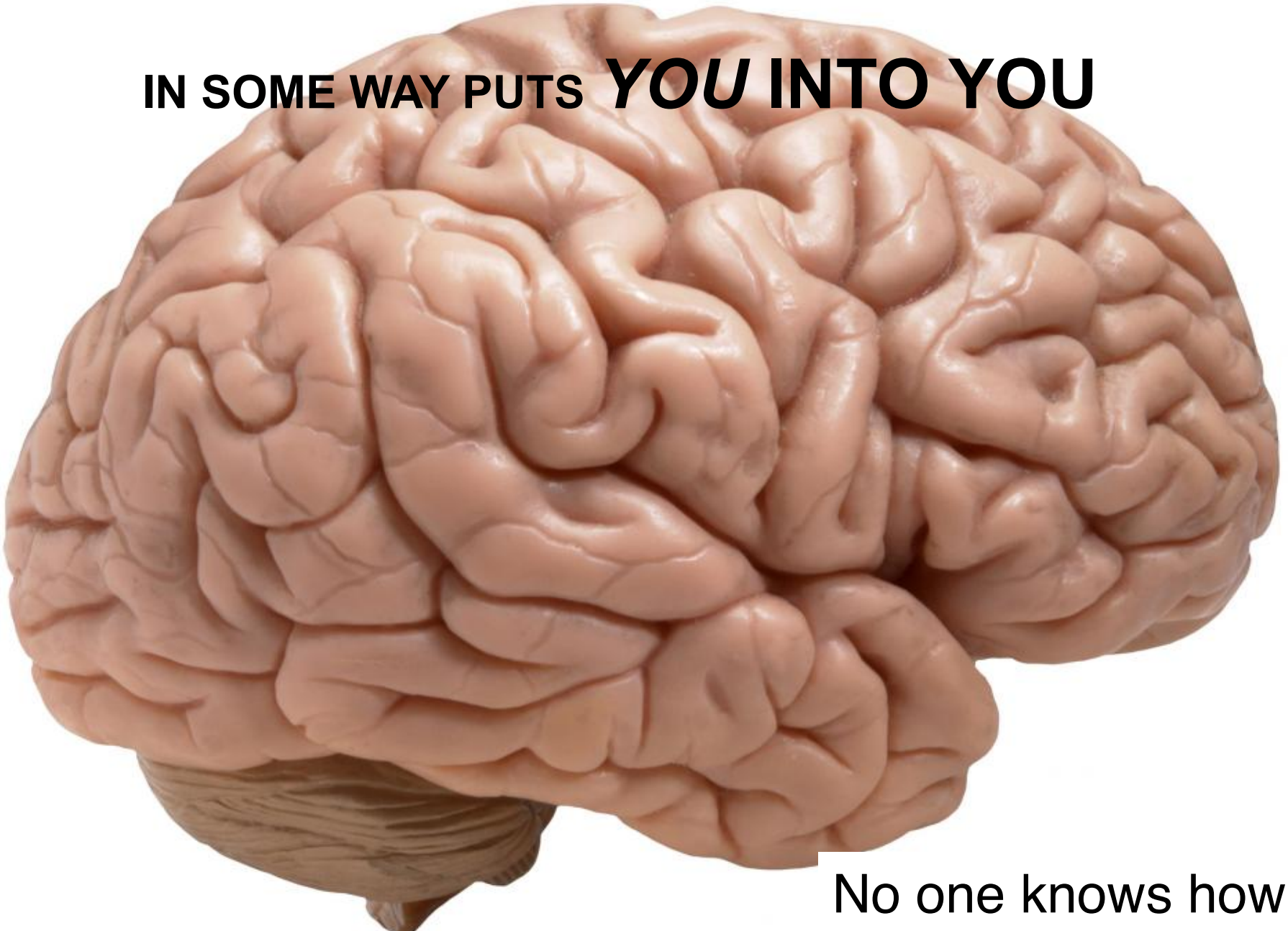
- Biologists first thought that proteins carry the building instructions
- Now it looks that proteins are something like rocks – useless without the building plan
- Instructions are probably written in DNA – but nobody knows how to exactely read them

How does a brain generate consciousness?

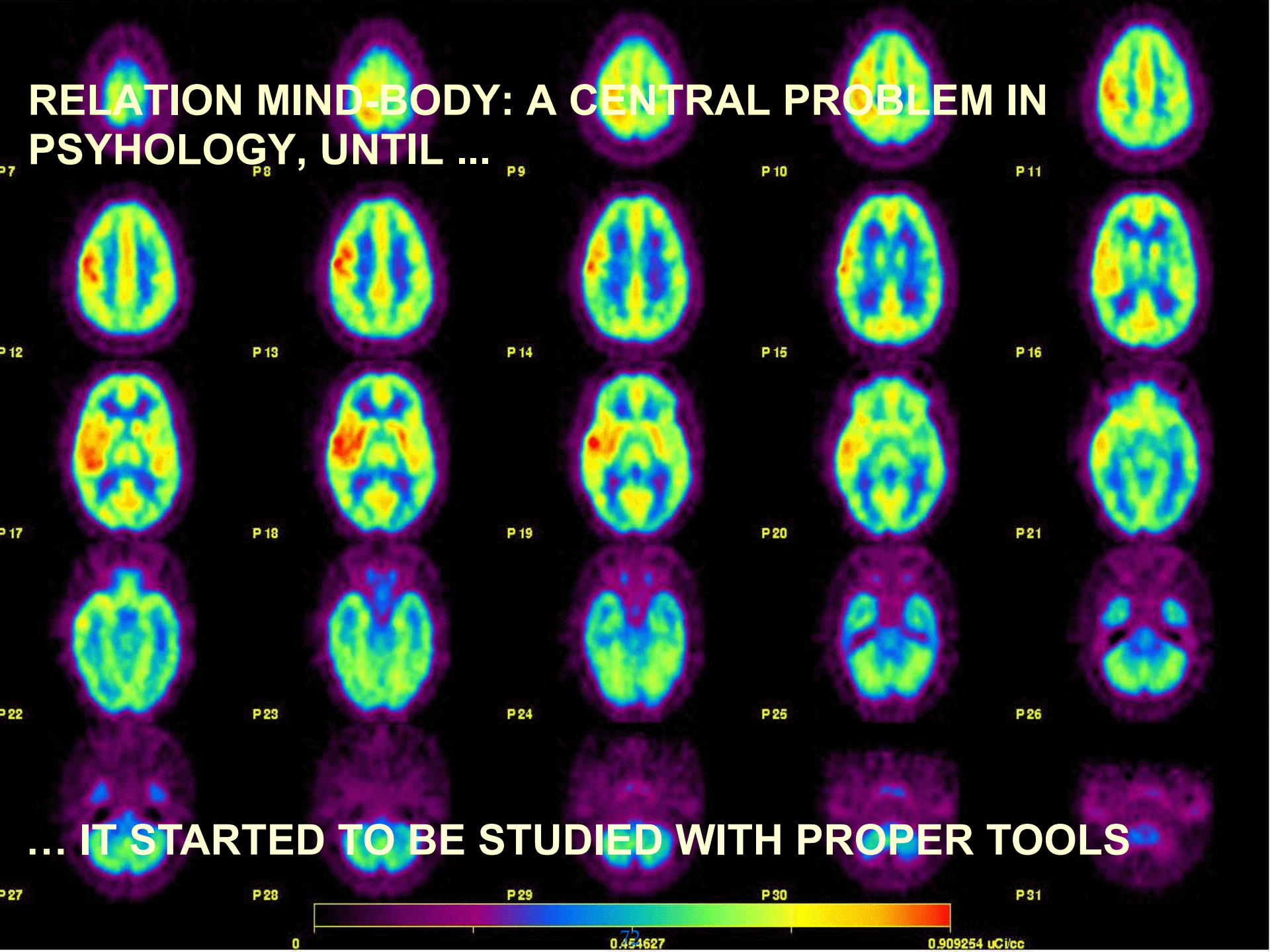


A BRAIN, A PIECE OF GRAY MASS – CCA 1.5 KG

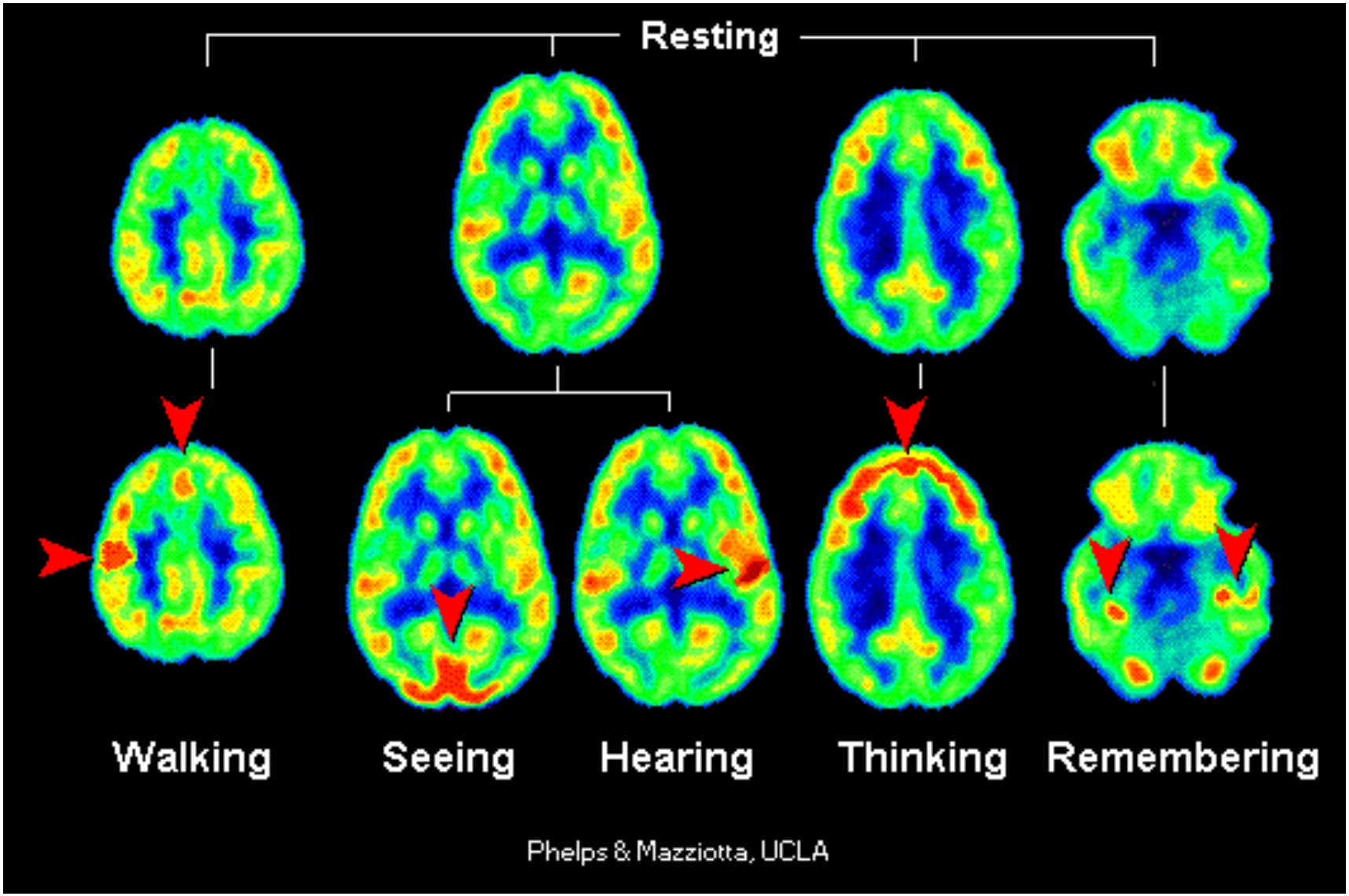
IN SOME WAY PUTS *YOU* INTO YOU



No one knows how!


