SAS Honors Seminar 256: Extraterrestrial Life

9/1/2011

Course organization

Standard meetings: TTh 4:30–5:50pm, Brett Hall Seminar Room

Office hours: M 2:00–3:30pm or by appointment (email is also good at any time: ajbaker[at]physics.rutgers.edu)

Course website:

http://www.physics.rutgers.edu/~ajbaker/honors256/

which contains a syllabus and links to online readings

Textbook: Bennett & Shostak, *Life in the Universe* (3rd edition)

Course grade: written assignments

20% weekly writing assignments

~1 typed page, single-spaced, response papers (prompts will be linked to course web page and provided in class)

15% mid-term research mini-project

quantitative analysis of a dataset, several options, due 11/3

30% end-of-term paper

10-15 typed pages, double spaced, on a topic of your choice; due 12/23, topic/scope/reference list submitted to me 12/6

Course grade: class discussions

Class meetings will mainly be devoted to discussions, led by students chosen at random at the beginning of each class.

You may lead 0–3 of the 27 class discussions.

For now: you may pass up to twice if your name is drawn, but your "risk" will increase by +1 and +2. (Don't skip: unexcused absences get a zero for participation!)

20% leadership of class discussions

15% participation in class discussions

Preparing for the "shotgun seminar"

Make sure you can print out all online material!

(1) Read background material from Bennett & Shostak.

(2) Read quickly through the higher-level material to get a sense of the main ideas, and write out a rough outline that you can use as a reference for leading discussion.

(3) Reread the higher-level material to fill in gaps in understanding (refer to cheat sheet, look up unfamiliar terms, etc.).

(4) Don't be shy about drawing your own conclusions!

Class preparation and written work

In preparing for class discussions, you may consult (a) any offline or online references, (b) each other, and/or (c) me as you work to understand the material we'll discuss.

In your written assignments, you need to work independently and be skeptical of online references (e.g., Wikipedia).

Writing will be evaluated for spelling+grammar+style as well as content. Any plagiarism will earn a zero; late work loses 10% per day.

Questions you may have...

Do I need to be a science major to do well in this course?

No! In 2008, students majoring in Chinese, economics, and psychology (among other subjects) earned A grades.

Do I have to understand everything I read to lead a discussion?

No! Do your best in preparing, but remember that calling out confusing points is a good way to spark discussion in class.

Will we discuss my favorite topic in this course?

If it's not already on the syllabus, you can suggest it for one of the two student choice classes at the end of the semester.

What is the subject of this course?

astrobiology (Lafleur 1941)

cosmobiology (Bernal 1952)

exobiology (Lederberg 1960)

bioastronomy (IAU 2004)

1941 definition by Lafleur: "consideration of life in the universe elsewhere than on earth"

1964 comment by Simpson: "this 'science' has yet to demonstrate that its subject matter exists!"

2008 definition by NASA: "study of the living universe"

Why include life on Earth?

...or rephrased: why does a course on "Extraterrestrial Life" spend the first few weeks discussing terran life!?

Answer: To address many astrobiological questions, we have no choice but to extrapolate from a sample of one.

Is this legitimate?

Copernican principle: our circumstances are not special

anthropic principle: our circumstances are special, because we're here

What sort of "life" will we focus on?

Ranges from intelligent life...

...to possible microfossils.

ALH84001: Martian meteorite

On earth: microbes in ocean dominate humans by a factor of 5000 in mass (Bennett & Shostak 5.2).

