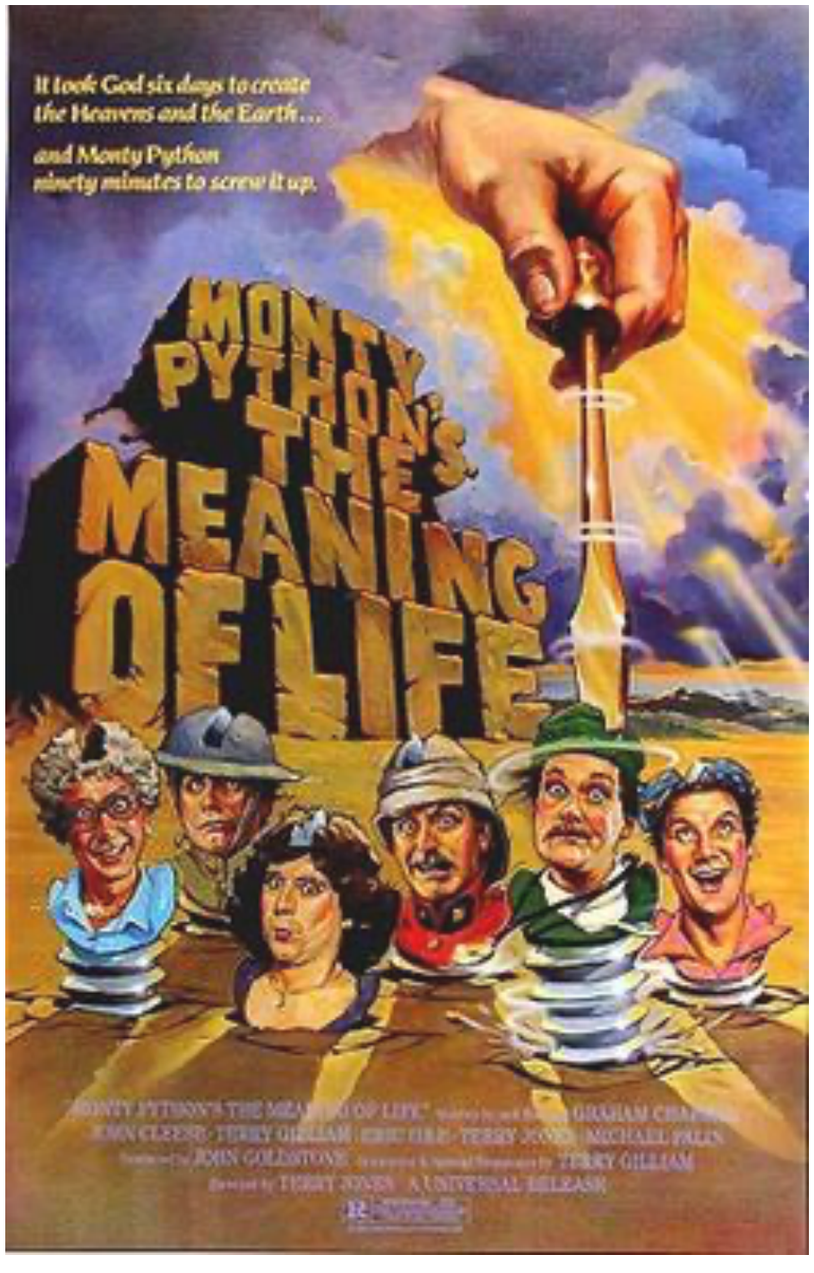
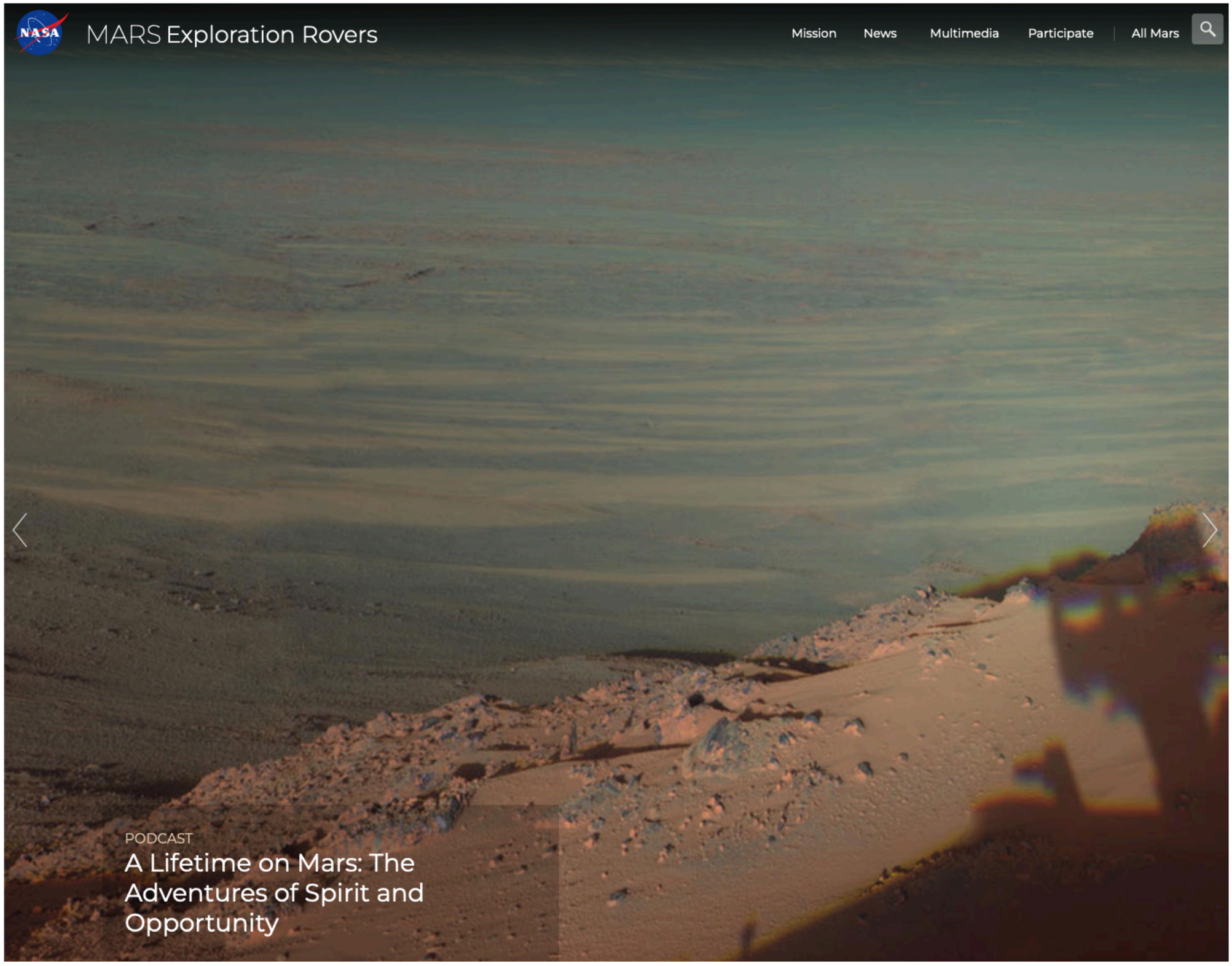
BIOL2107, Fall ’23

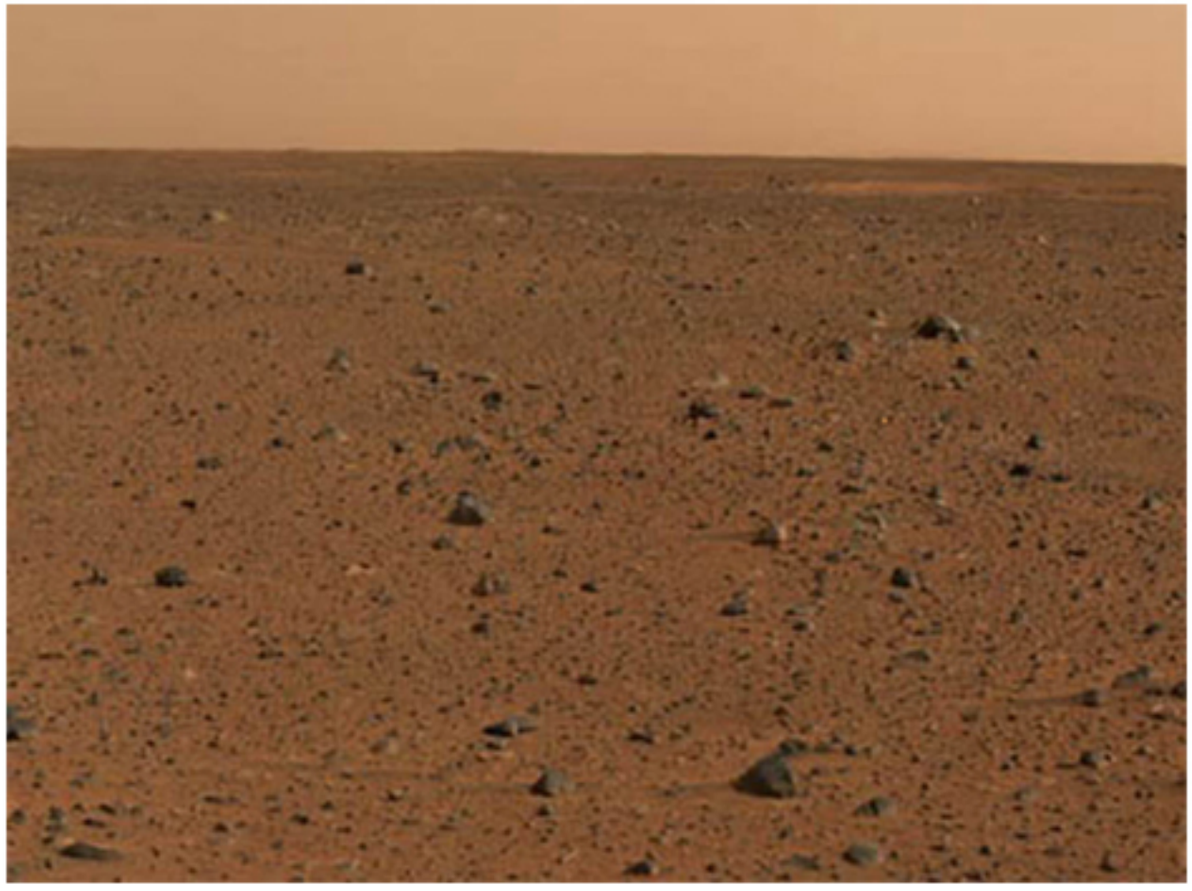


Lecture 1

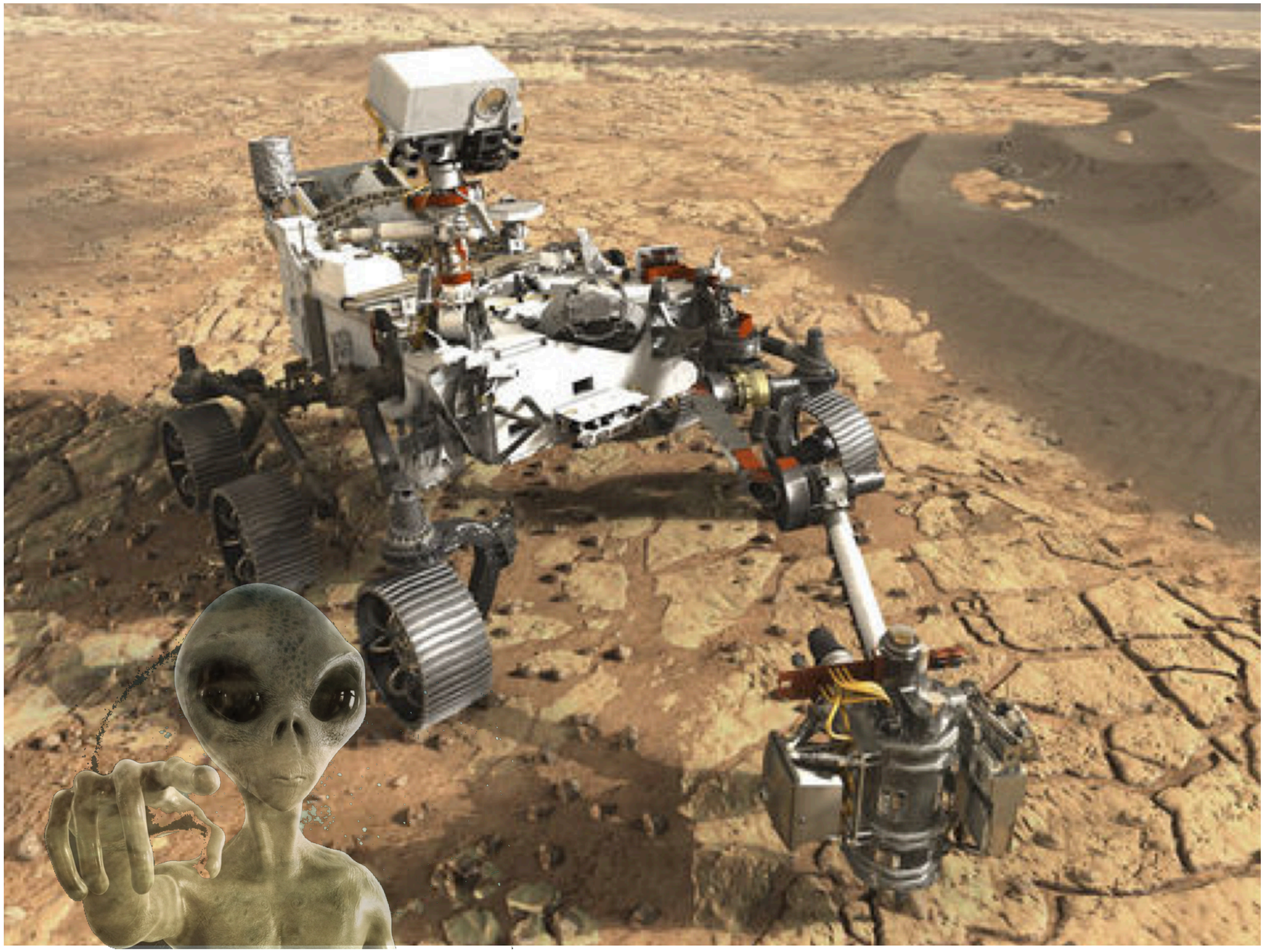
The Meaning of Life



https://mars.jpl.nasa.gov/mer/



https://mars.jpl.nasa.gov/mer/



...what is **Life**?

