



*Shapley Lecture*

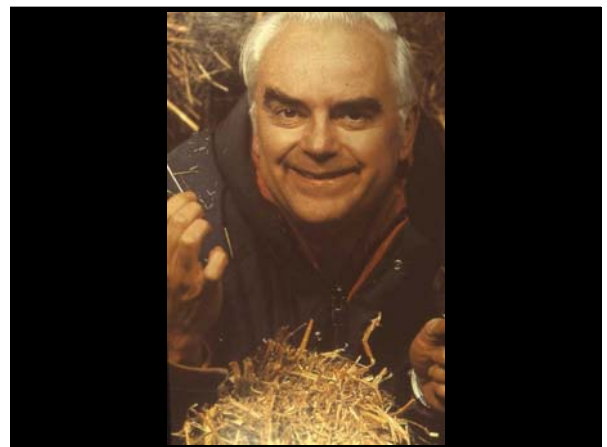
*American Astronomical Society*

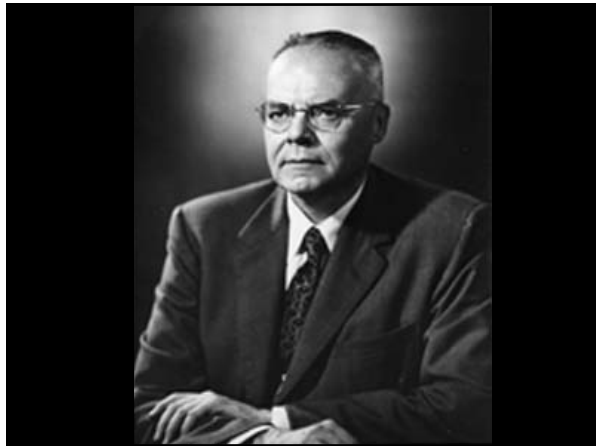
*University of Houston, Clear Lake*

*23 March, 2009*

*Searching for Unicorns and Extraterrestrial Civilizations*

Bob Rood  
University of Virginia

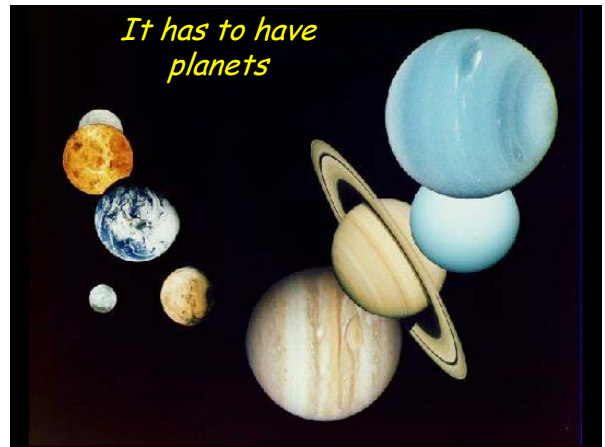




*Ok, Frank,  
How much will it cost?  
and  
Is there any chance of  
success?*