What does astrobiology encompass?

astronomy

geology

chemistry

atmospheric science

marine science

biochemistry

biology

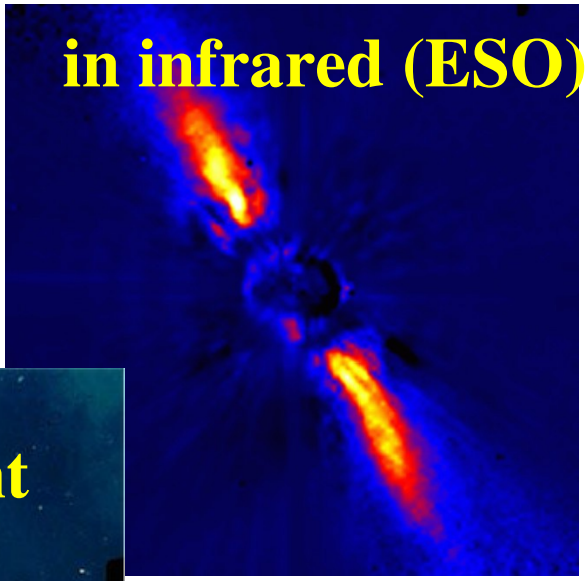
anthropology

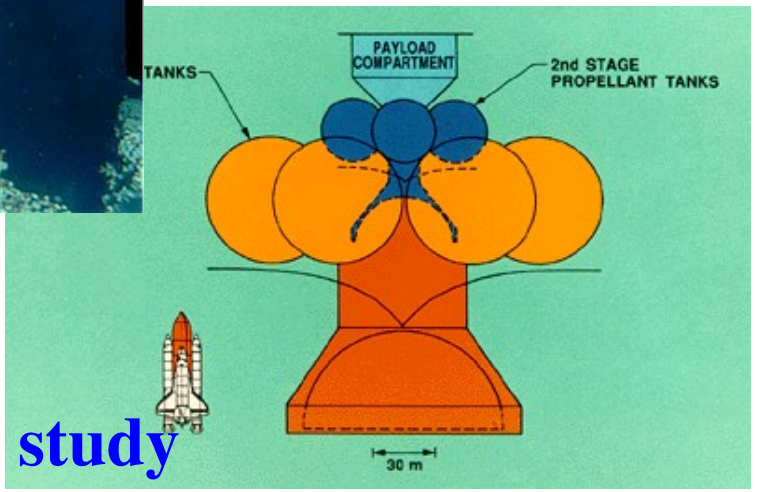
sociology

physics

engineering

Beta Pictoris

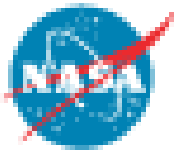




Daedalus design study

Is astrobiology a legitimate science?

NASA thinks so:



NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

in 1998, established the NASA Astrobiology Institute (NAI)
as a distributed organization led by the Ames Research Center
(http://astrobiology.nasa.gov/nai/).

Conference organizers agree:

last week = Instruments, Methods, and Missions for
Astrobiology XIV (conference 8152 at http://spie.org/)

next week = Extreme Solar Systems II
(http://ciera.northwestern.edu/Jackson2011/)

Quantifying our ignorance...

