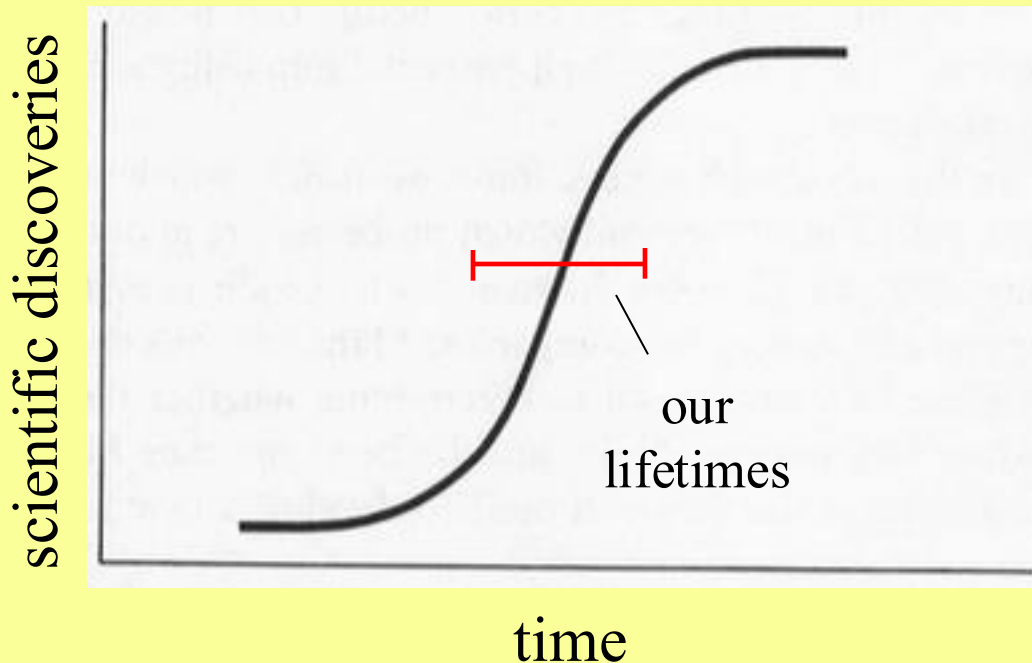


12 recent discoveries that have changed the debate about design in the universe

Part I

Michael S. Kent
Research scientist, Sandia National Labs. (retired)
90 publications on chemistry, biophysics, and materials science
www.abq-id.org/contact

Our opinion



within 40 yrs of our lifetimes:

expansion of the universe
CMB
fine-tuning in physics
molecular basis of life
genome sequences
model of particle physics
map brain functions
molecular machines
software of cell
exoplanets
etc

This is a unique time in the history of humanity

How does it function? (physics and chemistry)

Where did it come from? (a mind)



**The natural laws explain how it functions
but do not explain where it comes from.**

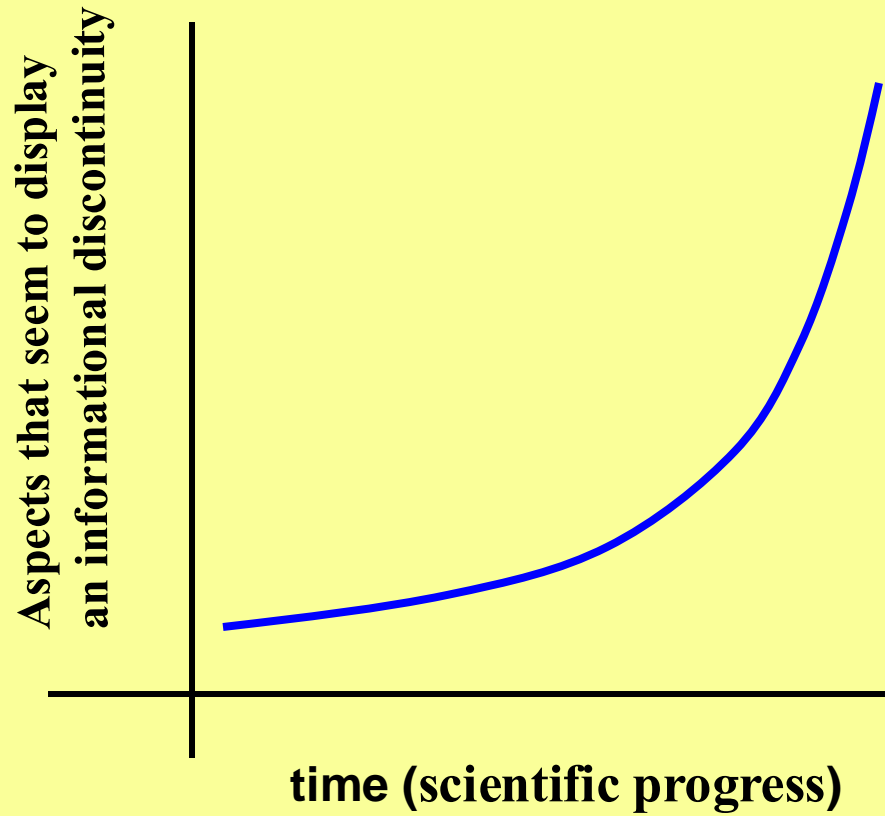
How does it function? (physics and chemistry)

Where did it come from? (a mind)



An informational discontinuity

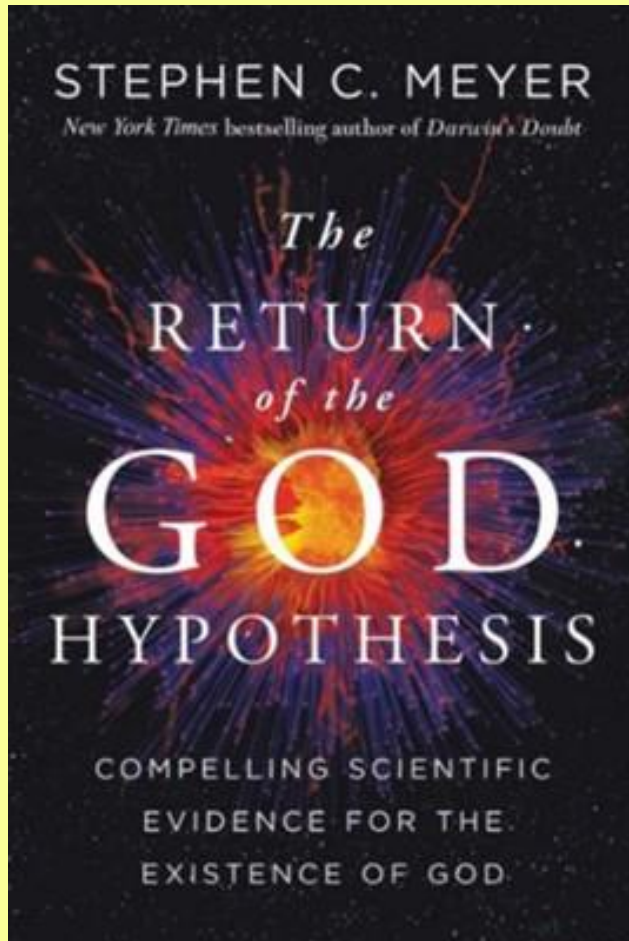
Our View: Trend with scientific progress



**12 recent discoveries that have
changed the debate about design in
the universe**

- 1. The universe (space-time, matter, energy)
had a beginning and will have an end.**

Two very recent books covering 3 topics



2021



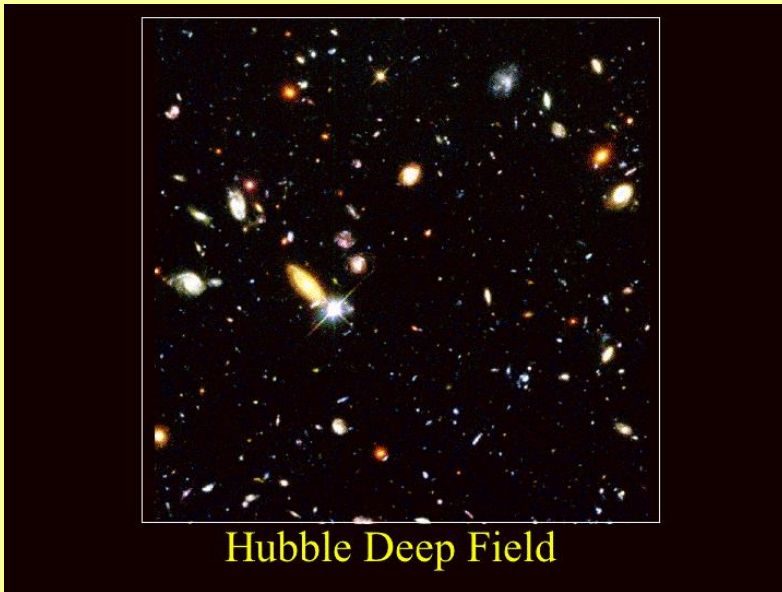
2022

God
The Science
The Evidence:
The Dawn of a
Revolution

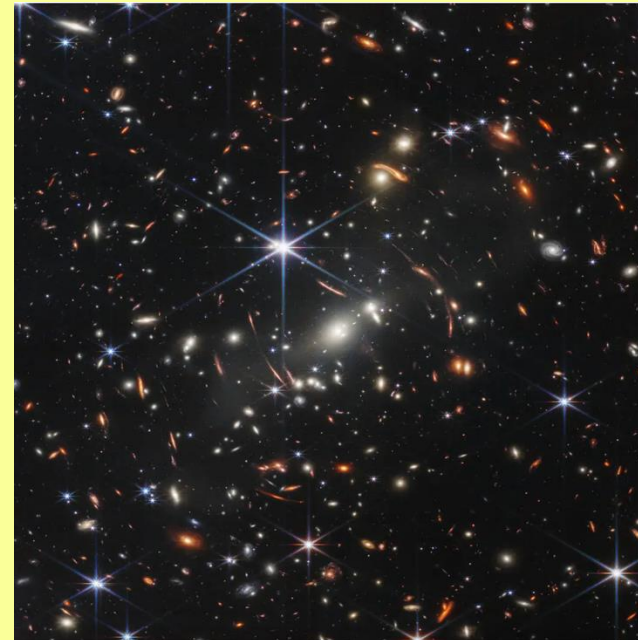
Science, God's
new ally!

Some important observations

1. Light and other forms of radiation are detected that originated from sources which are now very large distances (billions of light-years) away **and moving away from us.**



1995



James Webb Deep Field
2022

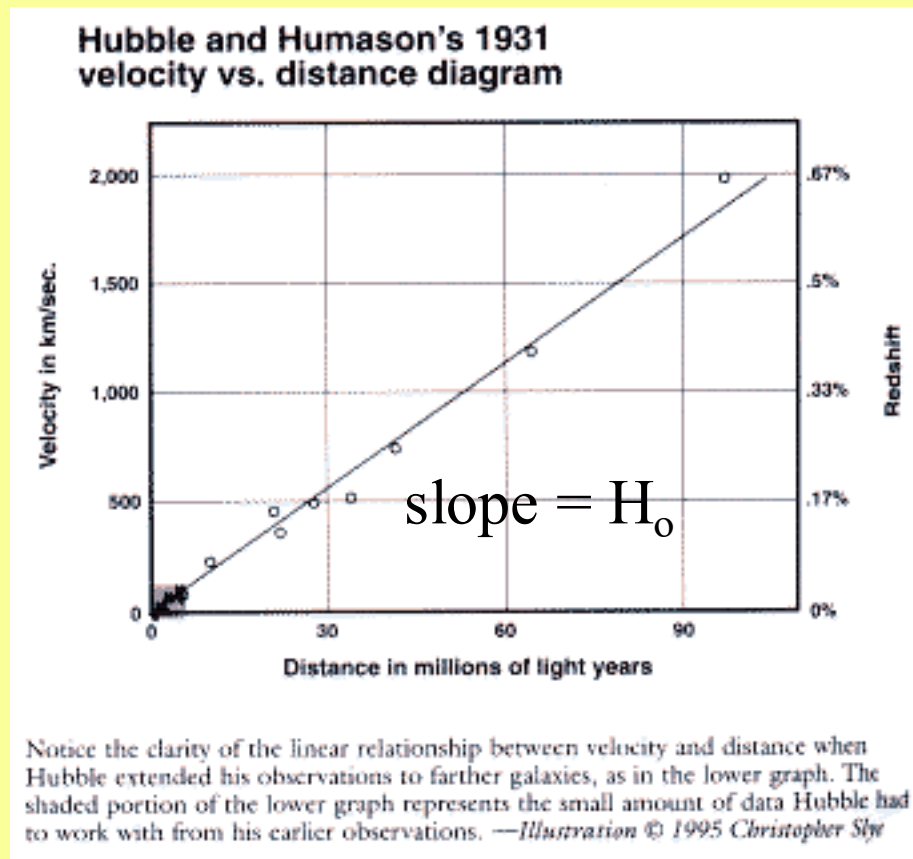
Credit:
NASA,
ESA,
CSA,
and
STScI

Some important observations

2. Red shifts - the wavelengths of radiation from each galaxy are shifted toward the red side of the spectrum by a factor roughly proportional to the distance of the galaxy from us.



