Are the laws of physics actually fine-tuned?

Jim Clarage
Department of Chemistry and Physics
University of St. Thomas

G

Gravitational Force

Gravity mysteries: Why is gravity fine-tuned?

"The feebleness of gravity is something we should be grateful for. If it were a tiny bit stronger, none of us would be here to scoff at its puny nature."

1 part in 10^{15}

0.000000000000001

proton and neutron

$m_p = 1.6726 \times 10^{-27}$ kg

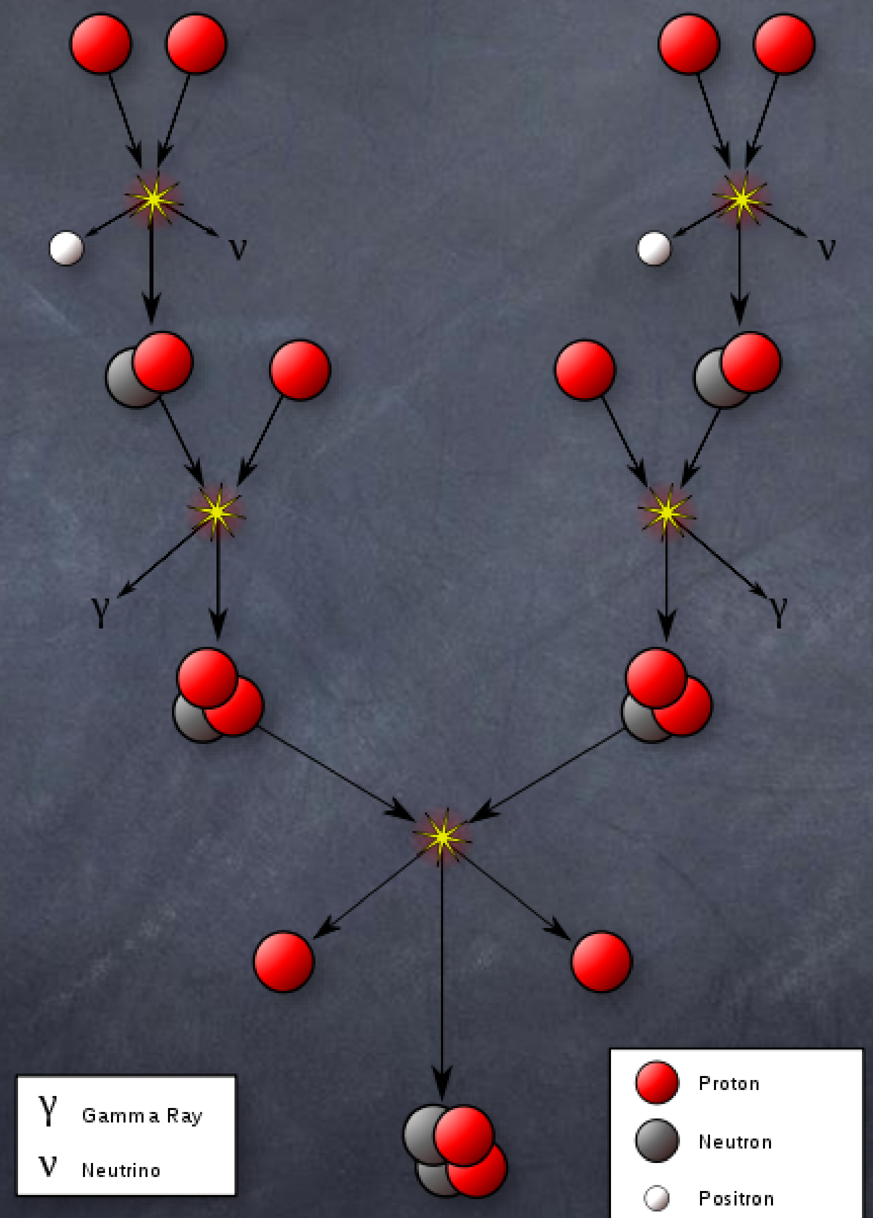
$m_n = 1.6749 \times 10^{-27}$ kg

If $m_p > m_n$ proton decays to neutron (no atoms)

If $m_p << m_n$ deuteron unstable (no pp reaction)

If $m_p \sim= m_n$ no beta decay possible

proton-proton chain reaction



$4\,^1H \rightarrow \,^4He + 2e^+ + 2\gamma + 2\nu_e$ (26.7 MeV)

Implications...

- Anthropic Principle
- Designer (aka Tuner)
- Multiverse

Anthropic Principle
(Brandon Carter, 1974)

Weak:
What we can expect to observe must be restricted by the condition necessary for our presence as observers.

Strong:
The Universe (and hence the fundamental parameters on which it depends) must be such as to admit the creation of observers within it at some stage.

Hoyle's Carbon resonance

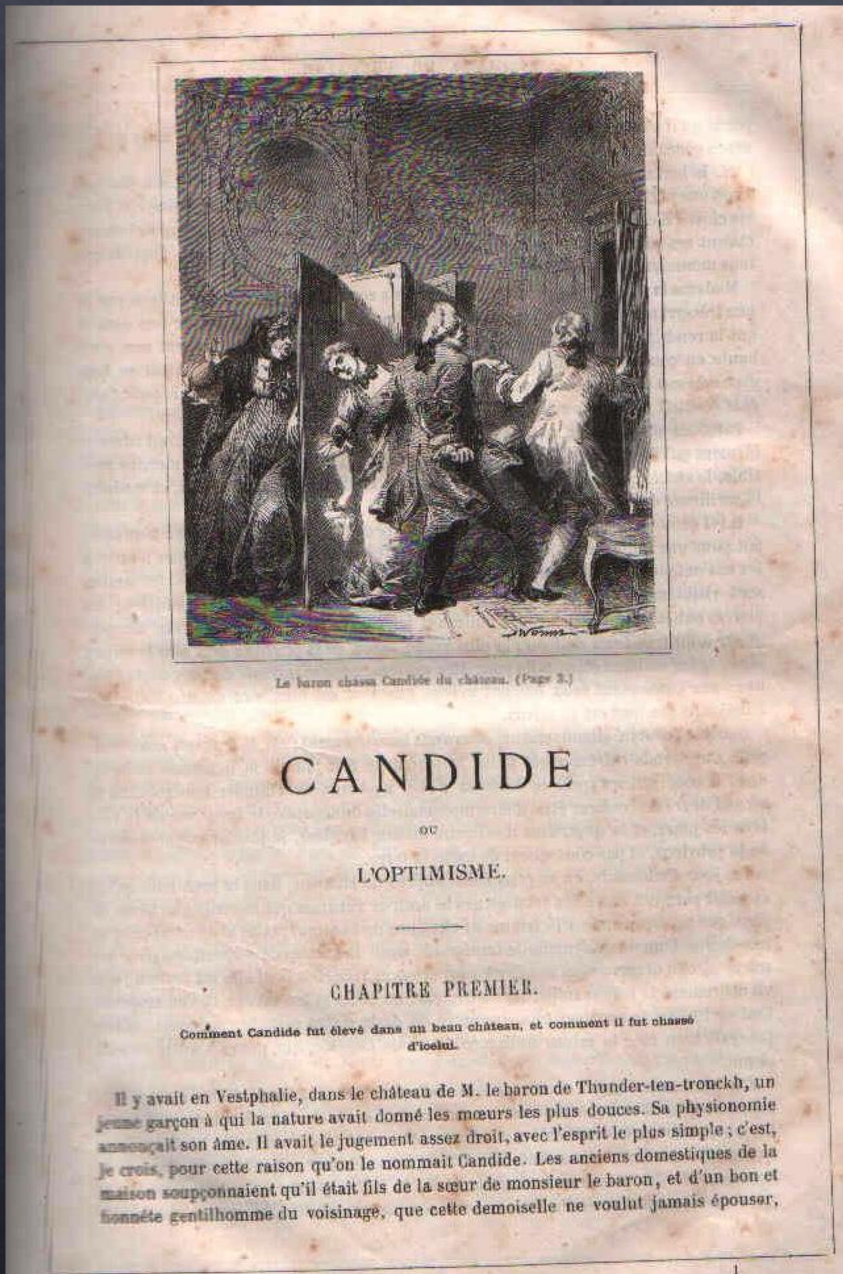
triple-alpha process

$3\ ^4He \rightarrow\ ^{12}C$

prediction: 7.65 MeV (1952)
measured: 7.656 MeV

Critique of fine-tuning

Literature



Le baron chassa Candide du château. (Page 3.)

CANDIDE

OU

L'OPTIMISME.

CHAPITRE PREMIER.

Comment Candide fut élevé dans un beau château, et comment il fut chassé d'icelui.