RELATION MIND-BODY: A CENTRAL PROBLEM IN PSYHOLOGY, UNTIL ...
P7
P8
P9
P10
P11
P12
P13
P14
P15
P16
P17
P18
P19
P20
P21
P22
P23
P24
P25
P26
P27
P28
P29
P30
P31
0
0.454627
0.909254 uCi/cc
... IT STARTED TO BE STUDIED WITH PROPER TOOLS

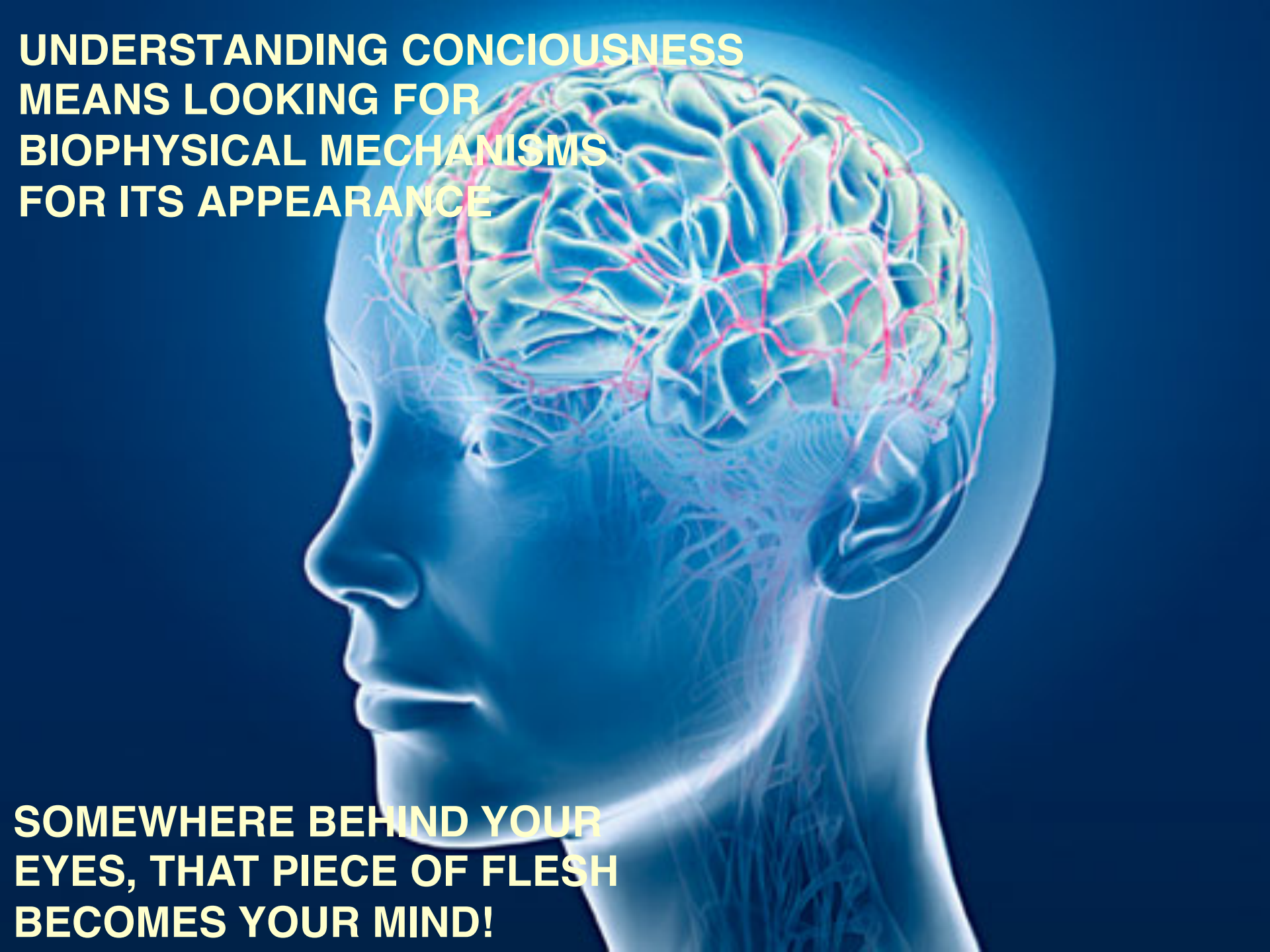
MRI & PET scaners: measuring brain activity



How does a brain generate consciousness?

- Traditional questions:
  - Is concsciousness = awakeness?
  - Is concsciousness = personality?
- Many theories about consciousness:
  - Antonio Damasio: self-consciousness evolved as regulatory mechanism, as a way in which brain understands what's going on in a body
  - Cristoph Koch: people have "consiousness neurons"
  - Bernard Baars: consciousness is a controling input for unconscious mechanisms like working memory, meaning of words, visual memory, study process ...


SOME PHILOSOPHERS ARE MAYBE STILL SENTIMENTAL AND THINKS THAT CONCIOUSNESS IS ABOVE THE MATTER
SCIENTISTS LIVE TO REDUCE WHAT IS APPARENTLY UNREDUCIBLE
… AND LEAVE SENTIMENTS OUTSIDE THE LABS ☺
http://fineartamerica.com/featured/soul-our-conscious-richard-hubal.html


UNDERSTANDING CONCIOUSNESS
MEANS LOOKING FOR
BIOPHYSICAL MECHANISMS
FOR ITS APPEARANCE
SOMEWHERE BEHIND YOUR
EYES, THAT PIECE OF FLESH
BECOMES YOUR MIND!

How Much Can Human Life Span Be Extended?

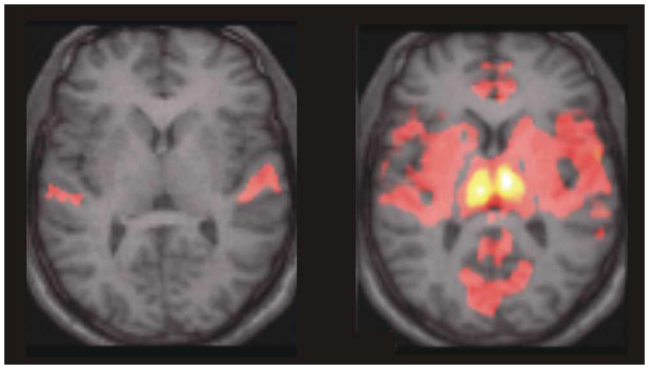
How Much Can Human Life Span Be Extended?

- Jeanne Calment, died in 1997, with 122 longest living human
- Experiments show that soon human life span will be between 100 and 110 years
  - In industrial countries 1 in 10 000 people lives more than 100 years
- Some ways to extend the life span with animals:
  - Lower calories intake
  - Reducing the growth factor (IGF-1)
  - Preventing the tissue oxidation
- All three reasons are probably interconnected (not yet proven)
- Can these strategies help humans to extend their life span?
- And do they want it?
- There are genetic studies on cousins that live longer
- Many scientists think that life span has a natural upper limit
- There are also many ethical questions: who can afford it?
- In close future some less drastic strategies:
  - Fighting the cardio-vascular disseases
  - Cancer prevention
  - ...

Why do we sleep?

Why do we sleep?

- All mamals sleep
  - And if they don't – they die
  - Faster than if they don't eat
- But no one knows WHY!
- Obviousle: by sleeping we rest our body
  - But by watching the TV we do the same ☺
- Leading theory about sleeping says:
  - While we are awake, some substances in a brain are created (some dissapear), and while we sleep the reverse process takse place
  - During the night, free from conciousness processss (altough not completely), a brain can focus on cleaning
- This theory has a problem to accomodate the REM phase, in which a brain is very active:
  - A phase of memory consolidation
  - But on contrary, pacients without REM phase did have problems with memory ...



And yet we have to explain the dreams ☺ …

Why do we die?

Why do we die?

- If you ask physicist: because of the 2nd law of thermodynamics!
- Biologists go in more details: maybe free radicals destroy our DNA, or thelomerases gets shorter and shorter
- But maybe the best is to ask ecologists!
- They calculate roughly:
  - Large species have slower energy distribution systems
  - Therefore they have slower metabolism
  - And that means logner life
- Both mouse and whale have the same number of heart beats: about 100 milion
  - Mouse has it distributed over 2 years
  - And whale over 80 years
- But why do we, humans, leave that long, while we are closer to mouse than to whale?
- Maybe because we are smarter
  - Really?
- Maybe the part of the answer is in looking how much energy is spent on the brain development and function of a, with respect to the resto of our body

Why do we die?

We all still have some time to find out ☺

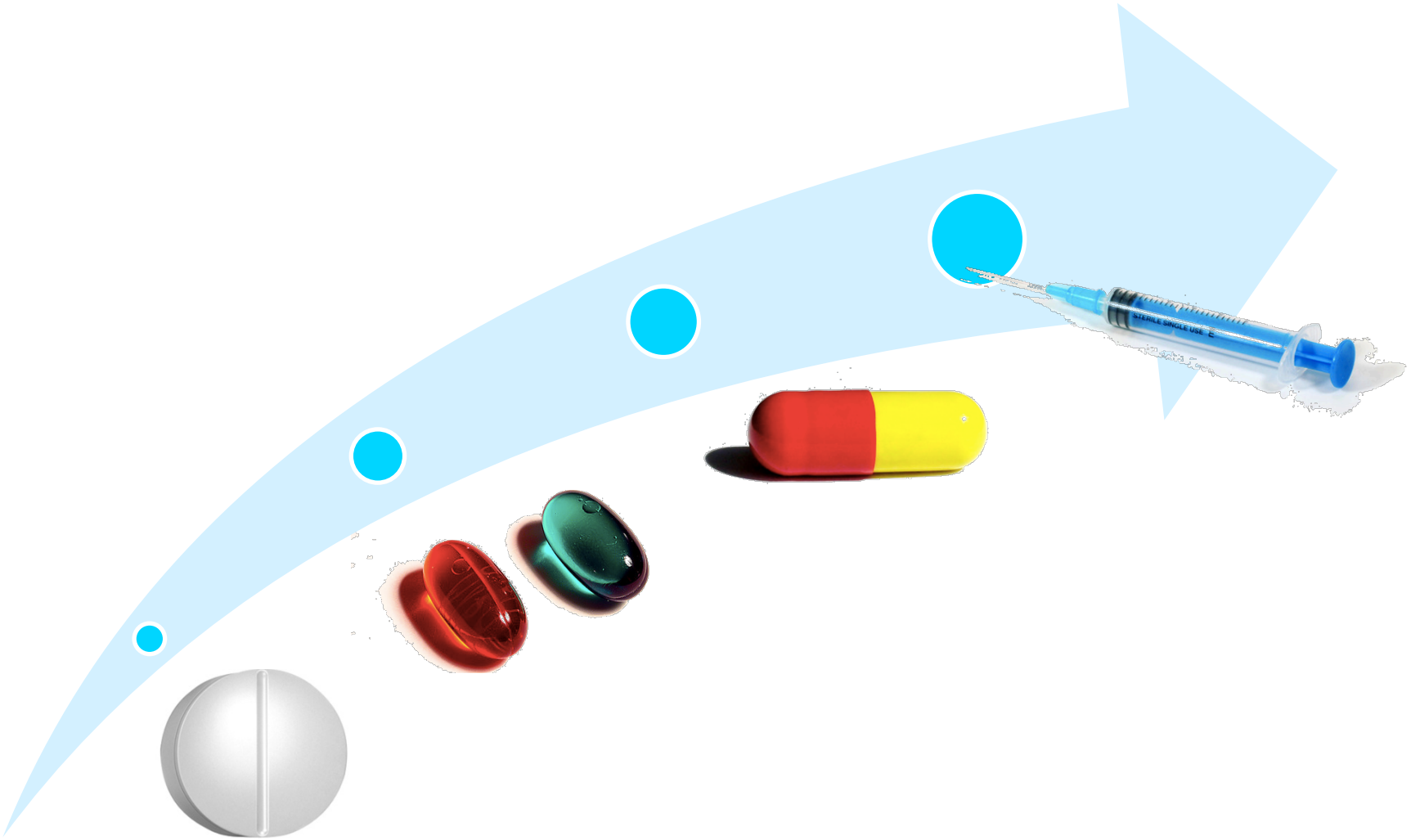
What happend to Neathertals?