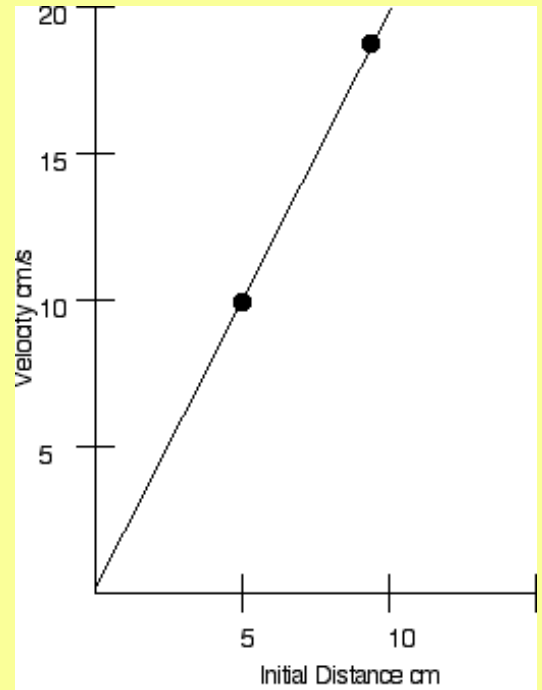
Edwin Hubble



The universe is expanding

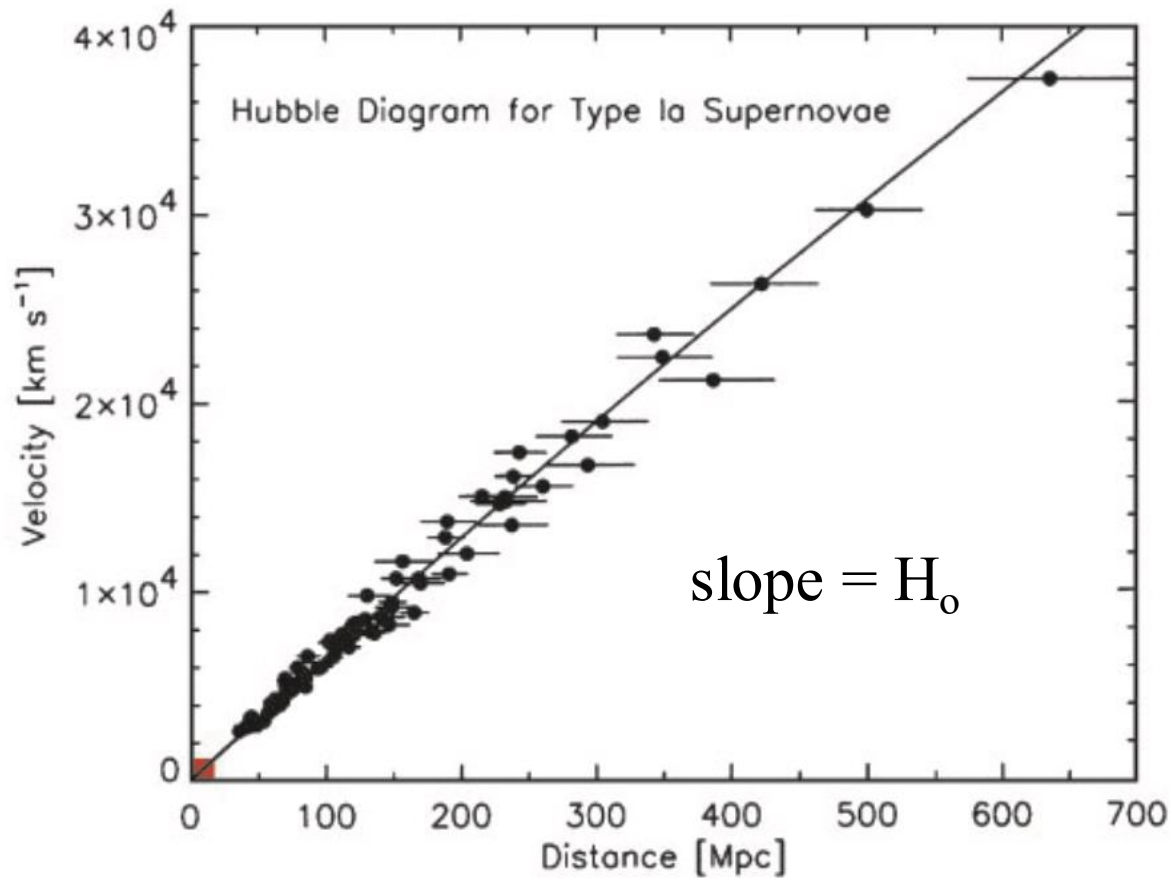
1931

Some important observations

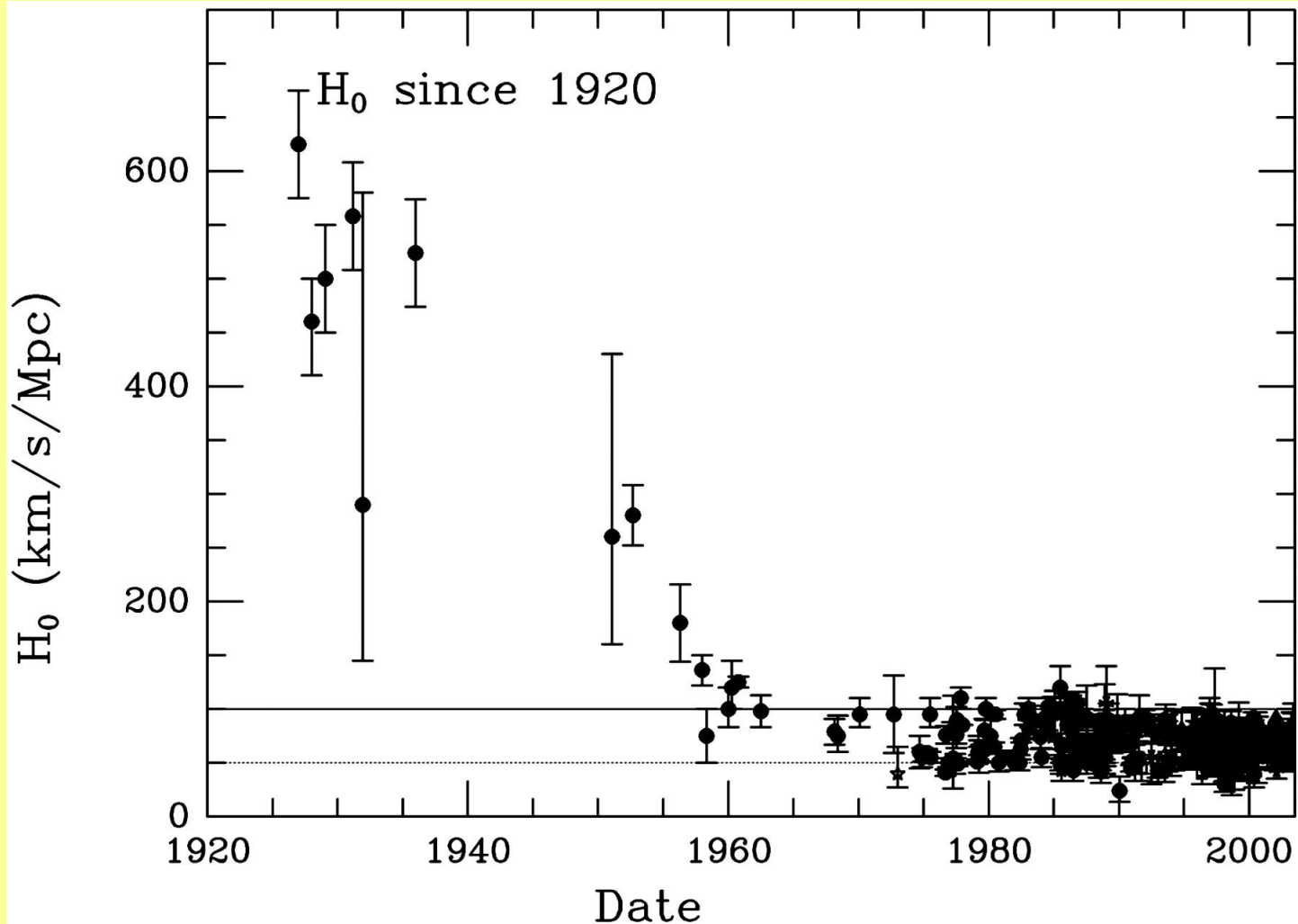


- light gets stretched en route
- galaxies recede faster at greater distances

Improvements since 1929



Improvements since 1929

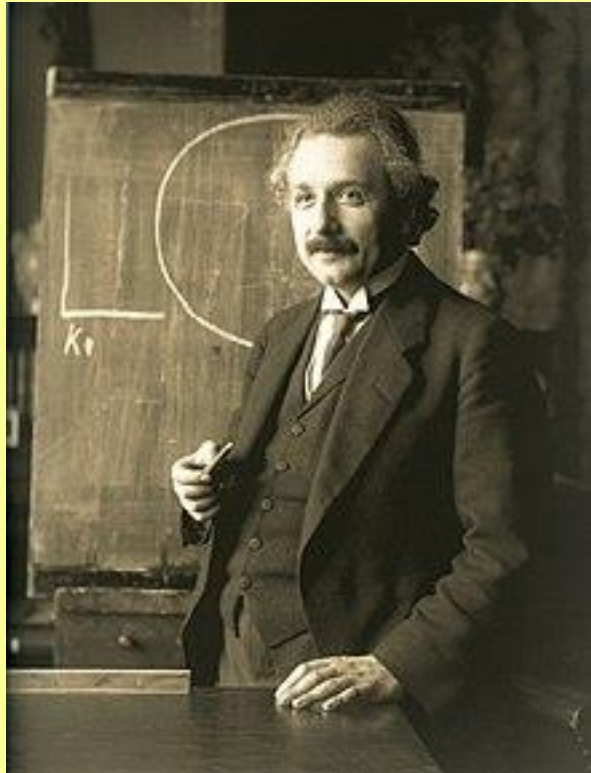


An important calculation



In 1922, prior to Hubble's measurements, Einstein's equations of general relativity (1915) were solved by Aleksandre Friedmann, a Russian physicist, showing that the universe could not be static.

An important calculation

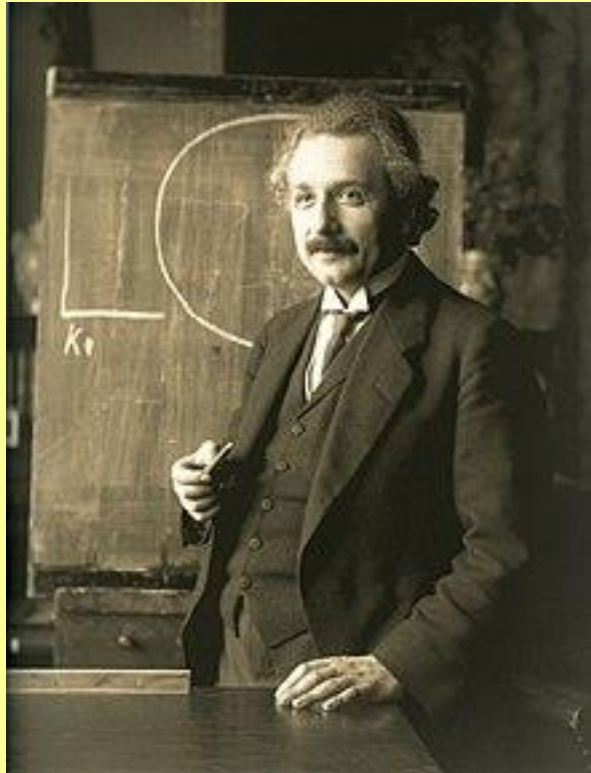


“The results concerning the non-stationary universe contained in [Friedmann’s] work appear to me suspicious. In reality, it turns out that the proposed solution given in it does not satisfy the field equations.”

A. Einstein, *Zeitschrift für Physik*,
Nov 17, 1922.

Einstein later realized that he made a mistake

An important calculation



“As Mr. Krutkov convinced me, and thanks to a letter from Mr. Friedmann, my objection was based on a miscalculation. I now consider Mr. Friedmann’s results to be correct. These provide **a new insight.**”

A. Einstein, Zeitschrift für Physik, May 21, 1923.

Einstein later realized that he made a mistake

This result provoked strong reactions:

“Philosophically, the notion of a beginning of the present order of nature is **repugnant** to me”

Arthur Eddington *Nature* 450, 127, (1931)

“I would like to reject it”

Phillip Morrison, *God and the Astronomers*,
1992, p 104

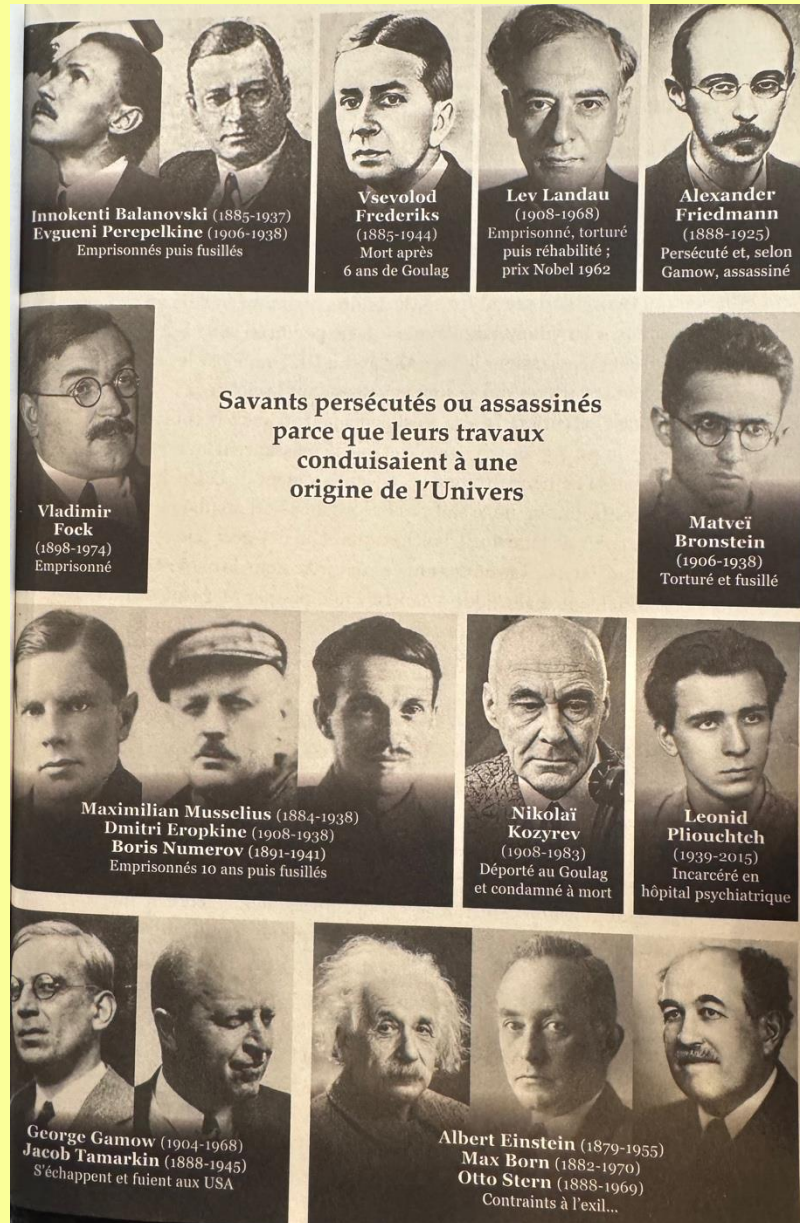
“**Distasteful** to the scientific mind”

Robert Jastrow, *God and the Astronomers*,
1992, p 105

“Many people do not like the idea that time had a beginning probably because it smacks of divine intervention”

Steven Hawking, *A Brief History of Time*,
1988, p 46

This result provoked strong reactions:



Scholars persecuted
or assassinated
because of their
work showing an
origin of the
universe.

**God
Science
Evidence**

Another important calculation

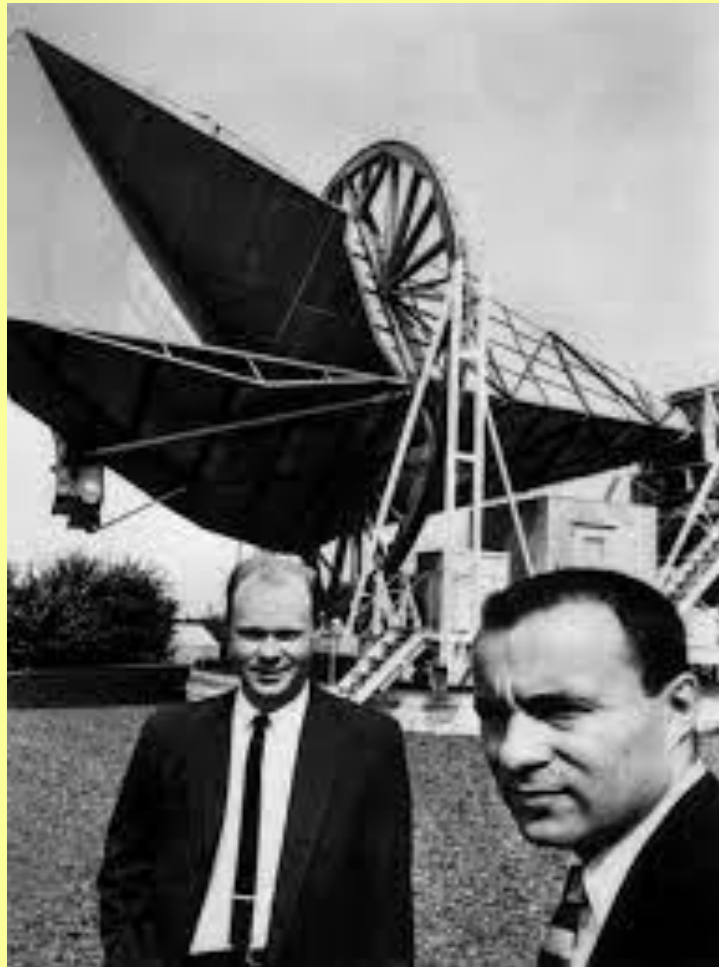


In 1948, Robert Hermann and Ralph Alpher predicted that a radiation should be left over from the initial creation event. They predicted the temperature and the wavelength distribution of that radiation.

$$3000 \text{ }^\circ\text{K} / 550 \text{ (expansion factor)} = \sim 5 \text{ }^\circ\text{K}$$

Some important observations

3. Cosmic microwave background (CMB) radiation – 1965

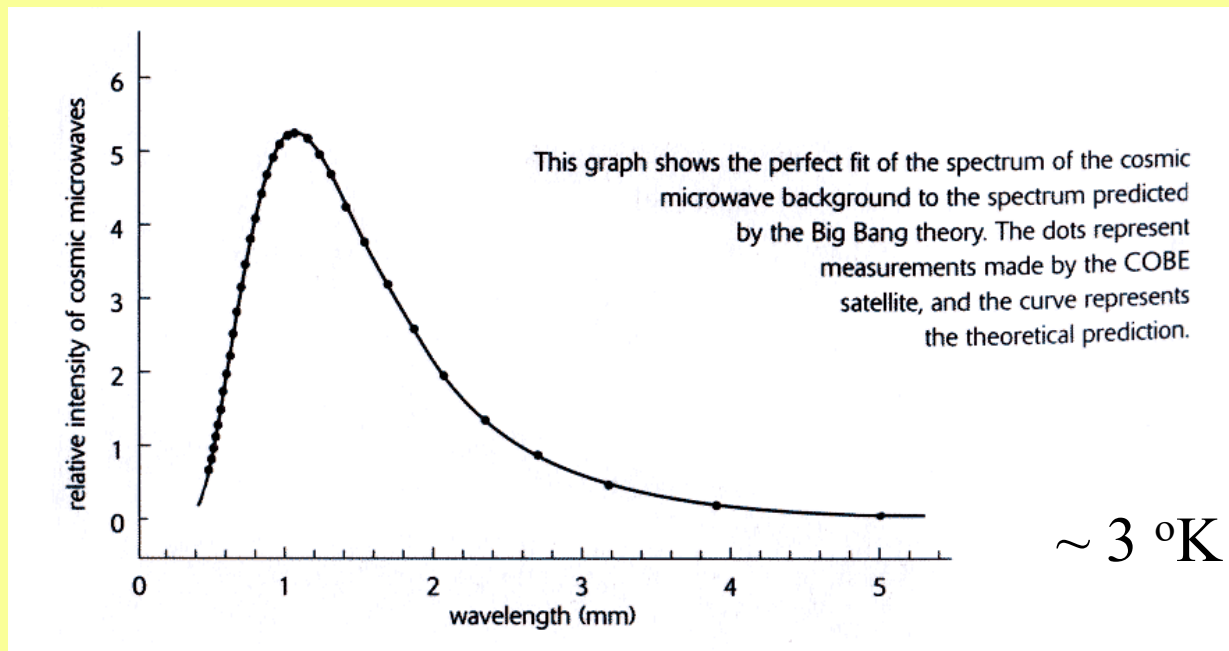


Arno Penzias and
Robert Wilson,

Bell Labs

Some important observations

3. Cosmic microwave background (CMB) radiation, nearly uniform in all directions. This radiation does not come from a single source, rather it exists at every point in the universe. Believed to represent radiation with a red-shift of 1,100. It is the earliest phenomenon that we will ever observe.



