SAS Honors Seminar 259: Extraterrestrial Life

9/3/2008

Course organization

Standard meetings: MW 4:30–5:50pm, Brett Hall Seminar Room
(one or two Mondays may shift to 7:40–9:00pm if possible)

Office hours: F 1:00–2:30pm or by appointment (email is also good at any time: ajbaker[at]physics.rutgers.edu)

Course website:
http://www.physics.rutgers.edu/~ajbaker/honors259/
which contains a syllabus and links to online readings

Textbook: Bennett & Shostak, *Life in the Universe* (2nd 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, details TBD, due 10/29

30% end-of-term paper

10-15 typed pages, single spaced, on a topic of your choice; due 12/22, topic/scope/reference list submitted to me 12/3

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 (look up unfamiliar terms, etc.).

Class preparation vs. 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 steer clear of online references (don't use 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.

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

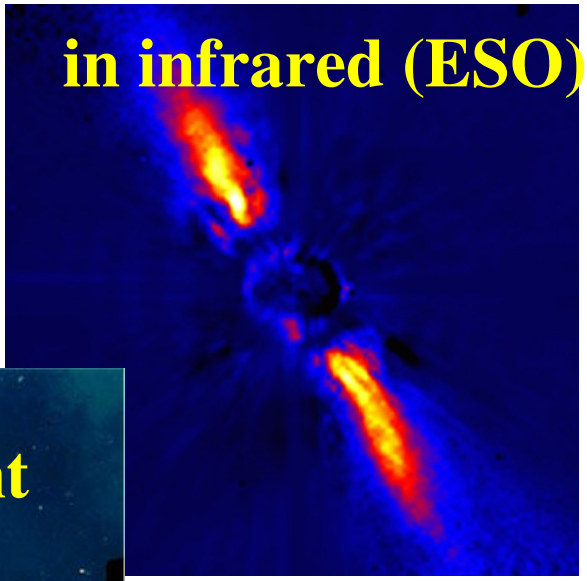
anthropology

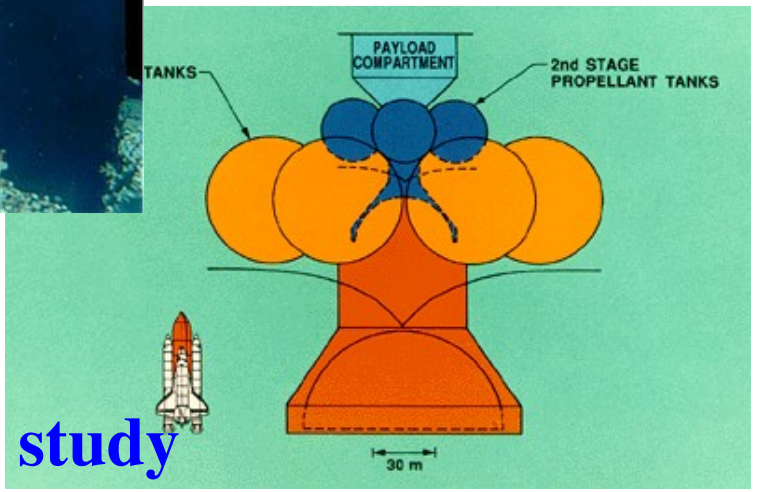
sociology

physics

engineering

Beta Pictoris

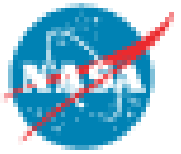




Daedalus design study

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 = 15th Annual Conference on the Origin of Life

(http://www.dbag.unifi.it/issol2008/)

this week = 8th European Workshop on Astrobiology

(http://www.space-x.eu/EANA08/)

Quantifying our ignorance...