In the early 1960's, **James Lovelock** was invited by NASA to participate in the scientific research for evidence of life on Mars.

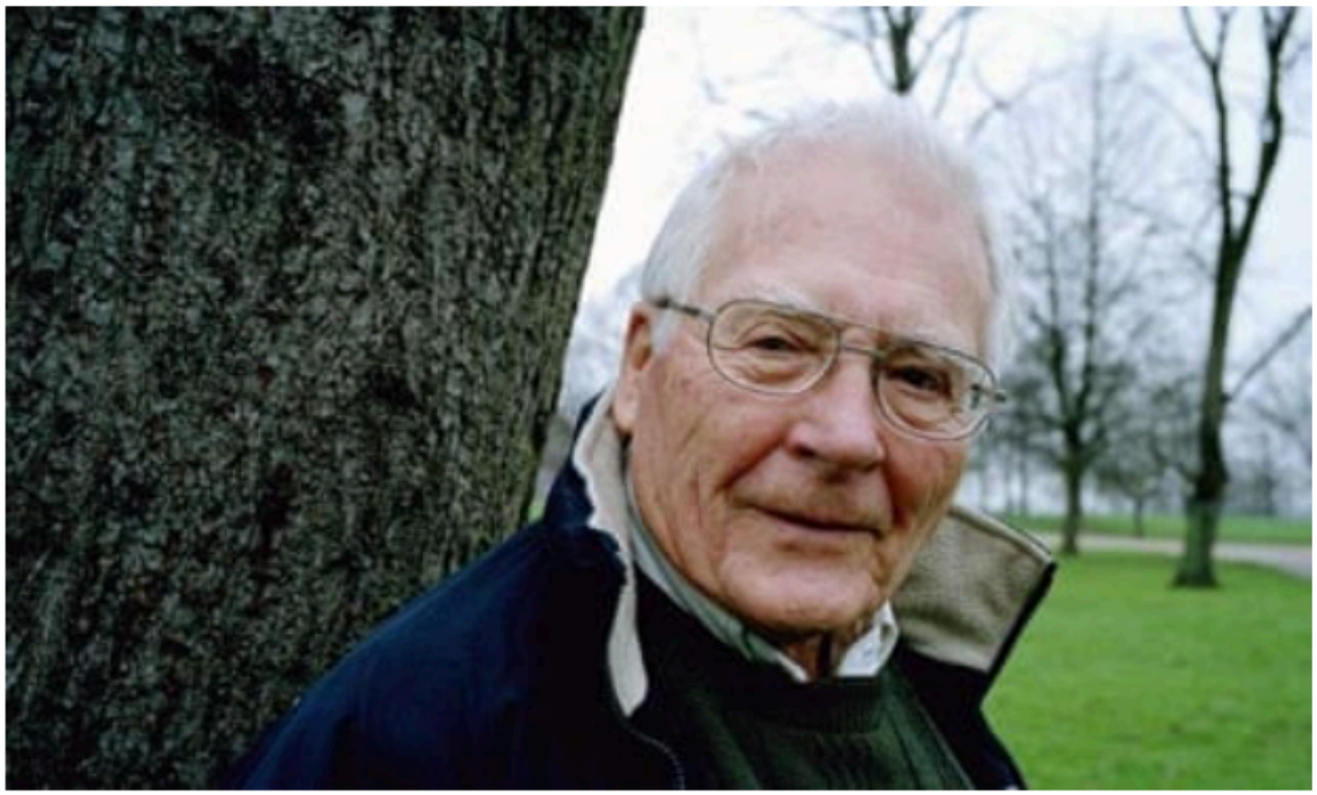
His job was to design instruments, capable of detecting the presence of life, which could be sent on a spacecraft to Mars. This wasn't straightforward, since it was hard to know what to test for: any life forms on Mars may be radically different from those on Earth.

This led him to think about what constitutes life, and how it can be detected. He decided that the most general characteristic of life was that it takes in energy and matter and discards waste products. He also reasoned that organisms would use the planet's atmosphere as a medium for this cyclic exchange, just as we breathe in oxygen and expel carbon dioxide. He speculated that life would therefore leave a detectable chemical signature on the Martian atmosphere.

David Orrell

James Lovelock: 'Enjoy life while you can: in 20 years global warming will hit the fan'

The climate science maverick believes catastrophe is inevitable, carbon offsetting is a joke and ethical living a scam. So what would he do? By Decca Aitkenhead



In 1965 executives at Shell wanted to know what the world would look like in the year 2000. They consulted a range of experts, who speculated about fusion-powered hovercrafts and "all sorts of fanciful technological stuff". When the oil company asked the scientist James Lovelock, he predicted that the main problem in 2000 would be the environment. "It will be worsening then to such an extent that it will seriously affect their business," he said.

"And of course," Lovelock says, with a smile 43 years later, "that's almost exactly what's happened."

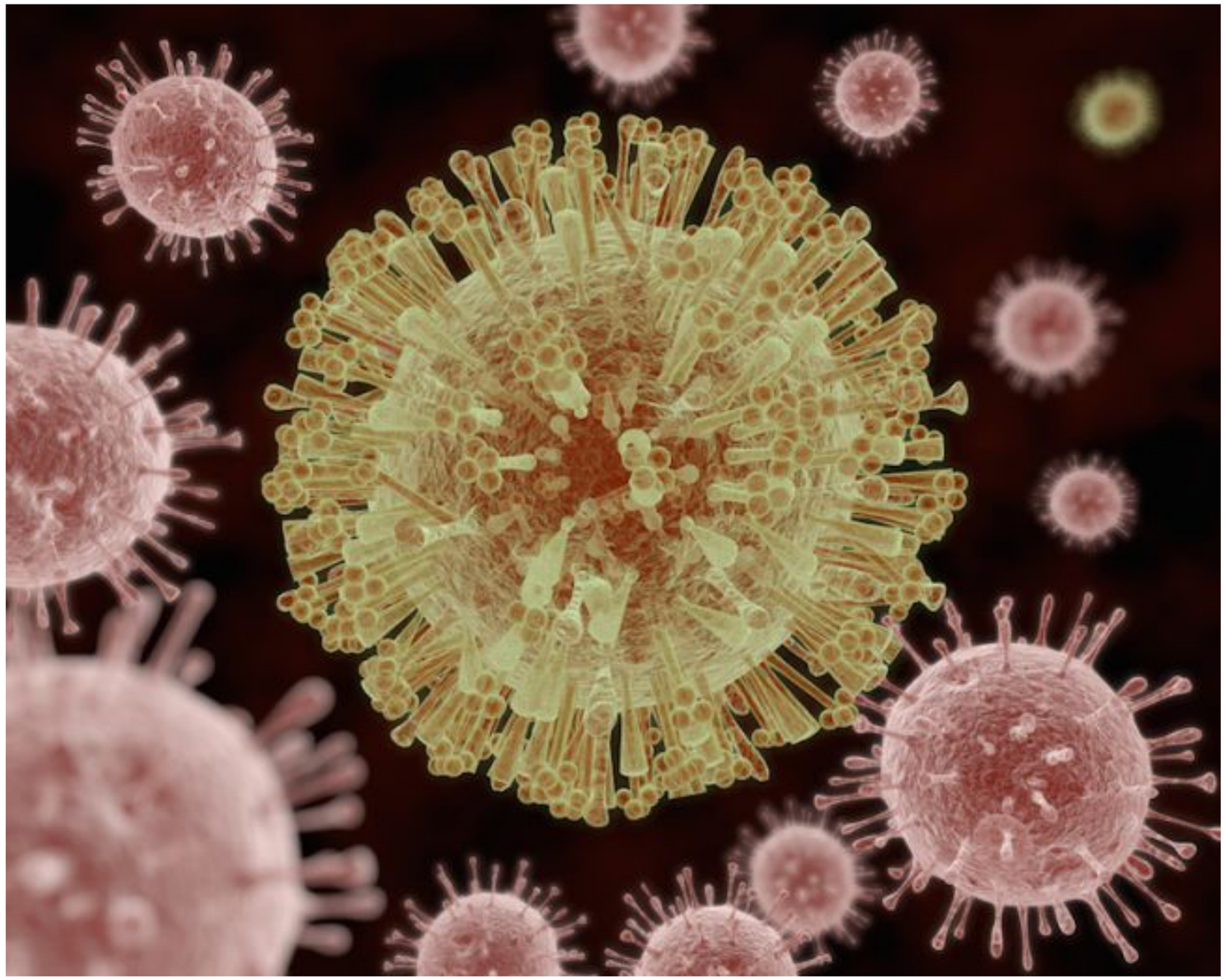
A Biologist Explains: What Is Life?

JV Chamary Contributor ⓘ
Science
I write about science and technology

'What is life?' is not simply a question for biology, but philosophy. And the answer is complicated by the fact that researchers from different fields have differing opinions on what they believe ought to be included in a definition. Philosopher Edouard Machery discussed the problem and presented it as a Venn diagram with circles for three groups -- evolutionary biologists, astrobiologists and artificial-life researchers -- using hypothetical features upon which they would converge (some biologists think viruses are alive while others believe the cell is essential, so assuming members would agree is controversial).

Are Viruses Alive?

By Laura Geggel - Associate Editor February 25, 2017



Something that is not alive, such as a virus, does not have “self-generated“ or “self-sustaining” actions, he said.

"I don't think viruses qualify as being alive. They are, in essence, inert unless they come into contact with a living cell," Adalja said. "There are some characteristics of viruses that put them on the borderline [of being alive] — they have genetic material: DNA or RNA. It's not the same thing as a rock, but it's clearly not the same thing as even bacteria, in terms of that self-sustaining and self-generated action."

https://www.livescience.com/58018-are-viruses-alive.html

Published: 06 August 2008

'Virophage' suggests viruses are alive

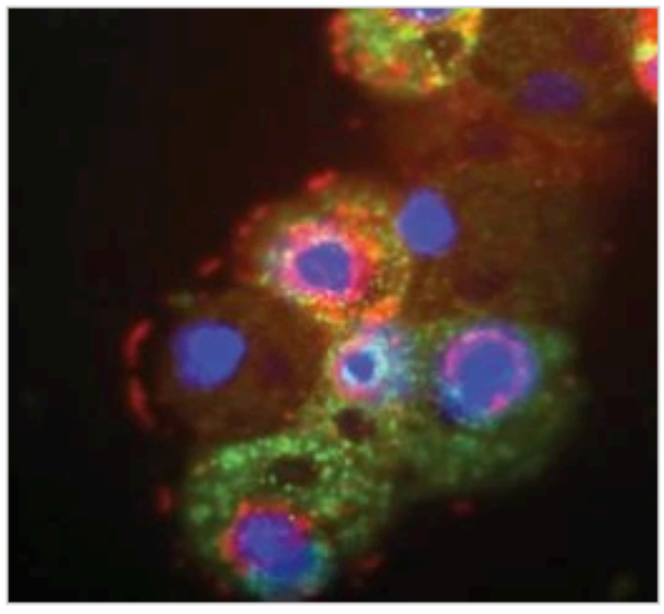
Helen Pearson

Nature **454**, 677 (2008) | Cite this article

Evidence of illness enhances case for life.

The discovery of a giant virus that falls ill through infection by another virus[1] is fuelling the debate about whether viruses are alive.

"There's no doubt this is a living organism," says Jean-Michel Claverie, a virologist at the the CNRS UPR laboratories in Marseilles, part of France's basic-research agency. "The fact that it can get sick makes it more alive."



Giant mamavirus particles (red) and satellite viruses of mamavirus called Sputnik (green). Credit: REF. 1

The “Major Oak” is thought to be between 800 and 1,000 years old.
Legend has it that the ancient oak not only provided Robin Hood with shelter, it was also the place where he and his “Merry Men” allegedly slept.