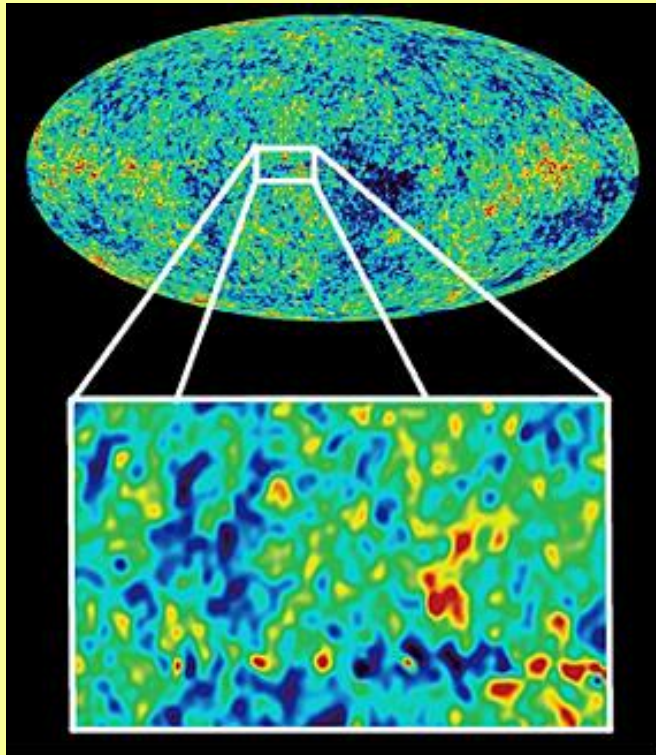
The universe expanded from a very hot, dense state

discovered by Penzias and Wilson, 1965

Some important observations

4. Discovery of fluctuations in CMB (explains how galaxies formed)

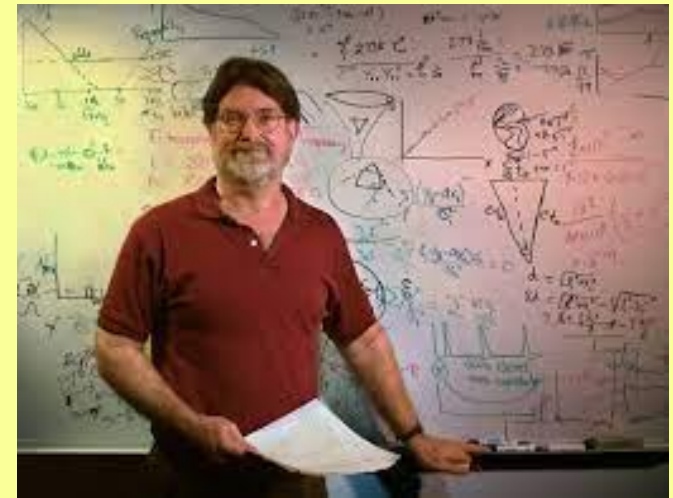
1992



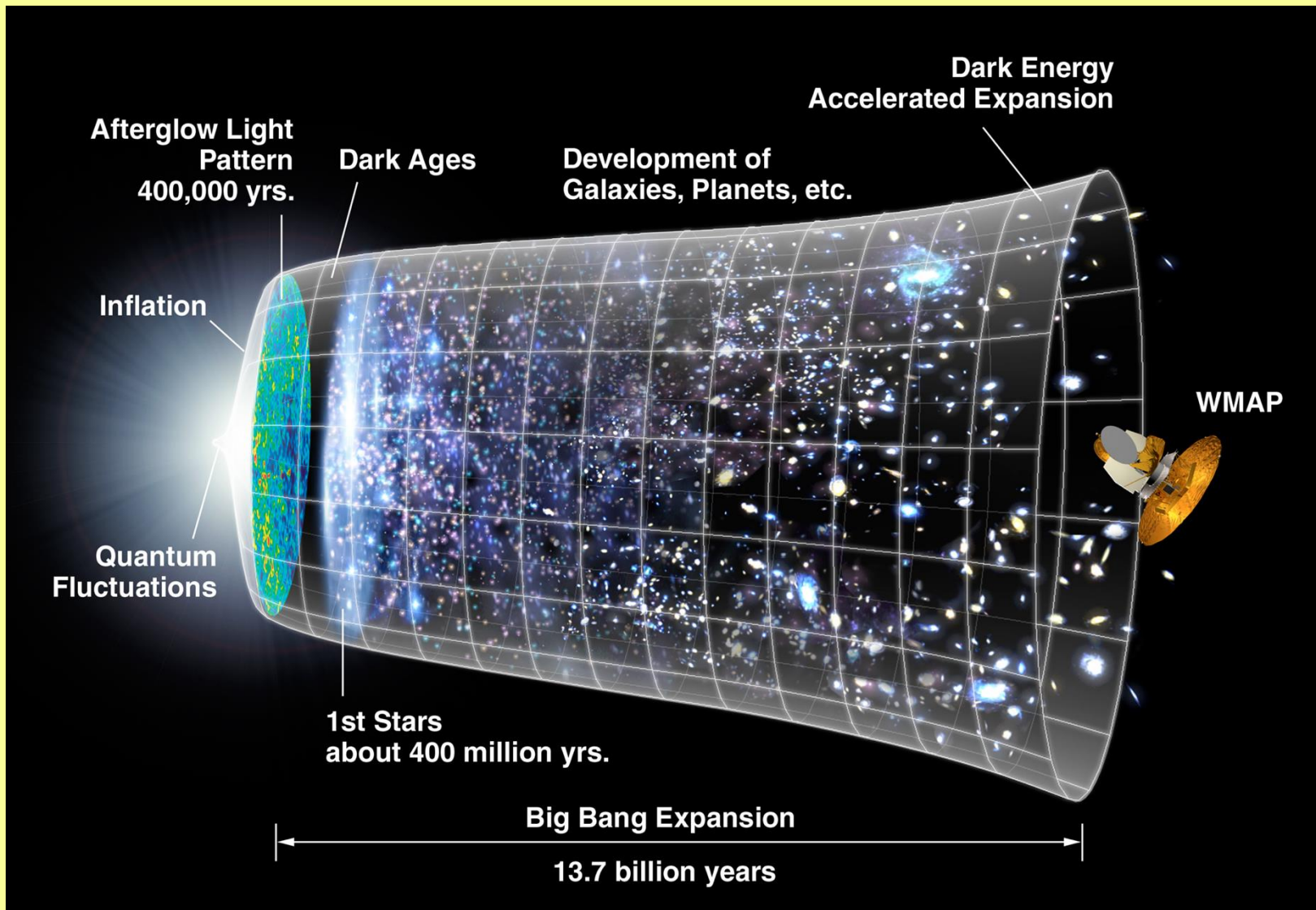
avg $T = 2.7 \text{ }^\circ\text{K}$

fluctuations of
1 part in 100,000

George Smoot



From Smoot Cosmology Group website



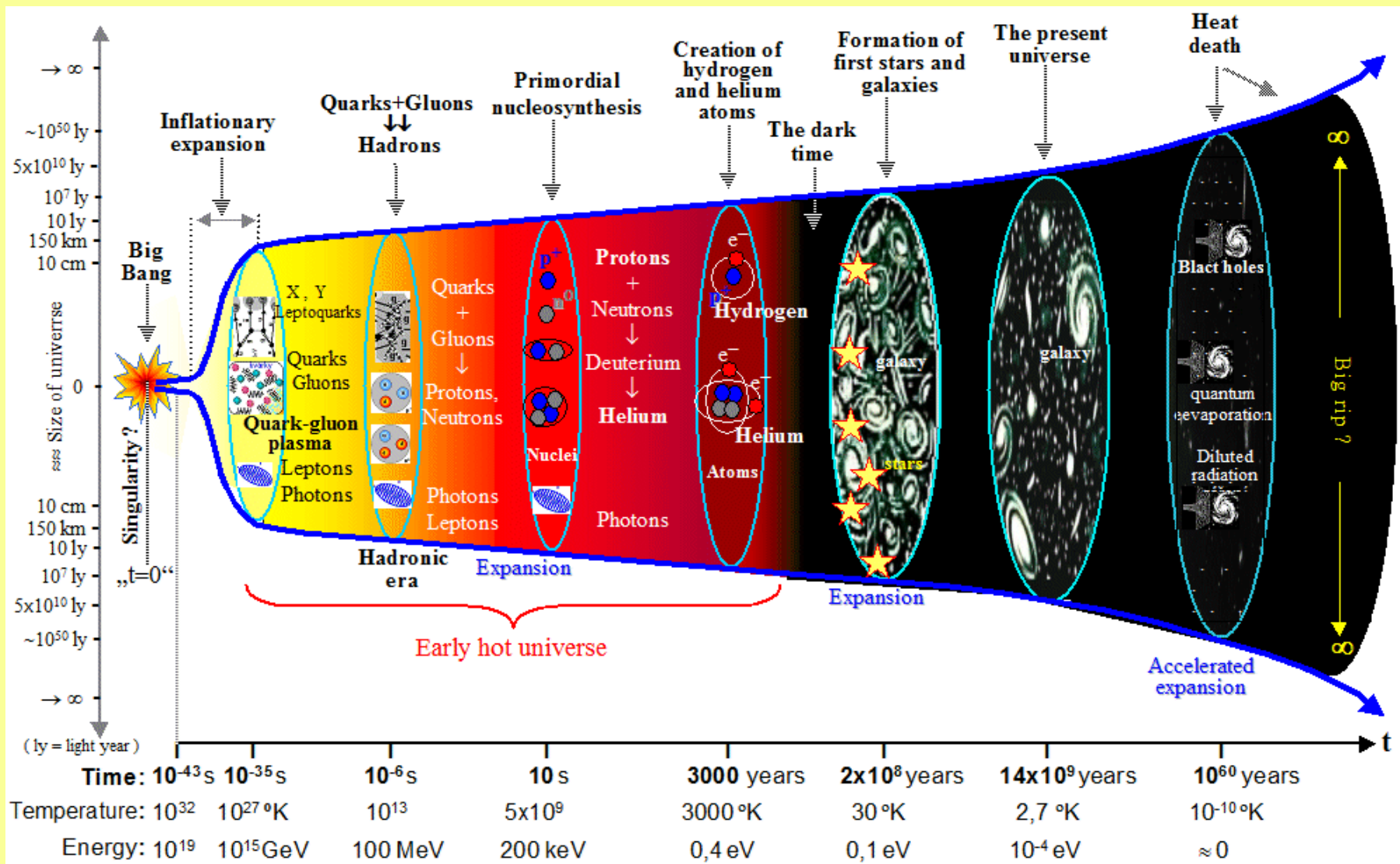
CMB is the earliest phenomenon that we will ever observe

Important theoretical developments:

1973: Hawking-Penrose-Ellis singularity theorems
based on general relativity (good to $r = 10^{-12}$ - 10^{-33} cm)

2003: Borde-Guth-Vilenkin theorem
generalized proof for a beginning to space, time
matter, and energy for any expanding universe

“With the proof now in place, cosmologists can no longer hide behind the possibility of a past-eternal universe ... There is no escape, they have to face the problem of a cosmic beginning.”
Vilenkin, Many Worlds in One , p 176



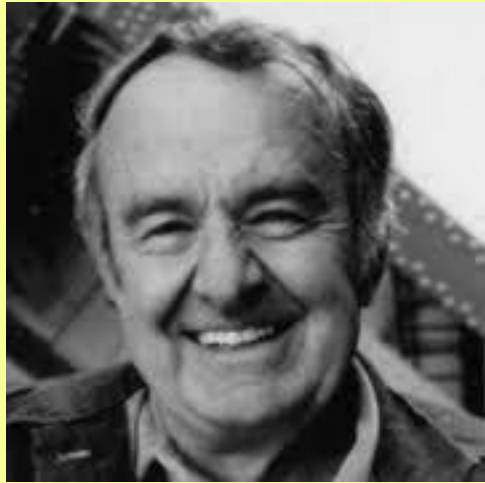
Implication

**there was a beginning to space, time matter,
and energy**

“If we extrapolate this prediction to its extreme, we reach a point when all distances in the universe have shrunk to zero. ... We cannot continue physical reasoning, or even the concept of spacetime, through such an extremity. ... On this view the big bang represents the creation event; the creation not only of all the matter and energy in the universe, but also of space-time itself.”

Paul Davies, Spacetime Singularities in
Cosmology, 1978

Alan Sandage



observational
astronomer

> 500 publications

“Here is evidence of what can only be described as a super natural event. There is no way that this could have been predicted within the realm of physics as we know it. ...

I now have to go from a stance as a complete materialistic rational scientist and say this super natural event, to me, gives at least some credence to my belief that there is some design put in the universe.”

Alan Sandage, *quoted in Return of the God Hypothesis*, 2021, p 108



NASA scientist,
astronomer

"For the scientist who has lived by his faith in the power of reason, the story ends like a bad dream. He has scaled the mountains of ignorance; he is about to conquer the highest peak; as he pulls himself over the final rock, he is greeted by a band of theologians who have been sitting there for centuries."