Što se dogodilo Neandertalcima?

- Bili su naši susjedi
- I to vrlo slični: izgledali kao mi, hodali kao mi, čak su možda i mislili poput nas
- Zašto su onda nestali?
- A mi ostali …
- Što ih je uništilo?
- Bili su vrlo slični našim direktnim prethodnicima Cro-Magnonima
  - Možda malo veći, mišičaviji i s većim mozgom
  - I vjerojatno su se miješali
- Prije cca 30 000 godina, odjednom su nestali
- Možda ih je uništila kronična bolest
- Ili možda loša podjela rada
- Cro-Magnonci su dijelili rad s obzirom na spol, Neadertalici nisu
- Nove teorije favoriziraju ovu drugu ideju
- Stoga izgleda da Neandertalce nije istrijebila neka bakterija, ili neki diktator, već prije tipovi poput Vilme i Kremenka

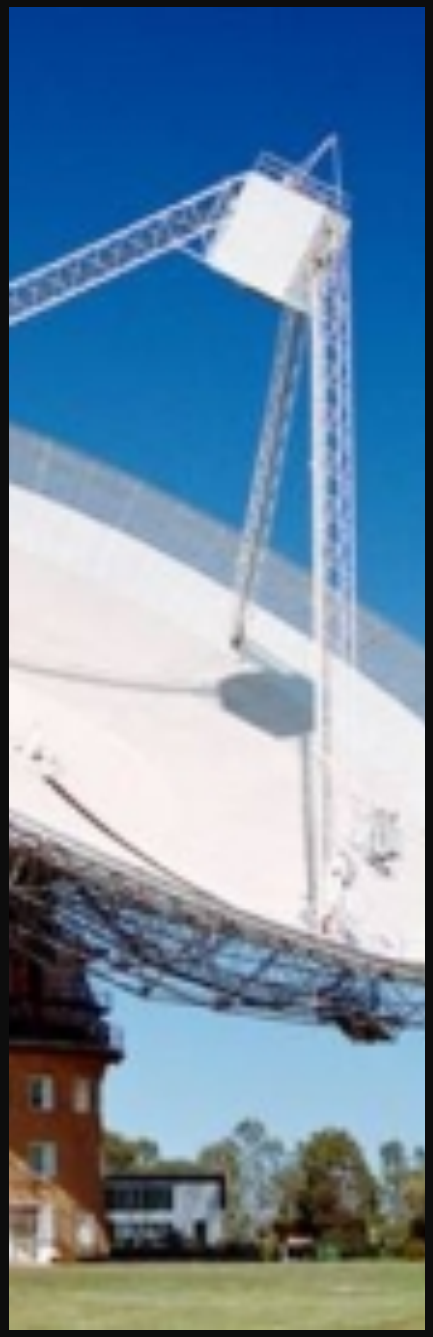
How does the placebo effect work?

How does the placebe effect work?

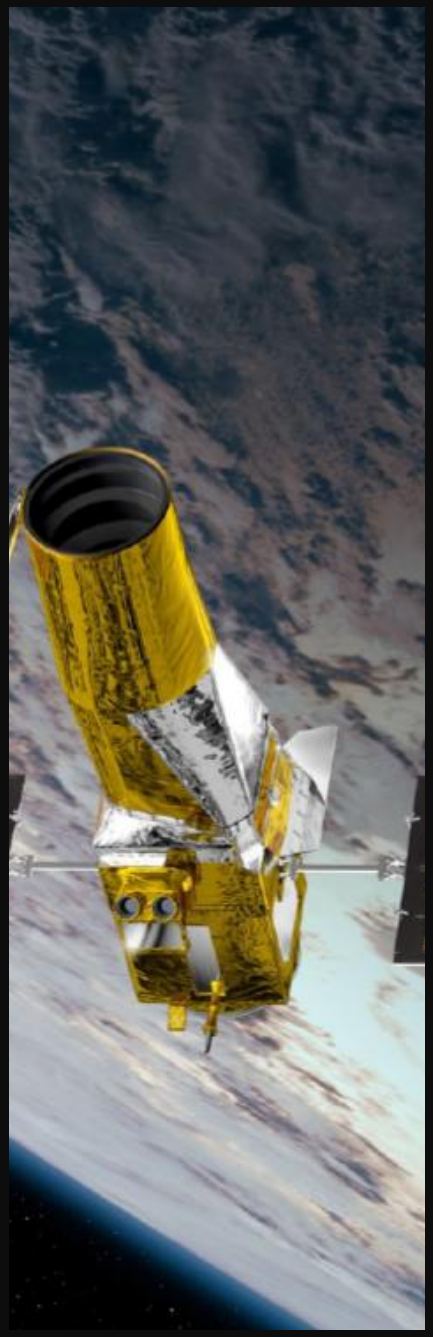


Are we alone in the Univers?

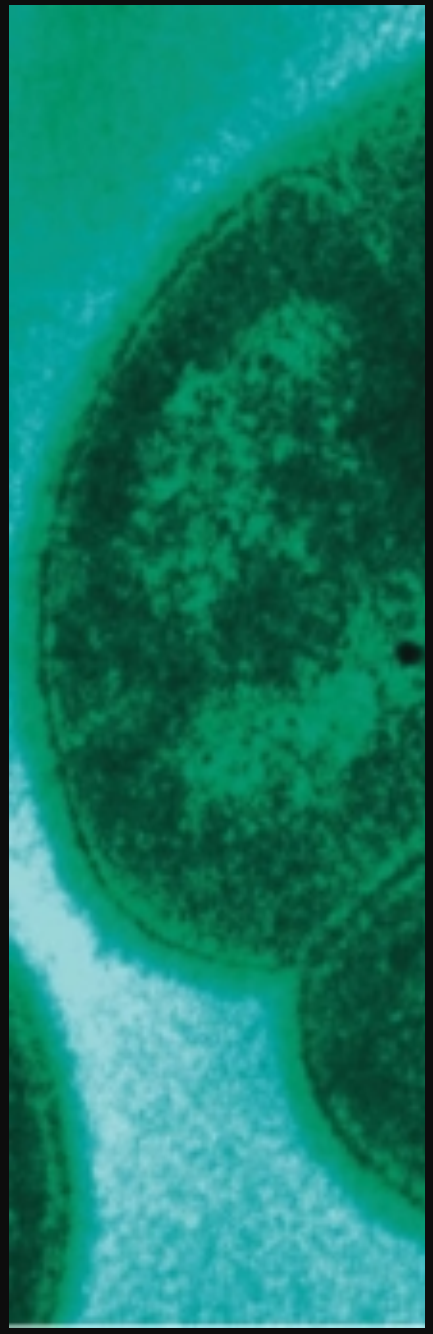
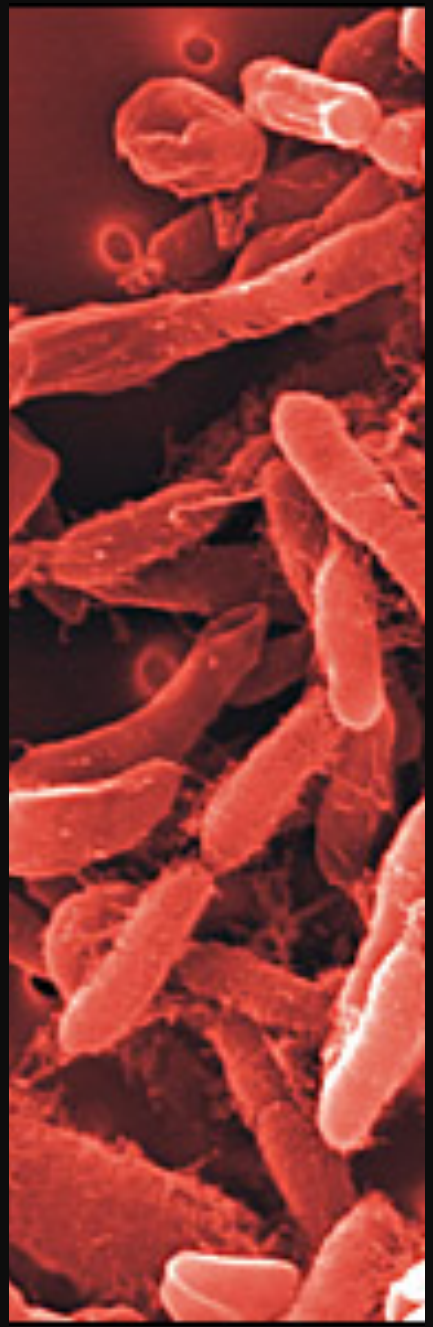