Il y avait en Vestphalie, dans le château de M. le baron de Thunder-ten-tronckh, un jeune garçon à qui la nature avait donné les mœurs les plus douces. Sa physionomie annonçait son âme. Il avait le jugement assez droit, avec l'esprit le plus simple ; c'est, je crois, pour cette raison qu'on le nommait Candide. Les anciens domestiques de la maison soupçonnaient qu'il était fils de la sœur de monsieur le baron, et d'un bon et honnête gentilhomme du voisinage, que cette demoiselle ne voulut jamais épouser,

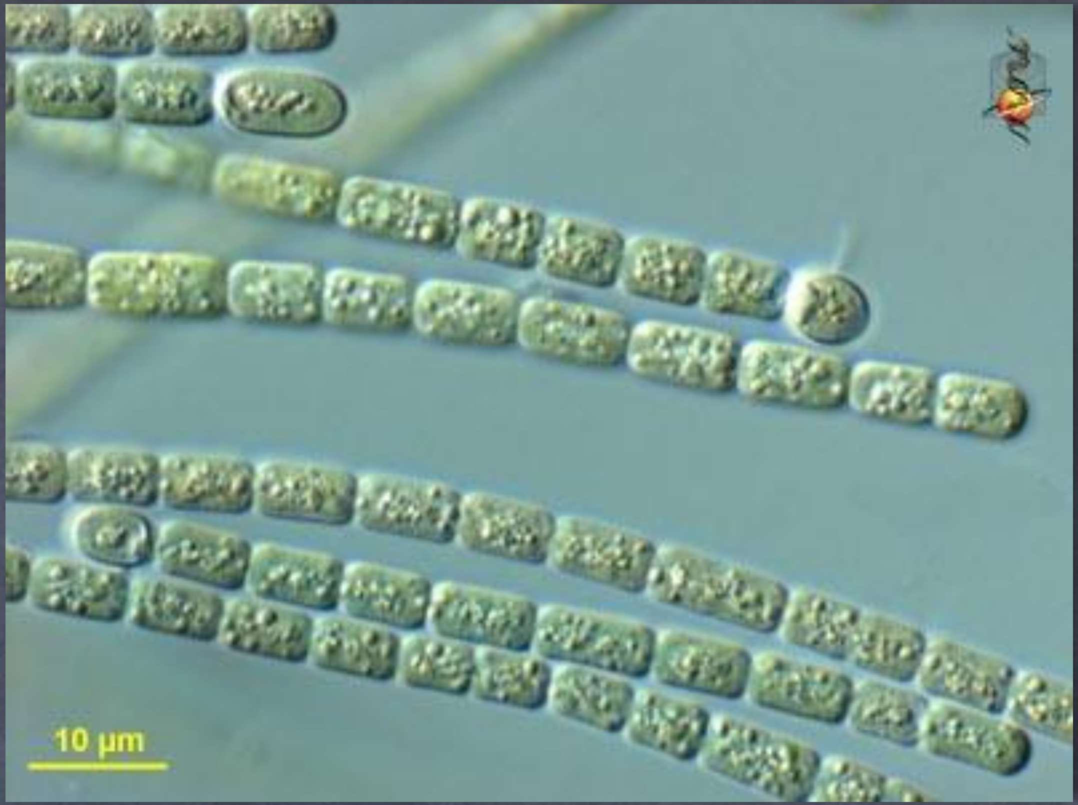
1

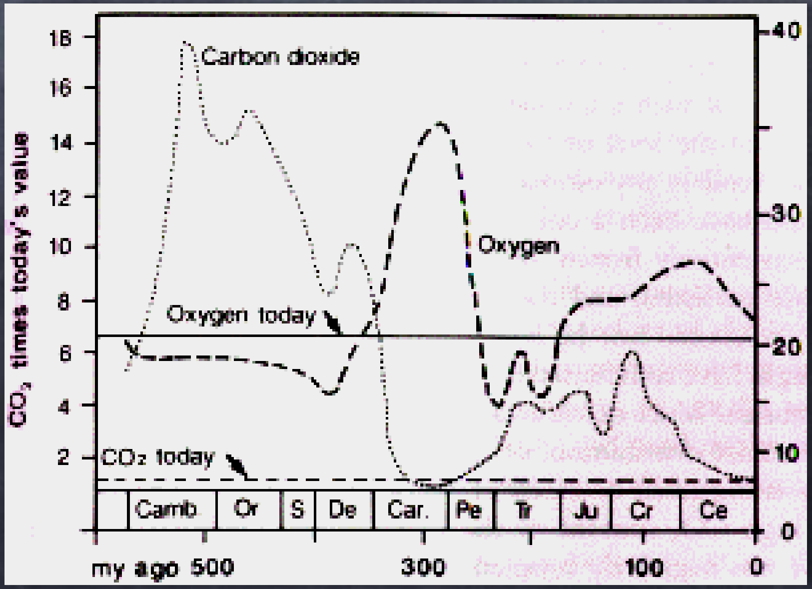
Voltaire's Candide, 1759

"There is a concatenation of all events in the best of possible worlds..."

-Master Pangloss,
teacher of the metaphysico-theologo-cosmolonigology

History...


10 µm


Carbon dioxide
Oxygen
Oxygen today
CO2 today
CO_2 times today's value
Camb
Or
S
De
Car.
Pe
Tr
Ju
Cr
Ce
my ago 500
300
100
0
18
16
14
12
10
8
6
4
2
40
30
20
10
0

History...

William Paley (1743–1805) used the watchmaker analogy in his book Natural Theology, or Evidences of the Existence and Attributes of the Deity collected from the Appearances of Nature, published in 1802.

[Contribution from Gates Chemical Laboratory, California Institute of Technology, No. 280]

THE NATURE OF THE CHEMICAL BOND. APPLICATION OF RESULTS OBTAINED FROM THE QUANTUM MECHANICS AND FROM A THEORY OF PARAMAGNETIC SUSCEPTIBILITY TO THE STRUCTURE OF MOLECULES

By Linus Pauling

Received February 17, 1931 Published April 6, 1931

During the last four years the problem of the nature of the chemical bond has been attacked by theoretical physicists, especially Heitler and London, by the application of the quantum mechanics. This work has led to an approximate theoretical calculation of the energy of formation and of other properties of very simple molecules, such as H_2, and has also provided a formal justification of the rules set up in 1916 by G. N. Lewis for his electron-pair bond. In the following paper it will be shown that many more results of chemical significance can be obtained from the quantum mechanical equations, permitting the formulation of an extensive and powerful set of rules for the electron-pair bond supplementing those of Lewis. These rules provide information regarding the relative strengths of bonds formed by different atoms, the angles between bonds, free rotation or lack of free rotation about bond axes, the relation between the quantum numbers of bonding electrons and the number and spatial arrangement of the bonds, etc. A complete theory of the magnetic moments of molecules and complex ions is also developed, and it is shown that for many compounds involving elements of the transition groups this theory together with the rules for electron-pair bonds leads to a unique assignment of

Goldilocks planet

- not too hot (nor cold)
- oxygen
- sunlight

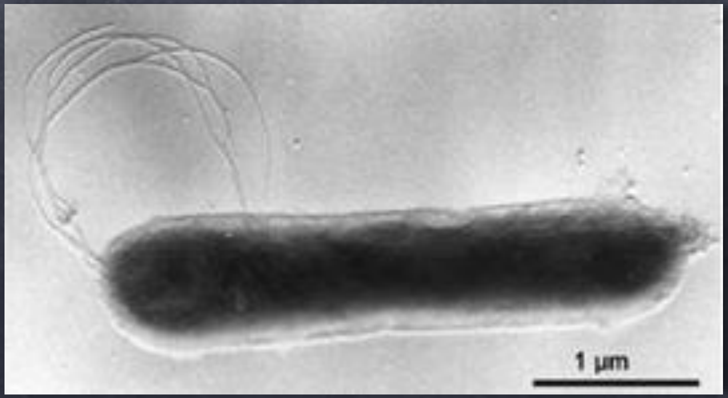
“Has the Earth a Corner on Life?” Kenneth Crist, Los Angeles Times, 1935


GUILLERMO GONZALEZ AND JAY W. RICHARDS
AUTHORS
REVIEWS
DOCUMENTARY
Q&A
LINKS
The Privileged Planet
Read a synopsis of the book
order now
HOW OUR PLACE IN THE COSMOS IS DESIGNED FOR DISCOVERY

QuickTime™ and a
Sorenson Video 3 decompressor
are needed to see this picture.