R. Jastrow, *God and the Astronomers*, 1992,
pg 107.

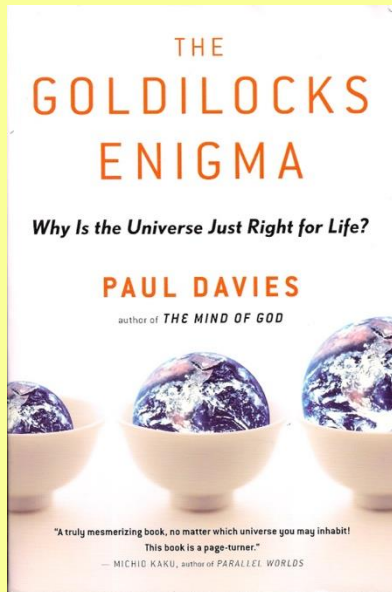
Summary:

**The universe (space-time, matter, energy)
had a beginning and will have an end.**

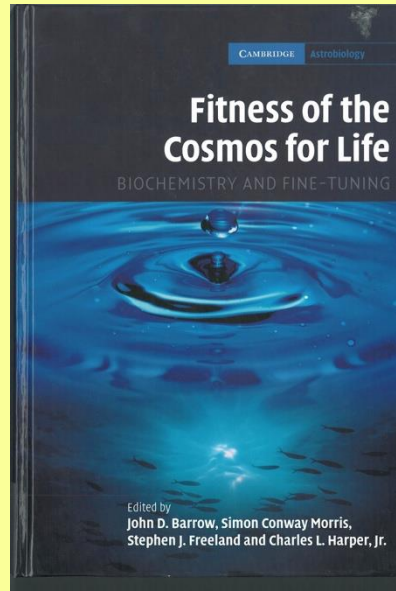
**Does the origin of the universe from nothing constitute
an informational discontinuity?**

12 recent discoveries that have changed the debate about design in the universe

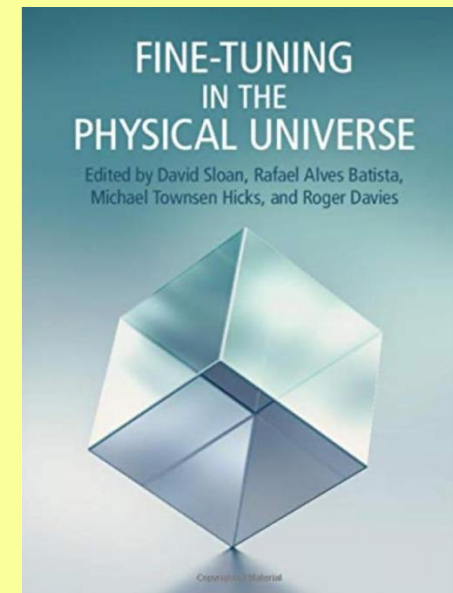
2. The laws of physics, the fundamental constants, and the initial conditions of our Universe, are fine-tuned to allow for the possibility of life



2006



2008



2020

Very important recent discovery

The precise values of these constants and initial conditions are critical for the universe to support life!

Periodic Table of Elements

1	IA	1	H	2	He																															
2	IIA	3	Li	4	Be																															
3	IIIB	11	Na	12	Mg	IIIB	IYB	YB	VIB	VIIIB	VII	IB	IB	IIIA	5	B	6	C	7	N	8	O	9	F	10	Ne										
4	19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
5	37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
6	55	Cs	56	Ba	57	*La	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn
7	87	Fr	88	Ra	89	+Ac	104	Rf	105	Ha	106	107	108	109	110																					

* Lanthanide Series
+ Actinide Series

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

-formation and stability of the elements

-ability to form chemical compounds

-types of stars and rates of burning

-etc

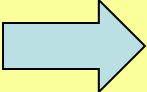
Timeline: Some important events on this topic

The Fitness of the Environment

Lawrence Henderson, 1913

The Unreasonable Effectiveness of Mathematics in the
Natural Sciences

Eugene Wigner, 1960

 Large Number Coincidences and the Anthropic Principle in
Cosmology

Brandon Carter, 1973

The Anthropic Cosmological Principle

John Barrow and Frank Tipler, 1986

Categories

1. Initial conditions:

- initial entropy

- expansion rate (cosmological constant)

- initial mass density

- tuning of “inflaton field”

2. Laws and constants of physics

3. Masses of fundamental particles

Constants and Ratios

Boltzmann's constant	$k = 1.38 \times 10^{-23} \text{ J/}^\circ\text{K}$
Planck's constant	$\hbar = 6.63 \times 10^{-34} \text{ J/s}$
Speed of light	$c = 3.00 \times 10^8 \text{ m/s}$
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ (N} \cdot \text{m}^2\text{)/kg}$
Weak force constant	$g_w = 1.43 \times 10^{-62} \text{ (SI units)}$
Strong force constant	$g_s = 15 \text{ (SI units)}$
Hubble constant	$H = 2 \times 10^{-18} \text{ (SI units)}$
Cosmological constant	$L = <10^{-53} \text{ (SI units)}$
Cosmic photon/proton ratio	$S = 10^9 \text{ (SI units)}$
Permittivity of free space	$\epsilon = 8.85 \times 10^{-12} \text{ (SI units)}$
Rest mass of a neutron	$M_n = 1.674 \times 10^{-27} \text{ kg}$
Rest mass of an electron	$M_e = 9.11 \times 10^{-31} \text{ kg}$
Rest mass of a proton	$M_p = 1.672 \times 10^{-27} \text{ kg}$
Electron or proton unit charge	$e = 1.6 \times 10^{-19} \text{ coul}$
Mass-energy relation	$c^2 = (E/m) \text{ J/kg}$

The four fundamental forces

		<u>rel. strength</u>
Strong nuclear force	(SF)	1
Weak nuclear force	(WF)	10^{-6}
Electromagnetic force	(EMF)	1/137
Gravitational force	(GF)	6×10^{-39}

Electromagnetic force - electrical charges, magnetism

If EMF were slightly weaker, electrons wouldn't be held in their orbits

If EMF were slightly stronger, electrons couldn't be shared among different atoms

Either way, no chemistry and no life!

The four fundamental forces

		<u>rel. strength</u>
Strong nuclear force	(SF)	1
Weak nuclear force	(WF)	10^{-6}
Electromagnetic force	(EMF)	1/137
Gravitational force	(GF)	6×10^{-39}

Strong nuclear force - holds nucleus together

If: **SF/EMF x 1.02** no stable hydrogen
 SF/EMF x 0.95 few if any elements other than hydrogen

Ward and Brownlee, Rare Earth, 2000.

Ratio of mass of proton to mass of electron (1,836)

This ratio determines the characteristics of orbits of electrons about nuclei. If this ratio were slightly different there would be no chemistry, and no life. S. Hawking cites this example as one of the many fundamental numbers in nature, and he says

"The remarkable fact is that the values of these numbers seem to have been **very finely adjusted** to make possible the development of life".

S. Hawking, *A Brief History of Time*, 1988, pg 125.



Fine structure constant and carbon atoms

It is true, for example, that the **fine structure constant α has to be close to 1/137 for carbon atoms to exist**, and carbon atoms are required for us to be here writing about cosmology. However, these arguments have nothing to do with explaining what physical laws led to this particular value of α

[Regarding a recent theory by S. Hawking and T. Hertog on this topic]

...it sounds to me a lot like the **despised fine-tuning**.

B. Richter, Physics Today, Oct 2006 p 8-9.

Some other examples

Ratio of the masses
of a neutron to the
proton

1 part in
1000

Lewis and Barnes, *A Fortunate Universe*, p. 79.

Ratio of the Weak
Nuclear Force to
the Strong Nuclear
Force

1 part in
10,000

Martin Rees, "Large Numbers and Ratios in
Astrophysics and Cosmology," *Philosophical
Transactions of the Royal Society London A*, 310
(1983): 317; Lewis and Barnes, *A Fortunate
Universe*, p. 78.

Ratio of the
Electromagnetic
Force to Gravity

1 part in
 10^{40}

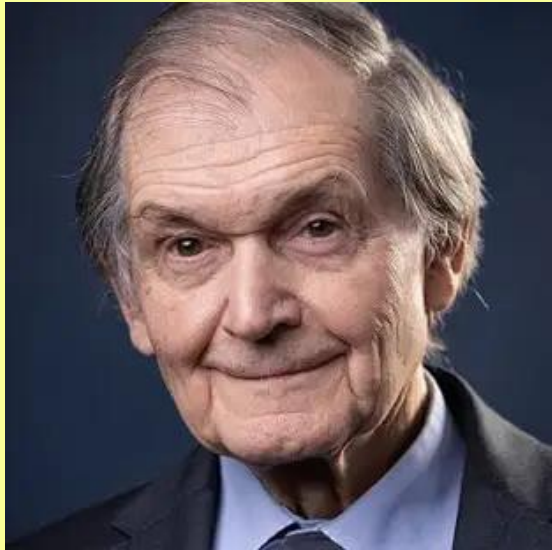
Davies, *The Accidental Universe*, pp. 71-73.

mass density, energy density of empty space

Which **fundamental fine-tuning problem** is one more willing to worry about, the flatness problem or the cosmological constant problem? The latter involves a **fine-tuning of over 120 orders of magnitude**, if the cosmological constant is nonzero and comparable to the density of clustered matter today, while the former involves **a fine-tuning of perhaps only 60 orders of magnitude**, if one arbitrarily fixes the energy density of the universe at the Planck time to be slightly less than the closure density.

L. M. Krauss, The Astrophysical Journal, 1998, 501: p 465.

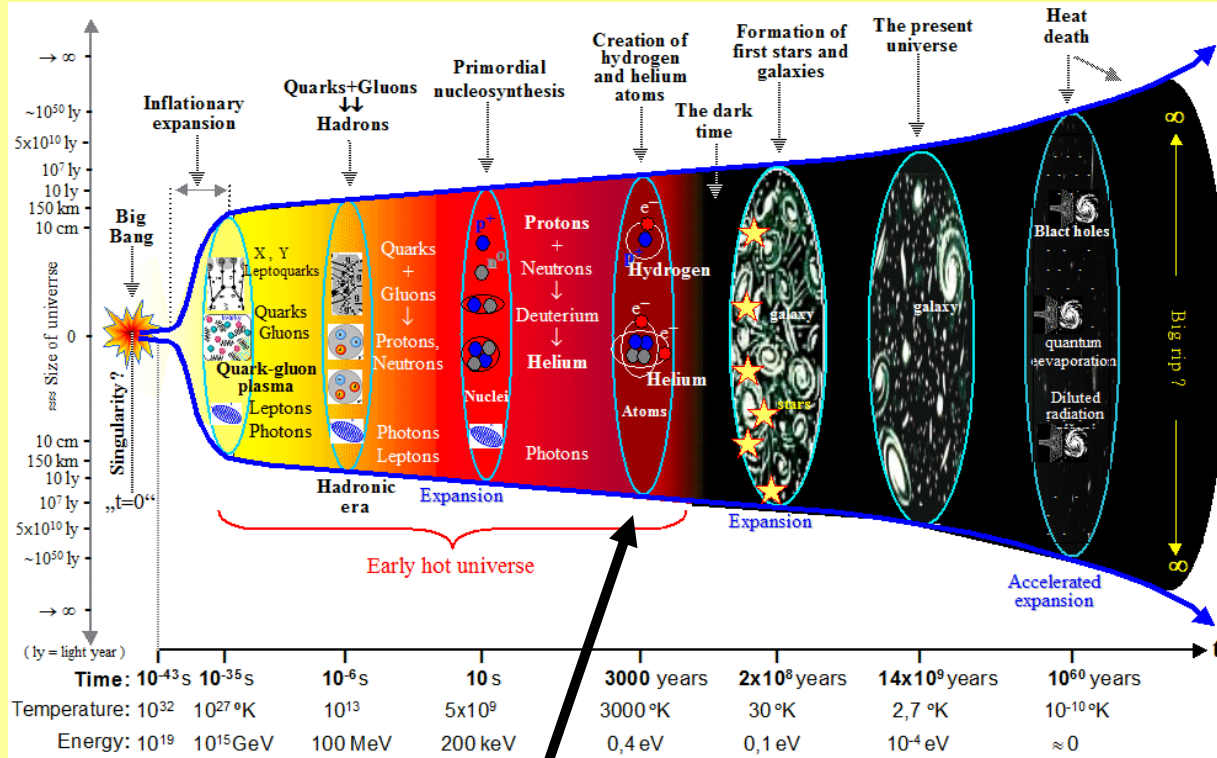
See also: <https://returnofthegodhypothesis.com/book/notes/> see note 8c



Roger Penrose
English mathematician
Nobel Laureate in Physics

“The initial state of the universe is certainly fine tuned. ... at least as precise as 1 part in 10^{123} ”

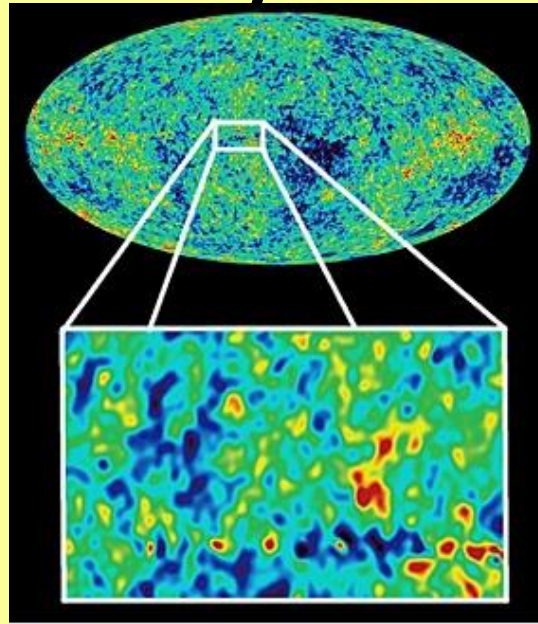
https://www.google.com/search?q=roger+penrose+entropy+of+the+universe+fine+tuning&oq=roger+penrose+entropy+of+the+universe+fine+tuning&gs_lcrp=EgZjaHJvbWUyCQgAEEUYORigATIHCAEQIRigATIHCAIQIRigATIHCAMQIRirAjIHCAQQIRirAtIBCTE1NzQzajBqNKgCALACAA&sourceid=chrome&ie=UTF-8#fpstate=ive&vld=cid:4059bf94,vid:yDqny7UzyR4,st:0



uniform mass and energy distribution:

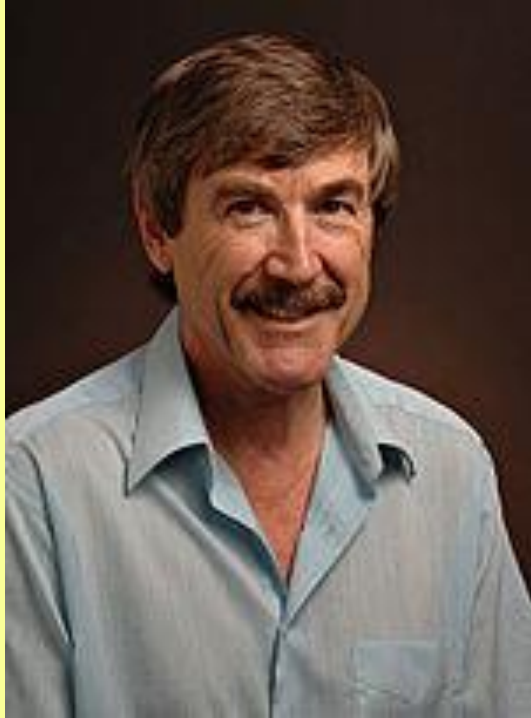
Low entropy initial state

1 in $10^{10^{123}}$



Fine-tuned fluctuations of 1 part in 100,000

•Tegmark, Max and Martin J. Rees, 1998, "Why is the cosmic microwave background fluctuation level 10^{-5} ", *The Astrophysical Journal*, 499(2): 526-532. doi:10.1086/305673



“The really amazing thing is not that life on earth is balanced on a knife-edge, but that the entire universe is balanced on a knife-edge and would be total chaos if any of the natural constants were off even slightly..”