UC Santa Cruz astronomer Frank Drake in Green Bank, WV

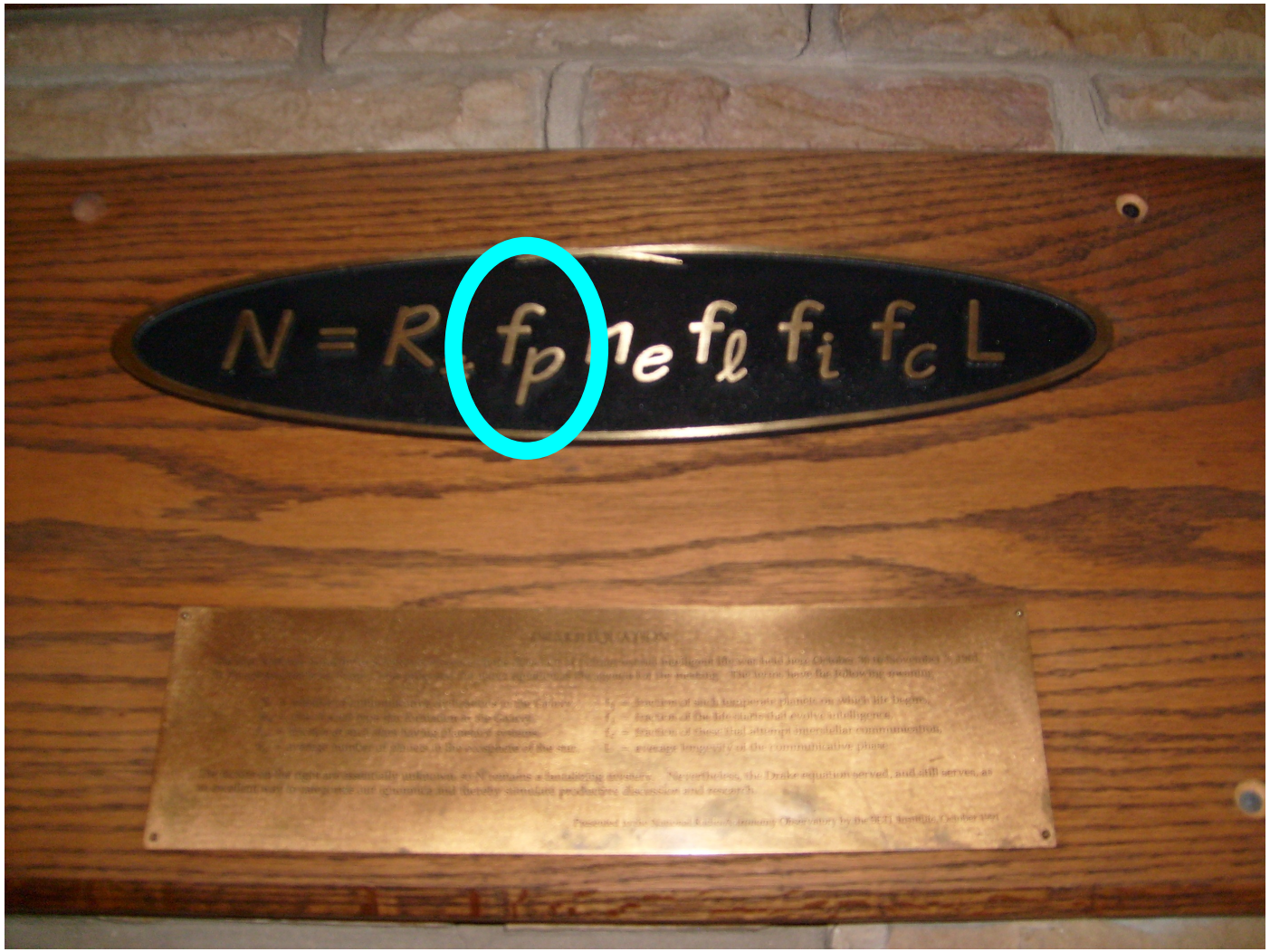
The Drake Equation

***N* = number of transmitting