UC Santa Cruz astronomer Frank Drake in Green Bank, WV

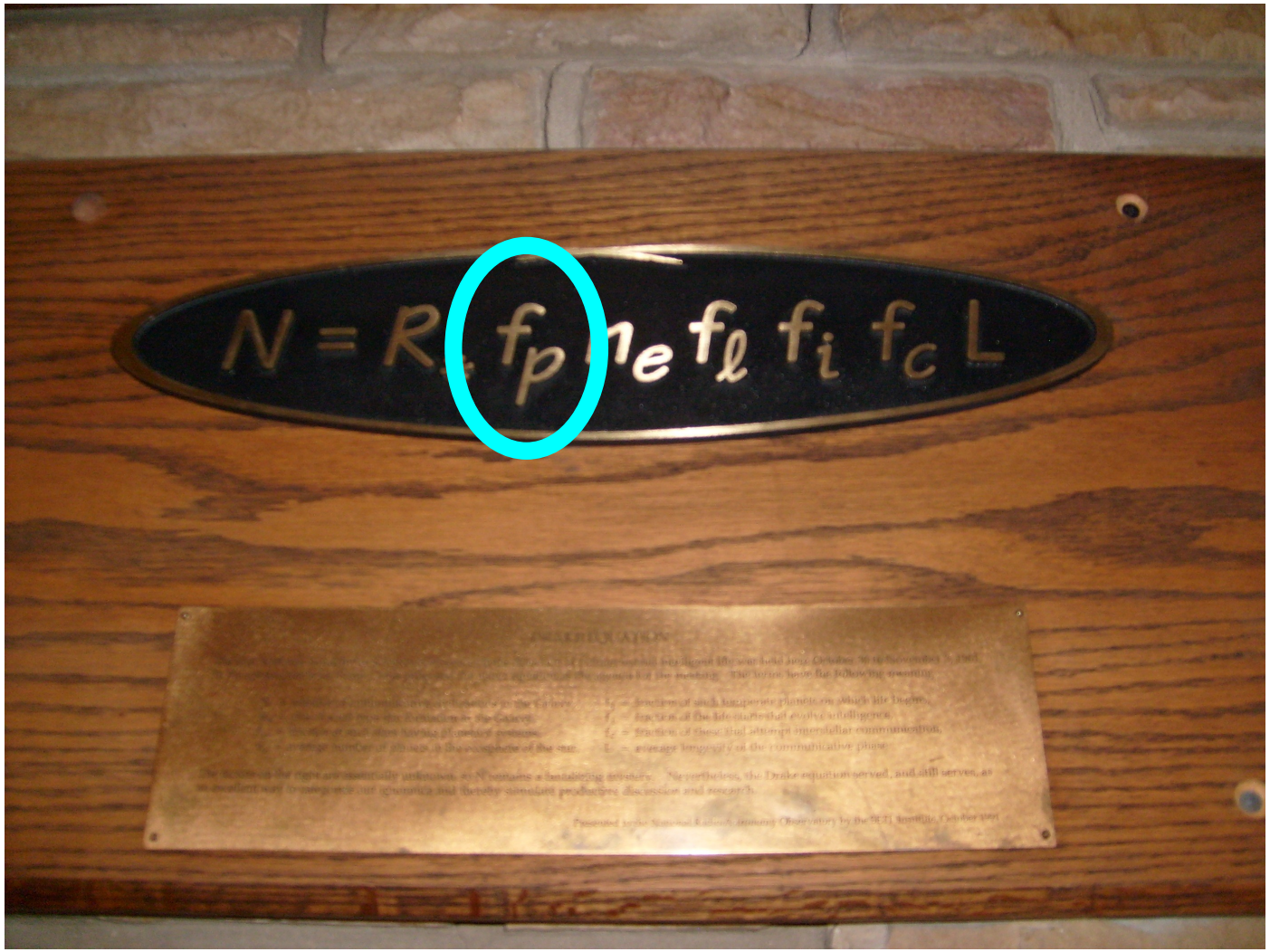
The Drake Equation

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