P. Davies, *The Goldilocks Enigma*, 2006, pg 149.



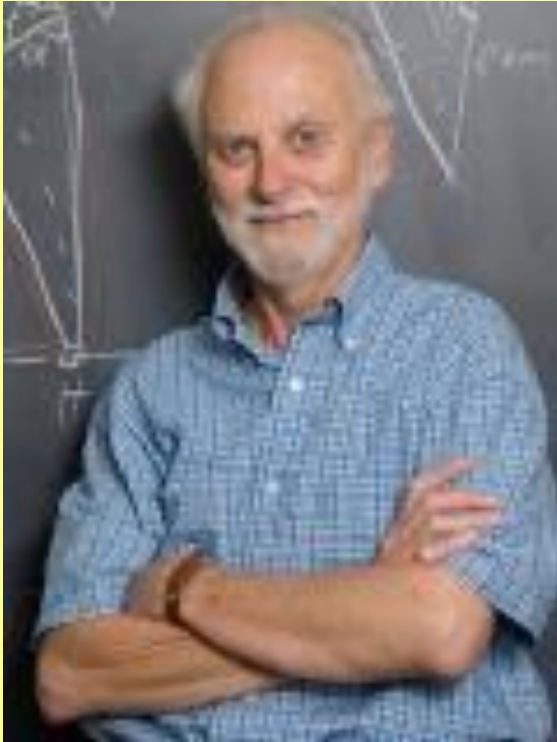
"A common sense interpretation of the facts suggests that a **superintellect has monkeyed with physics**, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me **so overwhelming as to put this conclusion almost beyond question.**"

Fred Hoyle, "The Universe: Past and Present Reflections", Annual Reviews of Astronomy and Astrophysics, 20 (1982), 16.



"Astronomy leads us to a unique event, a universe which was created out of nothing and **delicately balanced to provide exactly the conditions required to support life**. In the absence of an absurdly-improbable accident, the observations of modern science seem to suggest an underlying, one might say, supernatural plan."

Arno Penzias, quoted by Walter Bradley in "The Designed 'Just-so' Universe", 1999.



Astrophysicist
Prof. Emeritus of Astronomy,
Amherst College

"As we survey all the evidence, the thought insistently arises that some **supernatural agency -or rather Agency- must be involved**. Is it possible that suddenly, without intending to, we have stumbled upon scientific proof of the existence of a Supreme Being? Was it God who so providentially crafted the cosmos for our benefit?"

G. Greenstein, *Symbiotic Universe: Life and Mind in the Cosmos*, 1988, 27.

The universe is biocentric in its very essence

The “anthropic coincidences”

Summary:

It is a fact that the universe is fine-tuned to an astonishing degree at the most fundamental level to allow for the possibility of life

Does the fine-tuning of the universe constitute an informational discontinuity?

- 1. The universe (space-time, matter, energy) had a beginning and will have an end.**
- 2. The laws of physics, the fundamental constants, and the initial conditions of our universe, are fine-tuned to allow for the possibility of life**

From these two discoveries it is unavoidable that something really amazing has to be true!

Possible Explanations

1. God
2. Infinite universes (Multiverse, Spider-Man film)
3. Our universe is a computer program (The Matrix)

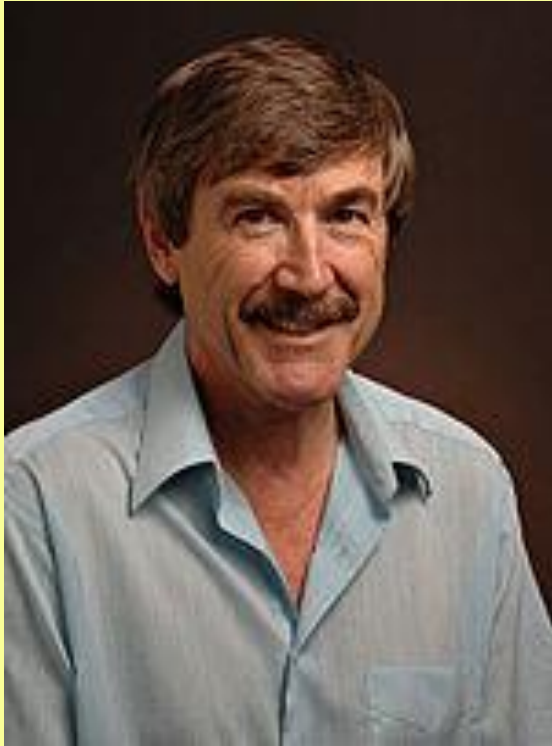
A graphic with a yellow background. At the top is a large image of Tom Holland as Spider-Man. Below it, the text "SPIDER-MAN" is written in large white letters, and "MULTIVERSE" is written in smaller white letters below it. A red circle with a white question mark is positioned in the center. Below the circle are two smaller images: one of Andrew Garfield as Spider-Man on the left and one of Tobey Maguire as Spider-Man on the right.

SPIDER-MAN

MULTIVERSE



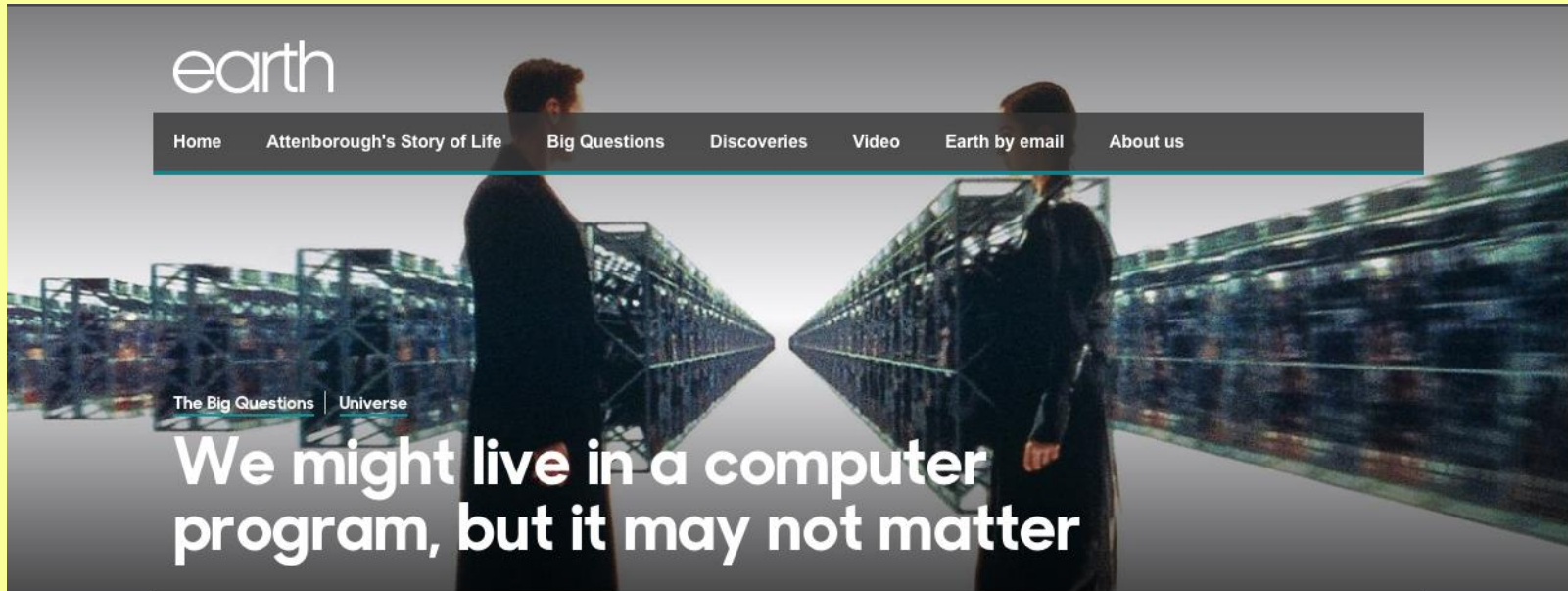
Multiverse?



“... it represents a huge departure from the way we normally do science, and many scientists are aghast at it. But ... **it may be the only answer.**”

Paul Davies, *The Goldilocks Enigma*, p 150.

Our universe is a computer program



Several physicists have suggested that our Universe is not real and is instead a giant simulation. Should we care?

By Philip Ball

5 September 2016

*This story is part of BBC Earth's "Best of 2016" list, our greatest hits of the year. **Browse the full list.***

Some scientists argue that there are already good reasons to think we are inside a simulation. One is the fact that our Universe looks designed.

The constants of nature, such as the strengths of the fundamental forces, have values that look fine-tuned to make life possible. Even small alterations would mean that atoms were no longer stable, or that stars could not form. Why this is so is one of the deepest mysteries in cosmology.

**12 recent discoveries that have
changed the debate about design in
the universe**

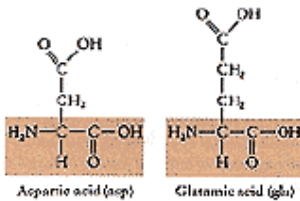
**3. Functional sequences of enzymes are
incredibly rare**

Proteins

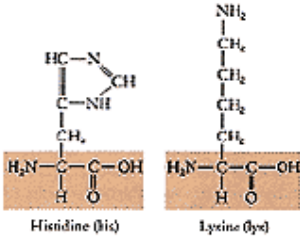
Amino acids

(20 in proteins)

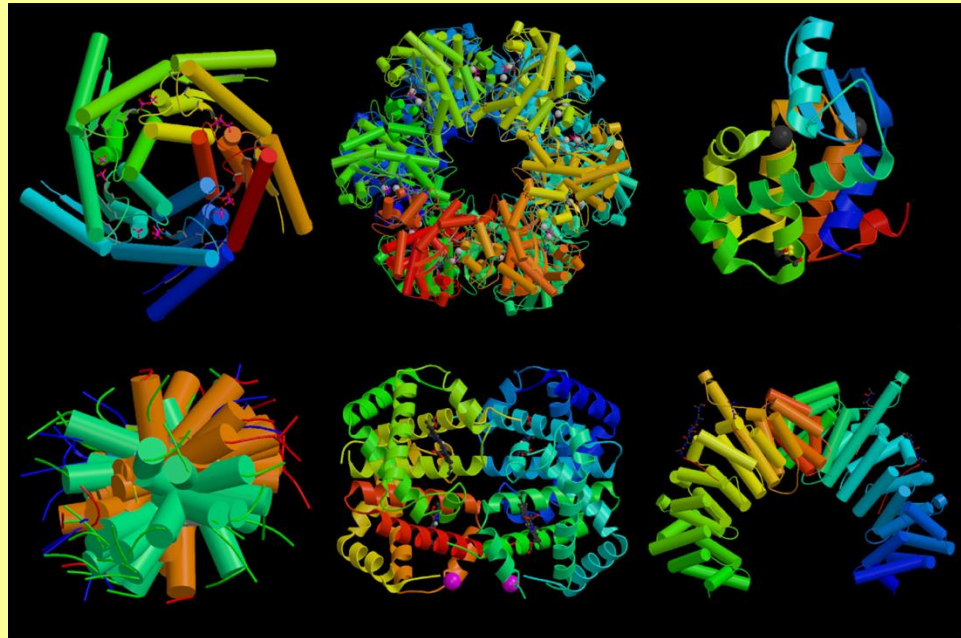
Acidic (negatively charged at pH 7)



Basic (positively charged at pH 7)



chains of amino acids fold into 3D structures



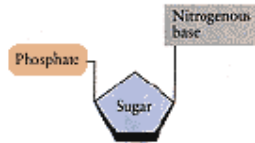
A chain of amino acids:

QYAPQTQSGRTSIVHLFEWRWVDIALECYRLGPKGFGGVQVSPNENVVVTNPSRPWWERYQPVSYKLCTRSGNENEFR
DMVTRCANNVGVRIYVDAVINHMCGSGAAAGTGTCGSYCNPGSREFPAVPYSAWDFNDGKCKTASGGIESYNDPYQVRDC
QLVGLLDLAEKDYVRSMIADYLNKLIDIGVAGFRIDASKHMWPGDIKAVLDKLNHNLNTNWFPAWSRPFIFQEVIDLGGE
AIKSSEYFGNGRVTEFKYGAKLGTVVRKWSGEKMSYLKNWGEWGFMPDRALVFVDNHDNQRGHGAGGSSILTFWDARL
YKVAVGFMLAHPYGFTRVMSSYRWARNFVNGEDVNDWIGPPNNGVIKEVTINADTTCGNDWVCEHRWREIRNMVWFRNV
VDGEPFANWWDNGSNQVAFGRGNRGFIVFNDDWQLSSTLQTGLPGGTCDVISGDKVGNSTGKIKVYVSSDGTAFQFIS
NSAEDPFIAIHAESKL

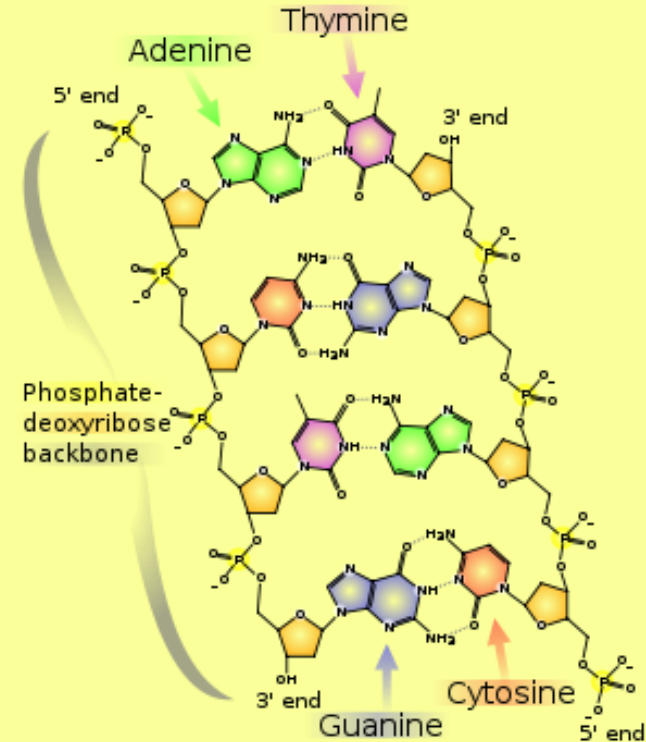
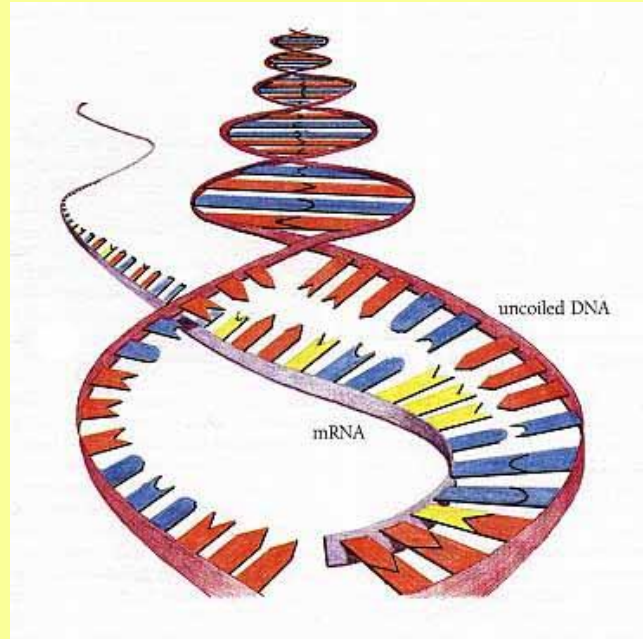
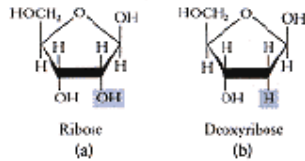
DNA

Nucleotides

(4 in DNA and RNA)



3-30 A nucleotide is made up of three different subunits: a phosphate group, a five-carbon sugar, and a nitrogenous base. As we shall see in Chapter 14, nucleotides can be linked together in long chains by condensation reactions involving the hydroxyl groups of the phosphate and sugar subunits.



A chain nucleotides:

ATCGCCTATATAGCGTACAATGGCTACATCGCCTATATAGCGTACAATGGCTACGTAGCTACGATGCTAGCTAGCTAGC
 GCTACATCGCCTATATAGCGTACAATGGCTACGTAGCTACGATGCTAGCTAGCTAGCATCGCCTATATAGCGTACAATGGCTAC
 ATCGCCTATATAGCGTACAATGGCTACGTAGCTACGATGCTAGCTAGCTAGCATCGCCTATATAGCGTACAATGGCTACATCGC
 CTATATAGCGTACAATGGCTACGTAGCTACGATGCTAGCTAGCTAGCATCGCCTATATAGCGTACAATGGCTACATCGCCTATAT
 AGCGTACAATGGCTACGTAGCTACGATGCTAGCTAGCTAGCGCTACATCGCCTATATAGCGTACAATGGCTACGTAGCTACGAT
 GCTAGCTAGCTAGCATCGCCTATATAGCGTACAATGGCTACATCGCCTATATAGCGTACAATGGCTACGTAGCTACGATGCTAG
 CTAGCTAGCATCGCCTATATAGCGTACAATGGCTACATCGCCTATATAGCGTACAATGGCTACGTAGCTACGATGCTAGCTAGC
 TAGC

History



**Structure of DNA
– 1953**

**DNA stores
information in a
4-letter code**

**Precise sequences
of proteins are
critical**

Mathematical Challenges to the Neo-Darwinian Interpretation of Evolution.