civilizations in the Milky Way**

The Drake Equation

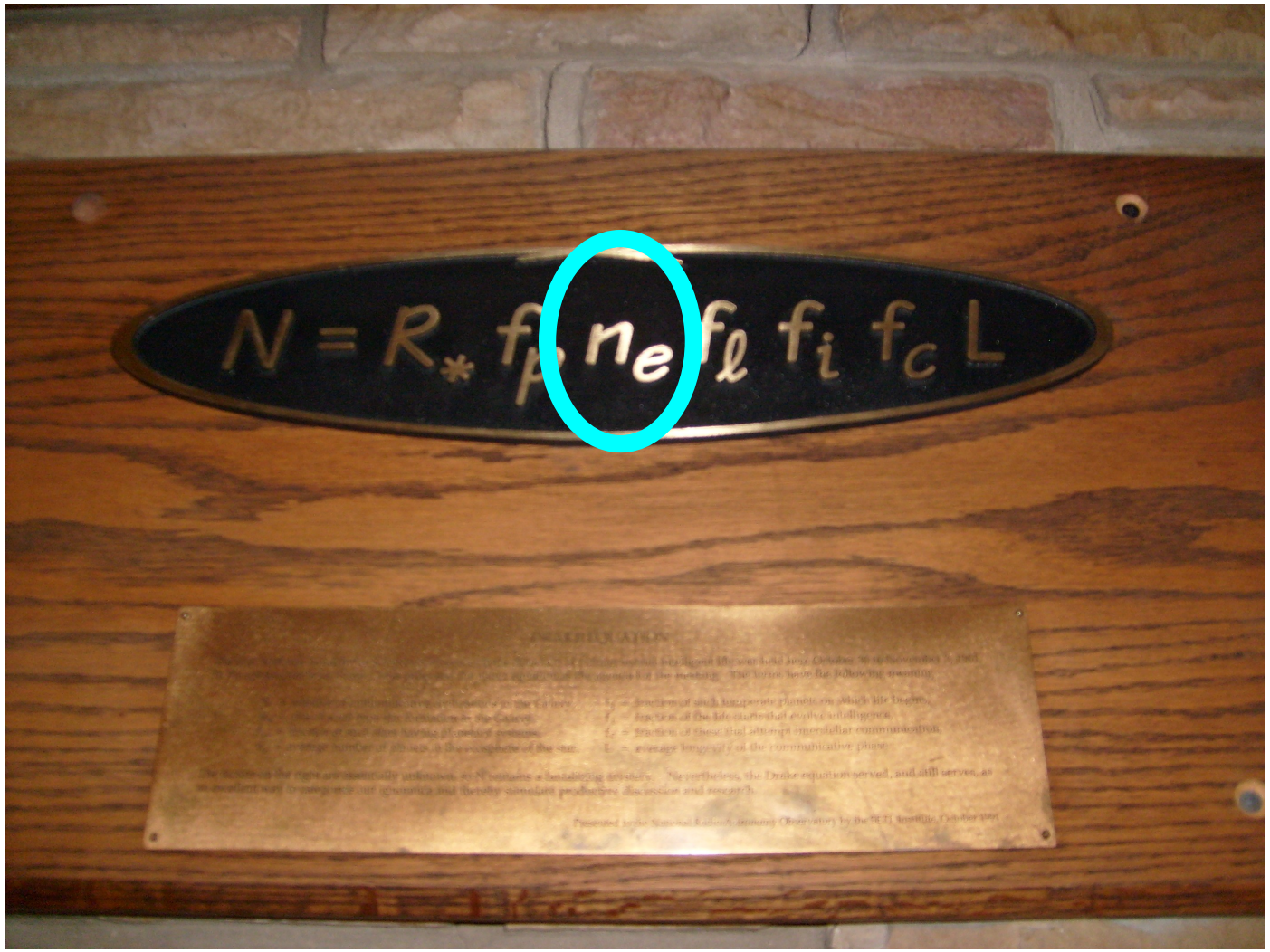
R_* = rate at which suitable stars form in Milky Way (yr^{-1})