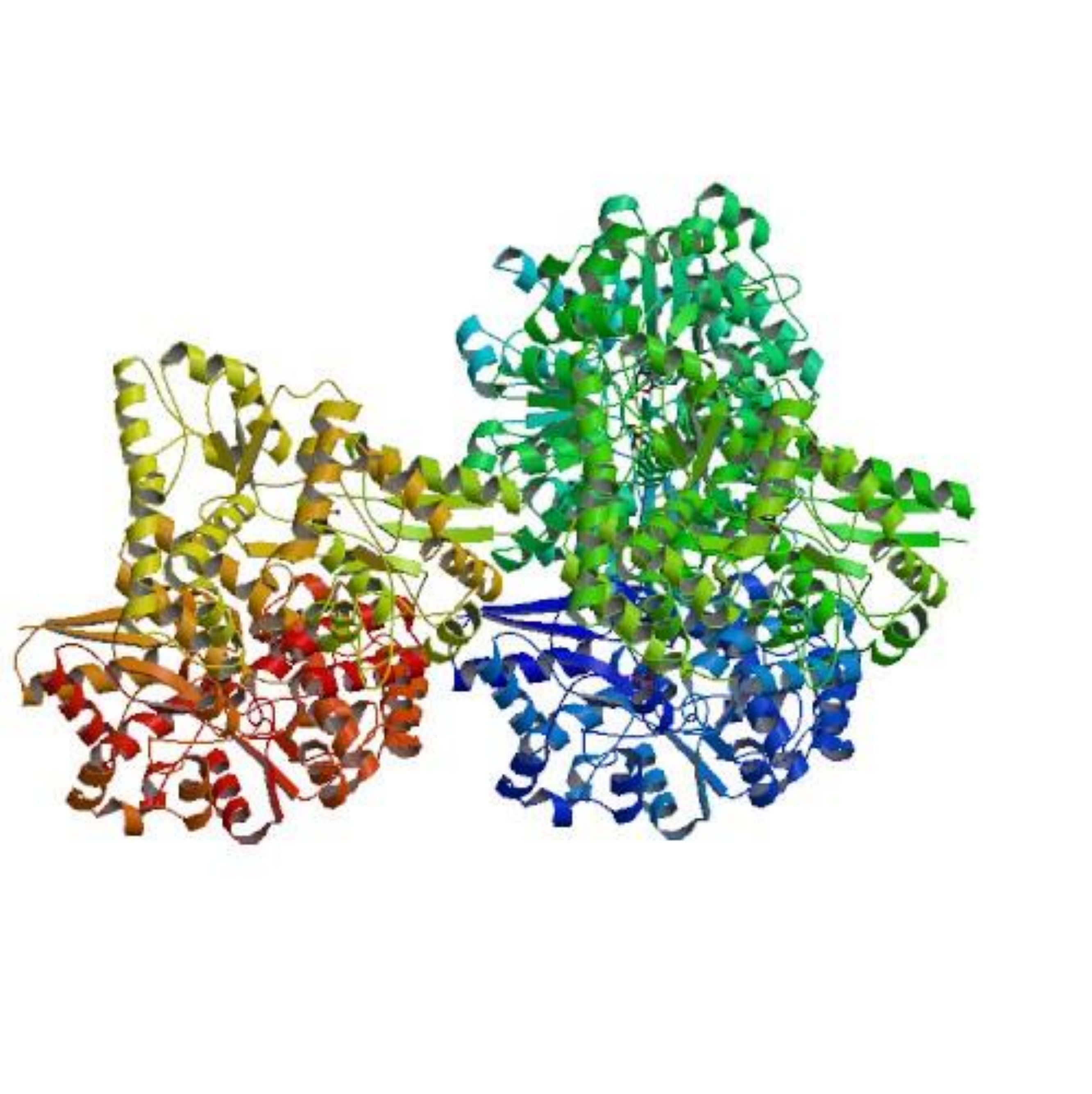
Goldilocks planet

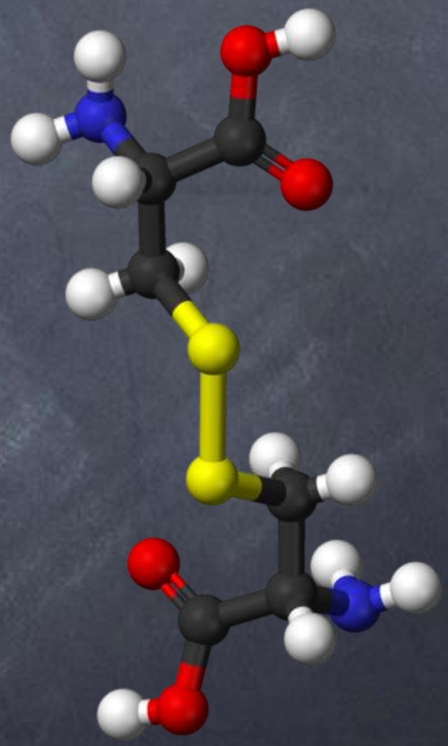
- not too hot (nor cold) thermophilic (118°C !)
- oxygen anaerobic (no oxygen)
- sunlight heat, sulfur



Aquifex pyrophilus

How to un-fry and egg





Cystine

Apollo 12 (1969)

Surveyor 3's camera (1967)

Streptococcus mitis

Language

“delicately dependent...”

“slightly different...” (14)

“very slightly stronger...”

“wildly improbable numerical accidents...”

“somewhat weaker...”

“tiny bit stronger...”

“Slightly” stats:
14 times in Davies, “The Accidental Universe”
20 times in Barrow, “The Constants of Nature: The Numbers That Encode the Deepest Secrets of the Universe”

G

$F_1 = 979.677941576350$
$F_2 = 979.677634377790$

$\Delta F \sim 1/10^7$

m = 100 kg, dr = 1.0m

feature article

Rare isotopes in the cosmos

Hendrik Schatz

Such stellar processes as heavy-element formation and x-ray bursts are governed by unstable nuclear isotopes that challenge theorists and experimentalists alike.

Hendrik Schatz is a professor of physics and astronomy at Michigan State University's department of physics and astronomy and National Superconducting Cyclotron Laboratory in East Lansing. He is also cofounder and associate director of the Joint Institute for Nuclear Astrophysics, an NSF Physics Frontier Center.

Radioactive nuclei with extreme neutron-to-proton ratios—rare isotopes—often decay within fractions of a second. Typically, they are not found on Earth unless produced at an accelerator. Yet nature produces copious amounts of them in supernovae and other stellar explosions in which the rare isotopes, despite their fleeting existence and small scale, imprint their properties. Large amounts of them also exist as stable layers in the crusts of neutron stars.

Rare isotopes are therefore intimately linked to fundamental questions in astrophysics. An example is the origin of the 50-odd naturally occurring elements between the iron region and uranium in the periodic table. As figure 1 shows, with recent progress in stellar spectroscopy and the continuing discovery of very old and chemically primitive stars, a "fossil record" of chemical evolution is now emerging. Nuclear science needs to make its own progress to match specific events to the observed elemental abundance patterns produced in stellar explosions. That has turned out to be a tremendous challenge. Nuclear theory is still far from being

Nuclear Astrophysics in the US exemplifies such a center. Across the Atlantic, Europe is witnessing such initiatives as the Extreme Matter Institute and the Munich Cluster of Excellence on the Origin and Structure of the Universe, both in Germany, and the international Challenges and Advanced Research in Nuclear Astrophysics network.

Origin of the elements

Nuclear processes in stars and stellar explosions have forged nature's chemical elements out of the hydrogen and helium left over from the Big Bang. Fusion reactions in stars drive the formation of elements with atomic numbers up to about that of iron. But fusion does not produce heavier elements; the nuclear binding energy per nucleon is maximal for nuclei around iron and nickel, so continued fusion would be endothermic.