Wistar Symposium, Philadelphia, April 1966.

Protein sequence space is too large to be searched

20^L where L is the length of the protein (ex. 20^{150})

Analogy: written language

“Protein sequence space is too large to be searched.”

50 characters with spaces

Analogy: written language

“Protein sequence space is too large to be searched.”



a
b
c
d
e
f
g
h
i
J
.
.
.

27 possibilities (26 letters + space)

Analogy: written language

“Protein sequence space is too large to be searched.”



a
b
c
d
e
f
g
h
i
J
.
.
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27 possibilities (26 letters + space)

Analogy: written language

“Protein sequence space is too large to be searched.”



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27 possibilities (26 letters + space)

Analogy: written language

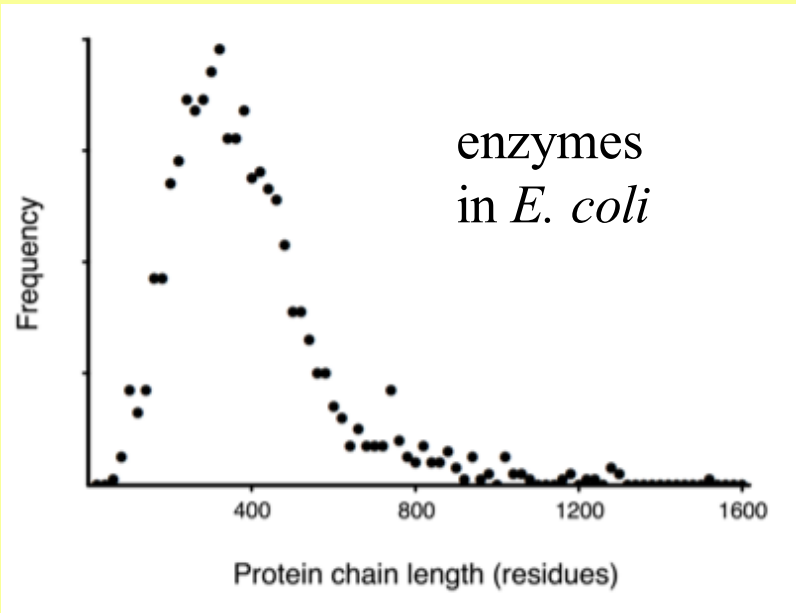
“Protein sequence space is too large to be searched.”

27^{50} possible sequences

How many are functional?

Two critical aspects

A.



20 types of amino acids, chains of amino acids 300 units long

20^{300} Possible sequences

Only a miniscule fraction of sequence space can be searched!

B. What fraction of sequences fold: ???

Three methods

1. Make sequences randomly and see how many fold
(forward approach)
2. Start with the folded protein and mutate portions
(reverse approach)
3. Analyze sequences in the protein data bank

Three methods

1. Make sequences randomly and see how many fold **too slow**
(forward approach)
2. Start with the folded protein and mutate portions
(reverse approach)
3. Analyze sequences in the protein data bank

Forward Approach – Small Proteins

Functional proteins from a random-sequence library

Anthony D. Keefe & Jack W. Szostak

Howard Hughes Medical Institute, and Department of Molecular Biology,
Massachusetts General Hospital, Boston, Massachusetts 02114, USA

Nature
2001, 410, 717

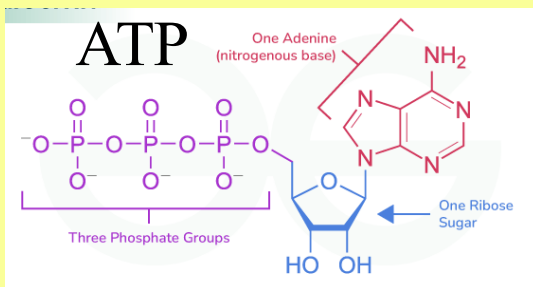
sequences of 80 amino acids

4 out of 6 trillion sequences **bound ATP**

very low-level functionality

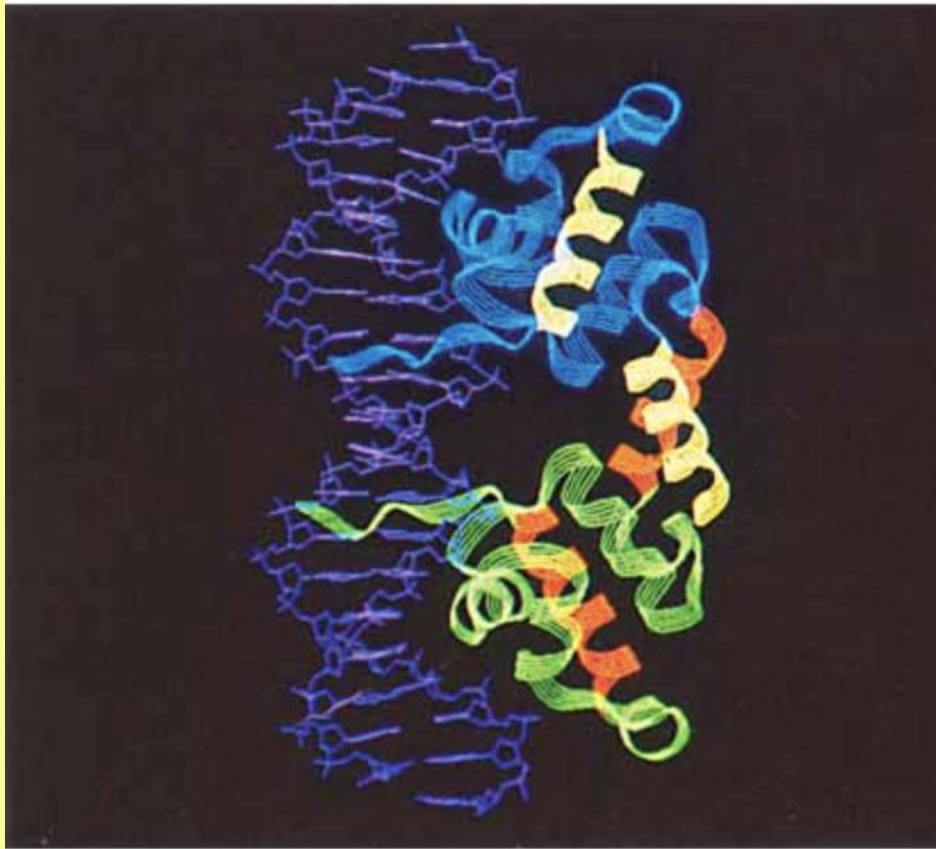
-unclear that sequences must fold to bind ATP

-subsequent work showed a 12 aa peptide binds to ATP



Reverse Approach

1990



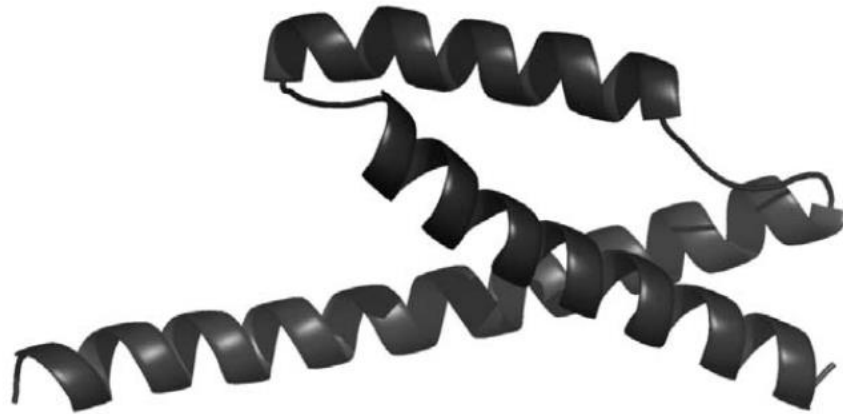
Estimated
fraction of
sequences that
adopt this fold

1 in 10^{63}

λ Repressor (N-terminal domain) - 92 amino acids

Reidhaar-Olsen and Sauer. Proteins: Struct.
Funct. and Genetics , 7, 306, **1990**.

a

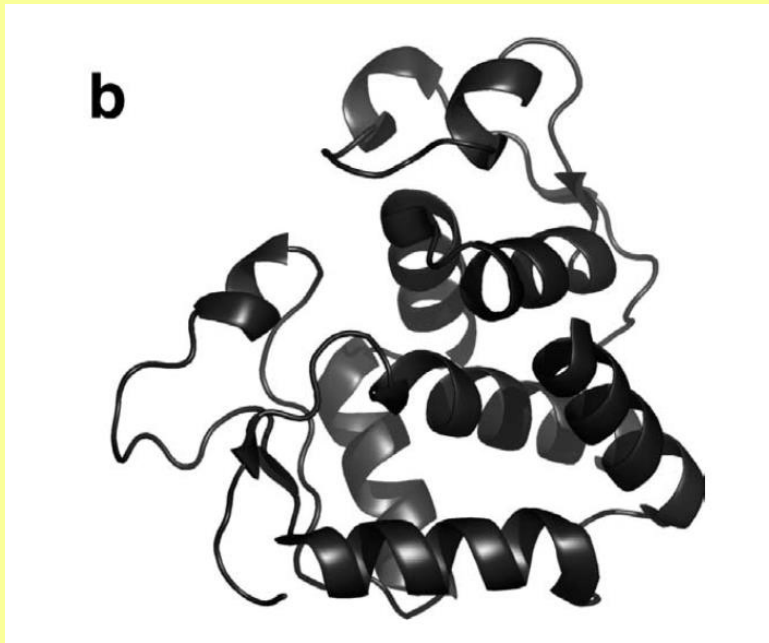


Estimated
fraction of
sequences that
adopt this fold

1 in 10^{24}

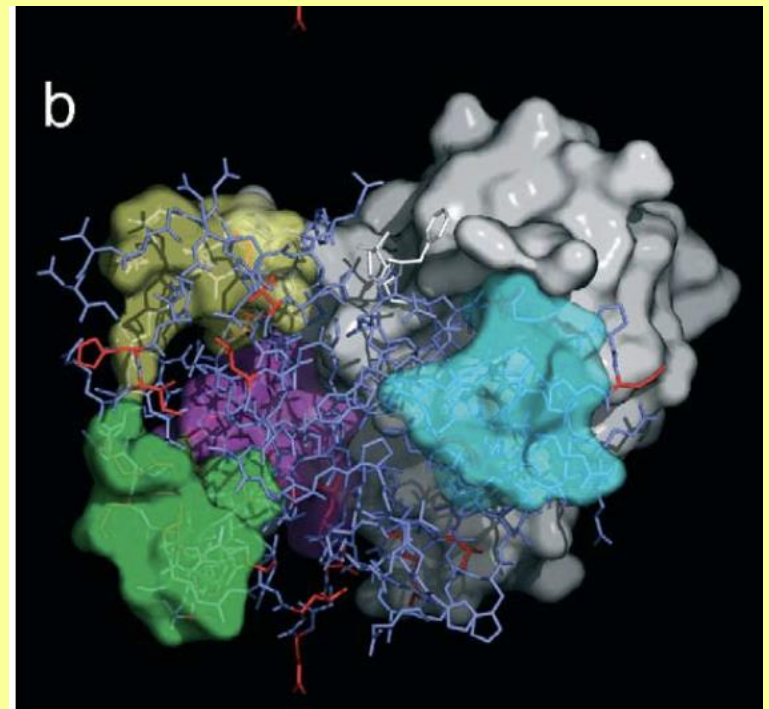
chorismate mutase - 93 amino acids

Taylor et al, Proc. Natl Acad. Sci. USA, 98,
10596–10601, **2001**.



β -lactamase, large domain
153 amino acids

Douglas Axe, J. Molec. Biol.
341, 1295, **2004**.

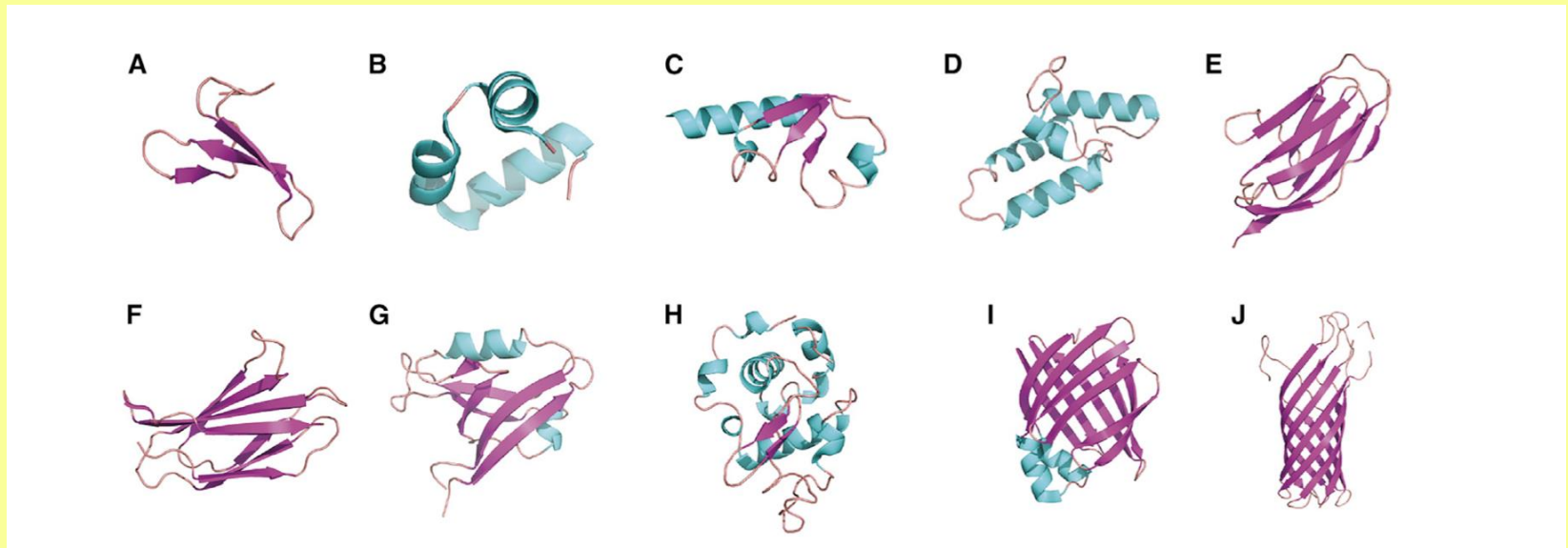


β -lactamase, large domain
153 amino acids

1 in 10^{77}

Method 3: bioinformatics

Protein folds they studied



Biophysical Journal, 2017, 113, 1719

sequence capacity estimated from:

- existing data for sequences for these types of fold
- mutational data

Method 3: bioinformatics

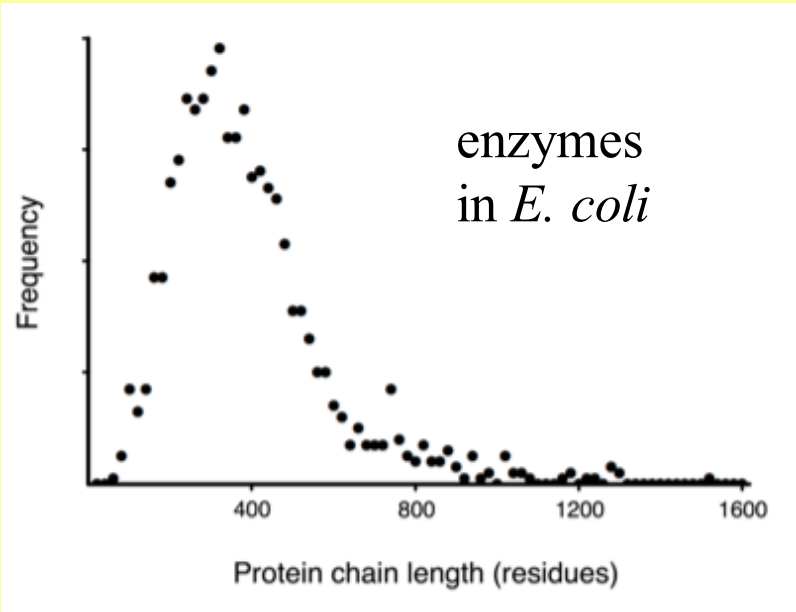
SC – sequence capacity
SC* – fraction of total

TABLE 1 Estimates of SC

Protein	<i>L</i>	Fold	SC	SC*	<i>M</i>
WW	35	all- β	9.9×10^{21}	2.9×10^{-24}	5800
Villin	35	all- α	1.6×10^{13}	4.7×10^{-33}	759
NTL9	56	α/β	3.2×10^{19}	4.4×10^{-54}	4828
IM7	87	all- α	1.6×10^{27}	1.1×10^{-86}	536
Titin I27	89	all- β	2.0×10^{78}	3.2×10^{-38}	55,422
TNfn3	90	all- β	8.5×10^{78}	6.9×10^{-39}	66,289
PDZ	94	α/β	1.2×10^{73}	5.8×10^{-50}	30,176
α -LA	123	α/β	1.1×10^{39}	1.0×10^{-121}	934
IFABP	131	α/β	3.0×10^{59}	1.1×10^{-111}	1691
OmpA	171	all- β	7.9×10^{96}	2.6×10^{-126}	31,397

L refers to the protein length, SC* is the absolute SC normalized by the total number of possible sequences (20^L), and *M* is the number of sequences in the MSA for each protein family.