The Drake Equation

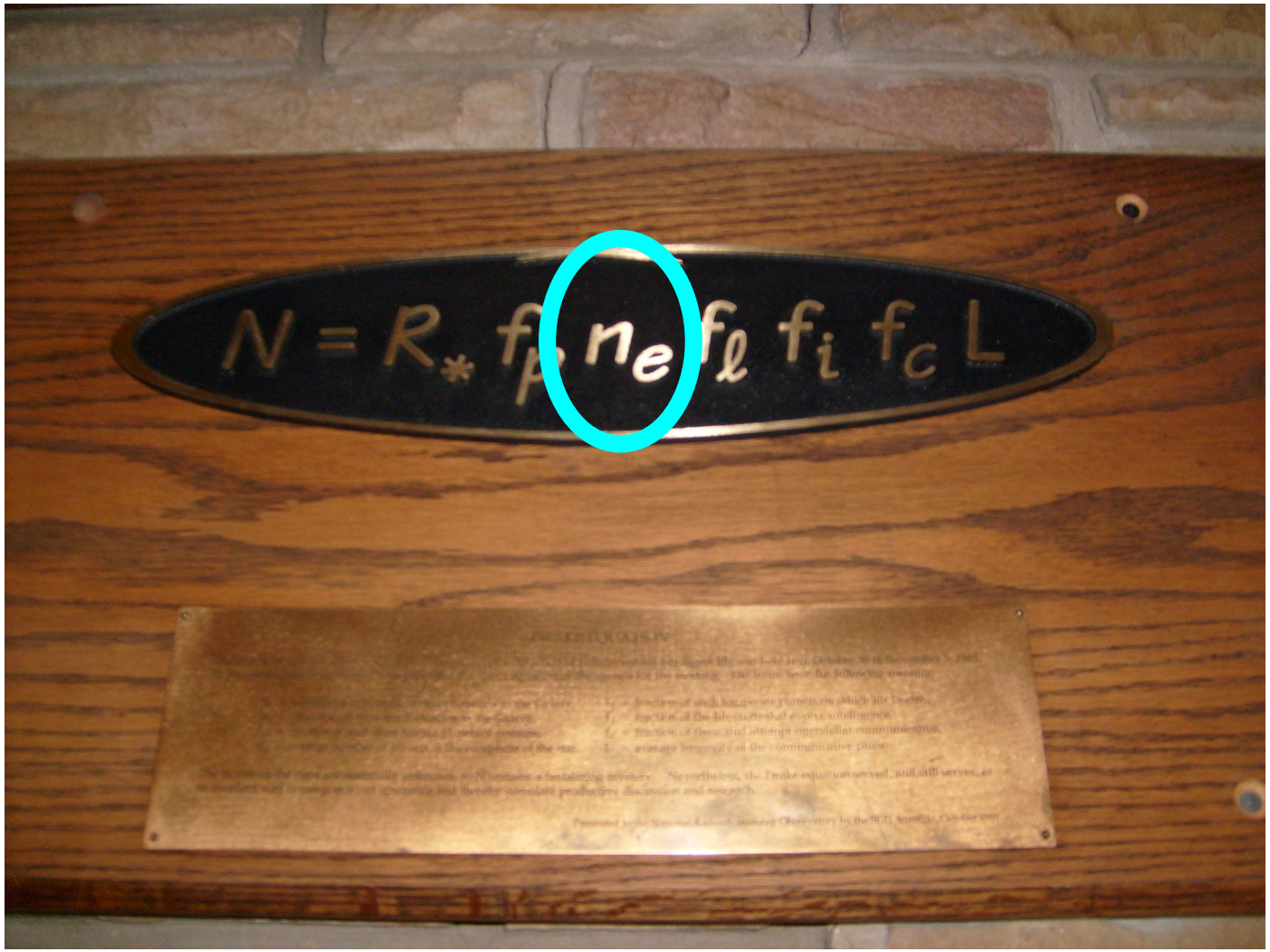
R_* = rate at which suitable stars form in Milky Way (yr^{-1})