The Major Oak may be several trees that fused together as saplings

The **Pechanga Great Oak** a coastal live oak located on a reserve near Temecula, California, USA

ANIMALS

A worm that survived 46,000 years in permafrost wows scientists

July 30, 2023 · 5:00 AM ET

Emma Bowman

A *Panagrolaimus kolymaensis* nematode is seen under the microscope at the University of Cologne's worm lab in Germany.

Video by Laura Villegas/screenshot by NPR

A Biologist Explains: What Is Life?

JV Chamary Contributor ⓘ
Science
I write about science and technology

'What is life?' is not simply a question for biology, but philosophy. And the answer is complicated by the fact that researchers from different fields have differing opinions on what they believe ought to be included in a definition. Philosopher Edouard Machery discussed the problem and presented it as a Venn diagram with circles for three groups -- evolutionary biologists, astrobiologists and artificial-life researchers -- using hypothetical features upon which they would converge (some biologists think viruses are alive while others believe the cell is essential, so assuming members would agree is controversial). Machery claimed that no criteria could fall within the overlap of all three circles, concluding that "the project of defining life is either impossible or pointless."

A list of features will also mention what life does -- processes like **growth, reproduction, ability to adapt and metabolism (chemical reactions whose energy drives biological activity)**.

Such views are echoed by experts such as biochemist Daniel Koshland, who listed his seven pillars of life as program, **improvisation, compartmentalization, energy, regeneration, adaptability and seclusion.**

https://www.forbes.com/sites/jvchamary/2019/03/27/what-is-life/#6524949d1c77

Published: 29 January 2011

Why I stopped worrying about the definition of life… and why you should as well

Edouard Machery

Synthese **185**, 145–164 (2012) | Cite this article

Abstract

In several disciplines within science—evolutionary biology, molecular biology, astrobiology, synthetic biology, artificial life—and outside science—primarily ethics—efforts to define life have recently multiplied. However, no consensus has emerged. In this article, I argue that this is no accident. I propose a dilemma showing that the project of defining life is either impossible or pointless. The notion of life at stake in this project is either the folk concept of life or a scientific concept. In the former case, empirical evidence shows that life *cannot* be defined. In the latter case, I argue that, although defining life may be possible, it is *pointless*. I conclude that scientists, philosophers, and ethicists should discard the project of defining life.

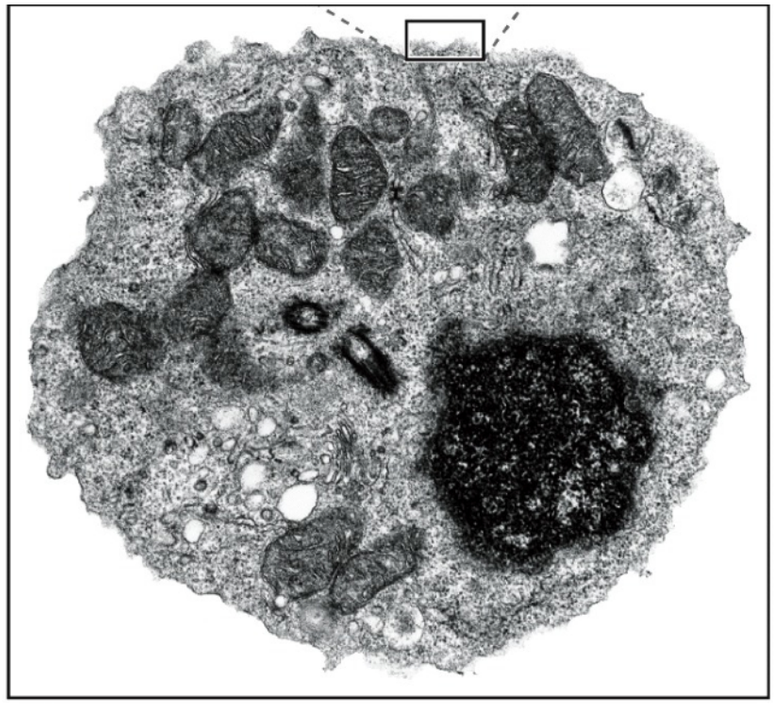
Animate or inanimate objects, living or dead organisms…

All living organisms adhere to the same chemical and physical laws

A Scientific Law is:

"a descriptive generalization about how some aspect of the natural world behaves under stated circumstances".

So how is "Life" ultimately defined…



Transmission electron micrograph of a cell

Figure 1.14
Biology: How Life Works

Living Organisms…

Biochemistry of Living forms "C H O N P S"

1 H 1.0079																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
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
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 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.4778	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.4	47 Ag 107.870	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	71 Lu 174.97	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	103 Lr (260)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 (269)	111 (272)	112 (277)	113	114 (285)	115 (289)	116	117	118 (293)

Chemical symbol
Atomic number
Atomic mass
(average of all isotopes)

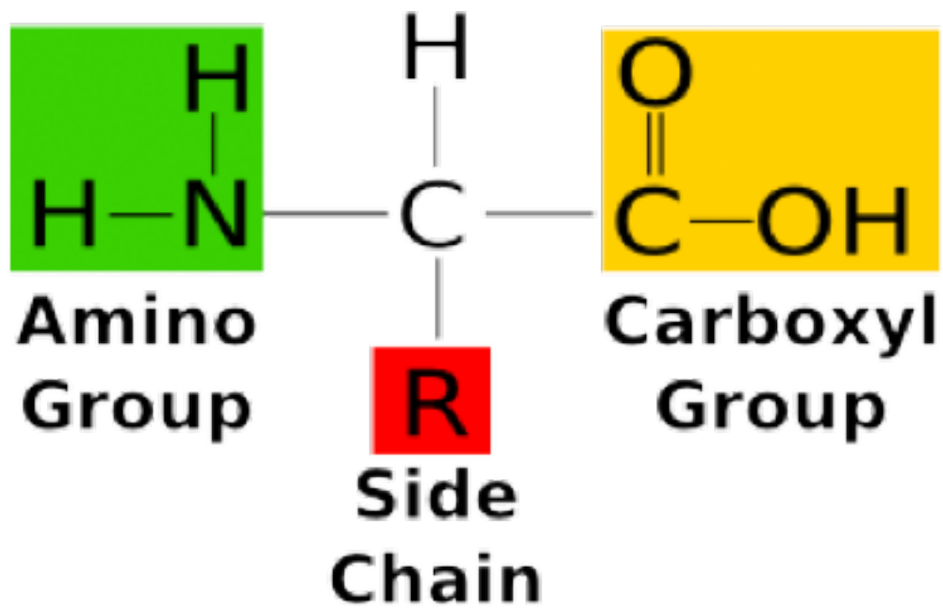
Lanthanide series	57 La 138.906	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04
Actinide series	89 Ac 227.028	90 Th 232.038	91 Pa 231.0359	92 U 238.02	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)

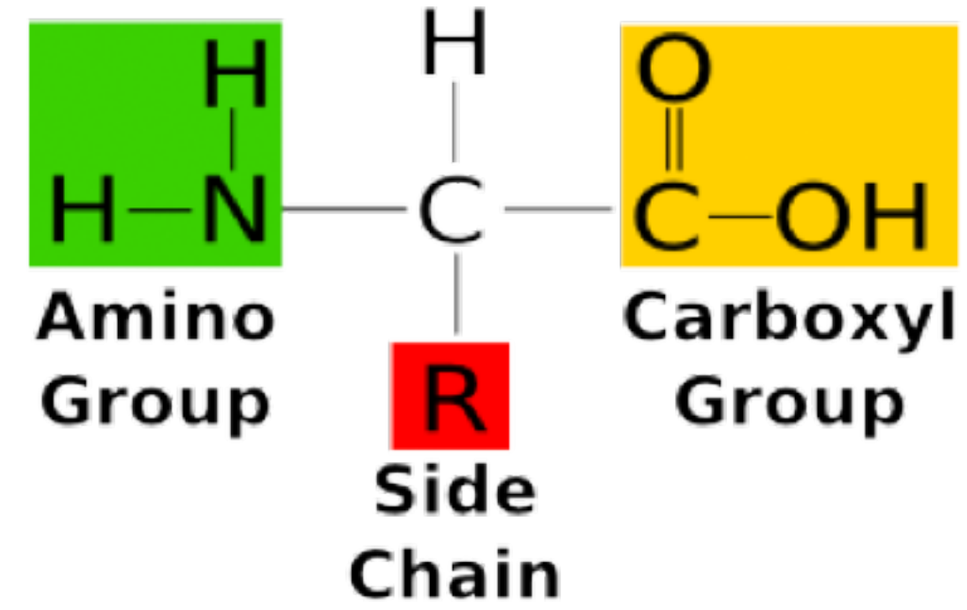
..nowadays 118

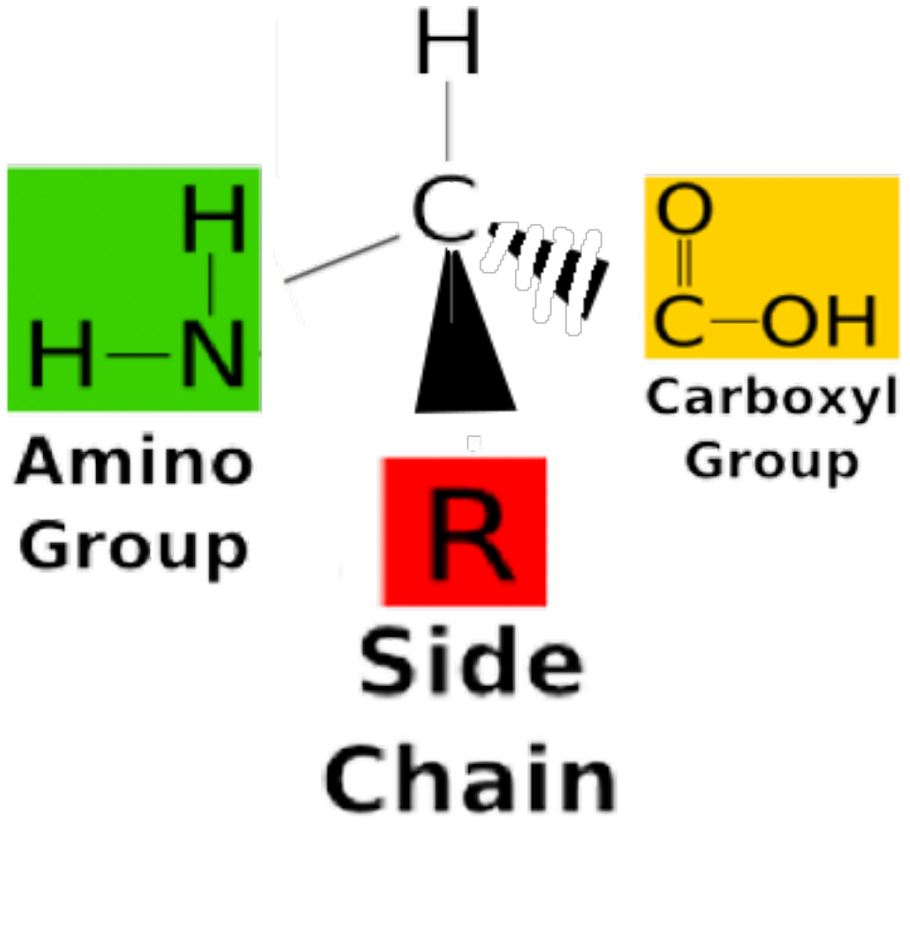
Which side of the Stage coach was the driver?