100 bilions
ALL THIS IS ONLY 5% OF THE UNIVERSE!
100 bilions




USAF
ULA
DELTA
Kepler
SEARCH FOR EARTH-SIZE PLANETS





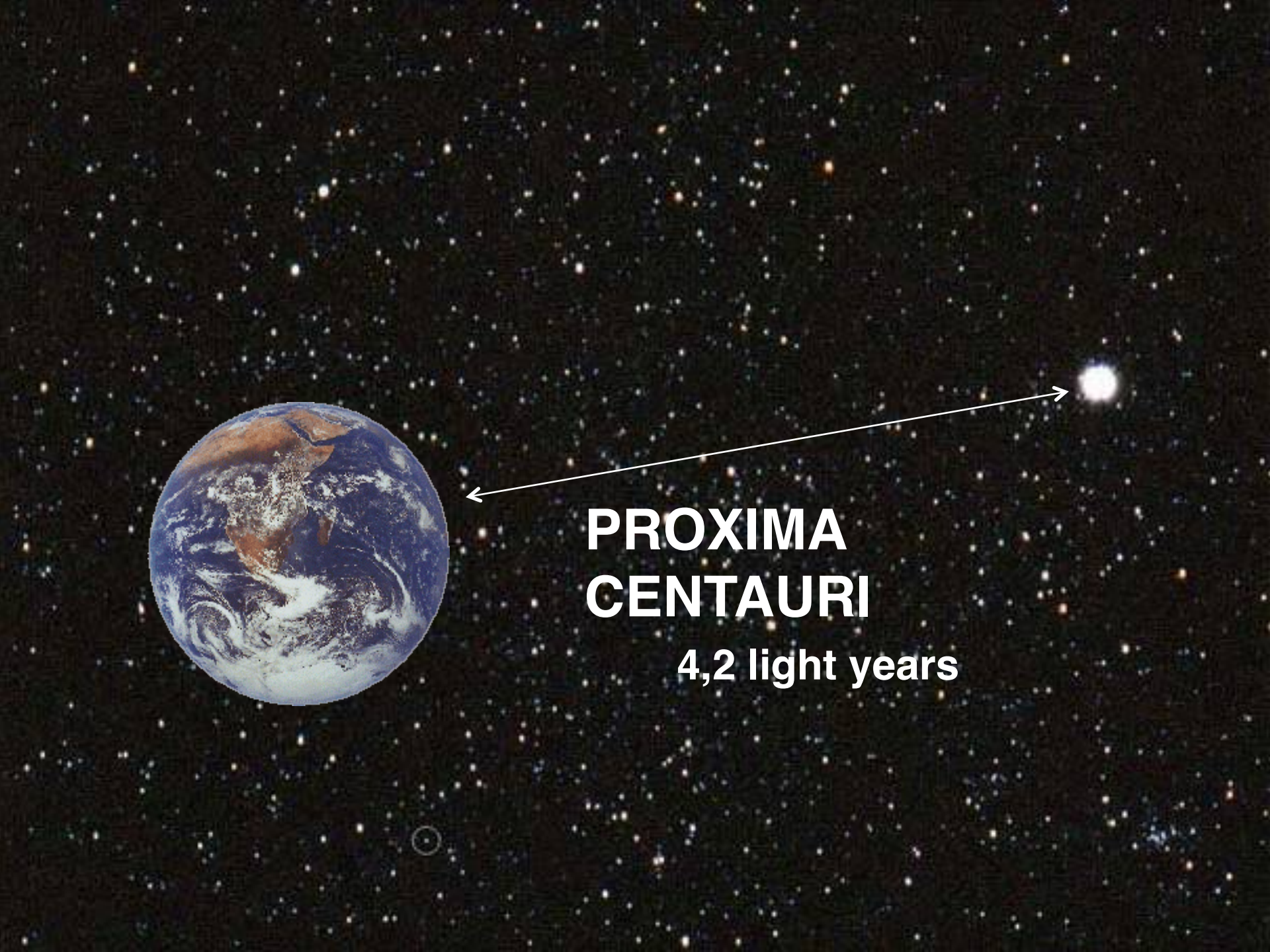




8 light
minutes

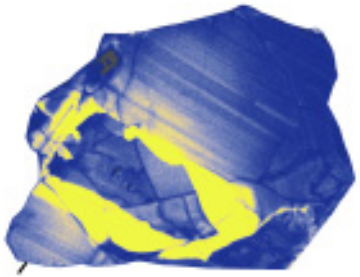
1 light year

=

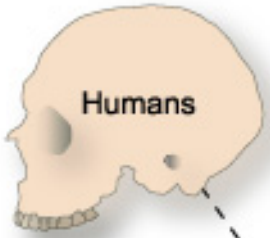
9 460 730 472 580,8 km


PROXIMA
CENTAURI
4,2 light years

EARTH HISTORY

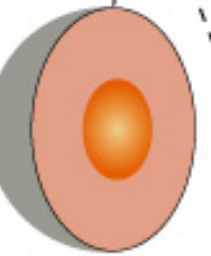


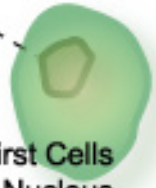
Oldest Zircon Crystal
4.4 billion years old