Heavier elements are thought to be built up by a neutron-capture process that iterates a two-step sequence. First, neutrons bombard a seed nucleus until a number have been

Hoyle's Carbon resonance

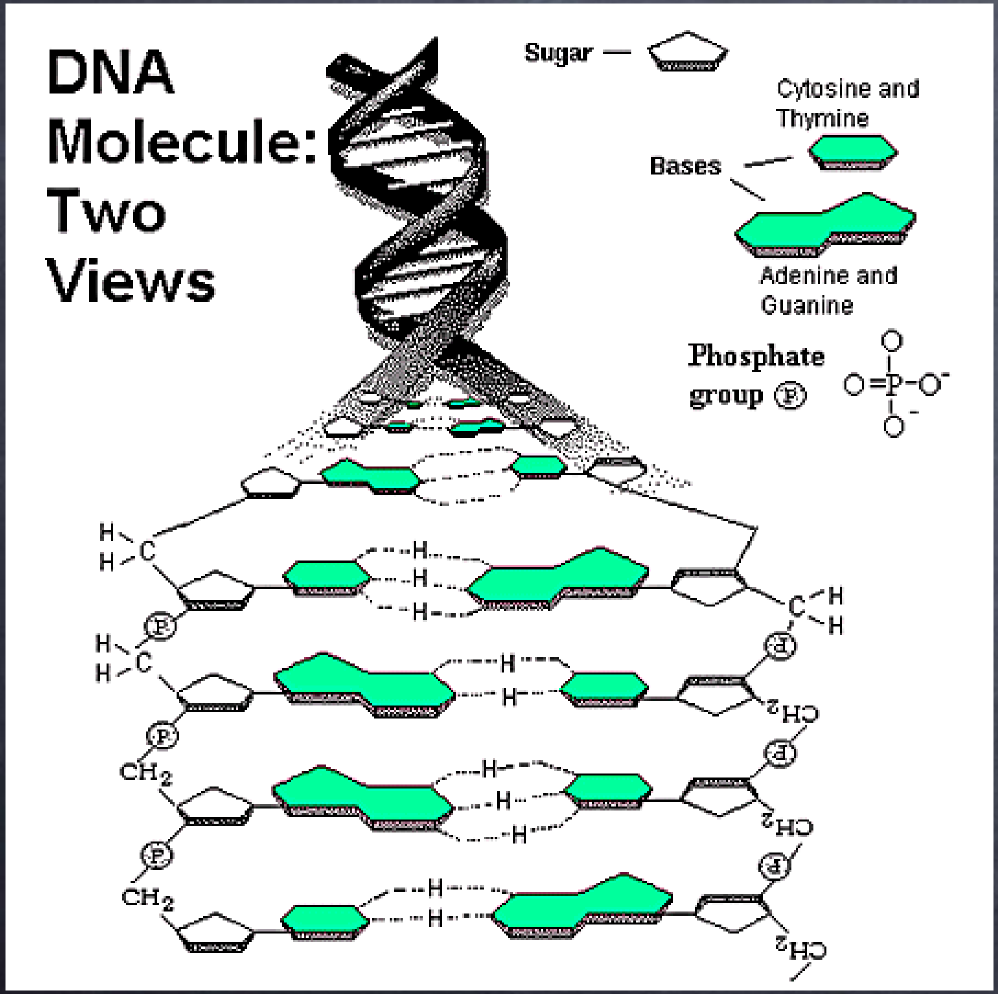
triple-alpha process

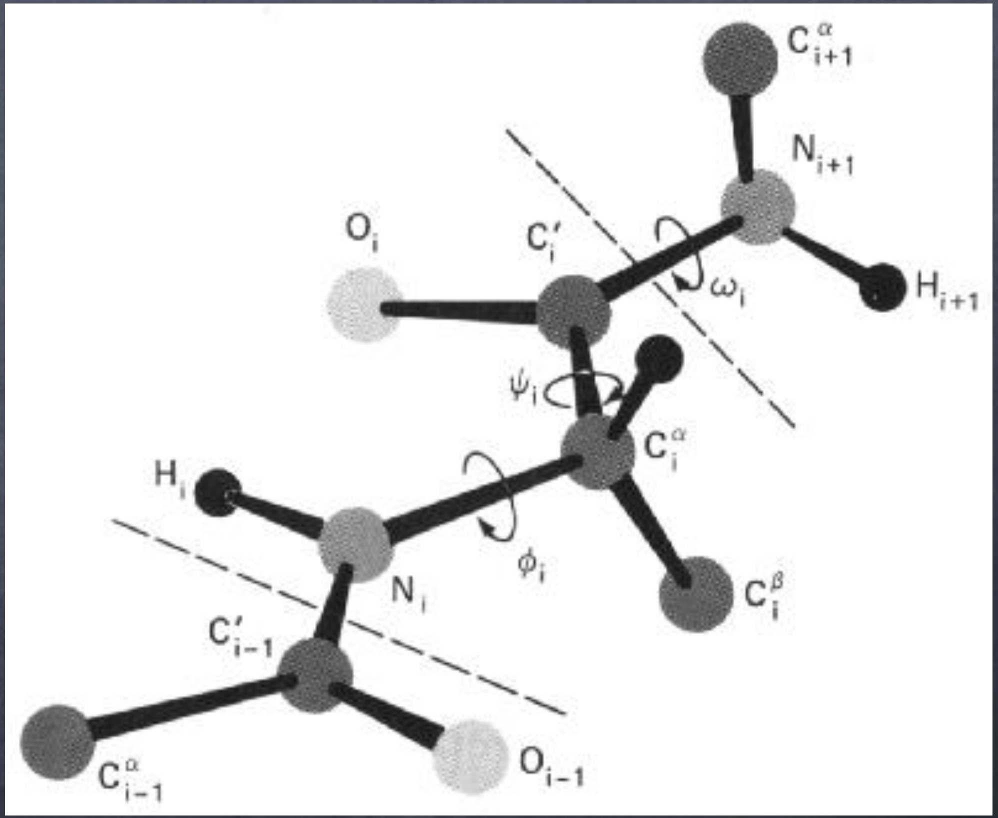
$3\ ^{4}He \rightarrow\ ^{12}C$

Steven Weinberg: fine = 20%

Chemistry

Carbon fixation





Mathematics

s-block 1 IA — New Designation / Original Designation

s-block 18 VIIIA

Non-Metals

Atomic #
Symbol
Atomic Mass

s-block | *d-block* | ***Transition Metals*** | *p-block*

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.0094																	2 He 4.00260
2	3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
3	11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
4	19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.91	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 to 71	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.03	89 to 103	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)	110 Uun (267)								

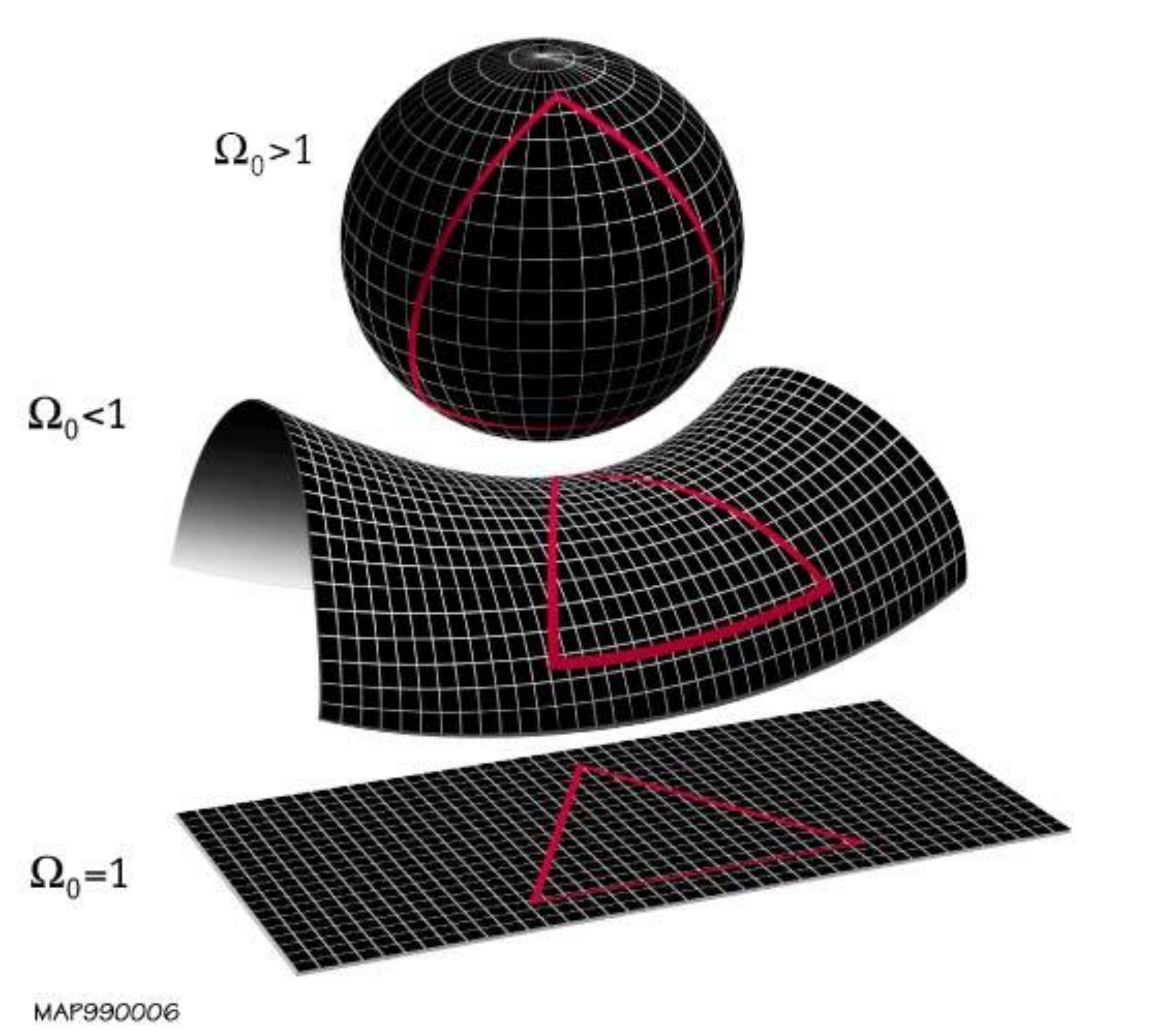
(Mass Numbers in Parentheses are from the most stable of common isotopes.)