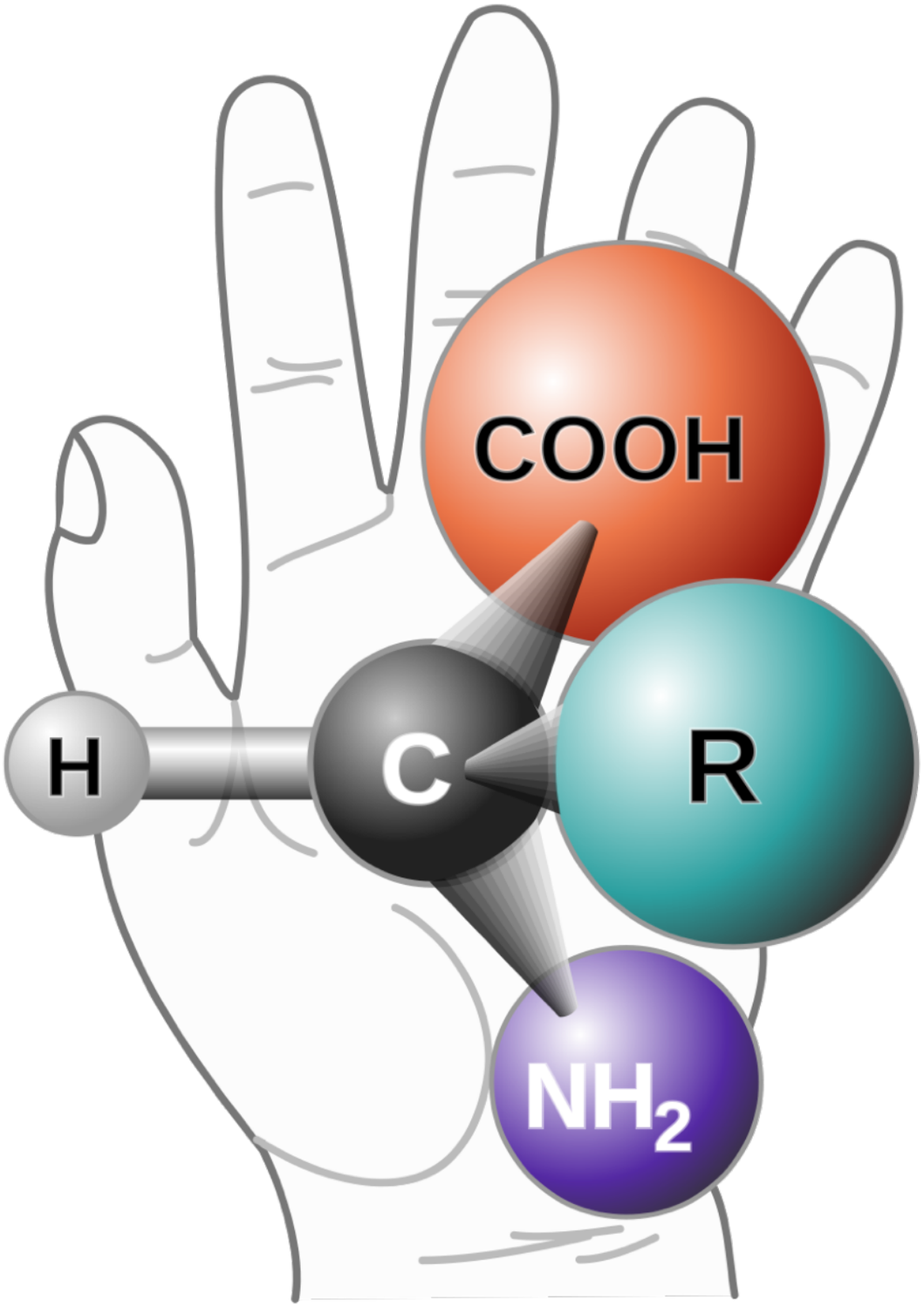
Who is “more” correct?

The importance of a “handshake”


H
H
H
N
C
O
C
OH
Amino
Group
R
Carboxyl
Group
Side
Chain

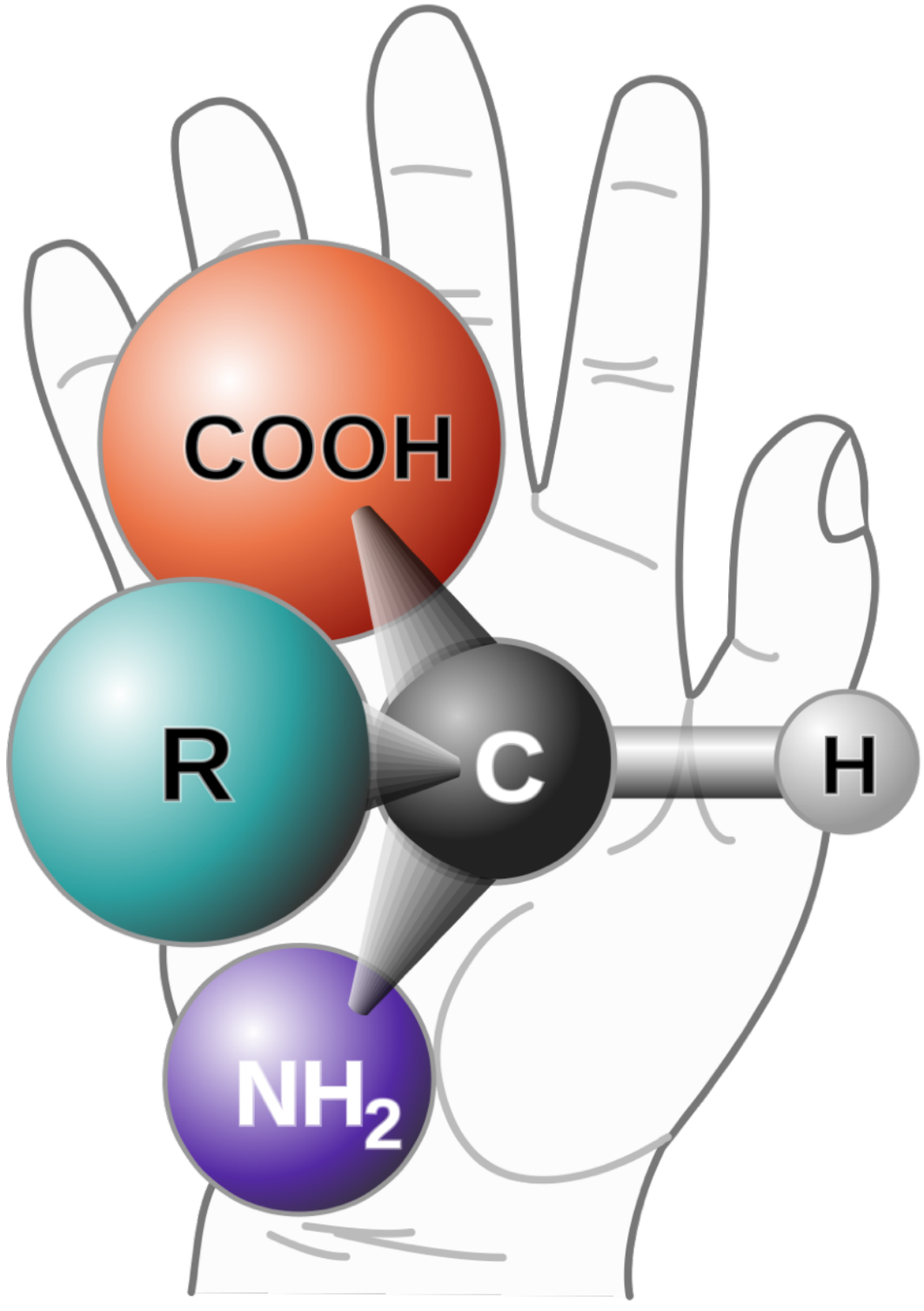

H
H
H—N
C
O
C—OH
Amino
Group
R
Carboxyl
Group
Side
Chain


H
H
H—N
C
O
C—OH
Amino
Group
R
Carboxyl
Group
Side
Chain



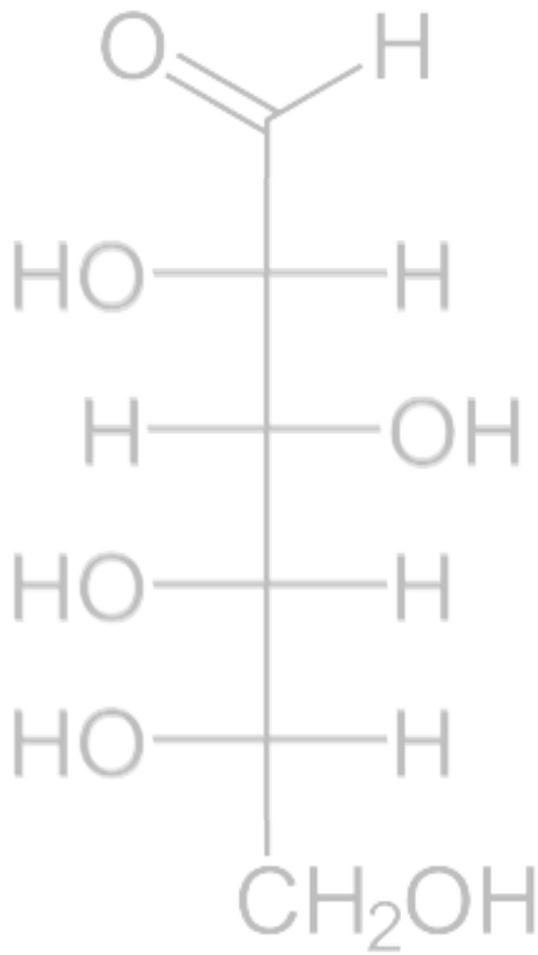
Left

Laevo

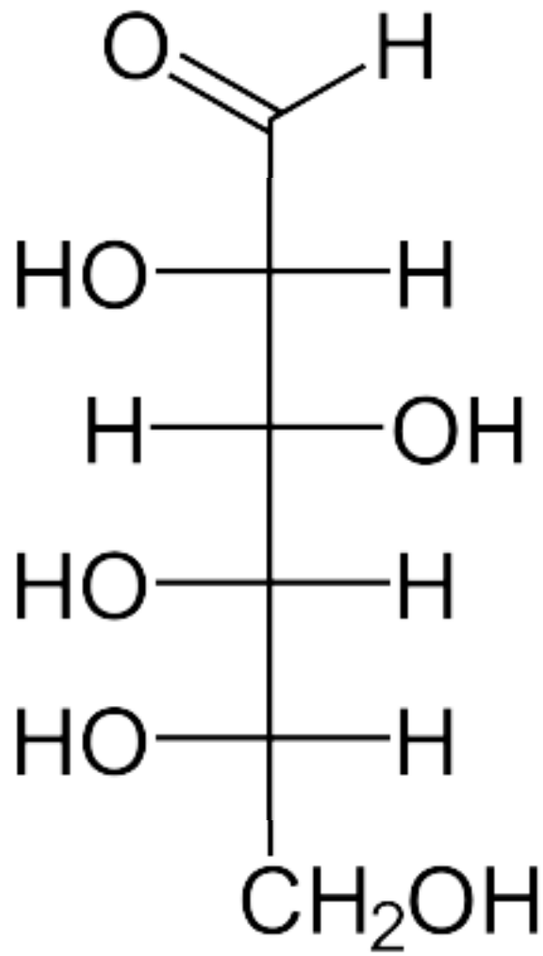


Right

Dextro



L-Glucose



D-Glucose

Stanford Report, October 17, 2007

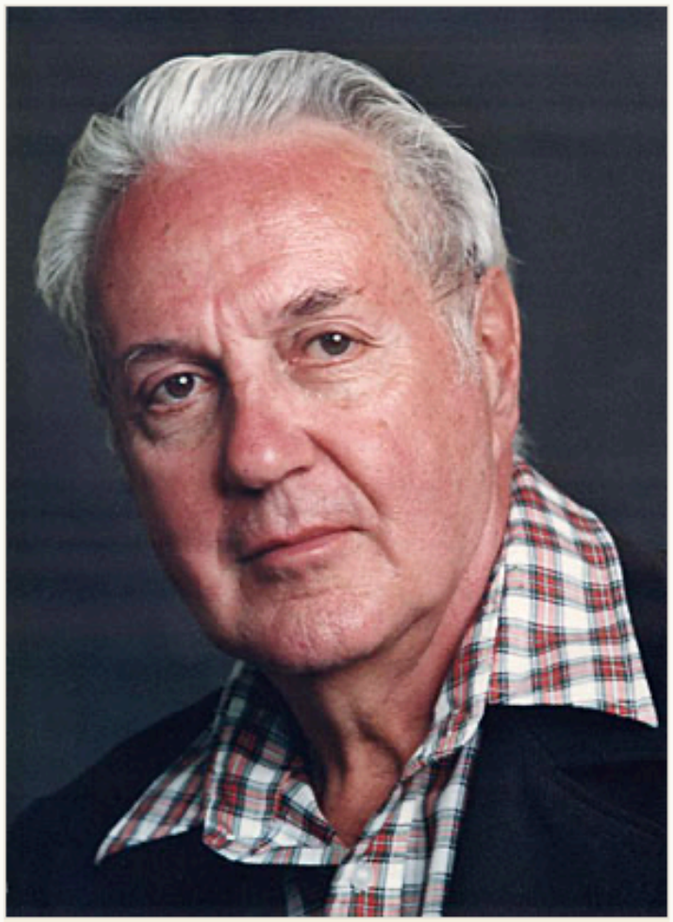
William Bonner, professor emeritus of chemistry, dead at 87

BY LOUIS BERGERON

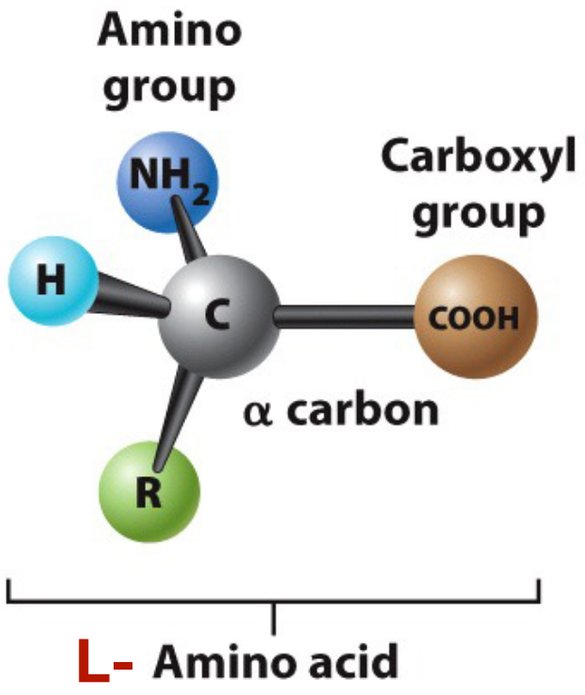
William A. Bonner, professor emeritus of chemistry at Stanford University, died Oct. 1 at Cedar Crest Nursing and Rehabilitation Center in Sunnyvale, where he had been recuperating from heart failure. He was 87.