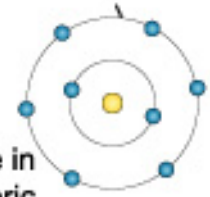


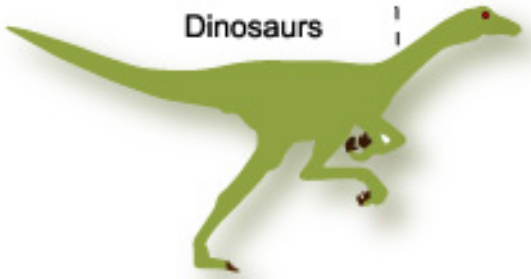
Billion Years Ago

4.56 4 3.5 3 2.5 2 1.5 1 0.5 0

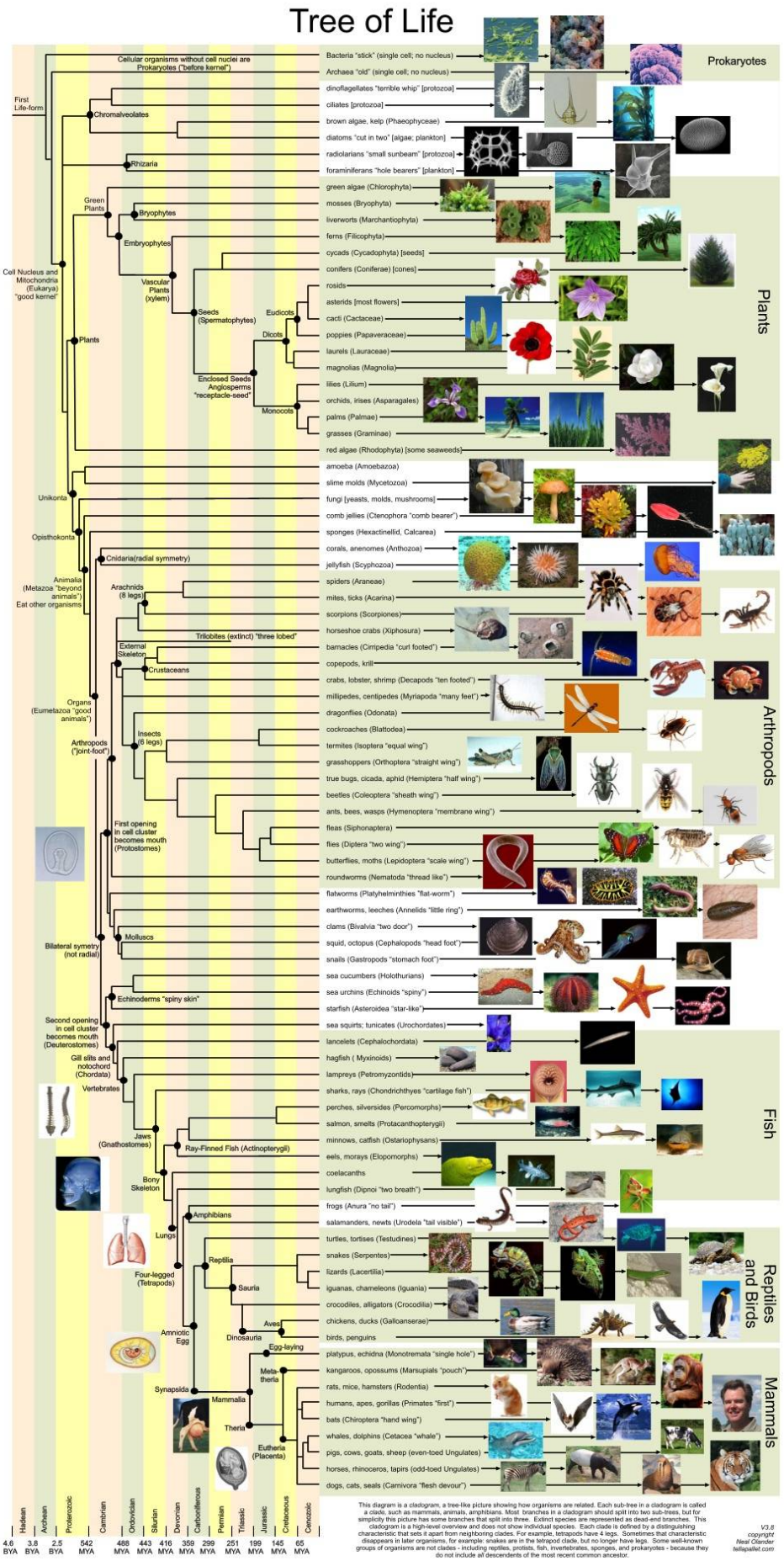












Tree of Life
Cellular organisms without cell nuclei are Prokaryotes ("before kernel")
First Life-form
Chromalveolates
Rhizaria
Green Plants
Bryophytes
Embryophytes
Vascular Plants (xylem)
Seeds (Spermatophytes)
Eudicots
Dicots
Enclosed Seeds Angiosperms "receptacle-seed"
Monocots
Cell Nucleus and Mitochondria (Eukarya) "good kernel"
Plants
Unikonts
Opisthokonta
Cnidaria(radial symmetry)
Animalia (Metazoa "beyond animals") Eat other organisms
Arachnids (8 legs)
Trilobites (extinct) "three lobed"
External Skeleton
Crustaceans
Organs (Eumetazoa "good animals")
Arthropods ("joint-foot")
Insects (6 legs)
First opening in cell cluster becomes mouth (Protostomes)
Molluscs
Bilateral symetry (not radial)
Echinoderms "spiny skin"
Second opening in cell cluster becomes mouth (Deuterostomes)
Gill slits and notochord (Chordata)
Vertebrates
Jaws (Gnathostomes)
Ray-Finned Fish (Actinopterygii)
Bony Skeleton
Amphibians
Lungs
Four-legged (Tetrapods)
Reptilia
Sauria
Amniotic Egg
Aves
Dinosauria
Egg-laying
Synapsida
Mammalia
Therapsida
Eutheria (Placenta)
Metatheria
Bacteria "stick" (single cell; no nucleus)
Archaea "old" (single cell; no nucleus)
dinoflagellates "terrible whip" [protozoa]
ciliates [protozoa]
brown algae, kelp (Phaeophyceae)
diatoms "cut in two" [algae; plankton]
radiolarians "small sunbeam" [protozoa]
foraminiferans "hole bearers" [plankton]
Prokaryotes
green algae (Chlorophyta)
mosses (Bryophyta)
liverworts (Marchantiophyta)
ferns (Filicophyta)
cycads (Cycadophyta) [seeds]
conifers (Coniferae) [cones]
rosids
asterids [most flowers]
cacti (Cactaceae)
poppies (Papaveraceae)
laurels (Lauraceae)
magnolias (Magnolia)
lilies (Lilium)
orchids, irises (Asparagales)
palms (Palmae)
grasses (Graminae)
red algae (Rhodophyta) [some seaweeds]
Plants
amoeba (Amoebazoa)
slime molds (Mycetozoa)
fungi [yeasts, molds, mushrooms]
comb jellies (Ctenophora "comb bearer")
sponges (Hexactinellid, Calcarea)
corals, anenomes (Anthozoa)
jellyfish (Scyphozoa)
spiders (Araneae)
mites, ticks (Acarina)
scorpions (Scorpiones)
horseshoe crabs (Xiphosura)
barnacles (Cirripedia "curl footed")
copepods, krill
crabs, lobster, shrimp (Decapods "ten footed")
millipedes, centipedes (Myriapoda "many feet")
dragonflies (Odonata)
cockroaches (Blattodea)
termites (Isoptera "equal wing")
grasshoppers (Orthoptera "straight wing")
true bugs, cicada, aphid (Hemiptera "half wing")
beetles (Coleoptera "sheath wing")
ants, bees, wasps (Hymenoptera "membrane wing")
Arthropods
fleas (Siphonaptera)
flies (Diptera "two wing")
butterflies, moths (Lepidoptera "scale wing")
roundworms (Nematoda "thread like")
flatworms (Platyhelminthies "flat-worm")
earthworms, leeches (Annelids "little ring")
clams (Bivalvia "two door")
squid, octopus (Cephalopods "head foot")
snails (Gastropods "stomach foot")
sea cucumbers (Holothurians)
sea urchins (Echinoids "spiny")
starfish (Asteroidea "star-like")
sea squirts; tunicates (Urochordates)
lancelets (Cephalochordata)
hagfish (Myxinoids)
lampreys (Petromyzontids)
sharks, rays (Chondrichthyes "cartilage fish")
perches, silversides (Percomorphs)
salmon, smelts (Protacanthopterygii)
minnows, catfish (Ostariophysans)
eels, morays (Elopomorphs)
coelacanths
lungfish (Dipnoi "two breath")
Fish
frogs (Anura "no tail")
salamanders, newts (Urodela "tail visible")
turtles, tortises (Testudines)
snakes (Serpentes)
lizards (Lacertilia)
iguanas, chameleons (Iguania)
crocodiles, alligators (Crocodilia)
chickens, ducks (Galloanserae)
birds, penguins
Reptiles and Birds
platypus, echidna (Monotremata "single hole")
kangaroos, opossums (Marsupials "pouch")
rats, mice, hamsters (Rodentia)
humans, apes, gorillas (Primates "first")
bats (Chiroptera "hand wing")
whales, dolphins (Cetacea "whale")
pigs, cows, goats, sheep (even-toed Ungulates)
horses, rhinoceros, tapirs (odd-toed Ungulates)
dogs, cats, seals (Carnivora "flesh devour")
Mammals
Hadean
Archean
Proterozoic
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Cenozoic
4.6 BYA
3.8 BYA
2.5 BYA
542 MYA
488 MYA
443 MYA
416 MYA
359 MYA
299 MYA
251 MYA
199 MYA
145 MYA
65 MYA
This diagram is a cladogram, a tree-like picture showing how organisms are related. Each sub-tree in a cladogram is called a clade, such as mammals, animals, amphibians. Most branches in a cladogram should split into two sub-trees, but for simplicity this picture has some branches that split into three. Extinct species are represented as dead-end branches. This cladogram is a high-level overview and does not show individual species. Each clade is defined by a distinguishing characteristic that sets it apart from neighboring clades. For example, tetrapods have 4 legs. Sometimes that characteristic disappears in later organisms, for example: snakes are in the tetrapod clade, but no longer have legs. Some well-known groups of organisms are not clades - including reptiles, protists, fish, invertebrates, sponges, and prokaryotes - because they do not include all descendents of the most recent common ancestor.
V3.8
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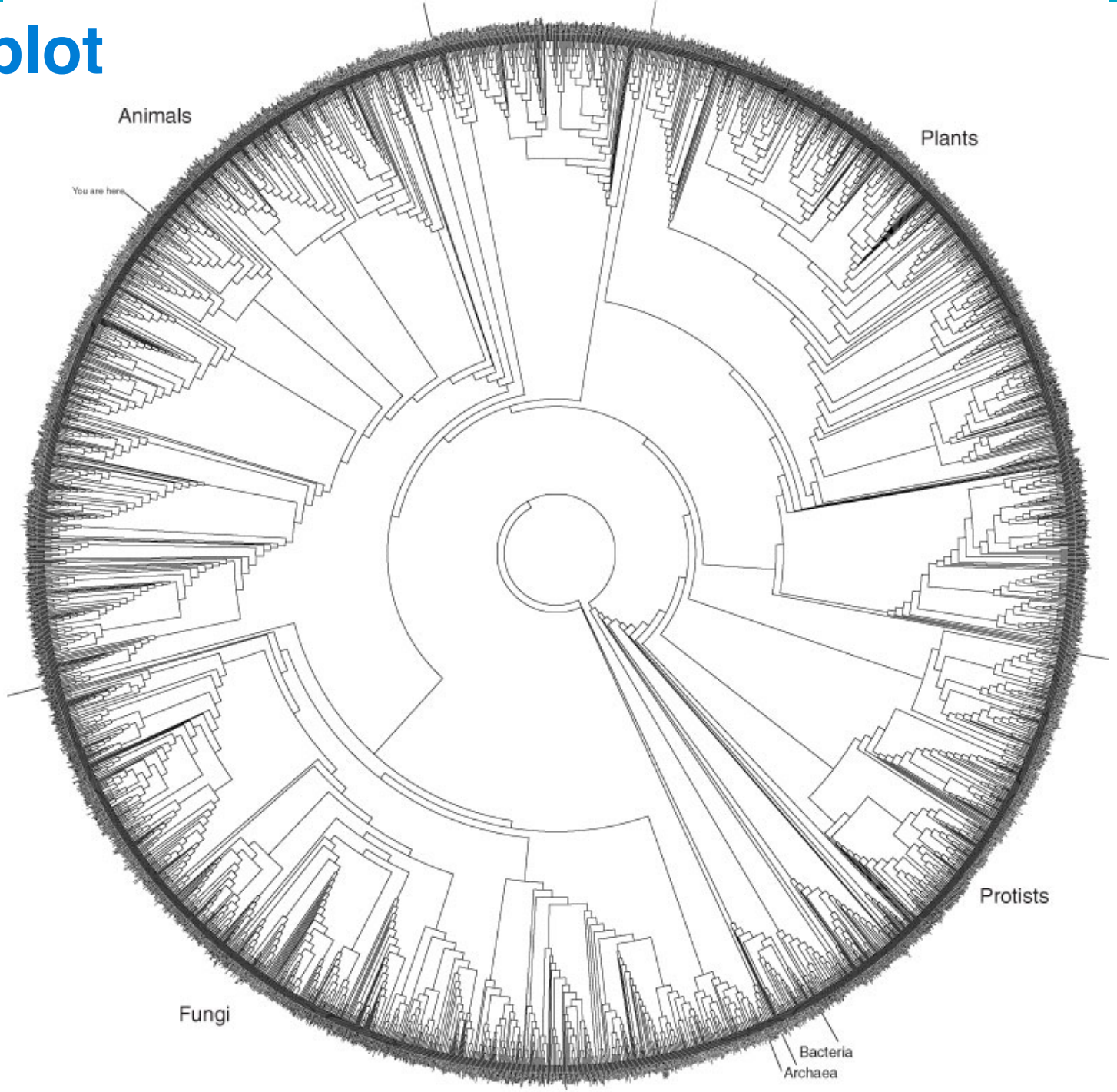
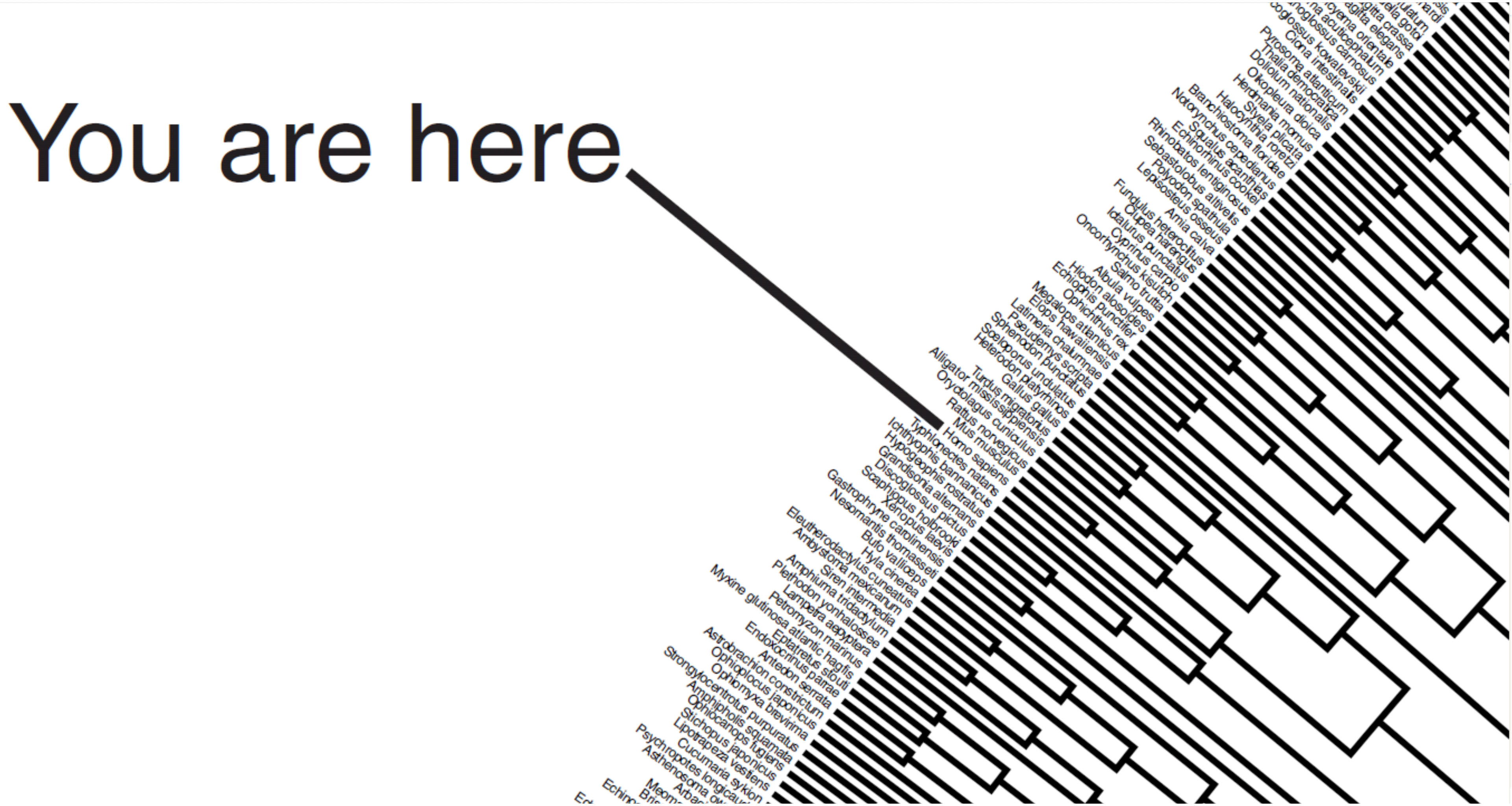
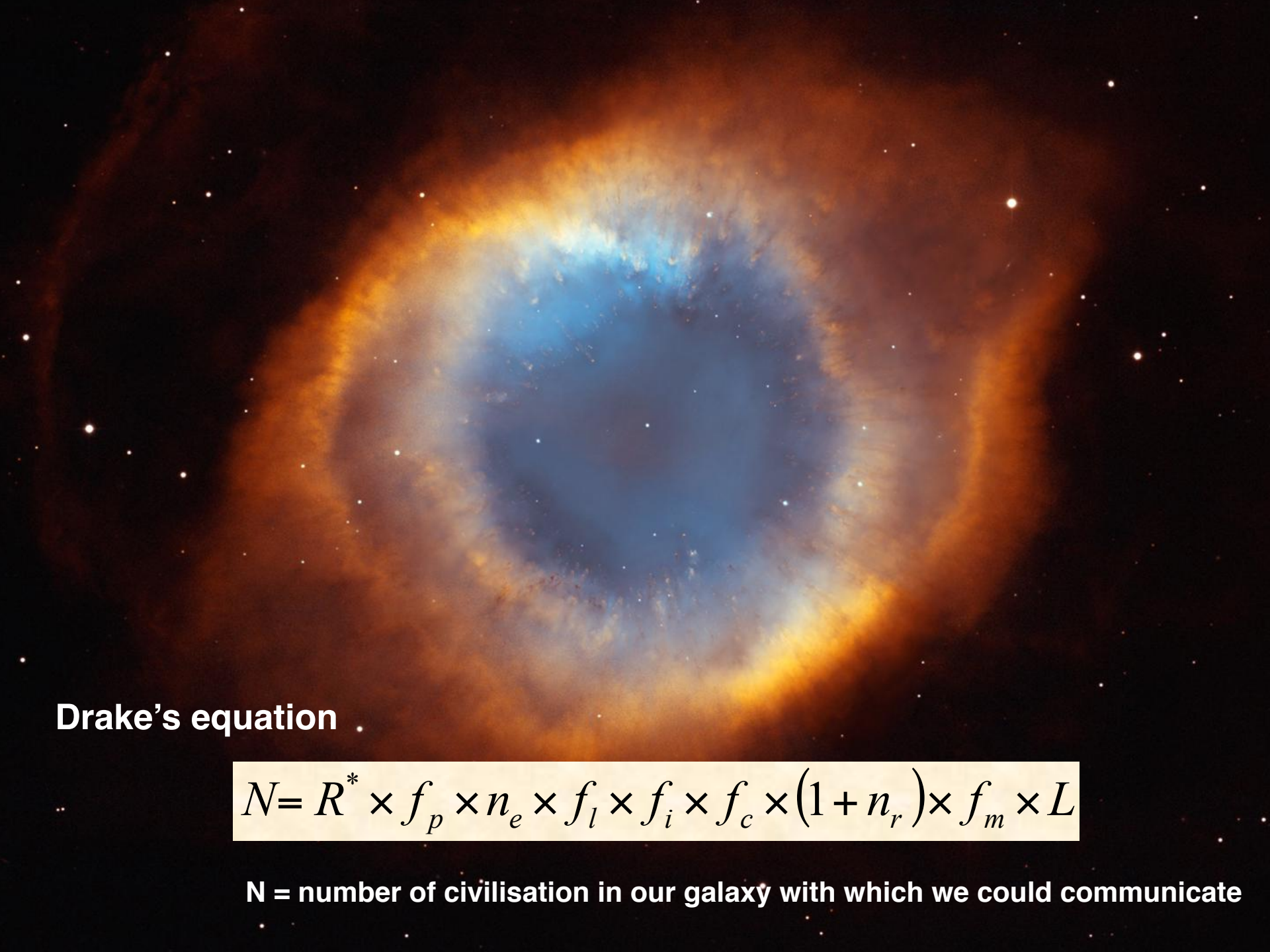
Neal Olander
tolweb.org