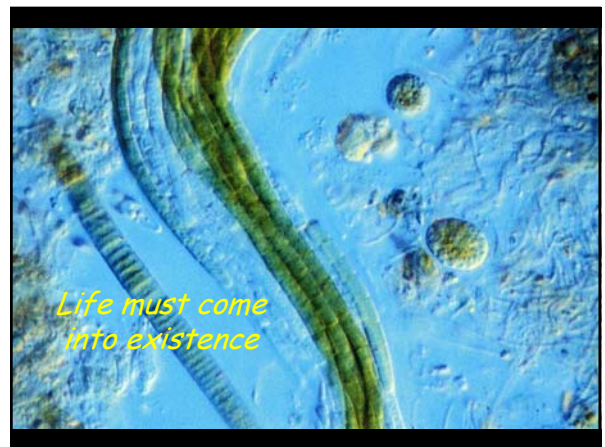
*You start with a  
star*



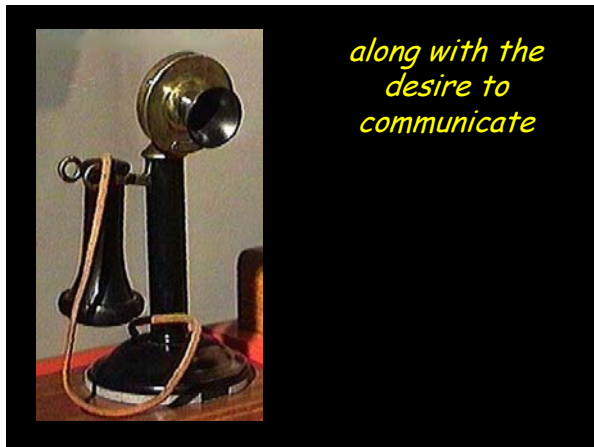
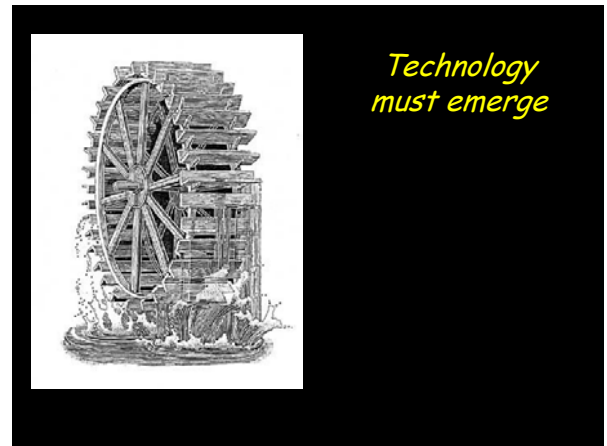
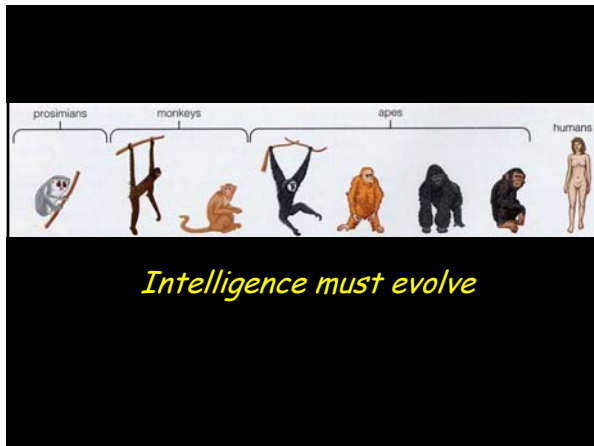
*It has to have  
planets*



*At least one  
planet must be  
earthlike*



*Life must come  
into existence*



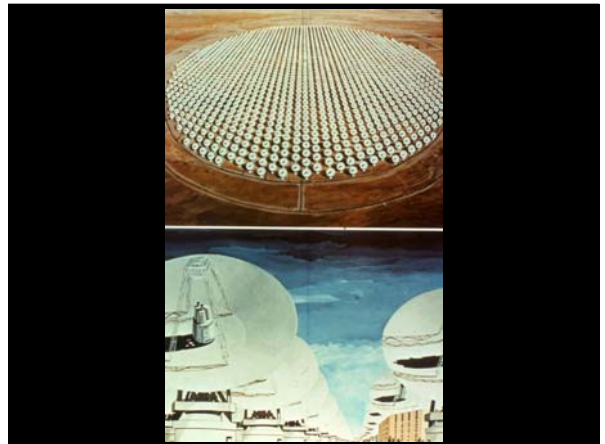
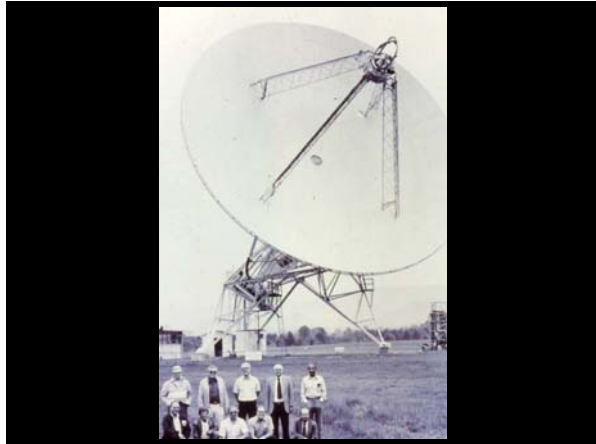
*The Drake Equation*