A member of the Stanford chemistry faculty for 37 years, his research interests centered on organic chemistry. In particular, he was intrigued with the question of how amino acids, the building blocks of proteins, developed the consistent structural asymmetry that enables proteins to fold themselves into the living structures that are the basis for all life on Earth.

Some organic molecules are asymmetric and characterized as either left-handed or right-handed, according to the orientation of the arrangement of atoms relative to the carbon core of the molecule. But while for most asymmetric molecules nature produces equal numbers of each orientation, the essential amino acids—and the proteins built of them—are almost exclusively left-handed. Why this should be so has puzzled scientists since its discovery.



William Bonner


Amino group
NH2
Carboxyl group
H
C
COOH
α carbon
R
L- Amino acid

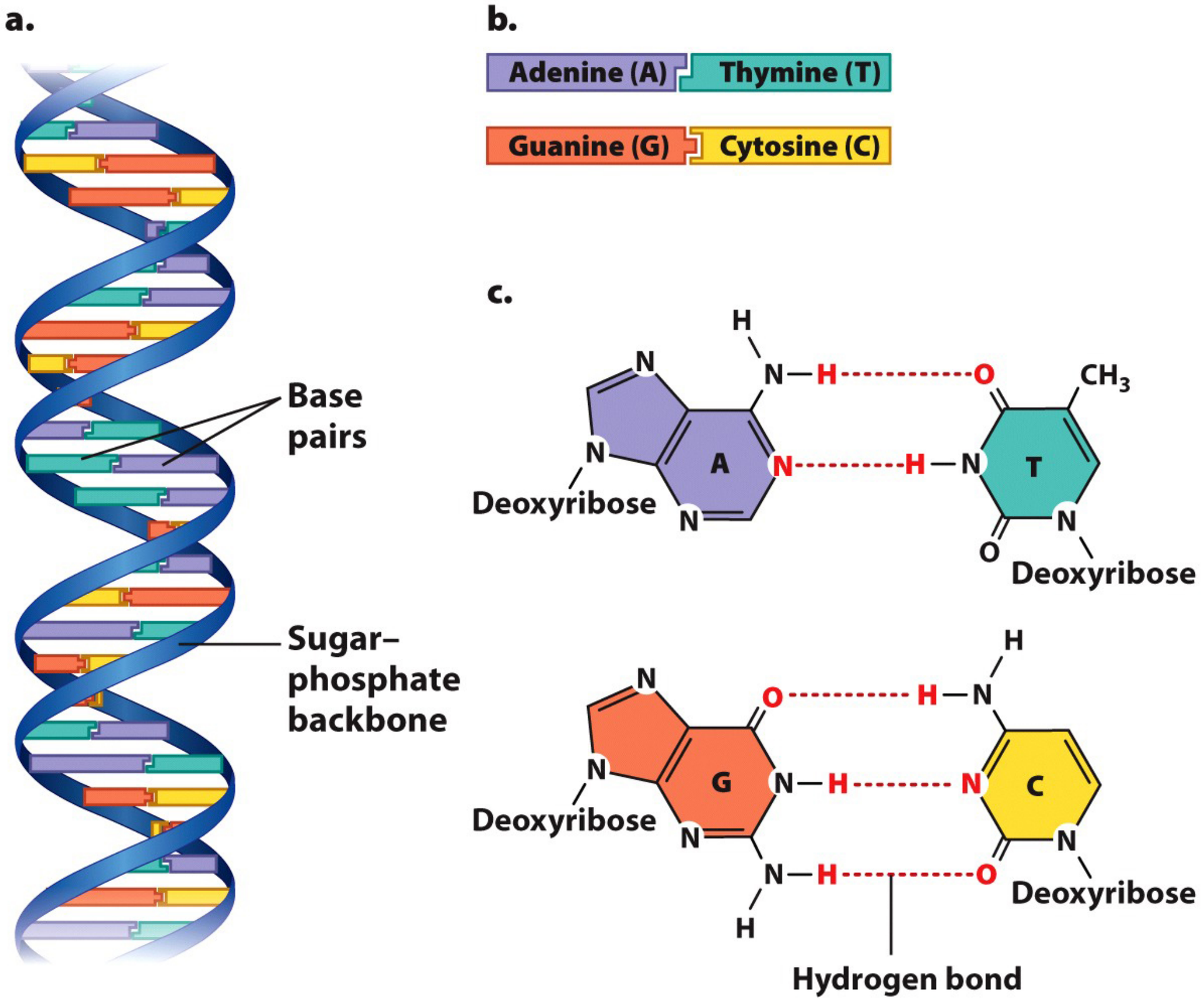


Figure 2.21
Biology: How Life Works

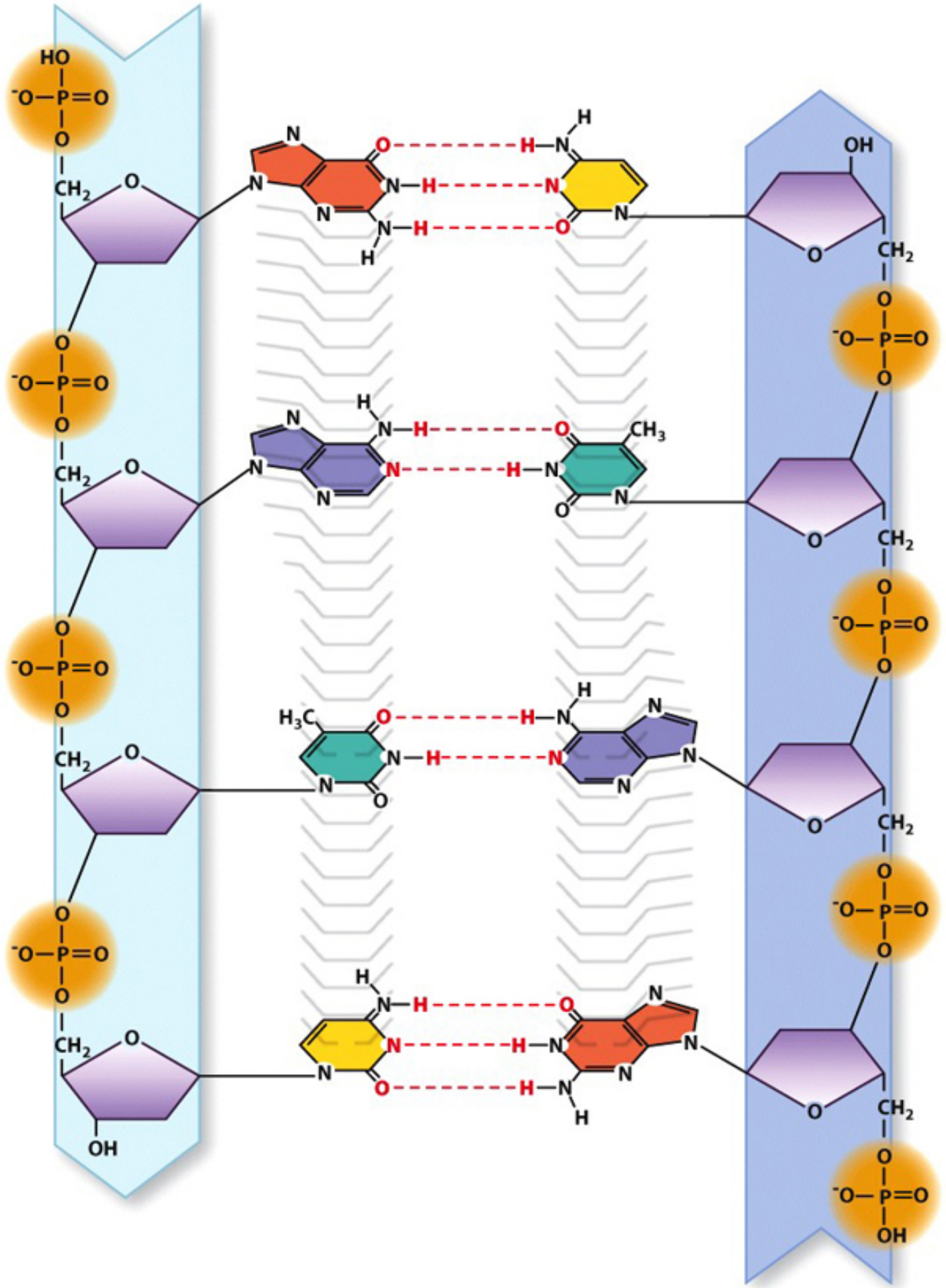
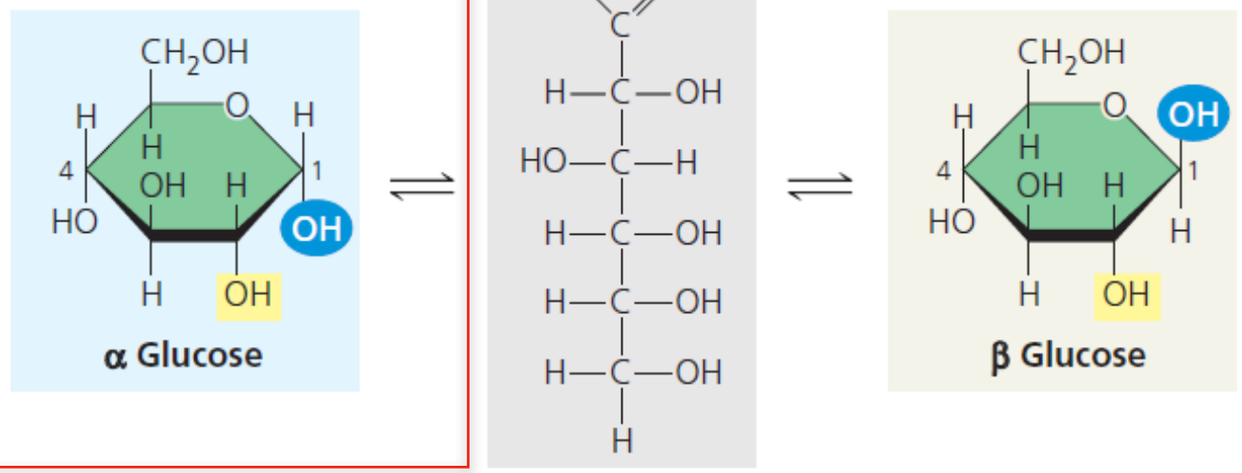
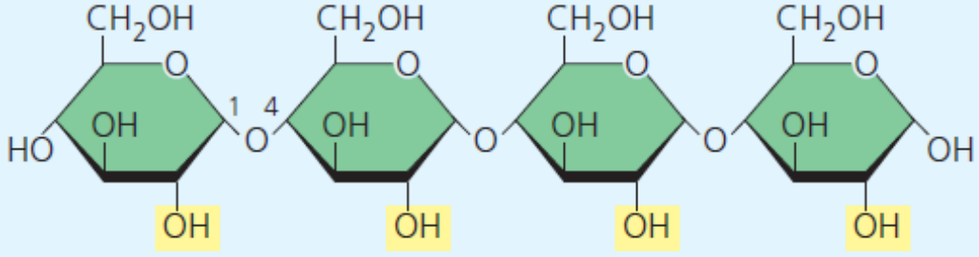


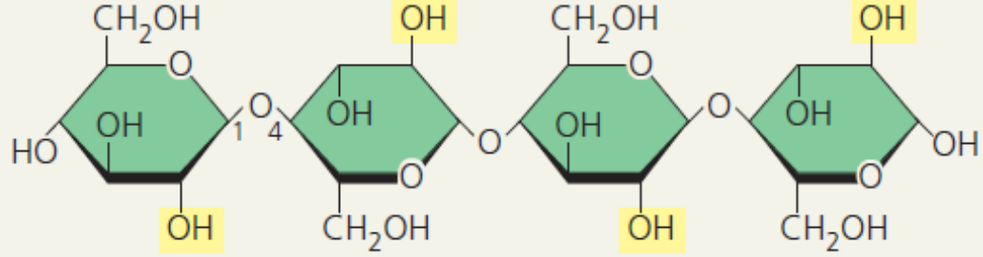
Figure 3.10
Biology: How Life Works

(a) **α and β glucose ring structures.** These two interconvertible forms of glucose differ in the placement of the hydroxyl group (highlighted in blue) attached to the number 1 carbon.