Phases
Solid
Liquid
Gas

Metals

Rare Earth Elements | *d-block* | *f-block*

Lanthanide Series	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
Actinide Series	89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)



$\Omega_0>1$
$\Omega_0<1$
$\Omega_0=1$
MAP990006

Biology

Stating the obvious

r_a = radius axle holes
r_b = radius lug bolt

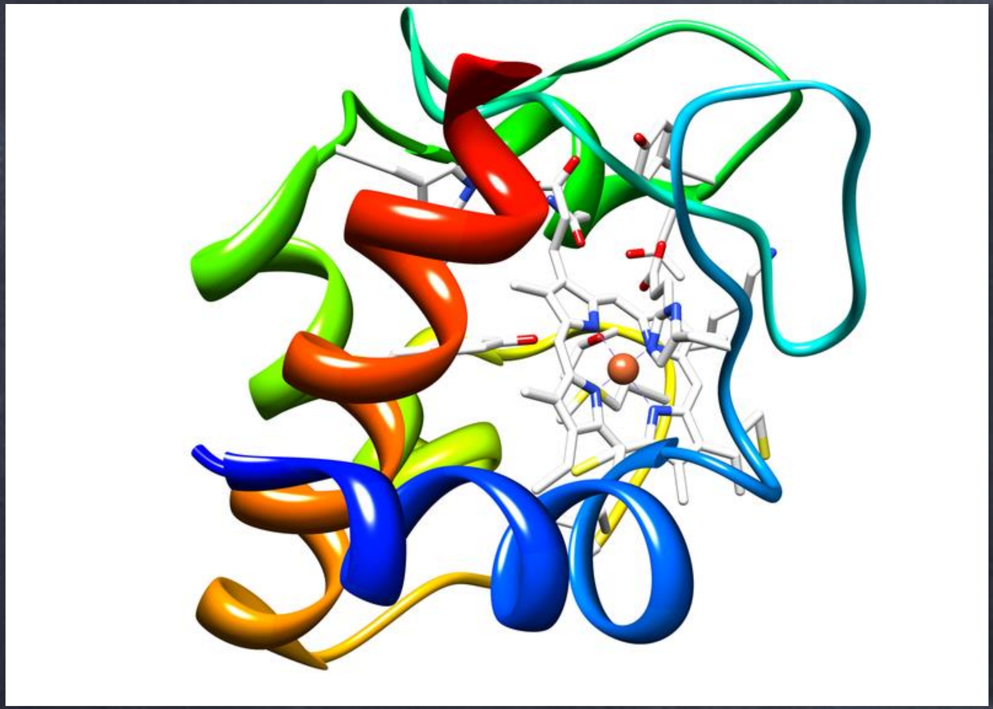
If $r_a > r_b$ unstable, decays 1-2mins.

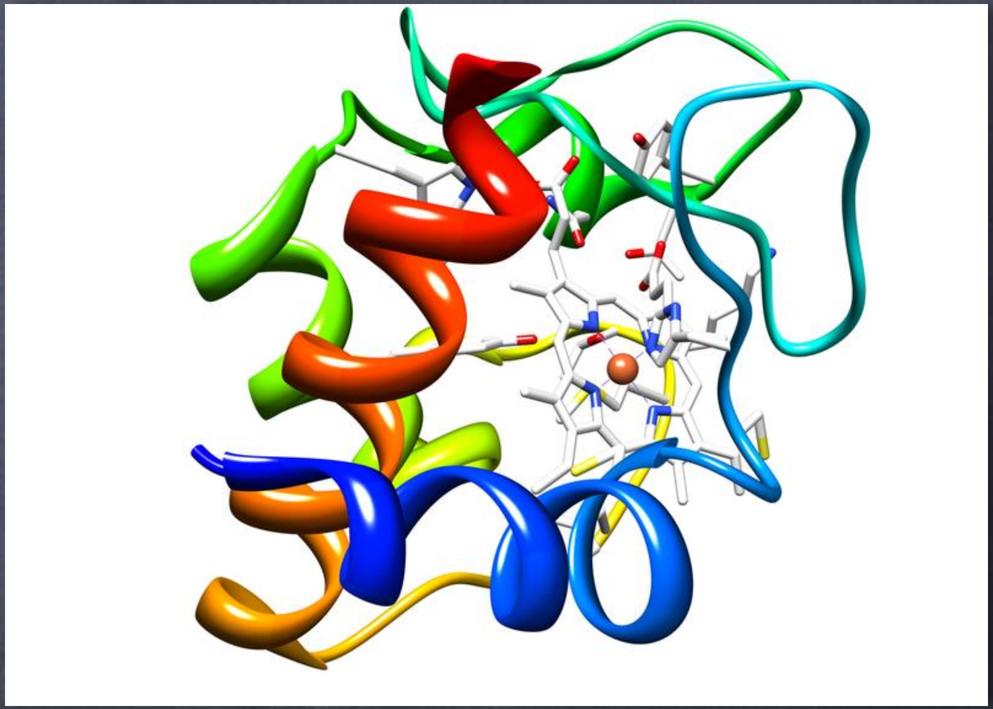
If $r_a < r_b$ bound state cannot form!

Conclusion: travel as we know it impossible w/out tuning.

Why don’t biologists have an Anthropic Principle?