The number of broadcasting civilizations,  $N$  is:


$$N = R_* f_p n_e f_l f_i f_c L$$

Conclude:  $N$  is plausibly  $> 1$

and possibly  $>$  million



1hT → ATA  
Next Generation Radio Telescope



*Electronics much cheaper in 21<sup>st</sup> century*

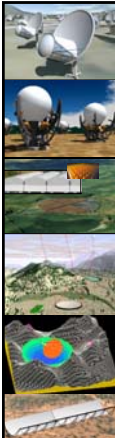
↓

*For a given collecting area optimum antenna size 5 m*

SETI Institute  
UC Berkeley

Thanks to Jill Tarter

*A modern Cyclops*  
*The Square Kilometer Array (SKA)*



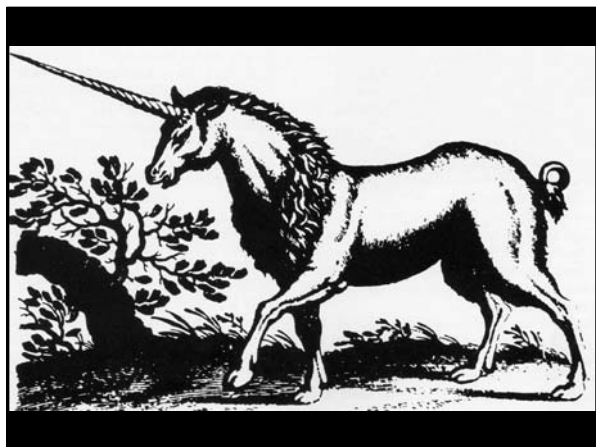

*400,000 5m antennae equivalent of Cyclops*



*A plausible Beast*



*not plausible*

**UNICORNS HORN**

Now brought in Use for the Cure of Diseases by an Experienced DOCTOR, the AUTHOR of this Antidote.

**A** Most Excellent Drink made with a true Unicorn's Horn, which doth **Effluently** Cure their Diseases.

Further, If any please to be **fastidied**, they may come to the Doctor and view the Horn.

*For every old Ulcers, Dropsie, Paining Gout, Confusions, Distillations, Length of Palpitation of the Heart, Fainting Fits, Convulsions, Stange kind Blights or Chaulms, Stomachy or Scurvy, The Greave, the Leprosy, the Glanders,*

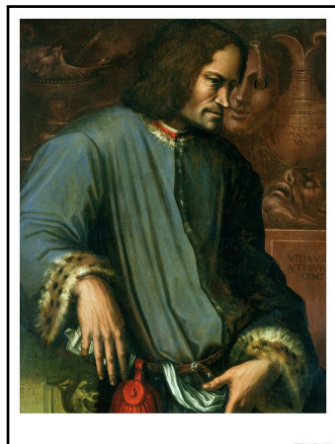
And all Distempers proceeding from a Cold Cause.

The Life of it is so prodigious, that it prevents Diseases and Infection by fortifying the Noble Parts, and potentially expels what is an Enemy to Nature, preserving the Vigour, Youth, and a good Complexion to Old Age: The Virtue is of such force, as so to rid an Infirmy from an odious Endurance: None can exceed this, for it is joyed with the Virtue of a true Unicorn's Horn, through which the Drink passeth, and being impregnated therewith, is drink wondrously Corroborate and Cure, drinking it want at any time of the Day, about a quarter of a Pint at a time, the oftenest the better, the Price is 2 s. the Quart.

Also as a preparative for this excellent Drink, and good against the Diseases above mentioned, and all Qualities in the body, is ready prepared twelve Pills in a Box to be taken at three Doses, according to Directions therein given, the Price is 2 s. the Box.

Whosoever hath Admirable Medicines for the Cure of the POX, or Running of the Reins, with all Symptoms and Accidents thereto belonging, whether Newly taken on, or long Continuance, and (by Gods Blessing) remove the Patient from the danger of the Disease presently, and perhaps the Cure with the greatest Speed and Secrecy imaginable, our Admirable Medicines, may have further Advice from the Doctor without Charge.

The Doctor Liveth in Houndsditch, next Door to Cam-Yard, leaving a Book Due under the Ark, where any Person may come to see.