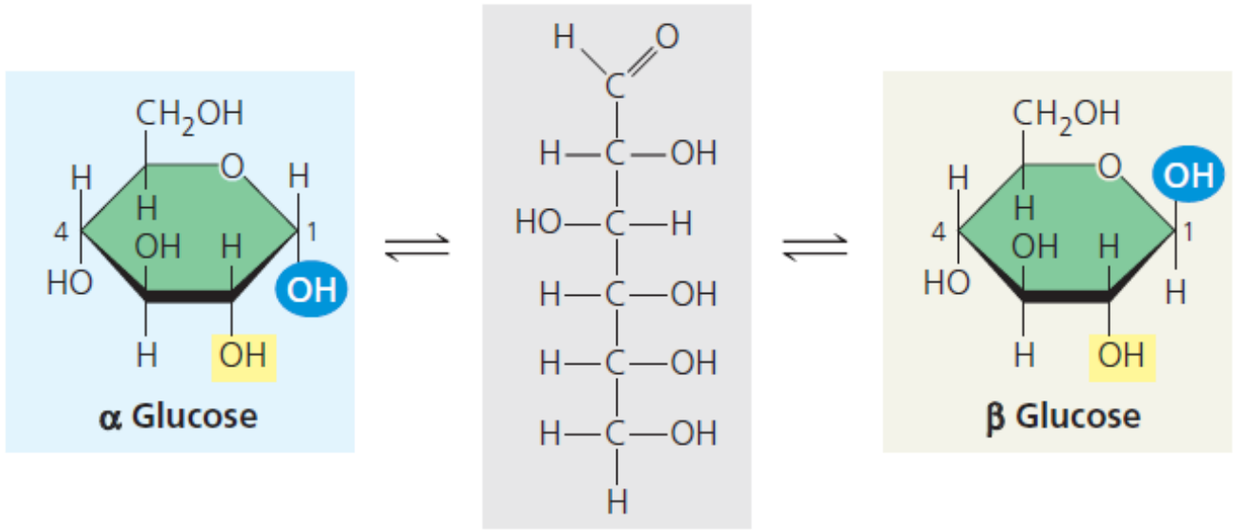
(b) **Starch: 1–4 linkage of α glucose monomers.** All monomers are in the same orientation. Compare the positions of the —OH groups highlighted in yellow with those in cellulose (c).

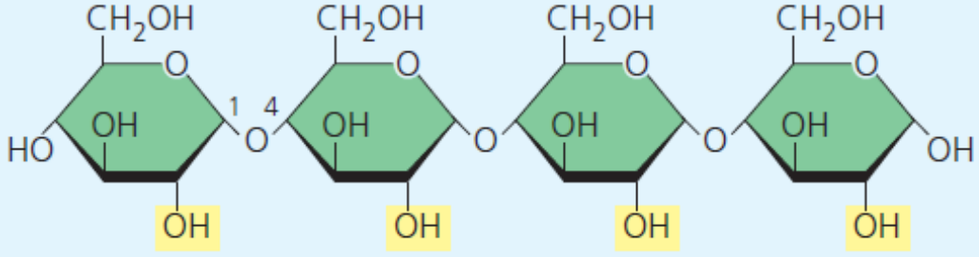


(c) **Cellulose: 1–4 linkage of β glucose monomers.** In cellulose, every β glucose monomer is upside down with respect to its neighbors. (See the highlighted —OH groups.)

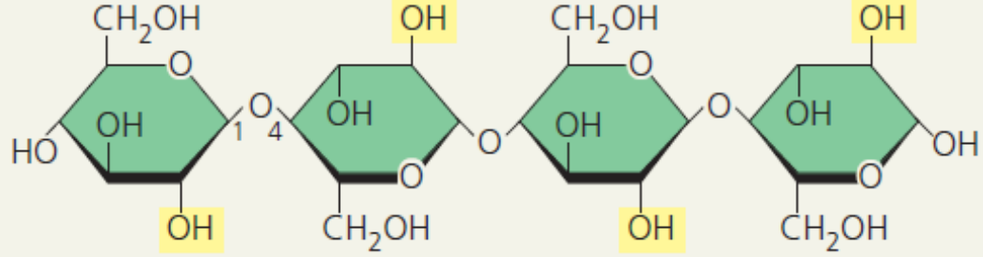
▲ **Figure 5.7** **Starch and cellulose structures.**

(a) **α and β glucose ring structures.** These two interconvertible forms of glucose differ in the placement of the hydroxyl group (highlighted in blue) attached to the number 1 carbon.





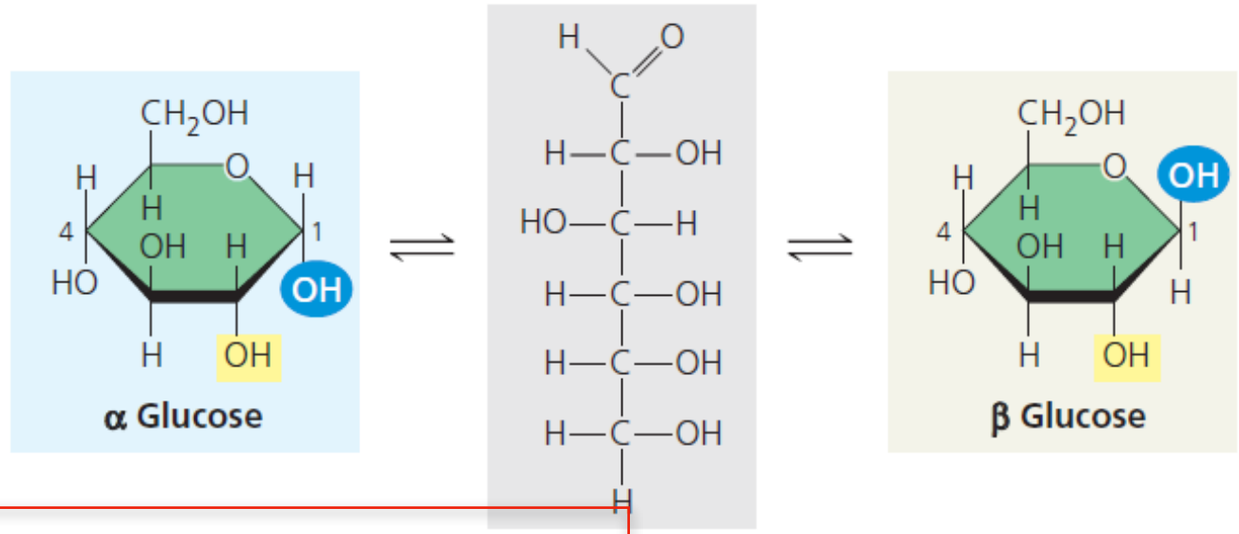
(b) **Starch: 1–4 linkage of α glucose monomers.** All monomers are in the same orientation. Compare the positions of the —OH groups highlighted in yellow with those in cellulose (c).

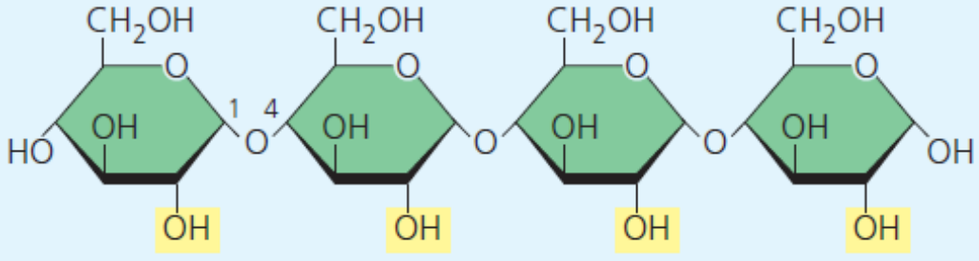


(c) **Cellulose: 1–4 linkage of β glucose monomers.** In cellulose, every β glucose monomer is upside down with respect to its neighbors. (See the highlighted —OH groups.)

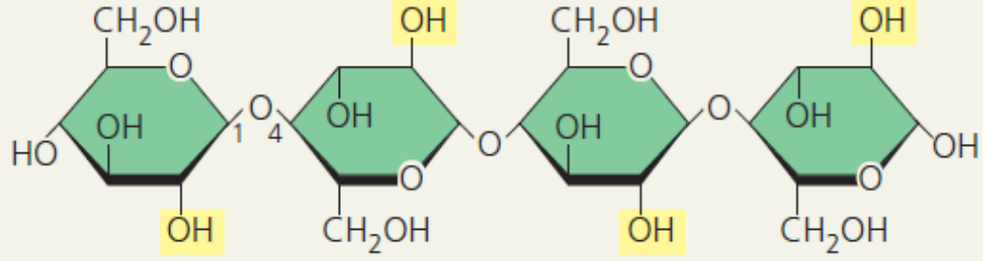
▲ **Figure 5.7** **Starch and cellulose structures.**

(a) **α and β glucose ring structures.** These two interconvertible forms of glucose differ in the placement of the hydroxyl group (highlighted in blue) attached to the number 1 carbon.





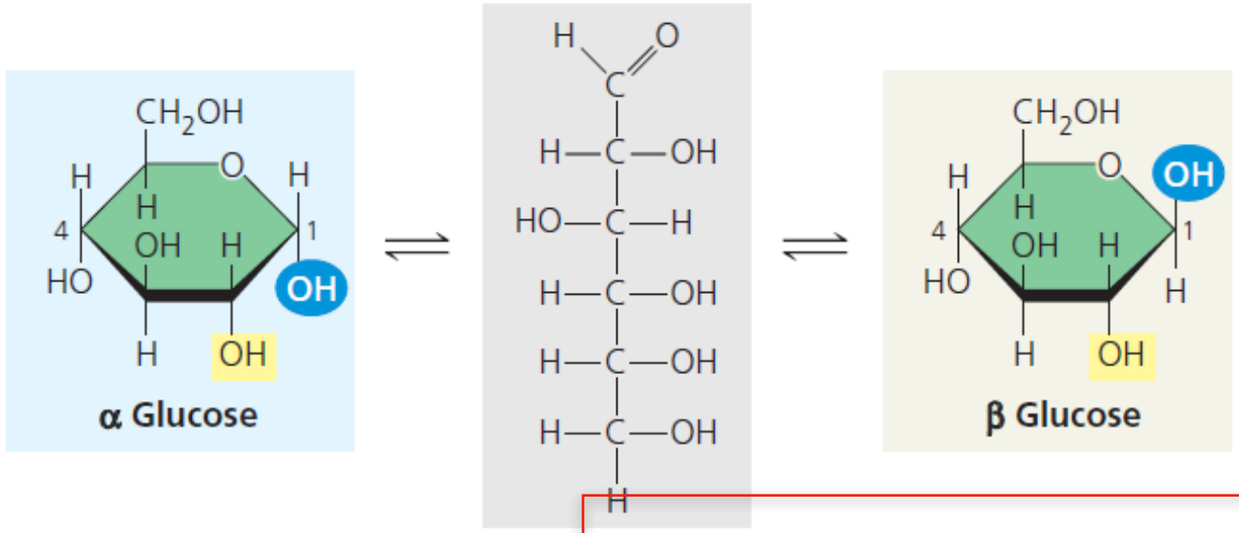
(b) Starch: 1–4 linkage of α glucose monomers. All monomers are in the same orientation. Compare the positions of the —OH groups highlighted in yellow with those in cellulose (c).

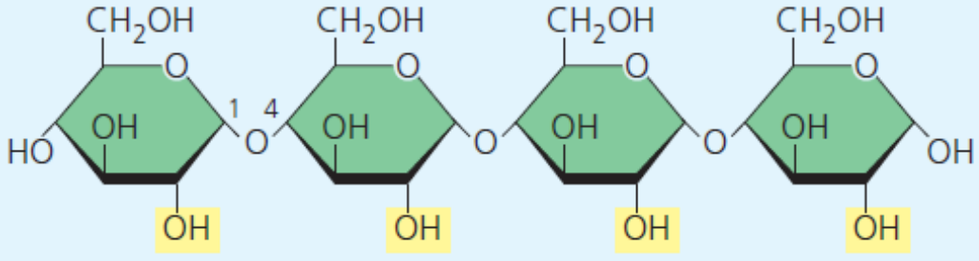


(c) Cellulose: 1–4 linkage of β glucose monomers. In cellulose, every β glucose monomer is upside down with respect to its neighbors. (See the highlighted —OH groups.)

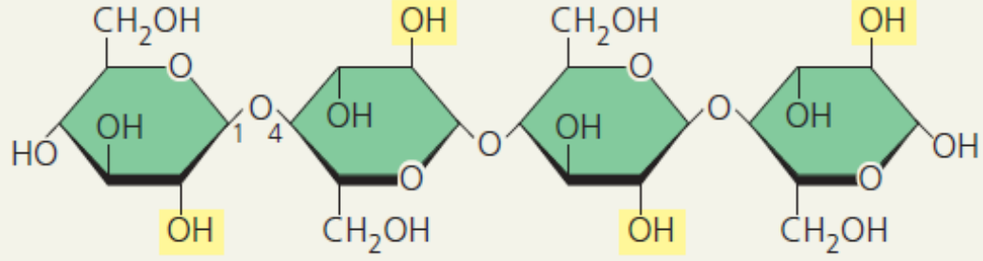
▲ **Figure 5.7** **Starch and cellulose structures.**

(a) **α and β glucose ring structures.** These two interconvertible forms of glucose differ in the placement of the hydroxyl group (highlighted in blue) attached to the number 1 carbon.