Hillis plot


Animals
You are here
Plants
Protists
Fungi
Bacteria
Archaea



You are here
Ciona intestinalis
Pyrosoma atlanticum
Thalia democratica
Doliolum nationalis
Oikopleura dioica
Herdmania momus
Styela plicata
Halocynthia roretzi
Branchiostoma floridae
Notorynchus cepedianus
Squalus acanthias
Echinorhinus cookei
Rhinobatos lentiginosus
Sebastolobus altivelis
Polyodon spathula
Amia calva
Lepisosteus osseus
Fundulus heteroclitus
Clupea harengus
Ictalurus punctatus
Cyprinus carpio
Oncorhynchus kisutch
Salmo trutta
Albula vulpes
Hiodon alosoides
Echiophis punctifer
Ophichthus rex
Megalops atlanticus
Elops hawaiensis
Latimeria chalumnae
Pseudemys scripta
Sphenodon punctatus
Sceloporus undulatus
Heterodon platyrhinos
Gallus gallus
Turdus migratorius
Alligator mississippiensis
Oryctolagus cuniculus
Rattus norvegicus
Mus musculus
Homo sapiens
Typhlonectes natans
Ichthyophis bannanicus
Hypogeophis rostratus
Grandisonia alternans
Discoglossus pictus
Scaphiopus holbrooki
Xenopus laevis
Gastrophryne carolinensis
Nesomantis thomasseti
Bufo valliceps
Hyla cinerea
Eleutherodactylus cuneatus
Ambystoma mexicanum
Siren intermedia
Amphiuma tridactylum
Plethodon yonhalossee
Lampetra aepyptera
Petromyzon marinus
Myxine glutinosa
Eptatretus stouti
Endoxocrinus parrae
Antedon serrata
Astrobrachion constrictum
Ophioplocus japonicus
Ophiomyxa brevirima
Strongylocentrotus purpuratus
Amphipholis squamata
Ophiocanops fugiens
Stichopus japonicus
Lipotrapeza vestiens
Cucumaria sykion
Psychropotes longicauda



Drake's equation

$$N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times (1 + n_r) \times f_m \times L$$

