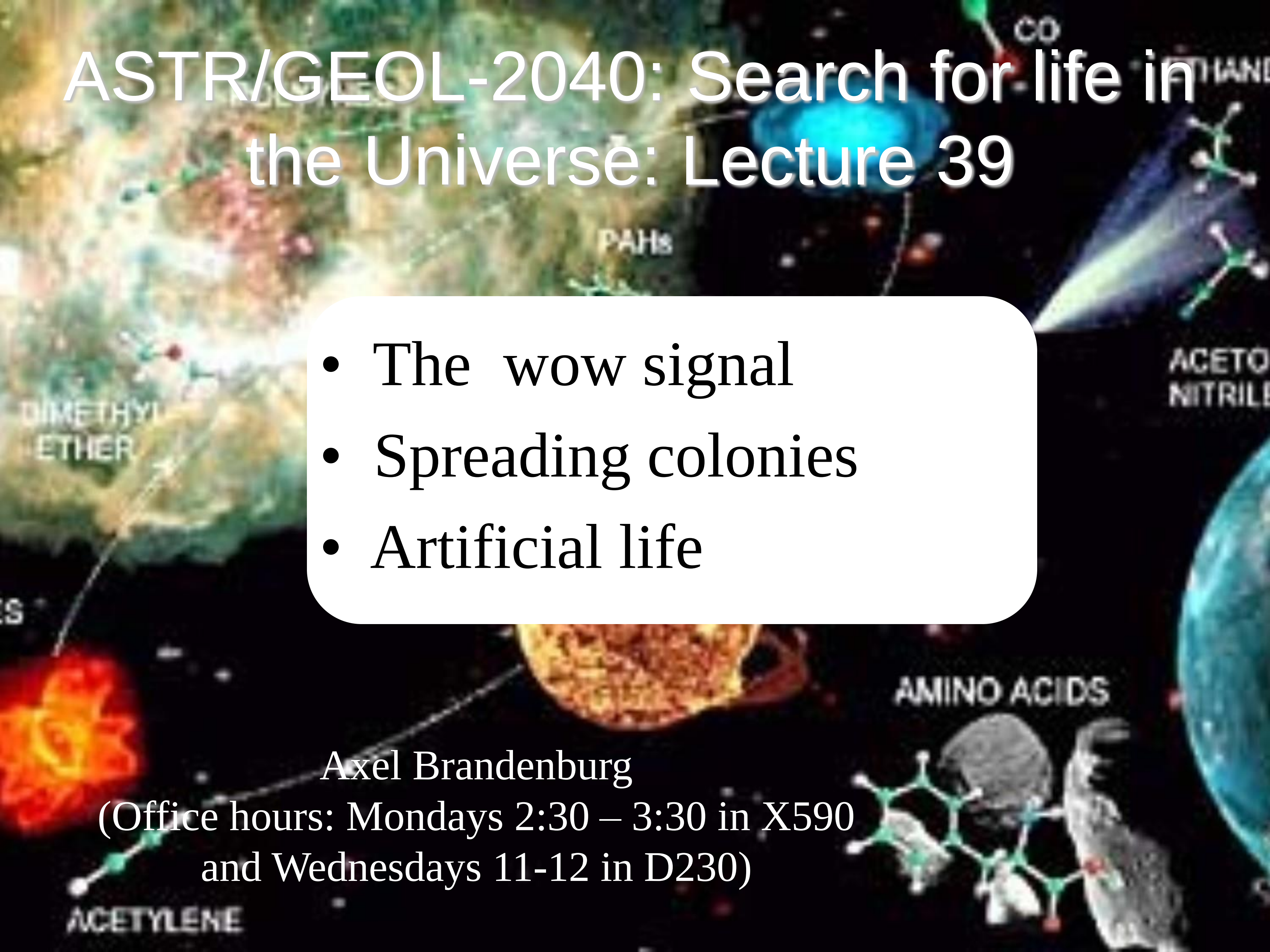
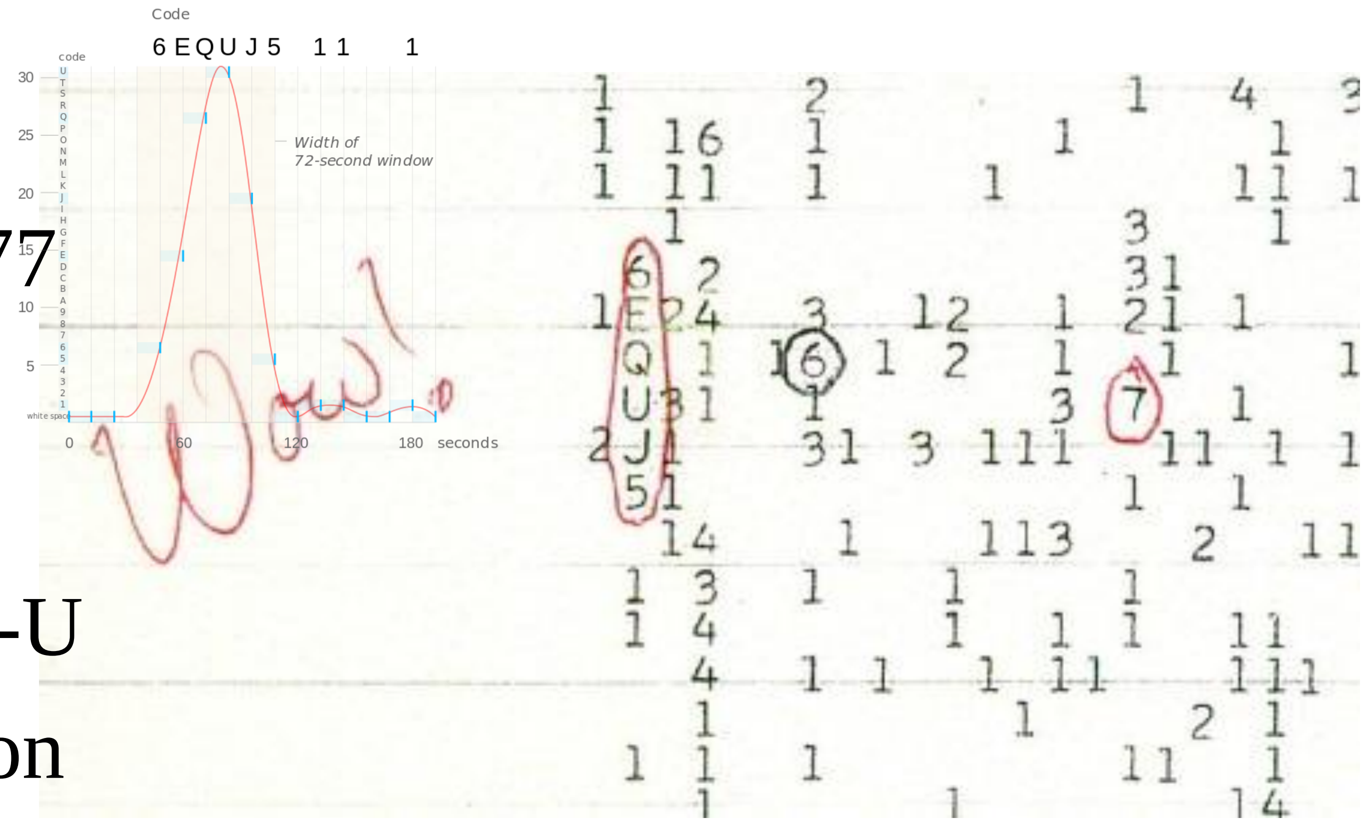
ASTR/GEOL-2040: Search for life in the Universe: Lecture 39