The Drake Equation



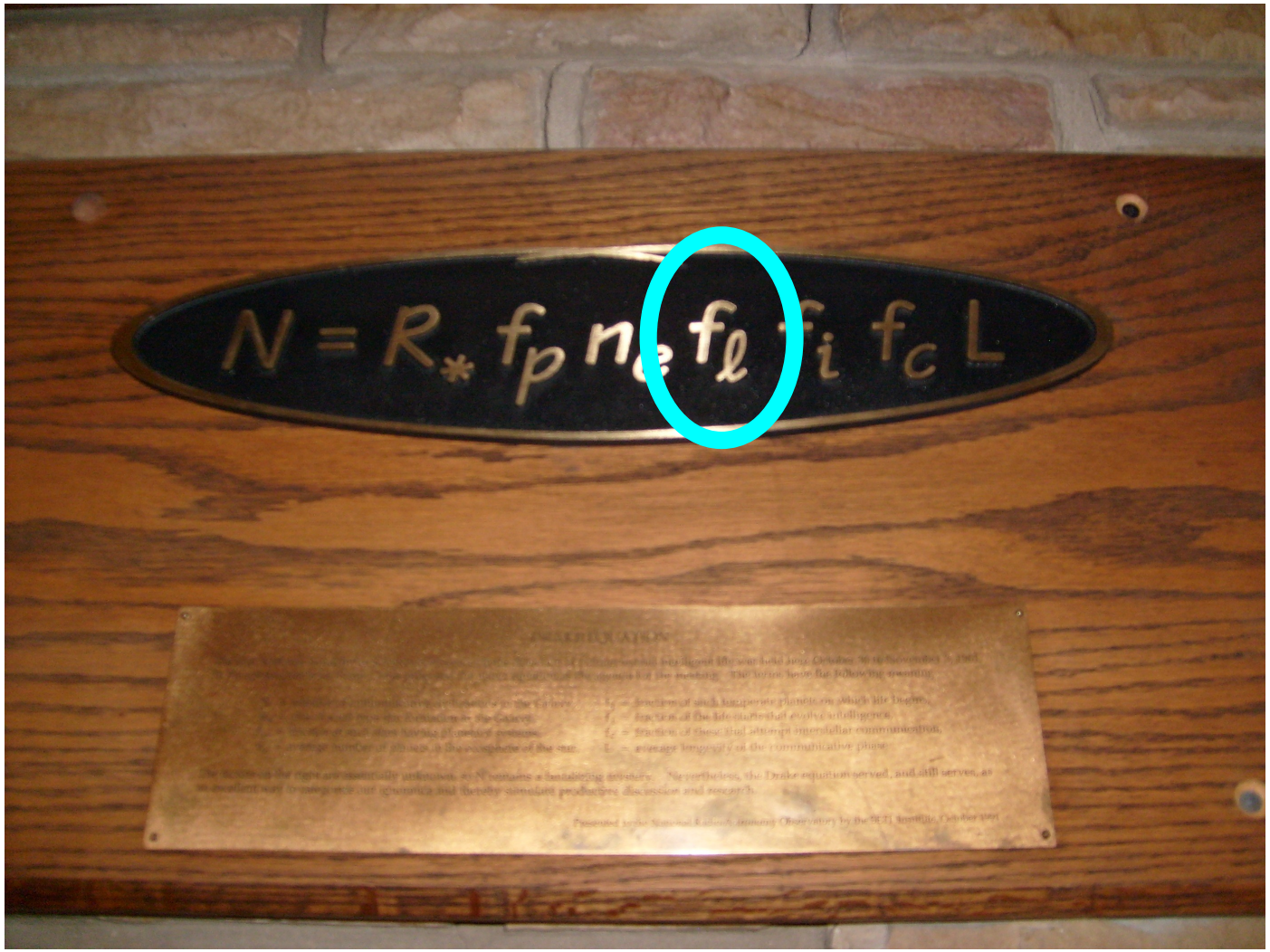
f_p = fraction of such stars that have planets