A.



20 types of amino acids, chains of amino acids 150 units long

20^{150} possibilities

Only a miniscule fraction of sequence space can be searched!

B. Fraction that fold (for 150 residue protein):

1 in 10^{77} (J. Molec. Biol. 2004)

< 1 in 10^{100} (Biophysical J. 2017)

Only a miniscule fraction are functional!

How were the functional sequences found?

“Overall, what the field of protein evolution needs are some plausible, solid hypotheses to explain how random sequences of amino acids turned into the sophisticated entities that we recognize today as proteins. Until that happens, the phenomenon of the rise of proteins will remain, as Tawfik says, **“something like close to a miracle.”**”

“Close to a Miracle: Researchers are debating the origins of proteins”

J. Amer. Soc. for Biochem. and Molec. Biol. Oct 2013

Summary:

Protein sequence space is far too large to be searched and functional sequences of enzymes are incredibly rare.

No one knows how they were found or where they came from.

Are the functional sequences of large proteins like enzymes an informational discontinuity?

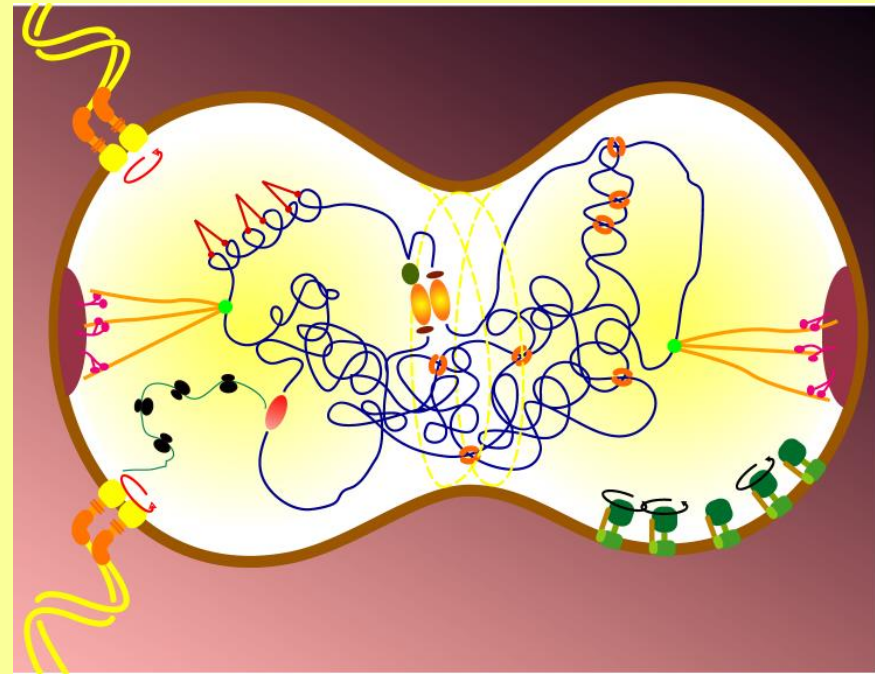
**10 recent discoveries that have
changed the debate about design in
the universe**

- 4. The number of genes in the simplest
free-living organism is about 450**

Minimal cells

Lots of Jobs to Do:

- Getting food and fuel
- Eliminating waste
- Converting raw materials to useful stuff
- Building molecular machines
- Repairing damage
- Copying and protecting genetic information
- Dividing the cell
- Controlling and coordinating all these
- Etc.



There is a machine (or system of machines) for every job

There is a system for making machines (central genetic apparatus)

There is a system of coordination among the machines

Minimal cells

RESEARCH ARTICLE

SYNTHETIC BIOLOGY

Design and synthesis of a minimal bacterial genome

Clyde A. Hutchison III,^{1*}† Ray-Yuan Chuang,^{1,†} Vladimir N. Noskov,¹
Nacyra Assad-Garcia,¹ Thomas J. Deerinck,² Mark H. Ellisman,² John Gill,³
Krishna Kannan,³ Bogumil J. Karas,¹ Li Ma,¹ James F. Pelletier,^{4,§} Zhi-Qing Qi,³
R. Alexander Richter,¹ Elizabeth A. Strychalski,⁴ Lijie Sun,^{1,||} Yo Suzuki,¹
Billyana Tsvetanova,³ Kim S. Wise,¹ Hamilton O. Smith,^{1,3} John I. Glass,¹
Chuck Merryman,¹ Daniel G. Gibson,^{1,3} J. Craig Venter^{1,3*}

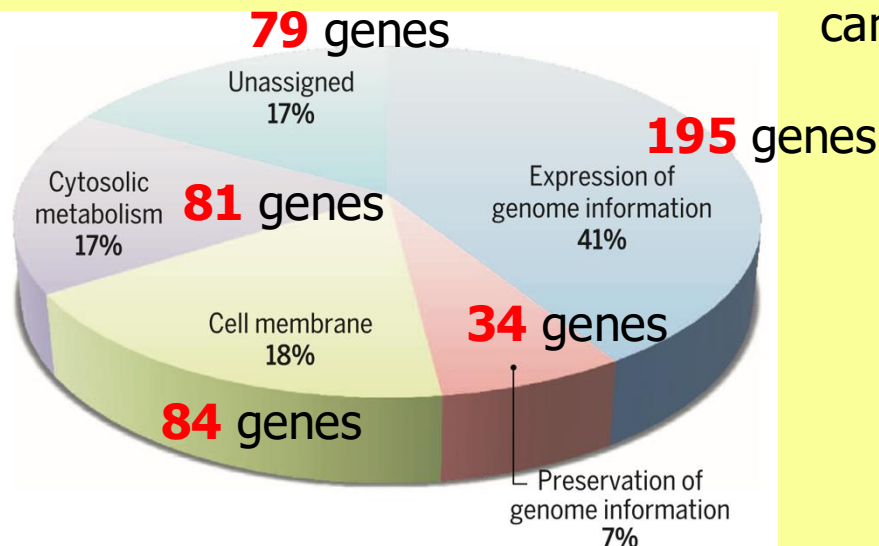
Science 351, aad6253 (2016)

Original *Mycoplasma mycoides* genome has **901** genes

M. capricolum with synthesized minimal genome from *M. mycoides* can survive with **473** genes

Fig. 6. Partition of genes into four major functional groups.

Syn3.0 has 473 genes. Of these, 79 have no assigned functional category (Table 1). The remainder can be assigned to four major functional groups: (i) expression of genome information (195 genes); (ii) preservation of genome information (34 genes); (iii) cell membrane structure and function (84 genes); and (iv) cytosolic metabolism (81 genes). The percentage of genes in each group is indicated.



438 protein-coding
35 RNA genes

Much smaller genome than any autonomously reproducing natural organism

Growth in rich medium

There is no such thing as a simple form of life!

"We now know not only of the existence of a break between the living and non-living world, but also that it represents the most dramatic and fundamental of all the discontinuities of nature. Between a living cell and the most highly ordered non-biological system, such as a crystal or snowflake, there is **a chasm as vast and absolute as it is possible to conceive.**"

M. Denton, *Evolution: A Theory in Crisis*, pg 250.

Ideas to explain life:

- 1. Infinite universes**
- 2. A simpler form of “life” came before the current forms and has since vanished.**
- 3. Life on earth was seeded by aliens**

Infinite Universes:

Biology Direct



Hypothesis

Open Access

The cosmological model of eternal inflation and the transition from chance to biological evolution in the history of life

Eugene V Koonin*

Address: National Center for Biotechnology Information, National Library of Medicine, National Institutes of Health, Bethesda, MD 20894, USA

Email: Eugene V Koonin* - koonin@ncbi.nlm.nih.gov

* Corresponding author

Published: 31 May 2007

Received: 10 May 2007

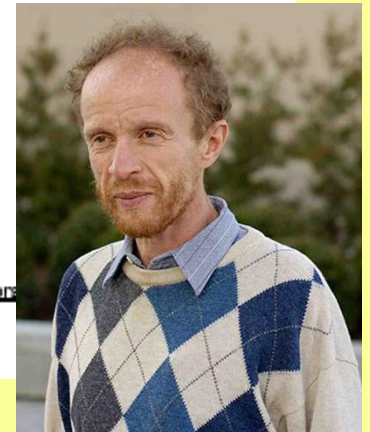
Biology Direct 2007, 2:15 doi:10.1186/1745-6150-2-15

Accepted: 31 May 2007

This article is available from: <http://www.biology-direct.com/content/2/1/15>

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Eugene Koonin
Senior Investigator
NIH

Infinite Universes:

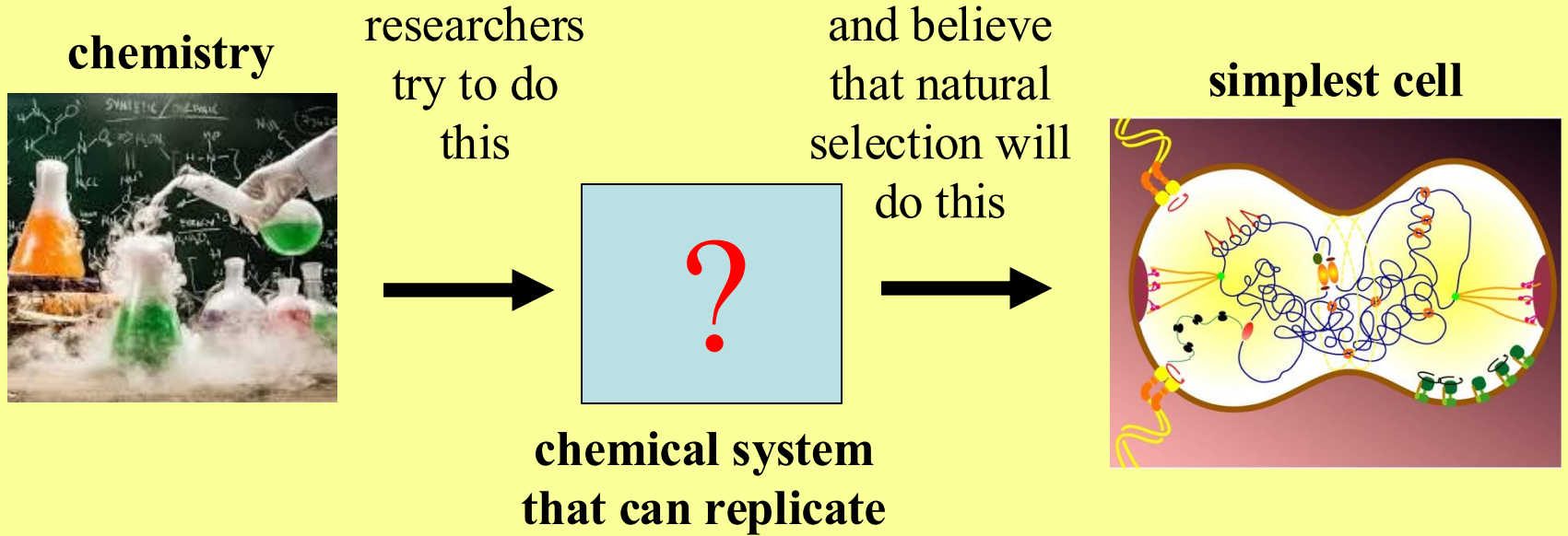
Abstract

Background: Recent developments in cosmology radically change the conception of the universe as well as the very notions of "probable" and "possible". The model of eternal inflation implies that all macroscopic histories permitted by laws of physics are repeated an infinite number of times in the infinite multiverse. In contrast to the traditional cosmological models of a single, finite universe, this worldview provides for the origin of an infinite number of complex systems by chance, even as the probability of complexity emerging in any given region of the multiverse is extremely low. This change in perspective has profound implications for the history of any phenomenon, and life on earth cannot be an exception.

Hypothesis: Origin of life is a chicken and egg problem: for biological evolution that is governed, primarily, by natural selection, to take off, efficient systems for replication and translation are required, but even barebones cores of these systems appear to be products of extensive selection. The currently favored (partial) solution is an RNA world without proteins in which replication is catalyzed by ribozymes and which serves as the cradle for the translation system. However, the RNA world faces its own hard problems as ribozyme-catalyzed RNA replication remains a hypothesis and the selective pressures behind the origin of translation remain mysterious. Eternal inflation offers a viable alternative that is untenable in a finite universe, i.e., that a coupled system of translation and replication emerged by chance, and became the breakthrough stage from which biological evolution, centered around Darwinian selection, took off. A corollary of this hypothesis is that an RNA world, as a diverse population of replicating RNA molecules, might have never existed. In this model, the stage for Darwinian selection is set by anthropic selection of complex systems that rarely but inevitably emerge by chance in the infinite universe (multiverse).



A simpler form of “life” came before the current forms of life and has since vanished.



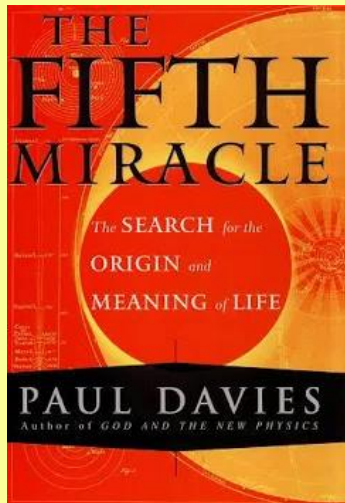
- RNA world
- Metabolism (proteins) first
- Assembly theory?

Life on earth was seeded by aliens:

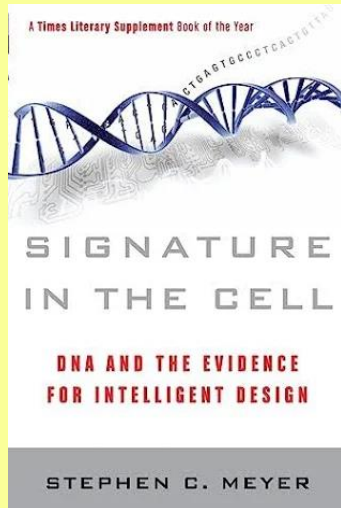
Recognizes that life on earth is an informational discontinuity and attributes that to a mind.

But this explanation only displaces the problem, because the question of where the alien life came from remains.