- The wow signal
- Spreading colonies
- Artificial life

Axel Brandenburg
(Office hours: Mondays 2:30 – 3:30 in X590
and Wednesdays 11-12 in D230)



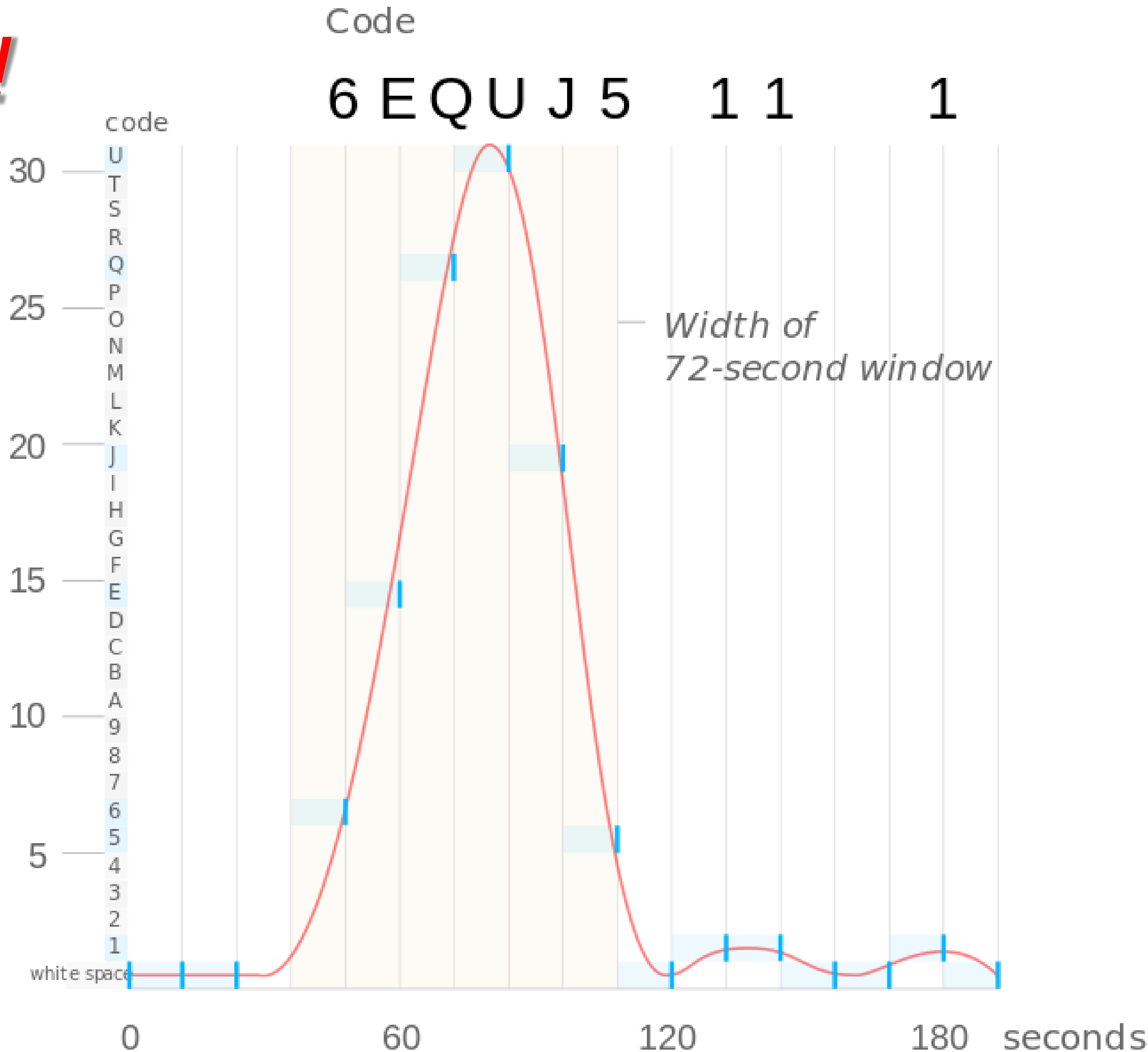
Wow!