The Drake Equation



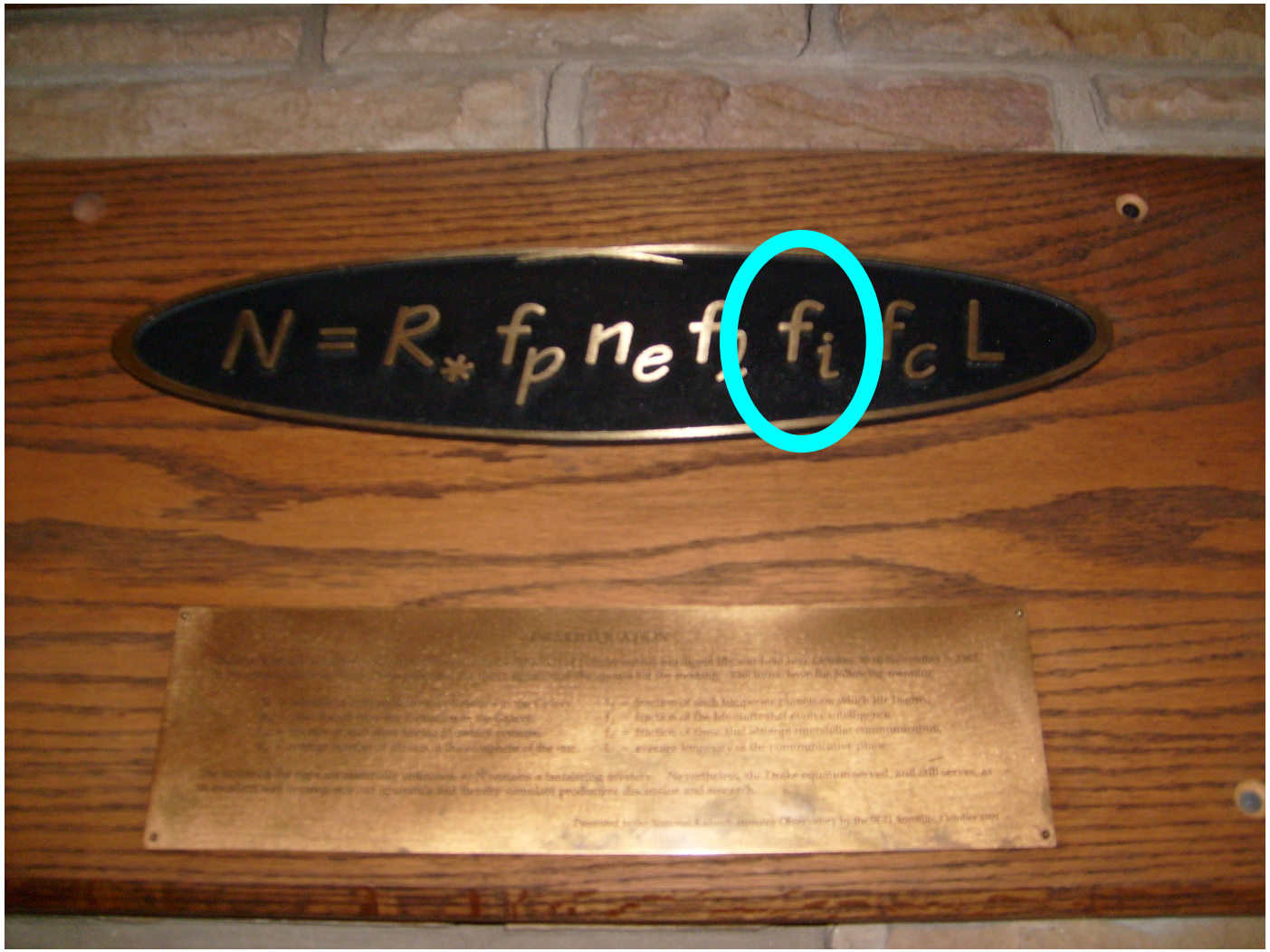
n_e = number of planets per planetary system that *could* support life