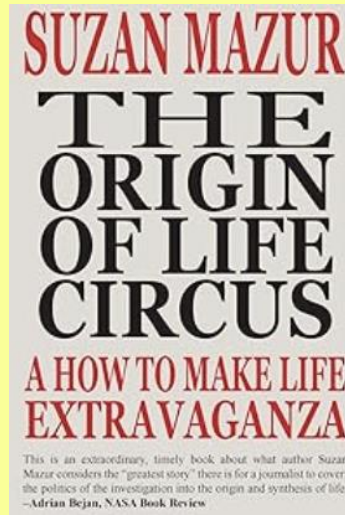
Other resources on the origin of life



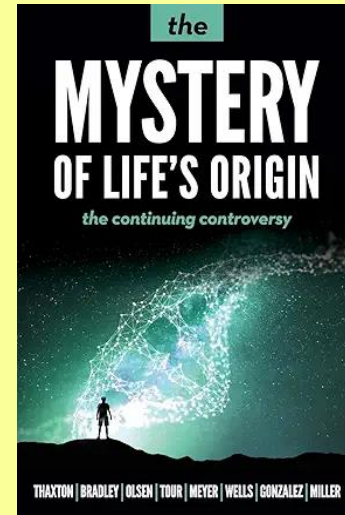
2000



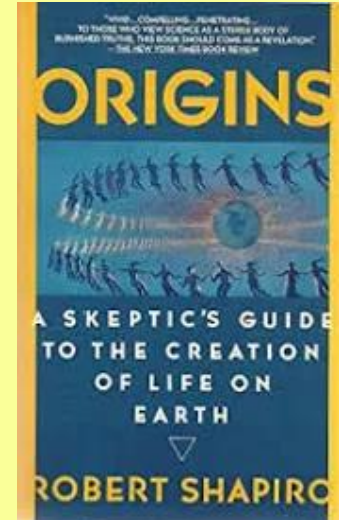
2009



2014



2020



1986

Summary:

There is no such thing as a simple form of life!

Life as it exists today is far beyond the reach of chance in a finite universe.

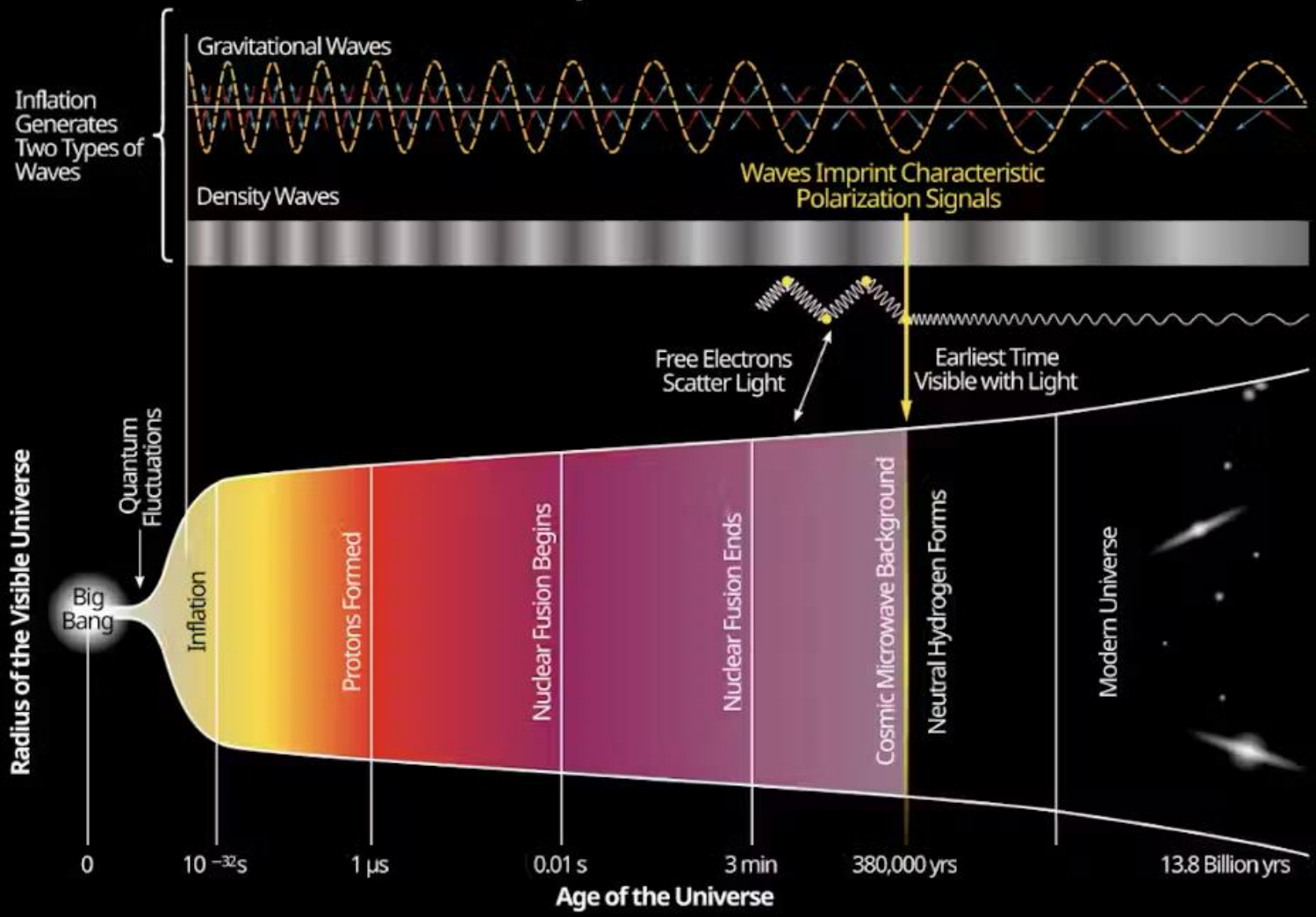
Is the simplest form of life, with 473 genes, an informational discontinuity?

Summary

- 1. The universe (space-time, matter, energy) had a beginning and will have an end.**
- 2. The laws of physics, the fundamental constants, and the initial conditions of the universe are fine-tuned to allow for the possibility of life.**
- 3. Protein sequence space is far too large to be searched and functional sequences of proteins are incredibly rare.
(~1 in 10^{77})**
- 4. The number of genes in the simplest free-living organism is about 450.**

Extra slides

History of the Universe

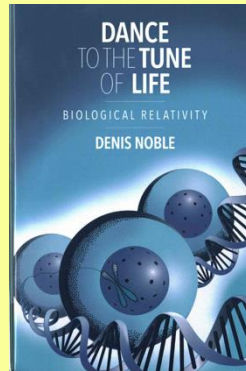
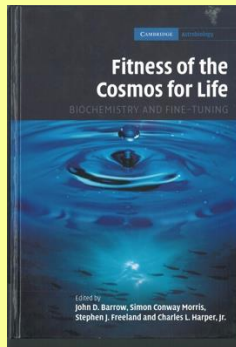
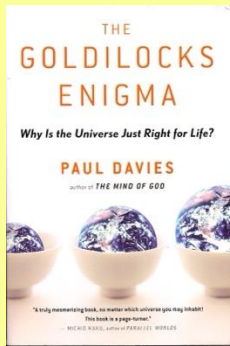


10 recent discoveries that have changed the debate about design in the universe

1. The universe had a beginning and will have an end
2. The Universe is fine-tuned to allow for life
3. Only a miniscule fraction of proteins are functional
4. About 450 genes in the simplest free-living organism
5. Life is based on a digital information processing system
6. Molecular machines and sophisticated software algorithms are essential to all life-forms
7. Random mutation + natural selection has severe limitations
8. The earth is fine-tuned to allow for life
9. In the fossil record new body plans appear without precursors
10. The junk-DNA paradigm has been shown to be false

Physical Sciences

fine-tuning
anthropic coincidences
habitability
discoverability
intelligibility
physical laws
etc



Life Sciences

origin of life
molecular machines
hardware and software of cells
micro and macro evolution
basic charact. of fossil record
etc

Cognitive Sciences

mind/brain
consciousness
personhood
abstract thought
reasoning
free will
etc

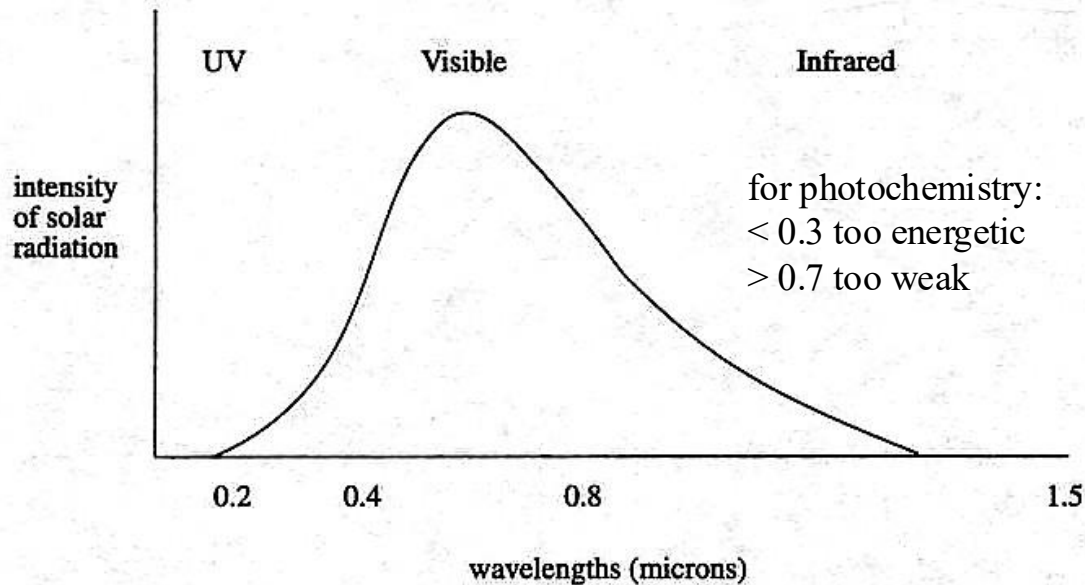


Thomas Nagel
NYU

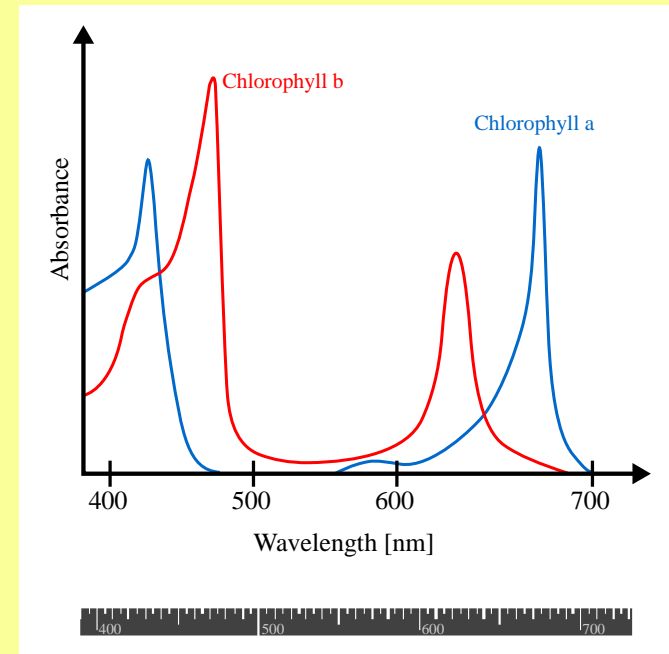


Energy from sun matched with that needed for photochemistry

The solar spectrum, showing the intensity of the sun's radiation between 0.1 and 1.50 microns.



solar spectrum



absorbance spectrum of chlorophyll

Energy from sun matched with that needed for photochemistry

$$m_p^2 G / [h c] \sim [e^2 / \{h c\}]^{12} [m_e / m_p]^4$$

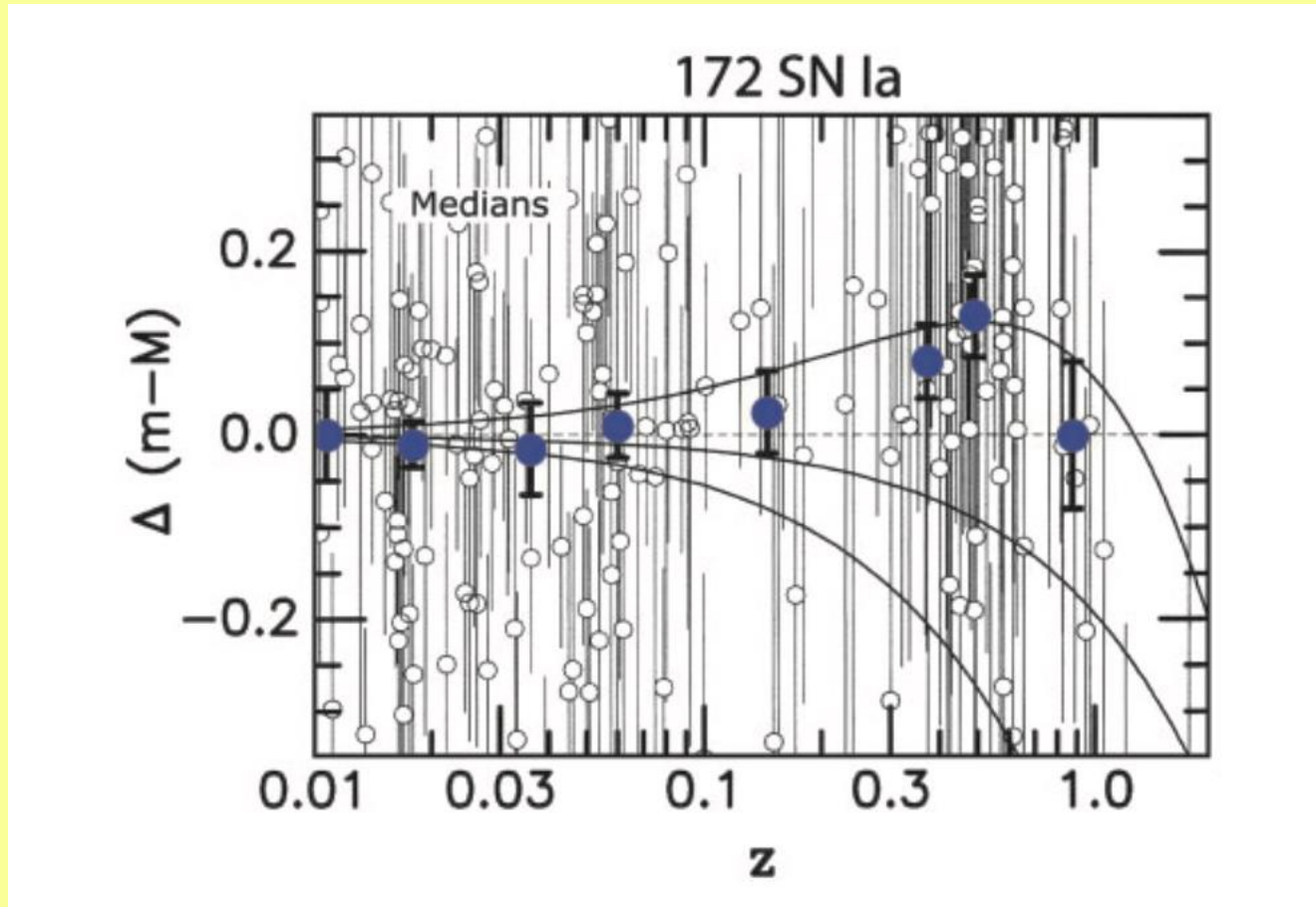
$$\alpha_G \sim [\alpha_{EM}]^{12} [m_e / m_p]^4$$

$$5.2 \times 10^{39} > \sim [2.2 \times 10^{39}]$$

from The Anthropic Cosmological Principle, 1986, p336

This occurs because the values of the universal constants h , c , G , m_e , m_p , e are **just right**.

Improvements since 1922



Some major issues in cosmology:

1. According to current models, $\sim 95\%$ of the stuff of the universe is “dark. (effects detected without observable causes)
 - dark matter
 - dark energy
2. Hubble tension – different measurements give different values for the Hubble constant

For a good summary see:

<https://www.livescience.com/space/after-2-years-in-space-the-james-webb-telescope-has-broken-cosmology-can-it-be-fixed>