The Drake Equation



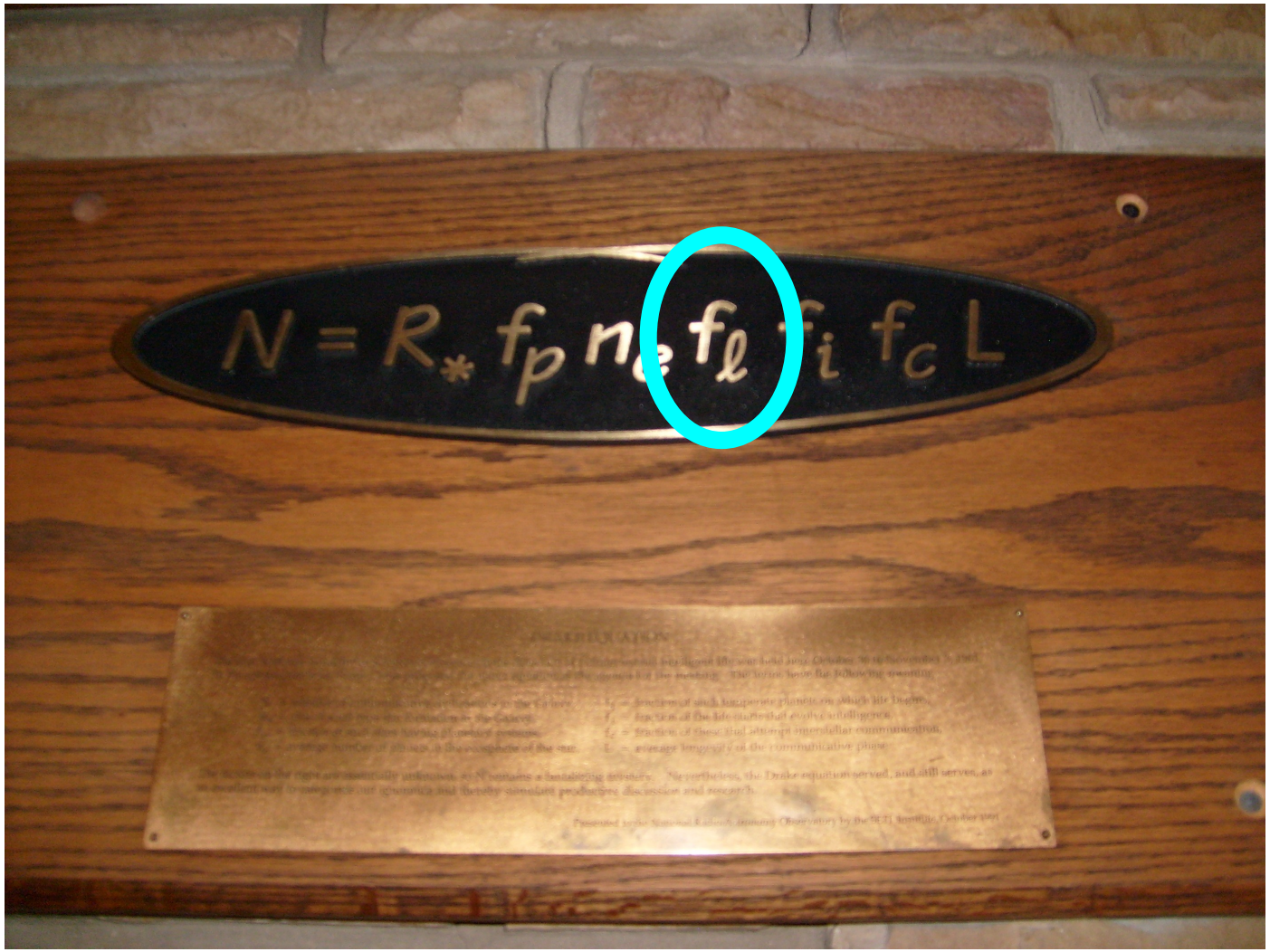
f_p = fraction of such stars that have planets