Biology

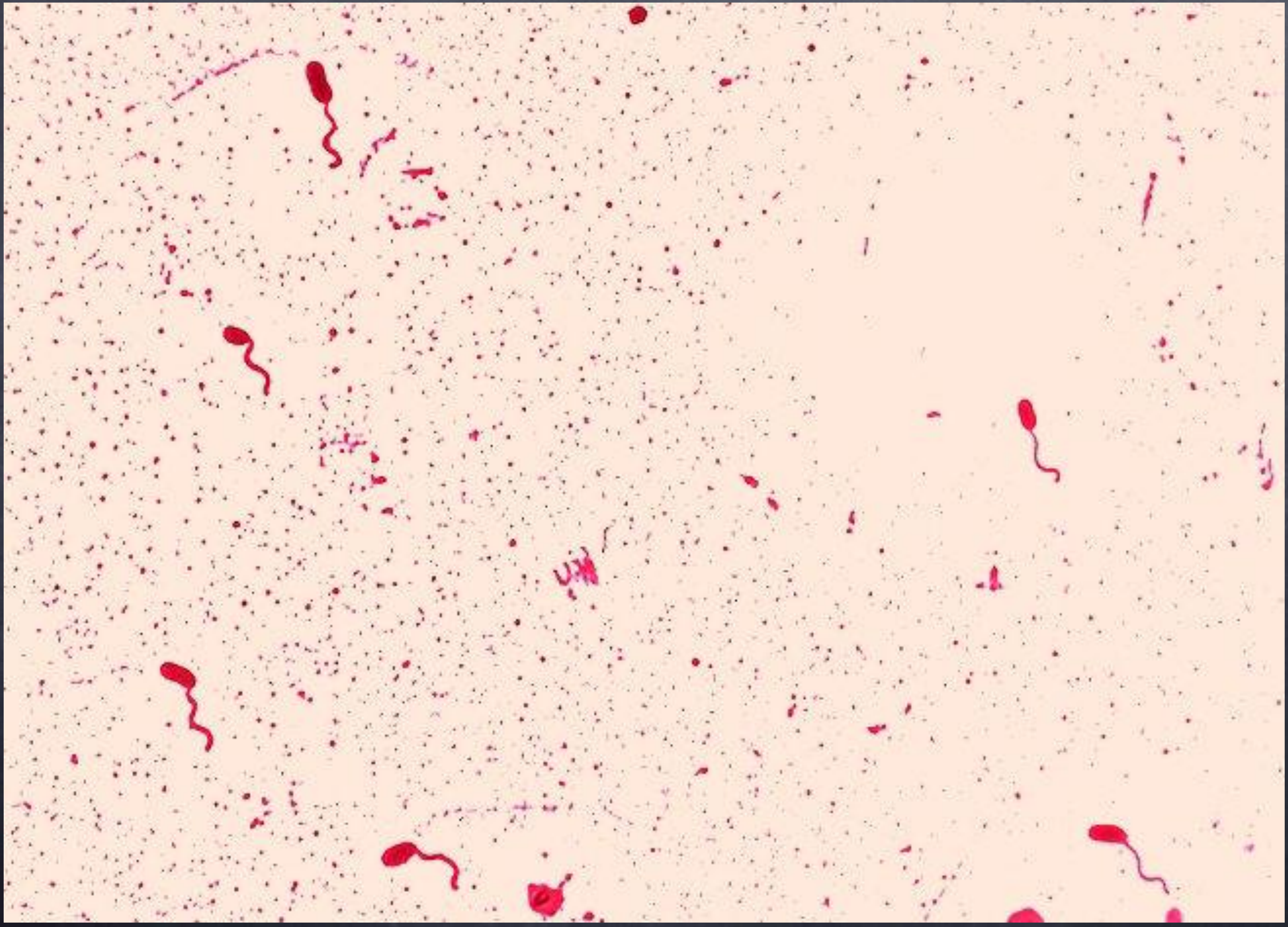




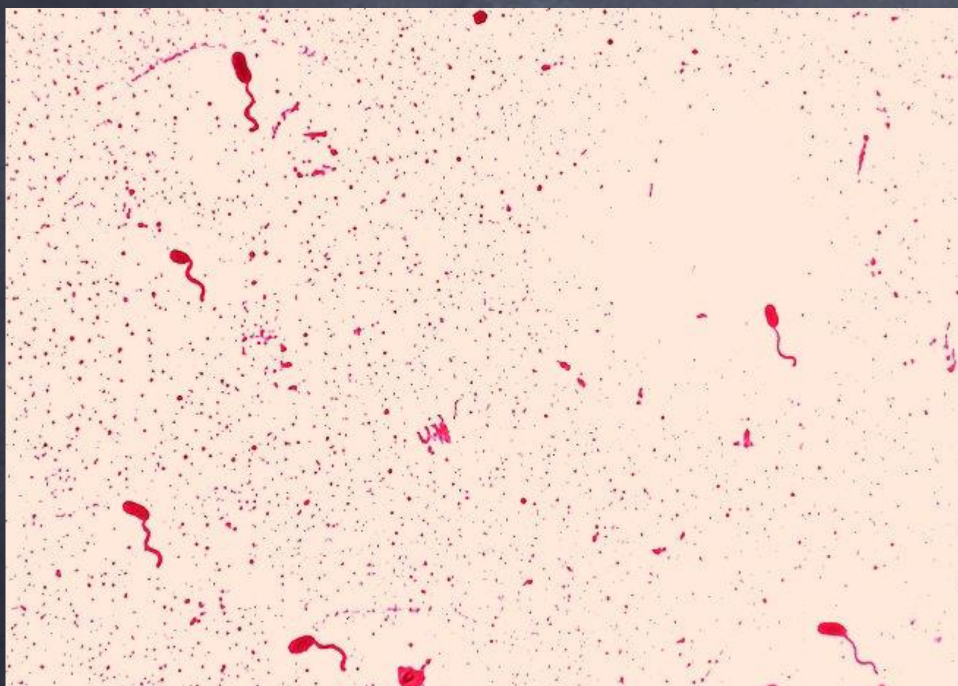
Cytochrome *c*,

Computer Science

Life qua Algorithm



Life qua Algorithm



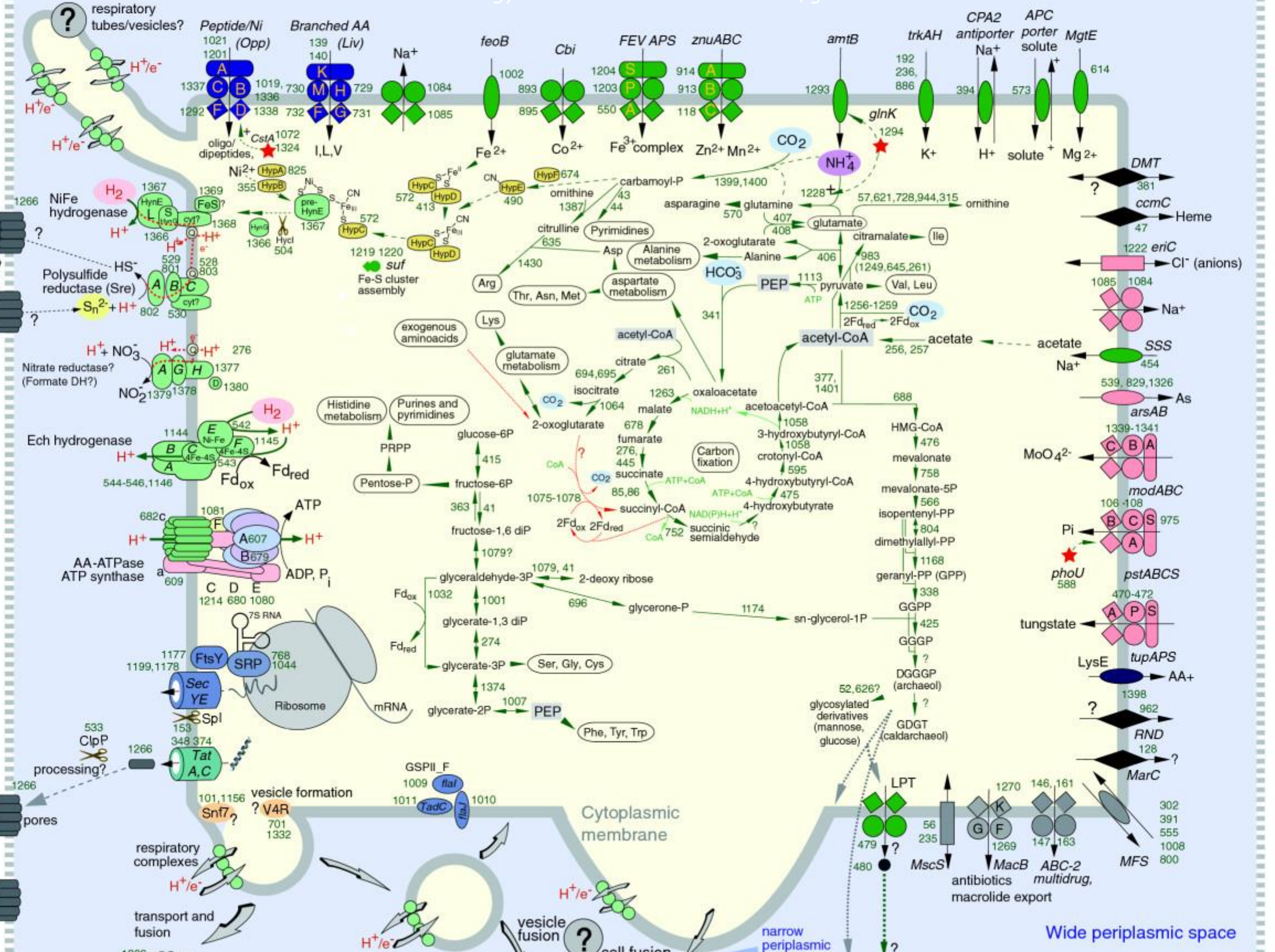
```
If C(t+1) >= C(t) {
TumbleTime = long;
}

Else {
TumbleTime = short;
}
```

Architecture Independent

```
// program to replicate Archimedes' calculation of pi // also shows numerical
problems - wdg 2008 #include <stdio.h> #include <math.h>float estimate(int); //
prototypeint main(void) {          int divs;     for(divs=1; divs<2000000; divs*=2) {
                    float pi = estimate(divs);                    printf("For
division=%d Pi is approximately %.5f\n", divs, pi );     }          return 0;}float
estimate(int divisions) {          int i;          float sum =0.0, width = 1.0/divisions;
          for( i=0; i<divisions; i++ ) {                    sum += width * sqrt( 1.0 -
(i*width)*(i*width) );     }          return 4*sum;}
```