N = number of civilisation in our galaxy with which we could communicate

N	=	R	x	f_p	x	n_e	x	f_l	x	f_i	x	f_c	x	L
9980		5		50%		2		100%		20%		100%		10000

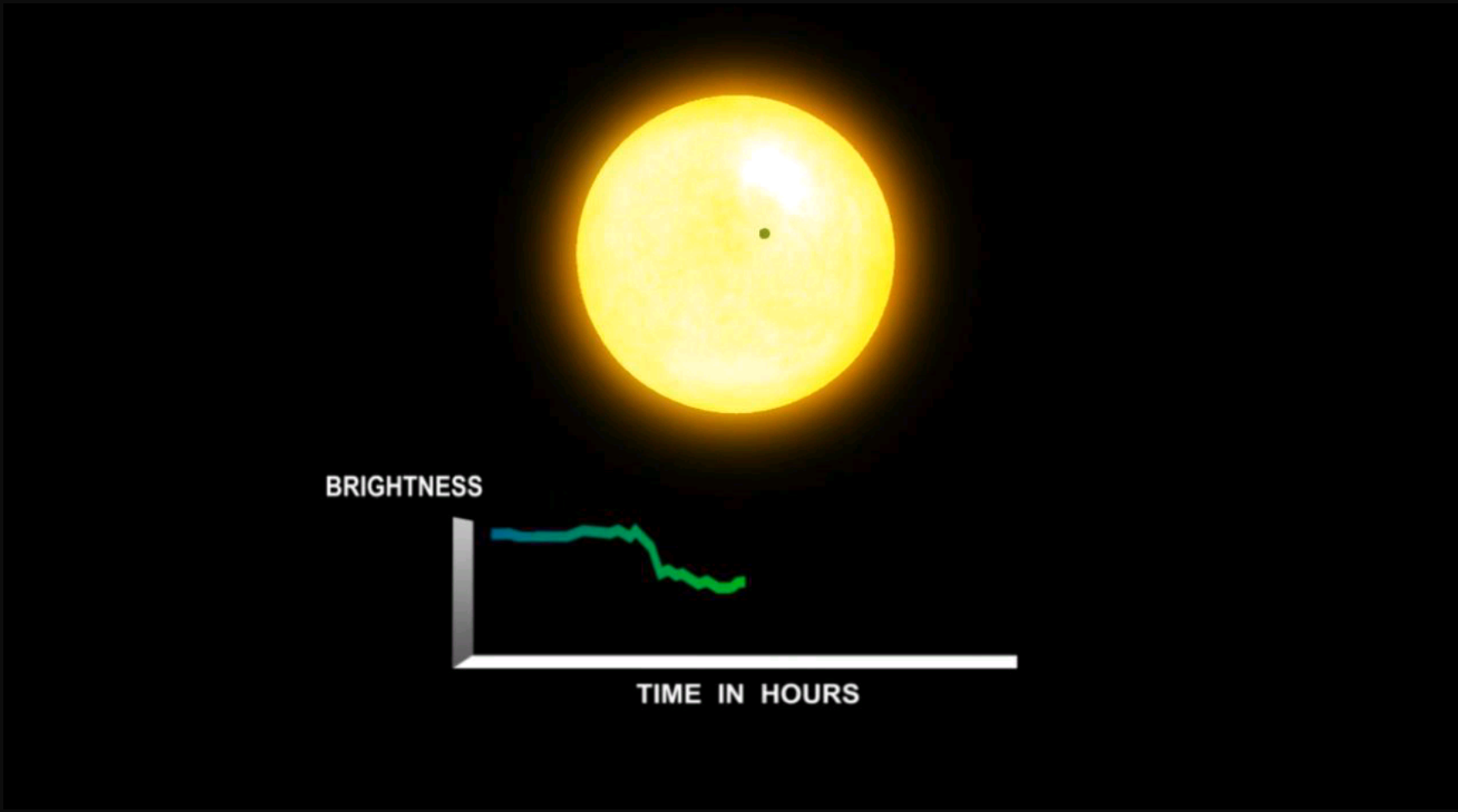
N

THE NUMBER OF COMMUNICATING CIVILIZATIONS IN OUR GALAXY

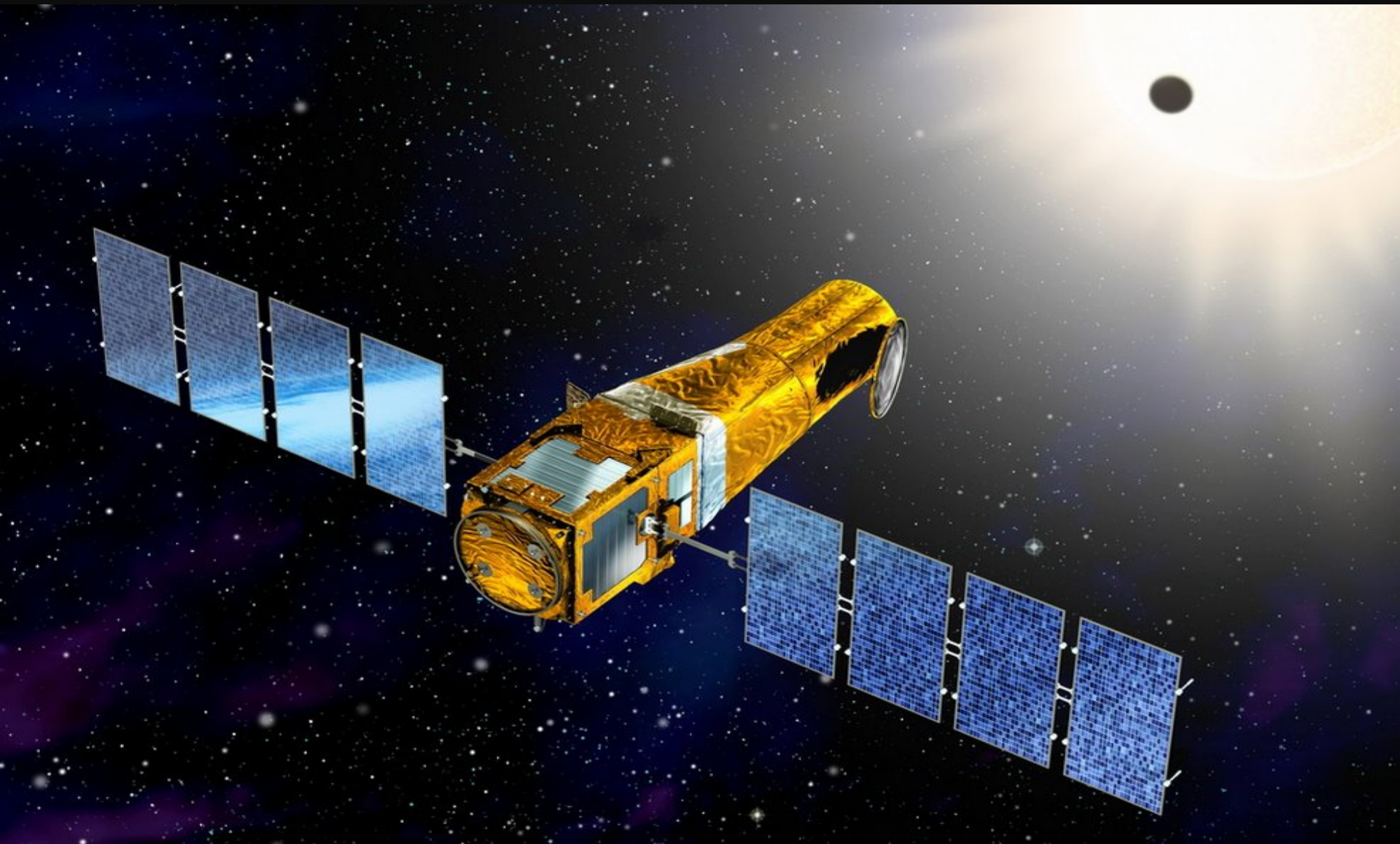
N is the number of communicating civilizations in the Milky Way today. Frank Drake's estimate of 10,000 is what gives hope to the SETI project, the Search for Extraterrestrial Intelligence. The search is limited to our galaxy, because while there may be intelligent life in other galaxies, we'd be unlikely to ever know of its existence because of the enormous distances. Since N is the product of all the terms multiplied together, if you make any variable zero, N automatically becomes zero as well. For terms that are percentages—if you think, for example, that only one in 10,000 planets would develop life—that fraction is equal to 0.01%.

SEE DRAKE'S VALUES

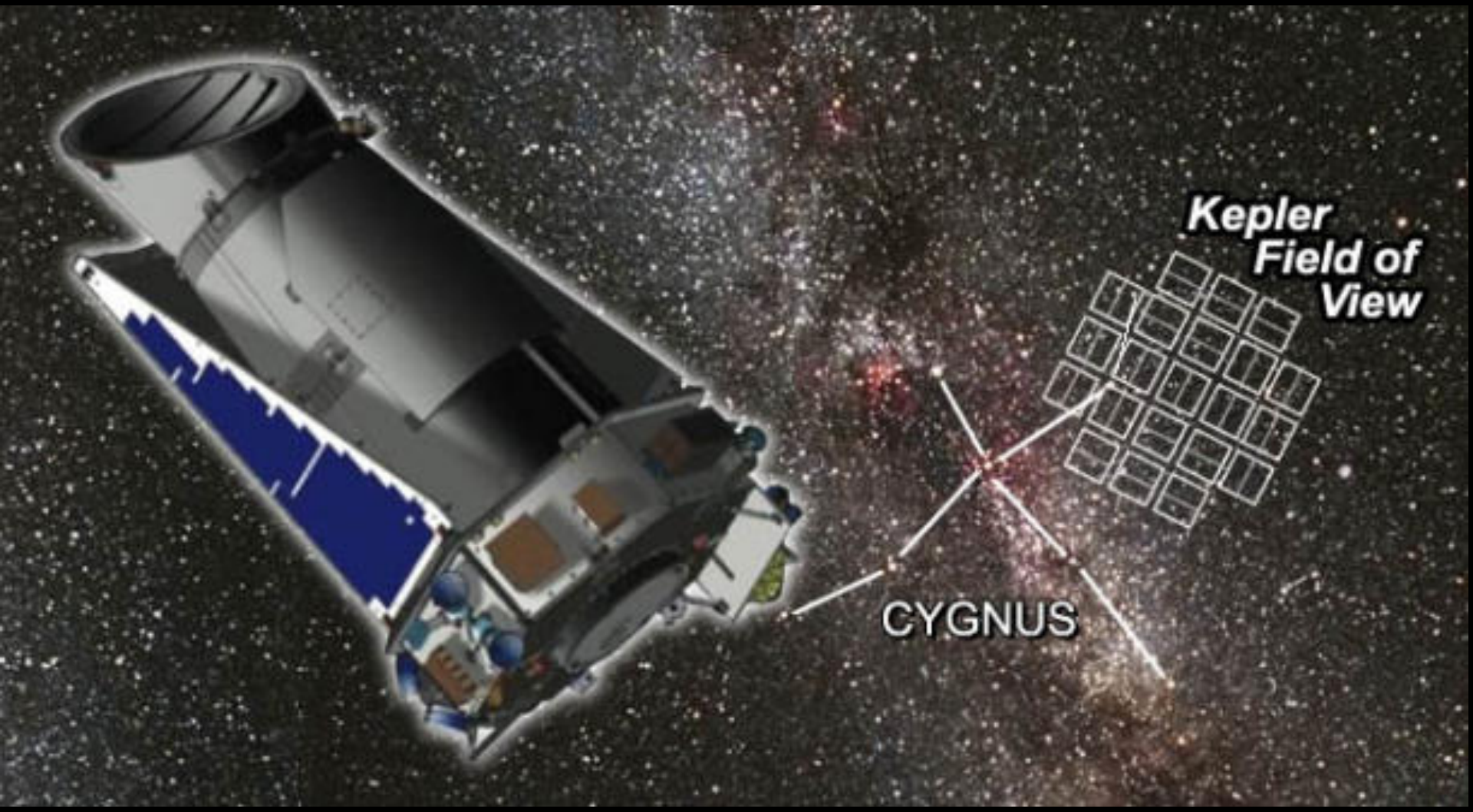
Planet transit - method

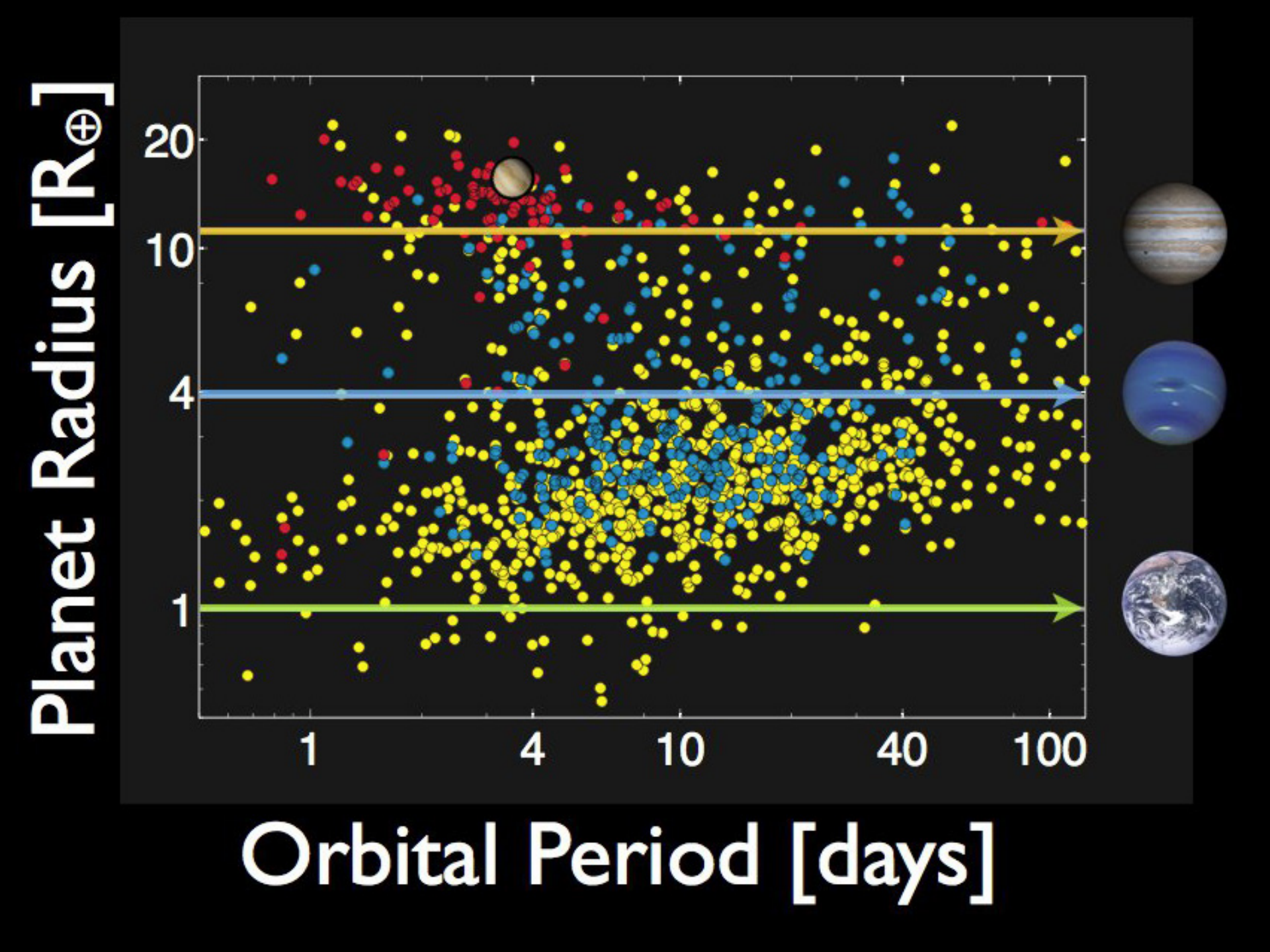


CoRoT – in space since 2007
Convection, **Ro**tation and Planetary **T**ransits



Kepler telescop – in orbit since 2009

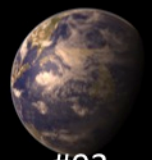



Planet Radius [R⊕]
20
10
4
1
1
4
10
40
100
Orbital Period [days]

Potential Habitable Worlds in the Universe


#01
KOI 736.01


#02
KOI 494.01

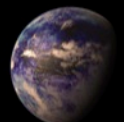

#03
KOI 784.01

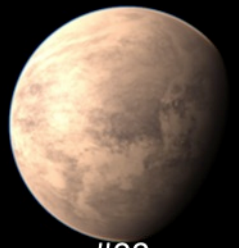

#04
KOI 610.01

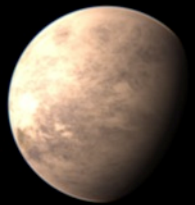

#05
KOI 947.01

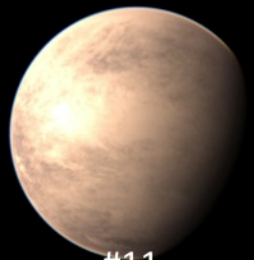

#06
KOI 817.01


#07
KOI 1361.01


#08
KOI 463.01


#09
KOI 701.03


#10
KOI 227.01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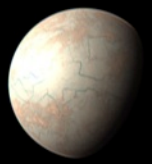
KOI 255.01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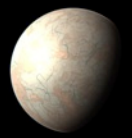
KOI 854.01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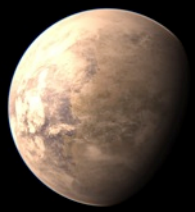
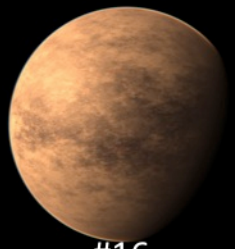
KOI 1026.01


#14
HD 85512 b

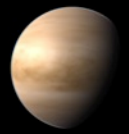

#15
KOI 268.01


#16
Gliese 581 d

Scientists are starting to identify potential habitable exoplanets in over 2,000 exoplanets that have been detected so far. Here is the current working list of 16 potential habitable exoplanets candidates ranked by similarity to Earth, from best to worst. All are to scale and can be compared to Earth, Venus, Mars, and Mercury below.