The Drake Equation



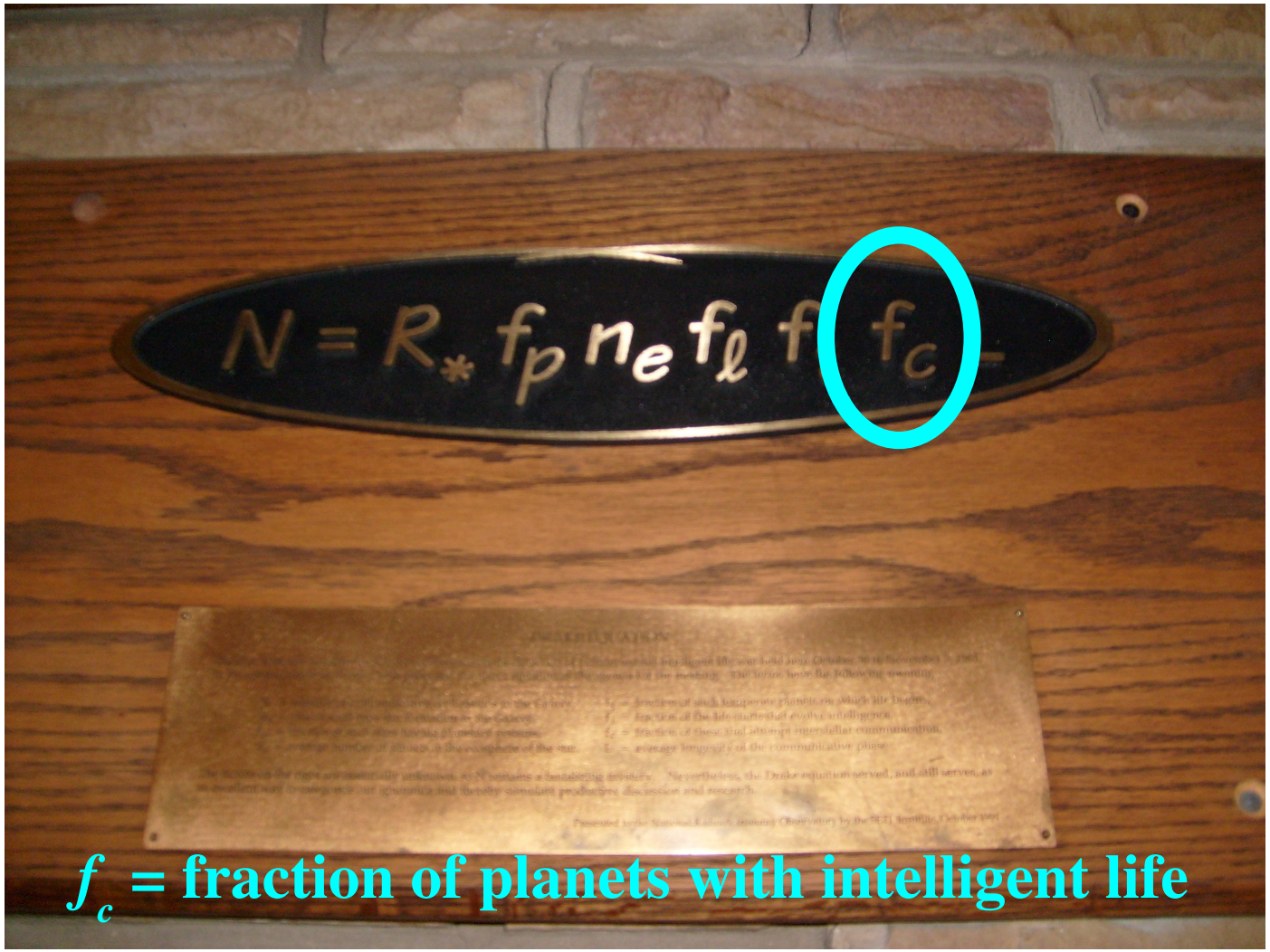
f_l = fraction of habitable planets on which life *did* evolve