Podar *et al.* *Genome Biology* 2008 **9**:R158   doi:10.1186/gb-2008-9-11-r158

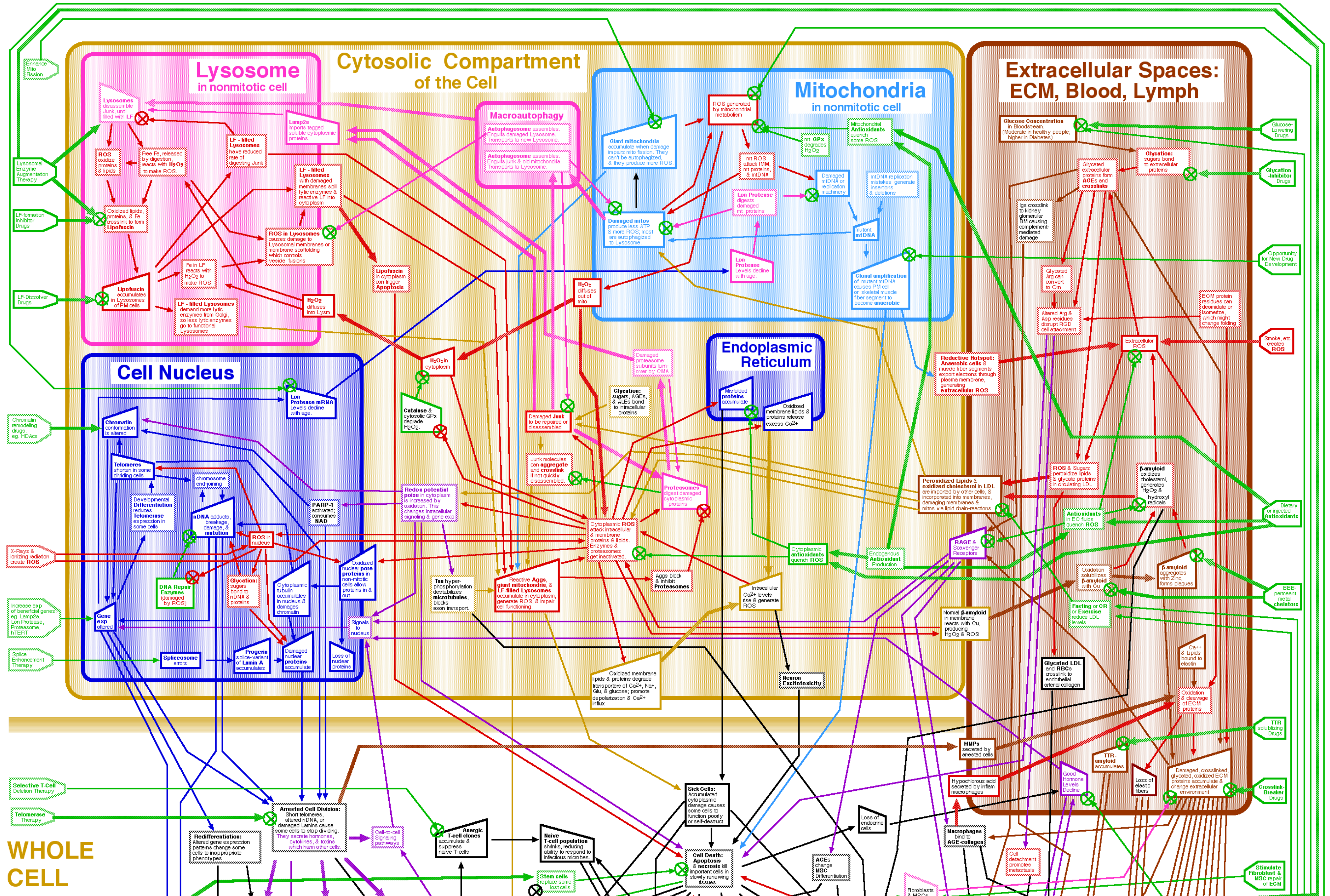


Systems Biology of Human Aging - Network Model 2009

Rev. 9 June 2009

Arrangement, text, & art by **John D. Furber**

www.LegendaryPharma.com/chartbg.html

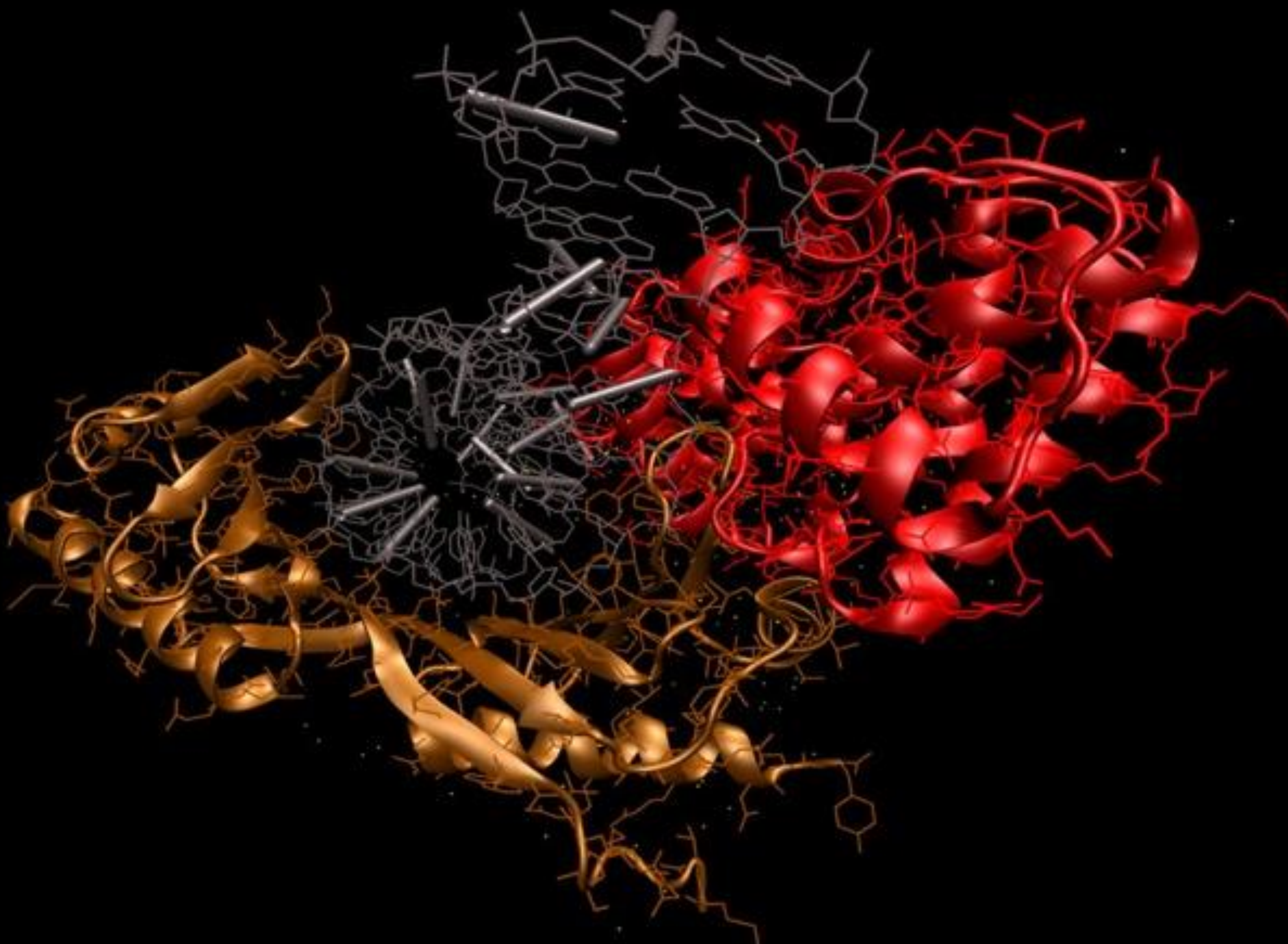


Complex Systems

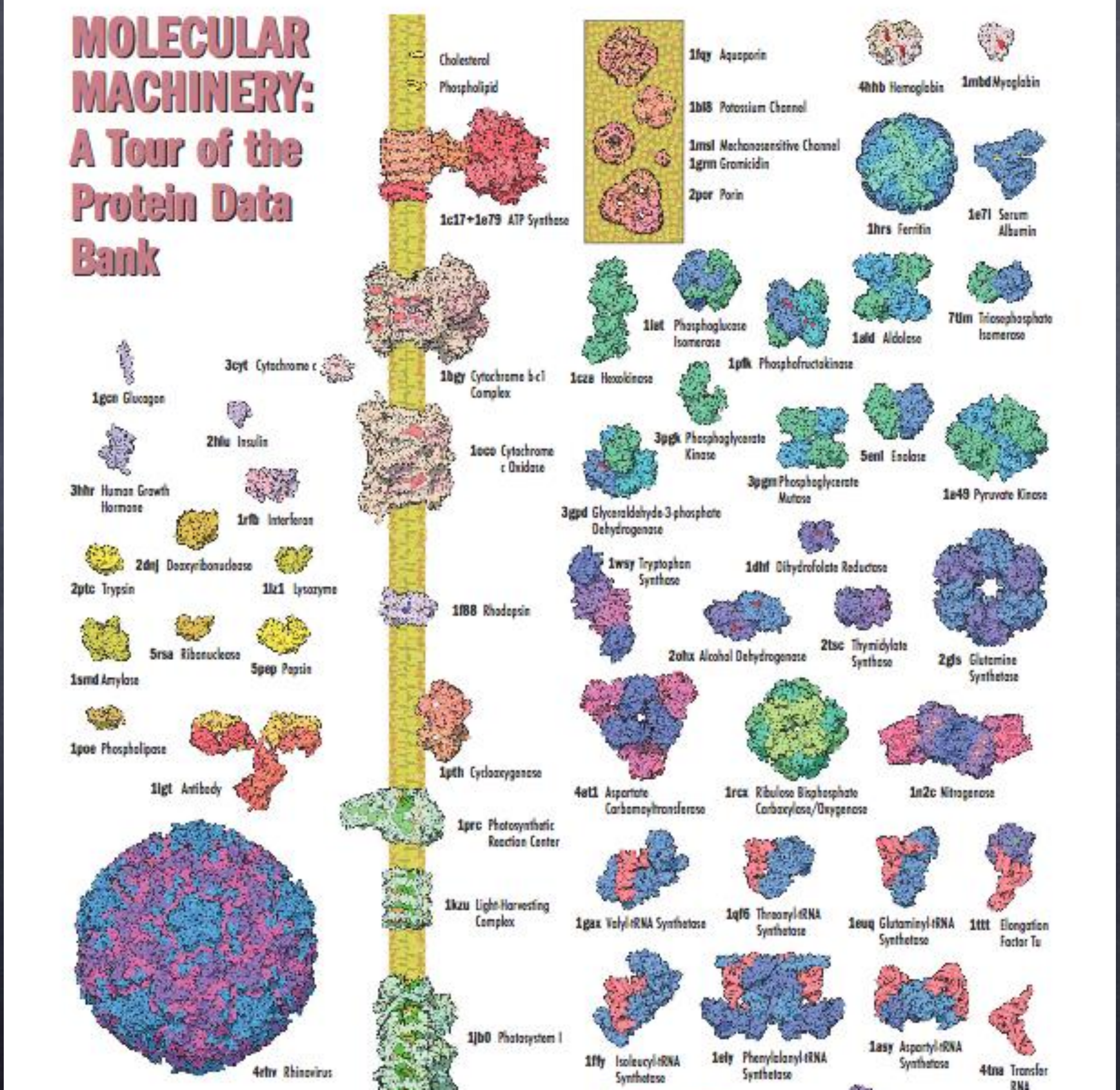
Pre-stating

“Never calculate anything until you already know the answer”

-Landau



TATA-box binding protein (TBP)

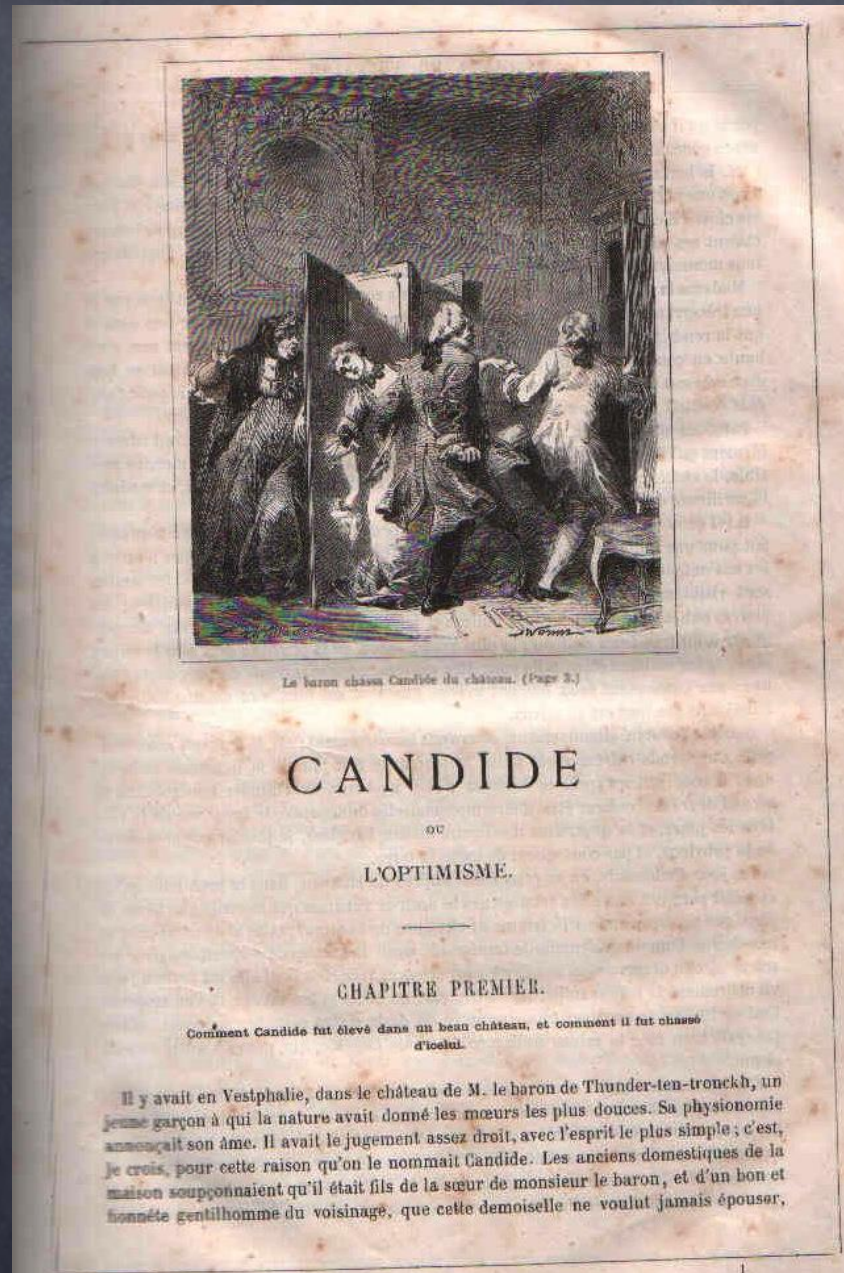

MOLECULAR MACHINERY: A Tour of the Protein Data Bank
Cholesterol
Phospholipid
1c17+1e79 ATP Synthase
1fqy Aquaporin
1bl8 Potassium Channel
1msl Mechanosensitive Channel
1grm Gramicidin
2por Porin
4hhb Hemoglobin
1mbd Myoglobin
1hrs Ferritin
1e7i Serum Albumin
3cyt Cytochrome c
1gcn Glucagon
2hiu Insulin
3hhr Human Growth Hormone
1rfb Interferon
2dnj Deoxyribonuclease
2ptc Trypsin
1lz1 Lysozyme
5rsa Ribonuclease
5pep Pepsin
1smd Amylase
1poe Phospholipase
1igt Antibody
4rhv Rhinovirus
1bgy Cytochrome b-c1 Complex
1occ Cytochrome c Oxidase