The Drake Equation



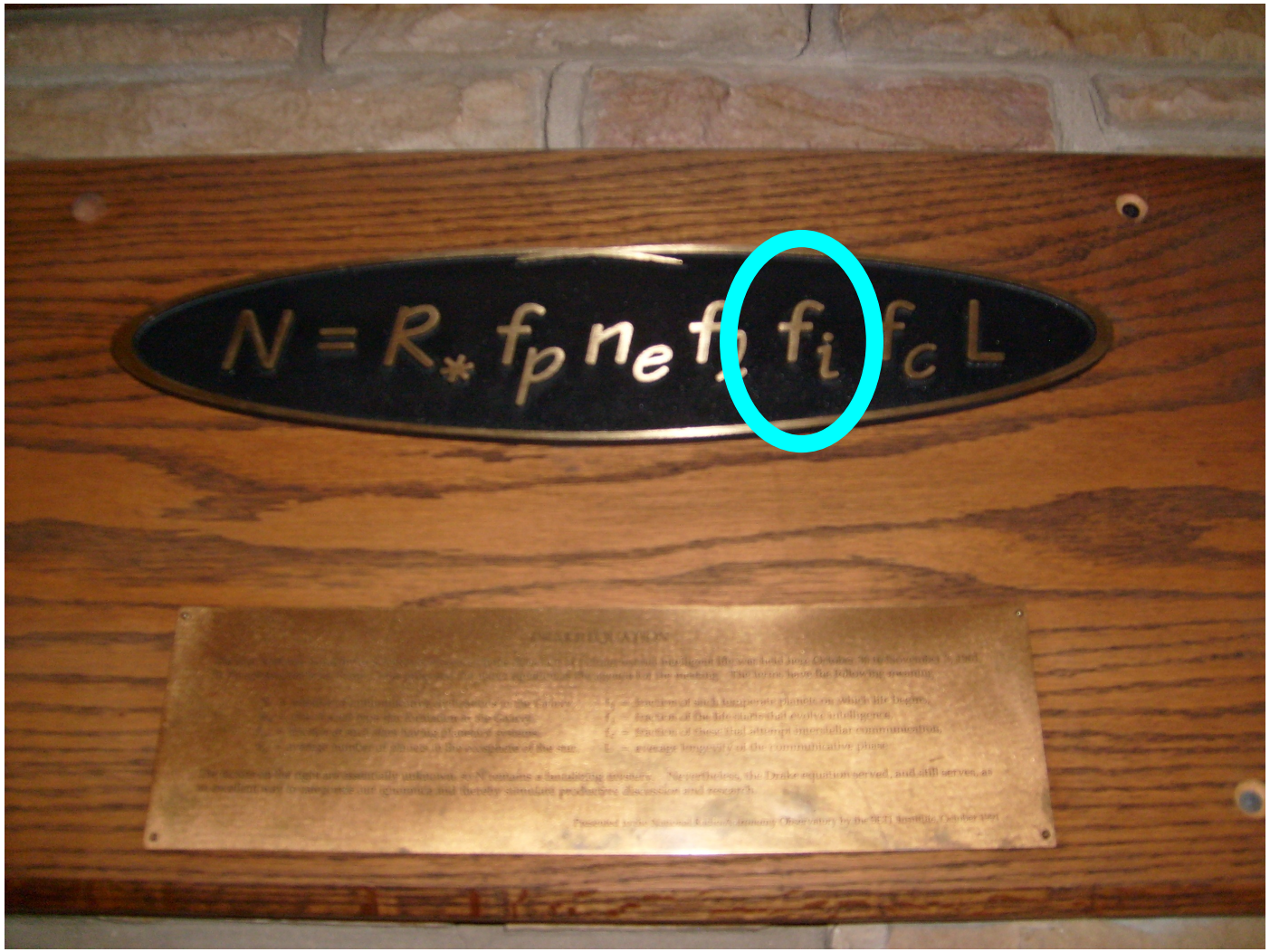
n_e = mean number of planets per solar system that *could* support life