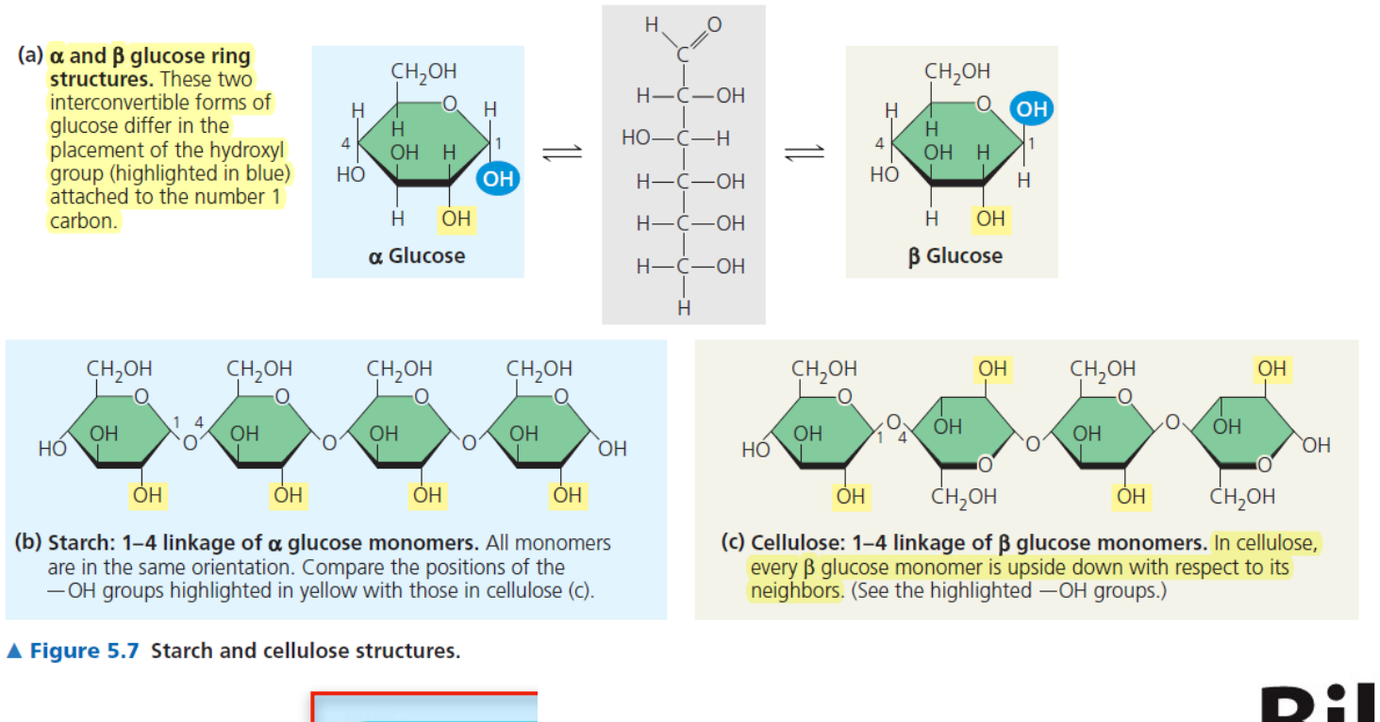


(b) **Starch: 1–4 linkage of α glucose monomers.** All monomers are in the same orientation. Compare the positions of the —OH groups highlighted in yellow with those in cellulose (c).



(c) **Cellulose: 1–4 linkage of β glucose monomers.** In cellulose, every β glucose monomer is upside down with respect to its neighbors. (See the highlighted —OH groups.)

▲ **Figure 5.7** **Starch and cellulose structures.**



▲ **Figure 5.7** Starch and cellulose structures.

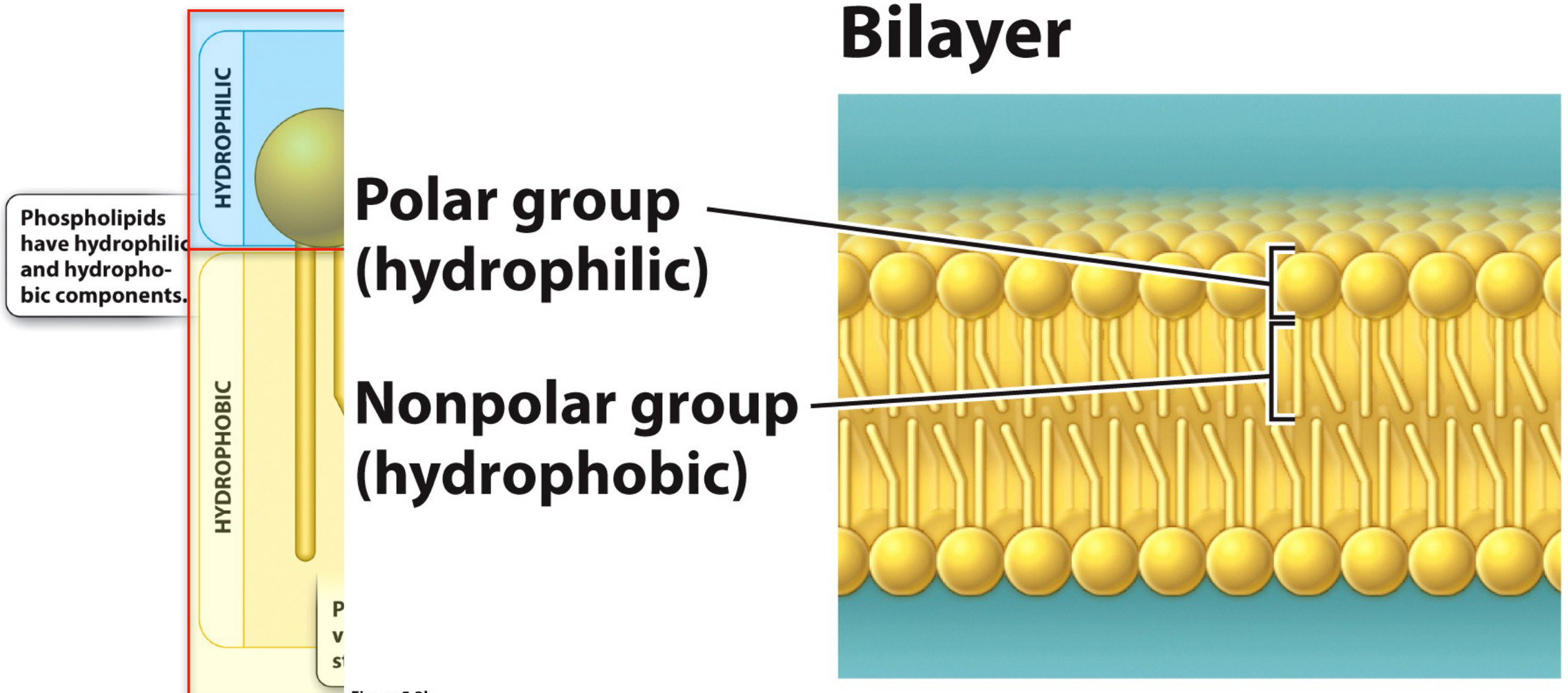
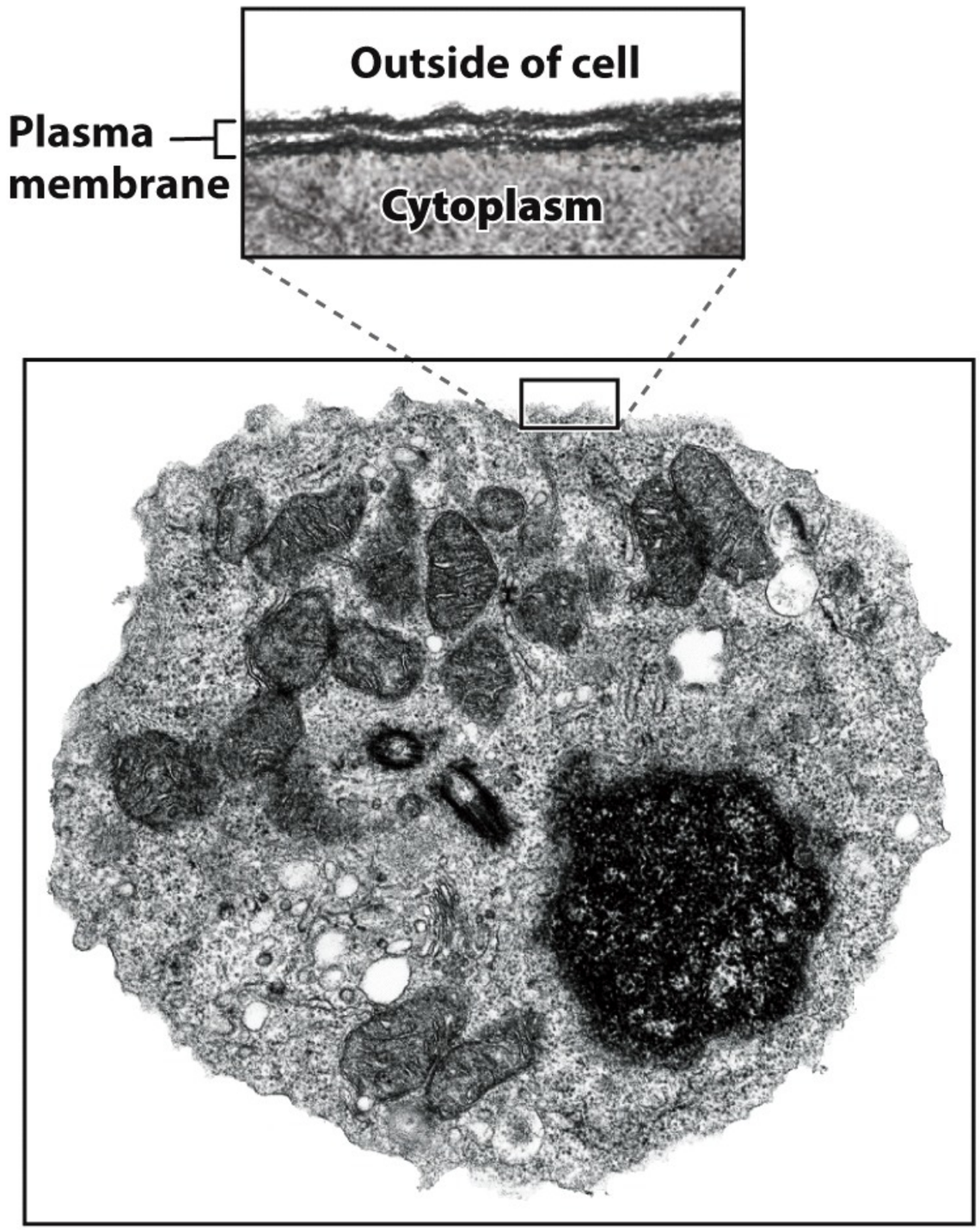


Figure 5.2
Biology: How Life Works

Figure 5.3b
Biology: How Life Works



Transmission electron micrograph of a cell

Figure 1.14
Biology: How Life Works

Some of the “facts” of Life…?

(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.

Some of the “facts” of Life…?

(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.

Some of the “facts” of Life…?

(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.

Some of the “facts” of Life…?

(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.

Some of the “facts” of Life…?

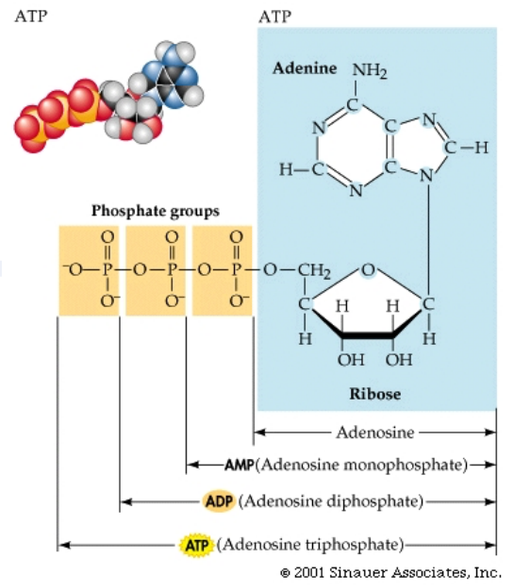
(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

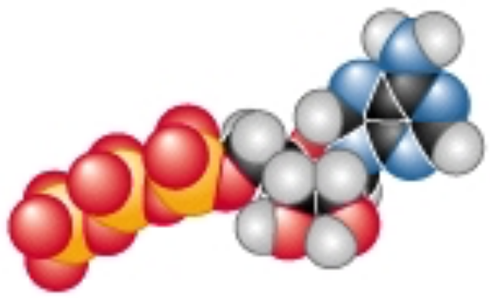
(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.

(e) Paradoxically, as a consequence of all these "requirements" suggest that a single living organism cannot exist (for any protracted length of time) by itself… ?