- Aug15, 1977
- Sagitarius
- 72 signal
- Intensity A-U
- No repetition

A common misconception is that the Wow! signal constitutes some sort of message. In fact, what was received appears to be an unmodulated, continuous wave signal with no encoded information; essentially a flash of radio energy. The string "6EQUJ5" is merely the representation of the expected variation of signal intensity over time, expressed in the particular measuring system adopted for th experiment.[6]

Wow!



Code
6 E Q U J 5 1 1 1
code
30
25
20
15
10
5
U
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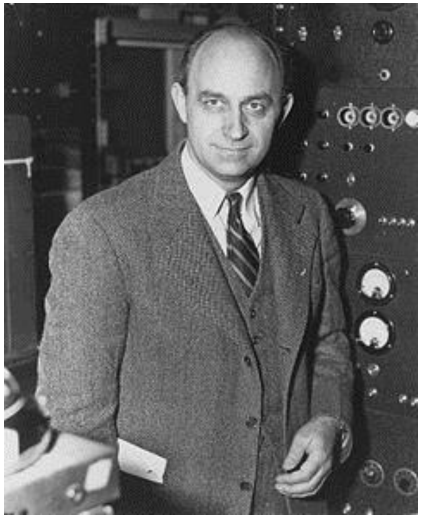
S
R
Q
P
O
N
M
L
K
J
I
H
G
F
E
D
C
B
A
9
8
7
6
5
4
3
2
1
white space
Width of
72-second window
0
60
120
180
seconds

Fermi Paradox



- Los Alamos visit in 1950
- Casual talks with Teller etc
- Scale & probability versus evidence

- There are billions of stars in the galaxy that are similar to the Sun,[2][3] many of which are billions of years older than Earth.[4][5]
- With high probability, some of these stars will have Earth-like planets,[6][7] and if the Earth is typical, some might develop intelligent life.
- Some of these civilizations might develop interstellar travel, a step the Earth is investigating now.
- Even at the slow pace of currently envisioned interstellar travel, the Milky Way galaxy could be completely traversed in a few million years.[8]

Spreading colonies

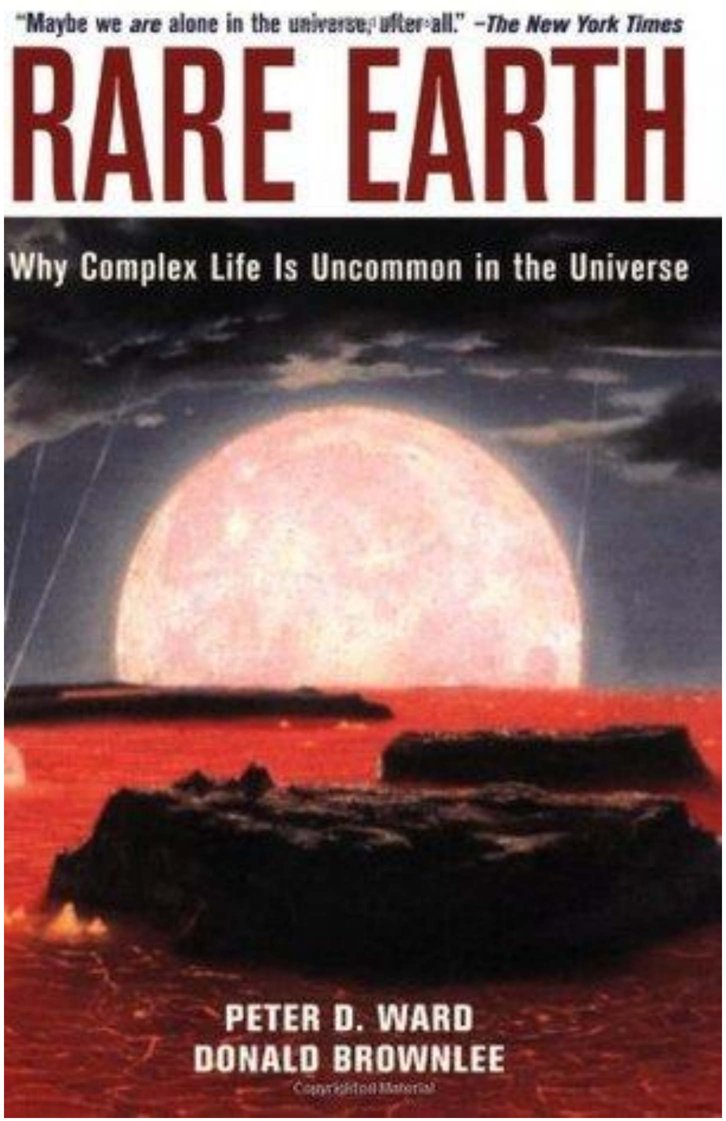
- Speed $V = d/(t_{\text{travel}} + t_{\text{consolidation}})$
- d distance between colonies ~ 10 ly
- Interstellar travel 0.1 c ➔ 100 yr
- $t_{\text{consolidation}} = 400$ yr
- 0.02 ly/yr
- 100,000 ly / (0.02 ly/yr) = 5 Myr