The Drake Equation



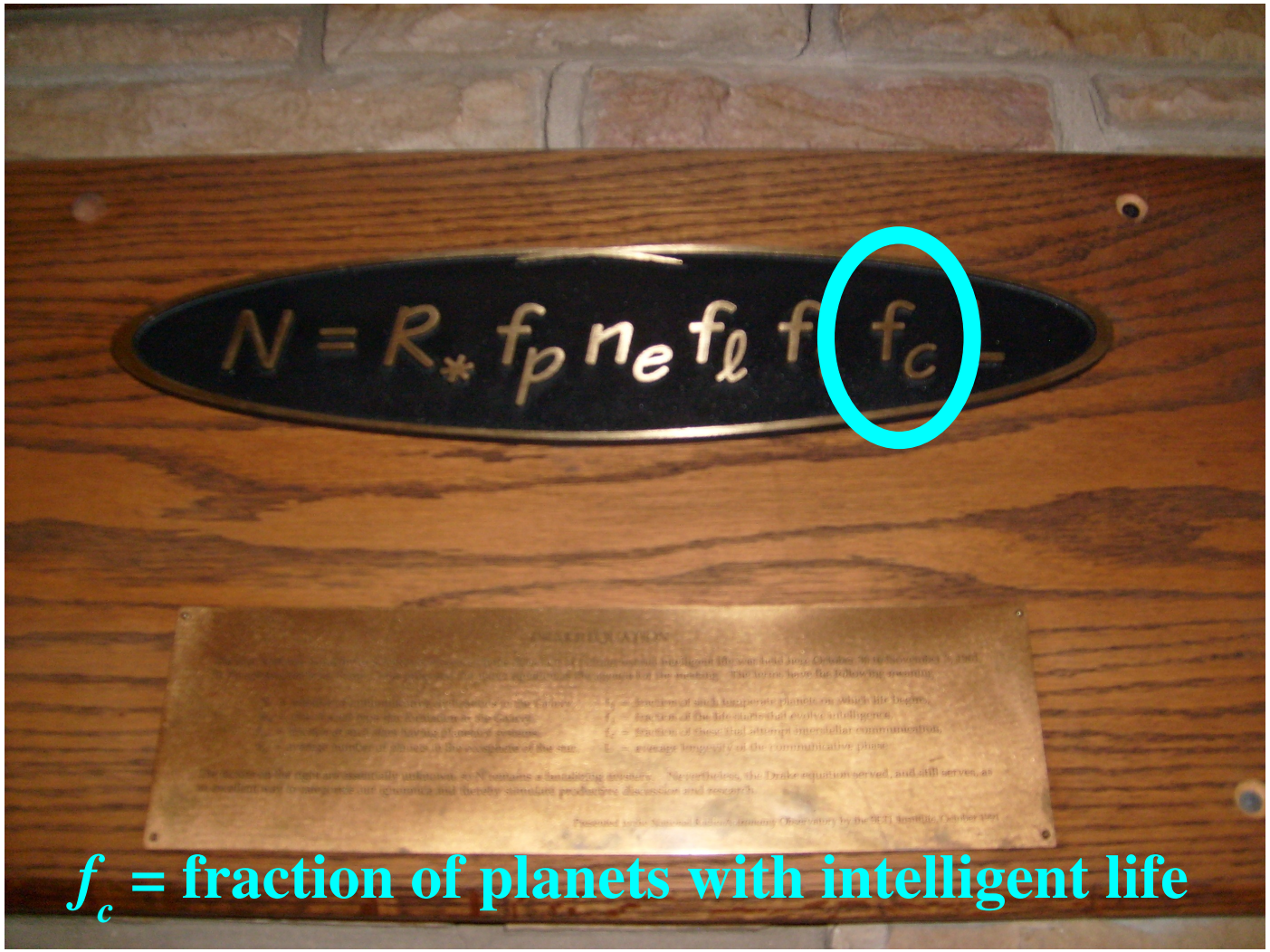
f_l = fraction of habitable planets on which life *did* evolve