ATP



ATP

Adenine NH_2

Phosphate groups

Ribose

Adenosine

AMP (Adenosine monophosphate)

ADP (Adenosine diphosphate)

ATP (Adenosine triphosphate)

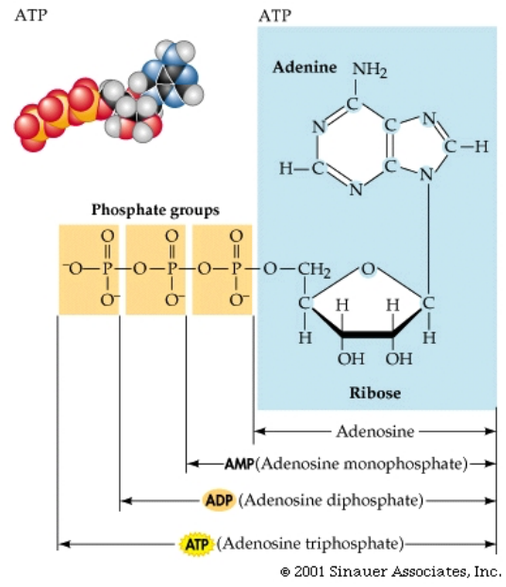
Some of the “facts” of Life…?

(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.



Some of the “facts” of Life…?

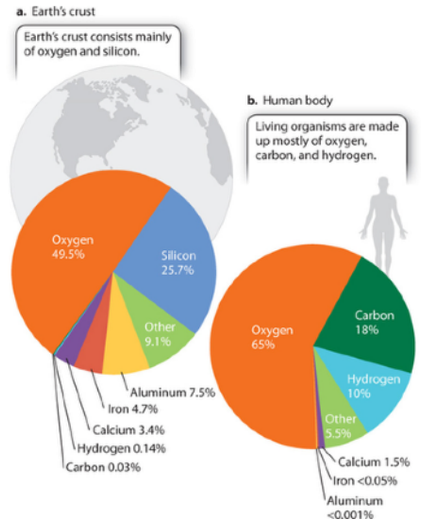
(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

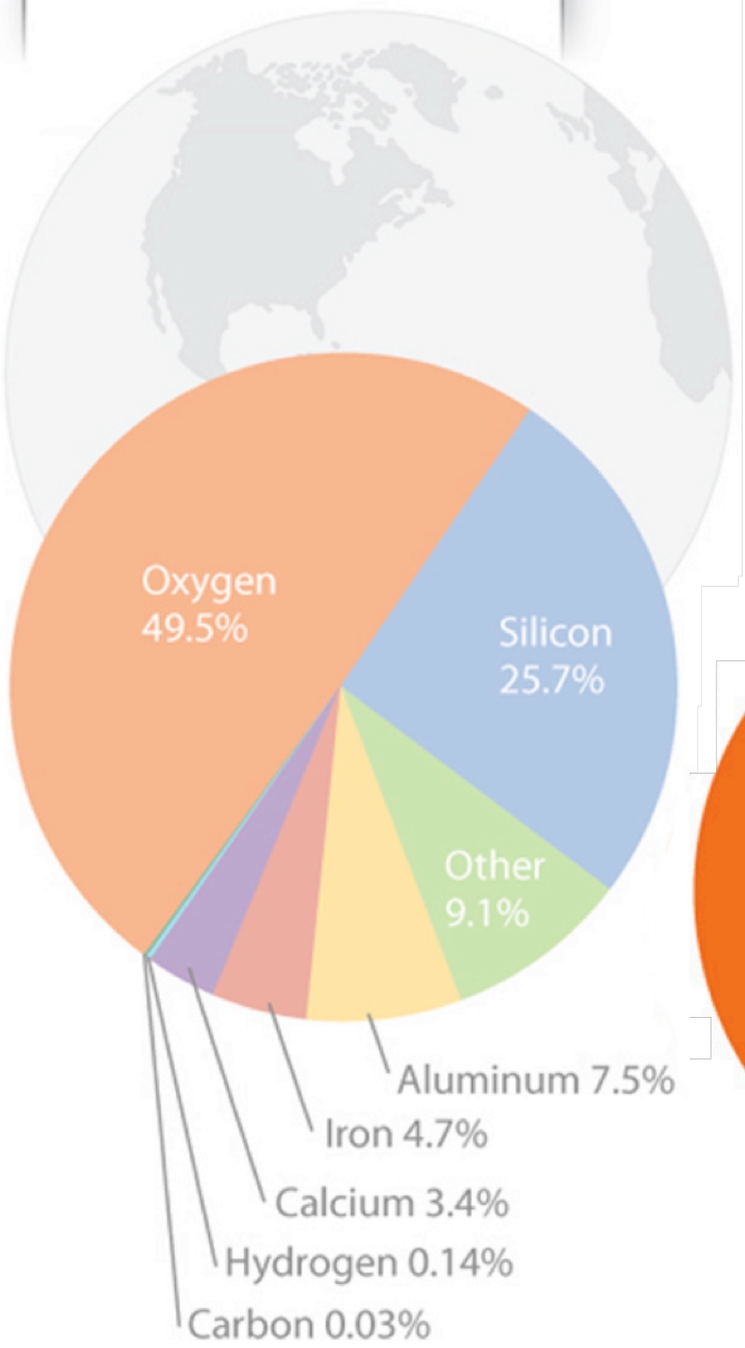
(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.

“Life” is the ultimate capitalist.



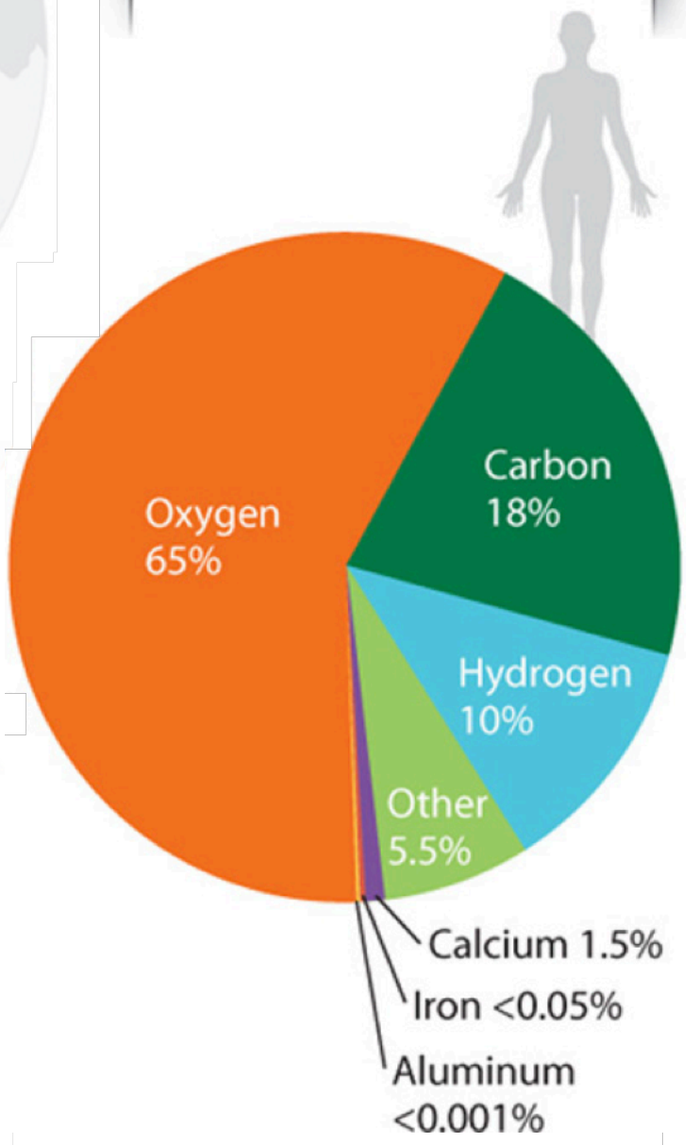
a. Earth's crust

Earth's crust consists mainly of oxygen and silicon.



b. Human body

Living organisms are made up mostly of oxygen, carbon, and hydrogen.



Some of the “facts” of Life…?

(a) Living organisms do exist -subject to the laws of chemistry and physics,

(b) One of the central characteristics of living organisms (but clearly not the only one, is the presence and maintenance of some type of reproducible boundary.

(c) the very act of living requires energy. But according to the "laws of physics.....energy can neither be created nor destroyed", so.....

(d) to survive -at least in our world- living organisms use organic elements..."CHONPS " to effectively cycle and recycle the available energy in all its forms.....at the expense of the local environment.

(e) Paradoxically, as a consequence of all these "requirements", I would suggest that a single living organism cannot exist
(for any protracted length of time) by itself… ?

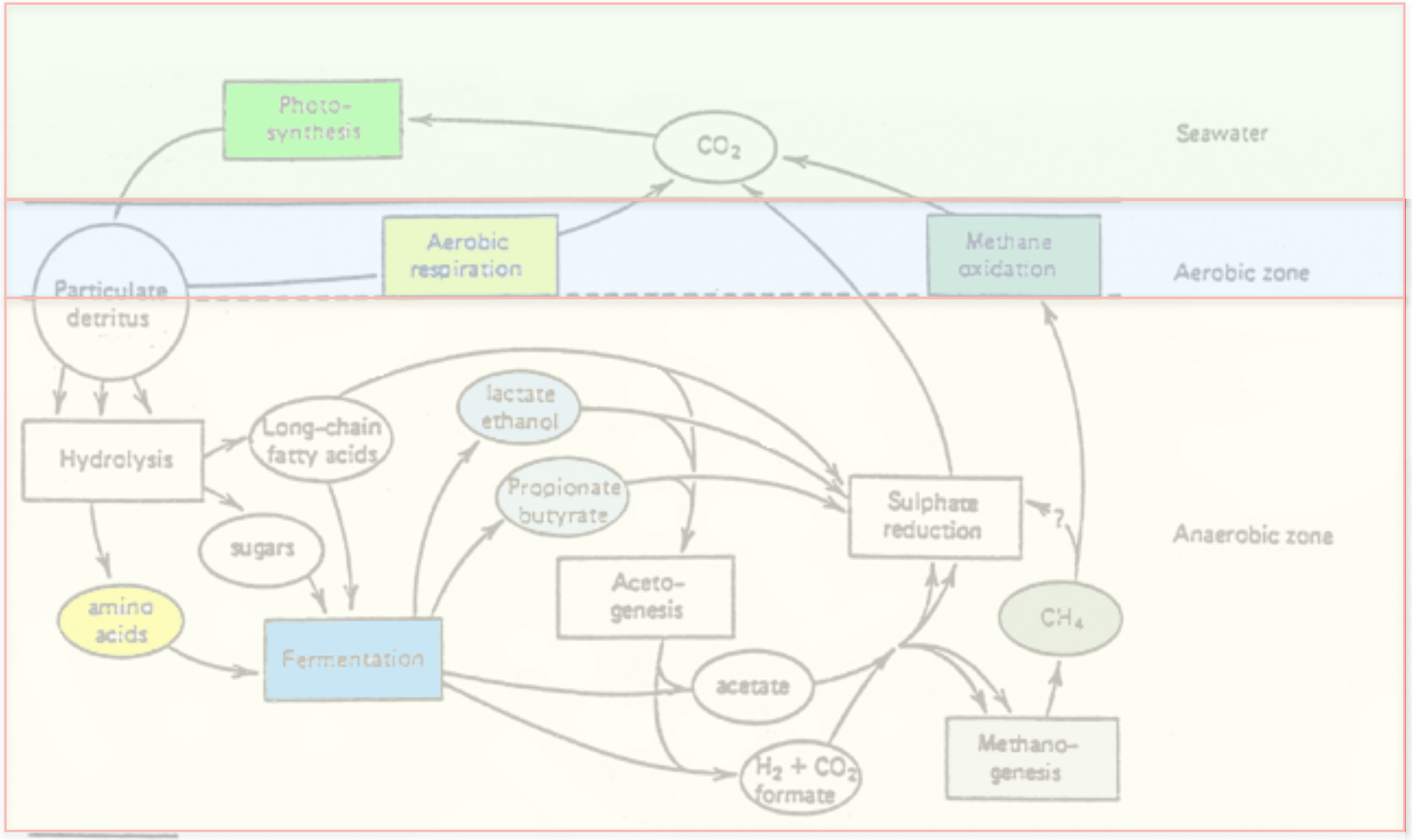


FIGURE 27.2

Degradation and cycling of organic matter in sediments in relation to bacterial sulphate reduction and methanogenesis. After T. H. Blackburn, "The Microbial Nitrogen Cycle," in Krumbein, W. E., ed., *Microbial Geochemistry*, Boston: Blackwell Publications (1983).

Gaia hypothesis…. ?

...But what am I that dare
Fancy that I can
Better conduct myself or have more
Sense than a common man?

William Butler Yeats "Stream and Sun at Glendalough"

The **Scientific Method**…

The **scientific method** is an empirical method of acquiring knowledge that has characterized the development of science since at least the 17th century (with notable practitioners in previous centuries). It involves careful observation, applying rigorous skepticism about what is observed, given that cognitive assumptions can distort how one interprets the observation. It involves formulating hypotheses, via induction, based on such observations; experimental and measurement-based statistical testing of deductions drawn from the hypotheses; and refinement (or elimination) of the hypotheses based on the experimental findings. These are *principles* of the scientific method, as distinguished from a definitive series of steps applicable to all scientific enterprises.[1][2][3]