1f88 Rhodopsin
1pth Cyclooxygenase
1prc Photosynthetic Reaction Center
1kzu Light-Harvesting Complex
1jb0 Photosystem I
1iat Phosphoglucose Isomerase
1ald Aldolase
7tim Triosephosphate Isomerase
1pfk Phosphofructokinase
1cza Hexokinase
3pgk Phosphoglycerate Kinase
5enl Enolase
3pgm Phosphoglycerate Mutase
1a49 Pyruvate Kinase
3gpd Glyceraldehyde-3-phosphate Dehydrogenase
1wsy Tryptophan Synthase
1dhf Dihydrofolate Reductase
2ohx Alcohol Dehydrogenase
2tsc Thymidylate Synthase
2gls Glutamine Synthetase
4at1 Aspartate Carbamoyltransferase
1rcx Ribulose Bisphosphate Carboxylase/Oxygenase
1n2c Nitrogenase
1gax Valyl-tRNA Synthetase
1qf6 Threonyl-tRNA Synthetase
1euq Glutaminyl-tRNA Synthetase
1ttt Elongation Factor Tu
1ffy Isoleucyl-tRNA Synthetase
1eiy Phenylalanyl-tRNA Synthetase
1asy Aspartyl-tRNA Synthetase
4tna Transfer RNA

Pre-stating, non-ergodicity

Time required to create all possible 200 residue proteins at least once:

10^{67} times the lifetime universe!

Stuart Kauffman, Investigations



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Voltaire's Candide, 1759