The Drake Equation



f_i = fraction of planets with life on which intelligence evolved

The Drake Equation

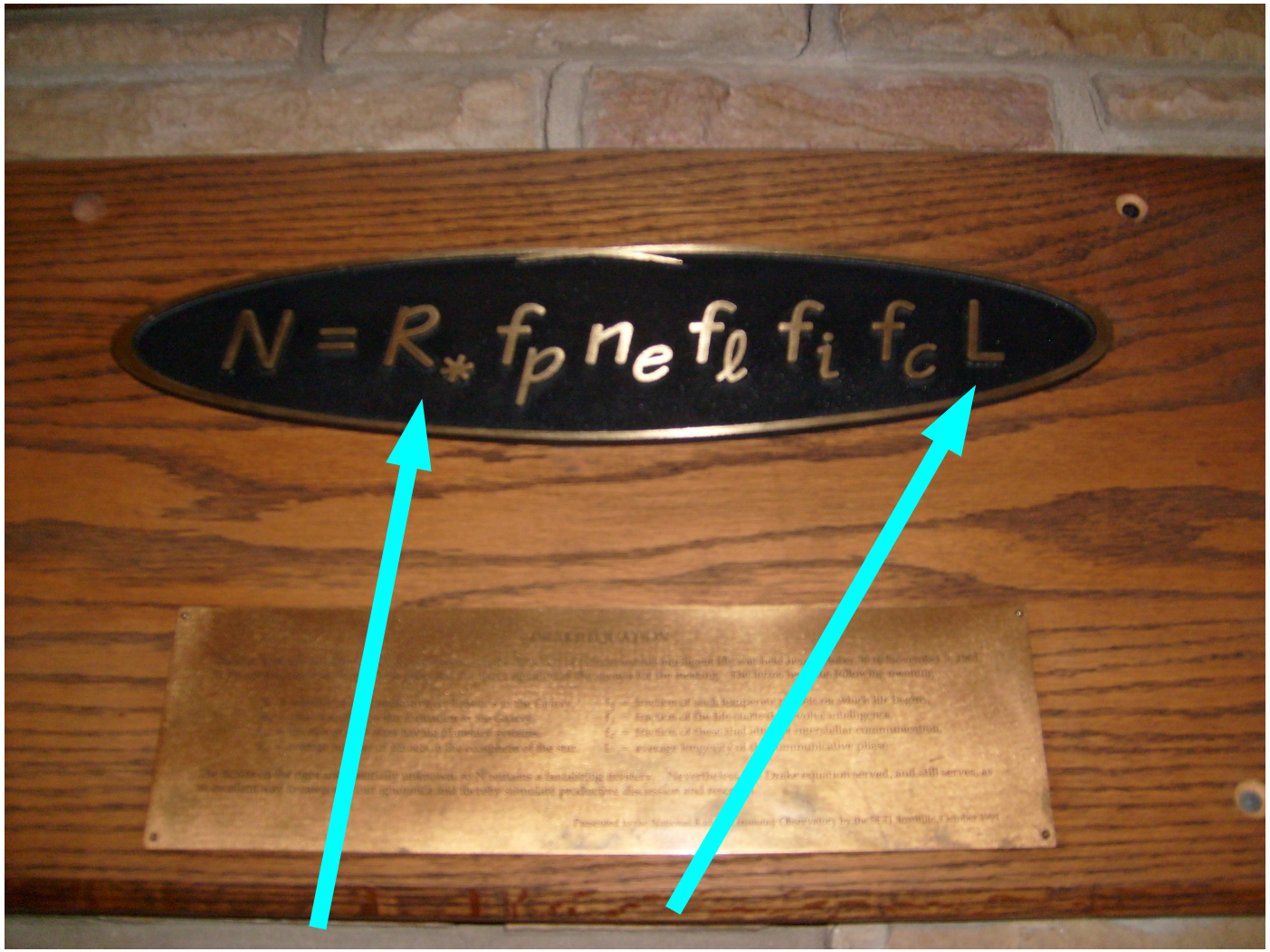


on which a transmitting *civilization* arises

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 (9/8)

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

Response paper for next class (9/8)

Write a statement justifying what *you* believe to be the appropriate level of involvement of Rutgers in the field of astrobiology. Do you favor a new department? an interdisciplinary degree program? an undergraduate major? no commitment at this time to such a speculative enterprise? Your statement should be specific but written at a level that is accessible to a nonspecialist (e.g., a university administrator).