Limited resources

- Implausible of advanced civilization
- Voyager 17.2 km/s, 1000 kg
- If 0.1 c, → 5 x 10^{17} J = 0.001 Earth annual consumption
- But has to be supplied from on-board fuel

Rare Earth Hypothesis

- Since ~2000
- Ward & Brownlee
- Intelligent life really rare
- Microbial life common



Where do we stand?

- Making many of the building blocks is easy
  - delived from space
  - early atmospheric ?reducing conditions
  - Deep-sea vents
  - Heat & pressure from impacts
- Many possibilities ← no conclusive answ.
- Unclear how to assemble them

Guidance from "artificial life"

- Not computer life (HW1), but microbial
  - Not Frankenstein → practical applications
- Engineering, start from existing organisms
- Making life from raw ingredients
  - Synthetic biology
- Safety issues

BS: 233-238

JCVI-syn1.0 → 3.0

- Genome modified from existing one
  - Minimalistic genome
  - Quasi-essential genes → robust growth
  - But otherwise synthesized from scratch
- Inserted into cell body of another bacterium
  - Its own genome removed
- Modified bacterium boots up/comes to life
  - Naturally reproduces/evolves

Practical applications?

- Bacteria inhale/exhale/eat/excrete
- Are small: target certain body parts
- Can they solve some of the outstanding problems of our time?

Practical applications?

- …..
- ……..
- ……………
- …………………

Think also of biologically engineered life

Practical applications?

- CO_2 sequestration
  - Converting $CO_2 \rightarrow CH_4$
  - $CH_4 \rightarrow$ fuel (CO_2 neutral)
- Cleaning up oil spills
  - Toxic waste removal
- Medical: e.g. attack cancer cells

Design and synthesis of a minimal bacterial genome

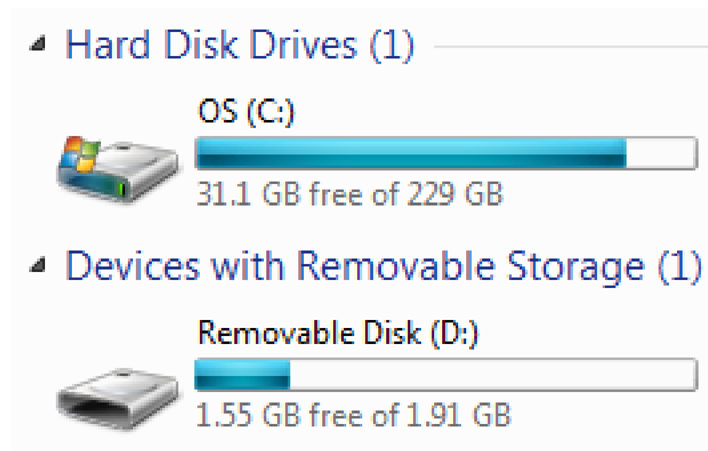
Clyde A. Hutchison III,[1*†] Ray-Yuan Chuang,[1†‡] Vladimir N. Noskov,[1] Nacyra Assad-Garcia,[1] Thomas J. Deerinck,[2] Mark H. Ellisman,[2] John Gill,[3] Krishna Kannan,[3] Bogumil J. Karas,[1] Li Ma,[1] James F. Pelletier,[4§] Zhi-Qing Qi,[3] R. Alexander Richter,[1] Elizabeth A. Strychalski,[4] Lijie 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*]