Solar System Terrestrial Planets


Earth


Venus


Mars


Mercury

Updated: Dec 5, 2011

CREDIT: The Habitable Exoplanets Catalog, Planetary Habitability Laboratory @ UPR Arecibo (phl.upr.edu)

SPACE.COM

www.space.com

Habitable Super-Earth?

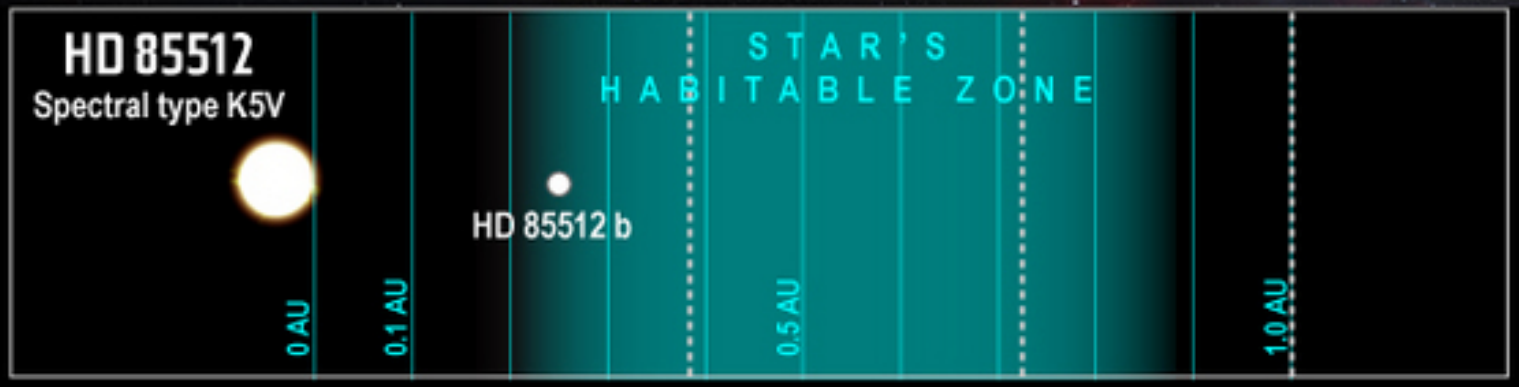
The planet HD 85512 b orbits within its star's habitable zone. Liquid water, a vital requirement for life as we know it, could exist on its surface.

Distance from Earth: **35 light-years**

Mass: **3.6 times that of Earth**

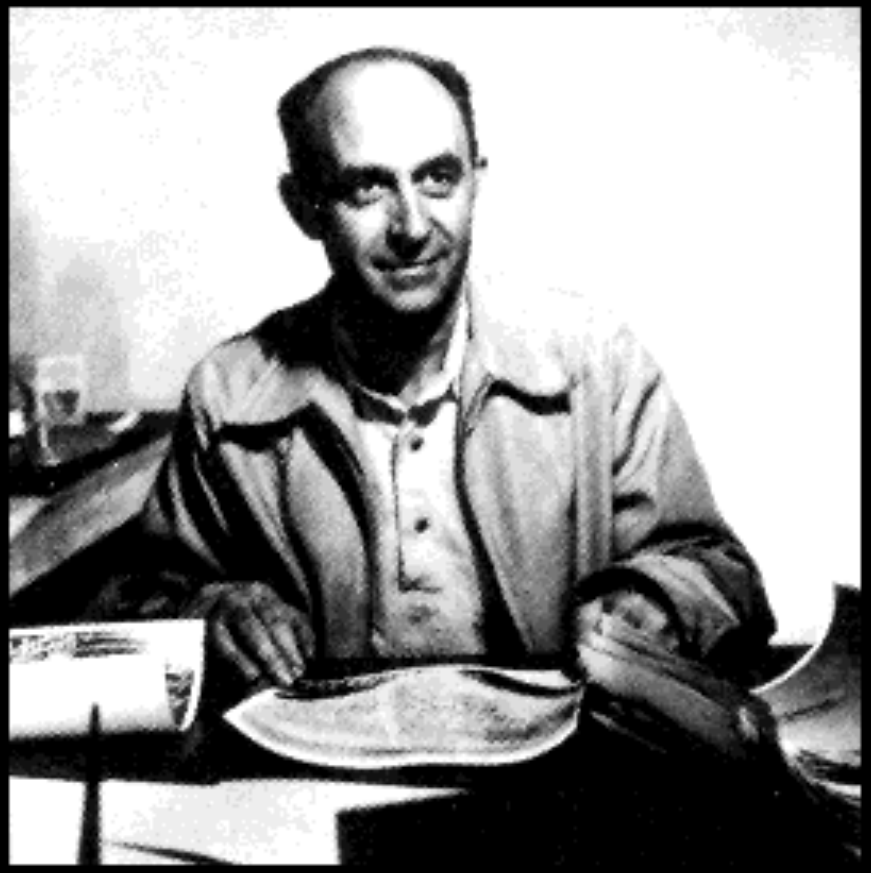
Surface temperature: **77 degrees F (25 degrees C)**

ARTIST'S CONCEPTION OF HD 85512 b (CREDIT: M. KORNMESSER, EUROPEAN SOUTHERN OBSERVATORY)

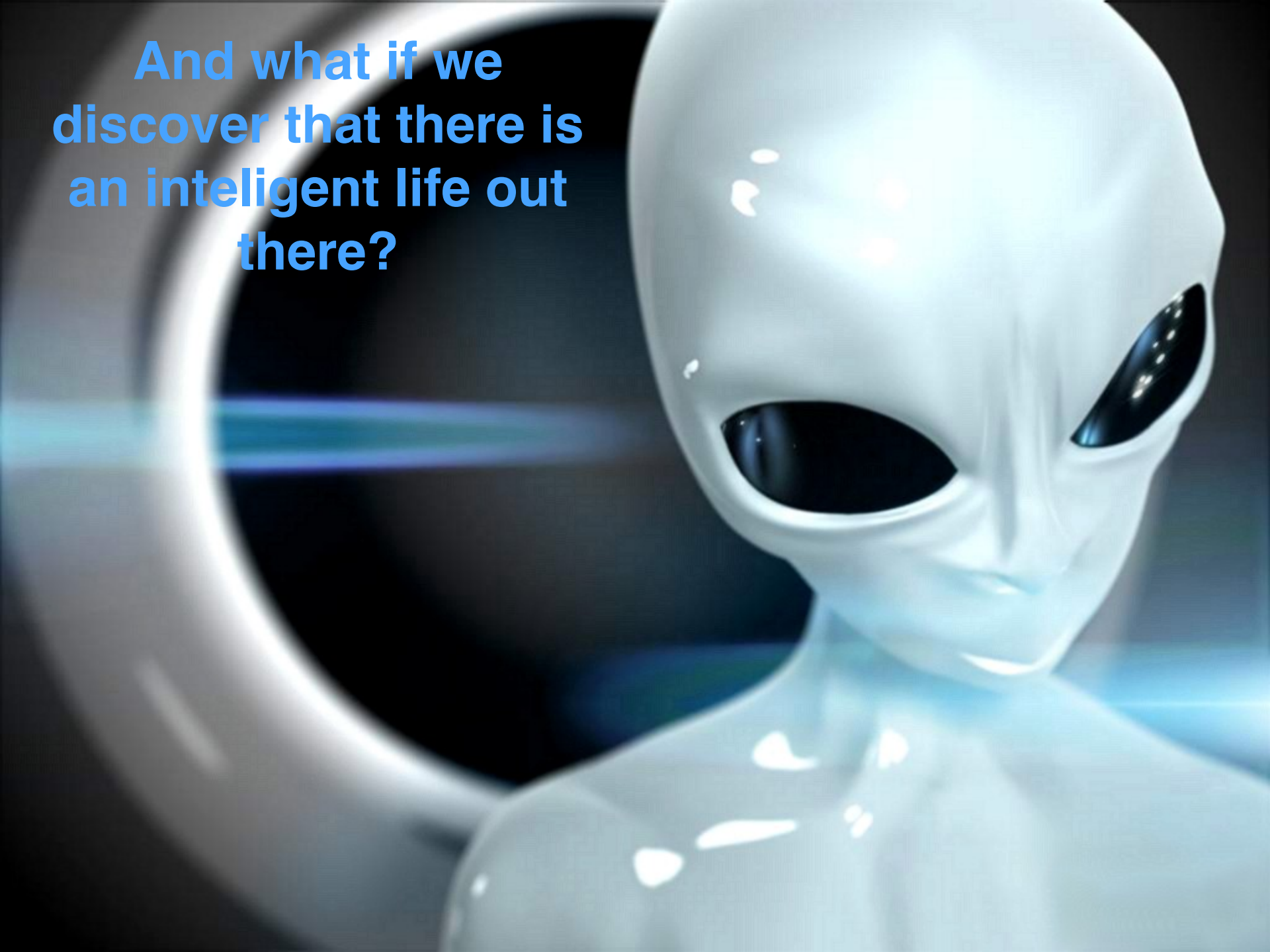


SOURCE: EUROPEAN SOUTHERN OBSERVATORY
http://www.exoplanet.hanno-rein.de/

FERMI's PARADOX



Where is everybody?


And what if we discover that there is an inteligent life out there?


There
Is
No
Gene
For
Race

EARTHLINGS

NARRATED BY JOAQUIN PHOENIX

NATURE ANIMALS HUMANKIND

Sources

- **Science Magazine:**
  125th Anniversary Issue – 125 Questions "What don't we know", http://www.sciencemag.org/sciext/125th/
- **Wired Magazine:**
  What we don't know,
  http://www.wired.com/wired/archive/15.02/bigquestions.html
- **US National Academy of Engineering:** Introduction to the Grand Challenges for Engineering,
  http://www.engineeringchallenges.org/cms/8996/9221.aspx

GRAND CHALLENGES FOR ENGINEERING


Make solar energy economical


Provide energy from fusion


Develop carbon sequestration methods


Manage the nitrogen cycle


Provide access to clean water


Restore and improve urban infrastructure


Advance health informatics


Engineer better medicines


Reverse-engineer the brain


Prevent nuclear terror


Secure cyberspace


Enhance virtual reality


Advance personalized learning


Engineer the tools of scientific discovery