The Drake Equation



f_i = fraction of planets with life on which intelligence evolved

The Drake Equation

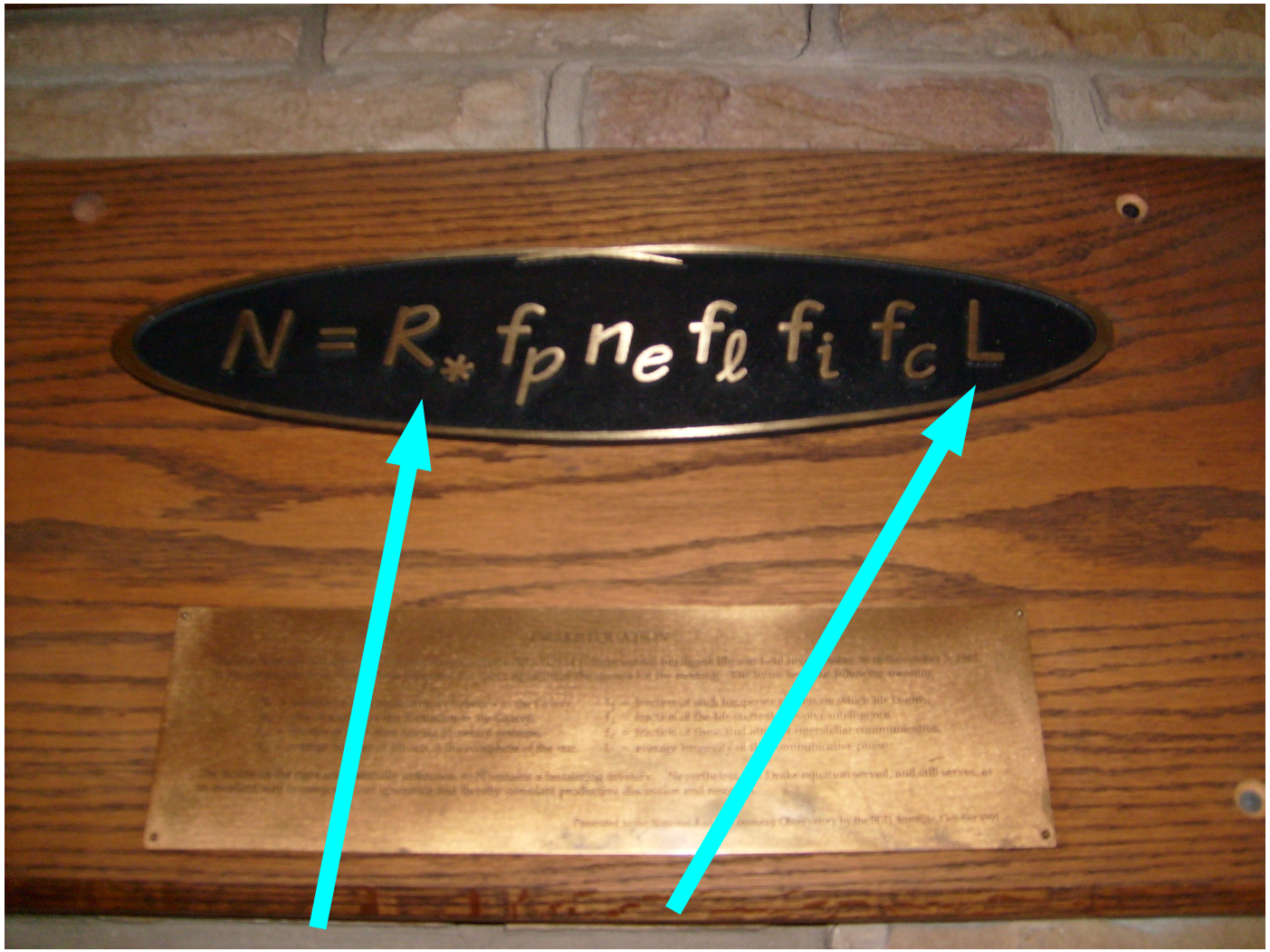


on which a transmitting *civilization* arises

The Drake Equation

***L* = mean lifetime of a transmitting civilization (yr)**

The Drake Equation



units: R_* ~ yr^{-1} and L ~ yr ⇒ N is dimensionless

What did Frank Drake guess in 1961?

$R_* \sim 10\ \mathrm{yr}^{-1}$

$f_p \sim 0.5$

$n_e \sim 2$

$f_l \sim 1$

$f_i \sim 0.01$

$f_c \sim 0.01$

$L \sim 10^4\ \mathrm{yr}$

$\Rightarrow N \sim 10$

Key value of the Drake Equation: highlights the fact that some factors are less certain than others!

Reading for next class (9/6)

A key question to ask before we dive into a discussion of "the living universe": what is life?

Bennett & Shostak 5.1-5.2, 5.6 – background

Chyba & McDonald (2002) [pp 215-222 only!] – review paper

Koshland (2002) – one biologist's stab at a definition

Cleland & Chyba (2002) – philosophical perspective

Popa (2010) – another stab at a definition, focusing on the origin of life

First response paper (due 9/13)

The British scientist Dr. James Lovelock has proposed that Earth's living organisms, in conjunction with its physical components (atmosphere, oceans, etc.) can be considered together as the equivalent of a single "superorganism." Do you feel that such an entity (dubbed "Gaia" by Lovelock) can satisfy all, some, or none of the definitions of "life" that we have discussed in this class? Write a statement explaining and justifying your answer to this question.