We used whole-genome design and complete chemical synthesis to minimize the 1079–kilobase pair synthetic genome of *Mycoplasma mycoides* JCVI-syn1.0. An initial design, based on collective knowledge of molecular biology combined with limited transposon mutagenesis data, failed to produce a viable cell. Improved transposon mutagenesis methods revealed a class of quasi-essential genes that are needed for robust growth, explaining the failure of our initial design. Three cycles of design, synthesis, and testing, with retention of quasi-essential genes, produced JCVI-syn3.0 (531 kilobase pairs, 473 genes), which has a genome smaller than that of any autonomously replicating cell found in nature. JCVI-syn3.0 retains almost all genes involved in the synthesis and processing of macromolecules. Unexpectedly, it also contains 149 genes with unknown biological functions. JCVI-syn3.0 is a versatile platform for investigating the core functions of life and for exploring whole-genome design.

Science 351, 1414-U73 (***2016***)

1 bp = one base pair

- 1 bp: A, T, G, C
- 1 bit: 0, 1
- 1 byte: a, b, c, A, ...
- 1 byte = 8 bit

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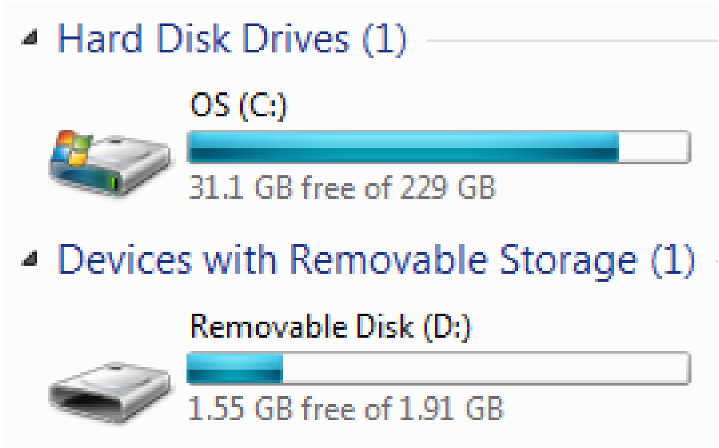
How much is 531 kbp?

A. 130 kbyte
B. 1.3 Mbyte
C. 13 Mbyte
D. 130 Mbyte
E. 1.3 Gbyte



1 base pair?

- 1 bit: 0, 1
- 2 bit: 00, 01, 10, 11
- 1 bp: A, T, G, C → 1 pb = 2 bit
- 1 byte = 8 bit = 4 bp → divide by 4

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^A ^B ^C ^D ^E ^F ^G ^H ^K ^L ^M ^N ^O ^P ^Q ^R ^S ^T ^U ^V ^W ^X ^Y ^Z
^[ ^\ ^] ^^ ^_ !  " # $ % & ' ( ) * + , - . / 0 1 2 3 4 5 6 7 8 9 : ; <
= > ?  @ A B C D E F G H I J K L M N O P Q R S T U V W X Y Z [ \ ] ^ _
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How much is 531 kbp?

A. 130 kbyte
B. 1.3 Mbyte
C. 13 Mbyte
D. 130 Mbyte
E. 1.3 Gbyte

because:
531/4 ~ 130

Human genome: 2.9 Gbp

A. 72.5 Mbyte
B. 725 Mbyte
C. 7.25 Gbyte
D. 72.5 Gbyte
E. 725 Gbyte

Human genome: 2.9 Gbp

A. 72.5 Mbyte
B. 725 Mbyte
C. 7.25 Gbyte
D. 72.5 Gbyte
E. 725 Gbyte

because:
2900/4 ~ 725

Next time

- Preparation for final exam
- Sample final on D2L

- See also midterm + quizzes
- See all homework