*Lorenzo de  
Medici owned a  
unicorn horn*



*What's in it for the unicorn?*

*What's in it for ET to send signals that a primitive civilization like us might detect?*

*What are the habits of these unicorns?*

*The Drake Equation*

The number of broadcasting civilizations,  $N$  is:

$$N = R_* f_p n_e f_l f_i f_c L$$

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$R_*$  is known: 1—10 stars/year

$n_e$  is almost certainly  $< 1$

all  $f$ 's are  $\leq 1$ , so

$$N \approx L$$

$L$  could be  $10^9$  years

$$N = R_* f_p n_e f_l f_i f_c L$$

*Conclusions:*

- *Communicating civilizations are plausible*
- *$N$  is large only if  $L$  is large*
- *Even if  $L$  is large  $N$  may not be large*

*but beware of:*

*Spin*

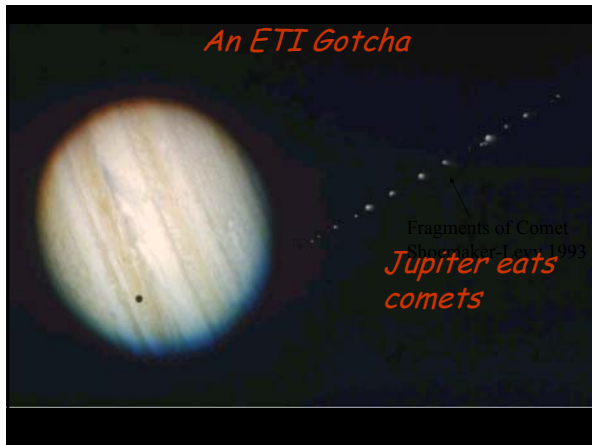
*"All of these newly discovered planets make ET life more likely"*

*Bull*

## Hidden subscripts

For example:

- If  $R_*$  is really  $R_{\text{solar-type star 56yr old closer than 1 kpc}}$  then  $R_* \approx 10^{-3}$  stars/year



## My spin on this

There is no significant chance for success unless  $L$  is very large --- millions or billions of year as a technological civilization

At a 100 years we are probably the youngest TC in the Galaxy

## 3 other simple results

- Unless civilizations which have a cosmic limit on  $L$  are very rare ( $P \ll 10^{-3}$ ), they are the ones we are most likely to contact.
- We are most likely to contact the most "luminous" civilizations.
- "They" know we're here only if there are 10's of millions of civilizations.



*What will a long-lived,  
power rich, technological  
civilization look like?*

They will conserve energy,  
i.e., the 1<sup>st</sup> law of  
thermodynamics

They will obey the 2<sup>nd</sup> law of  
thermodynamics, i.e., they  
must deal with their waste  
energy

They will worry about

\$

- *Directed beacon costs \$10<sup>6</sup>/year*
  - o *They know we're here*
    - *Closer than 100 light years*
    - *10's of millions of civilizations*
  - o *They know an earthlike planet is here*
    - *May need to broadcast for 10<sup>8</sup> years*

- *Omnidirectional beacons cost \$10<sup>12</sup>/year*
  - o *Significant fraction of Earth's entire energy budget*
  - o *We cannot have a significantly larger energy use without frying the Earth*

*The 2<sup>nd</sup> law of thermodynamics requires that energy use at the very least produces waste heat.*



Energy input or  
Total Wattage Intercepted:  
Terrestrial or TWIT

1 TWIT  $\approx 2 \times 10^{17}$  watts

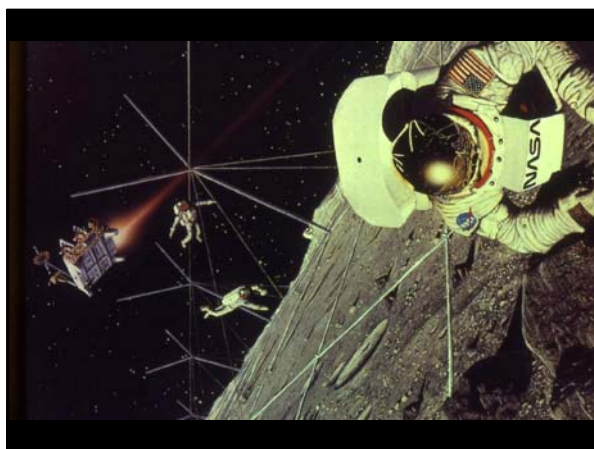
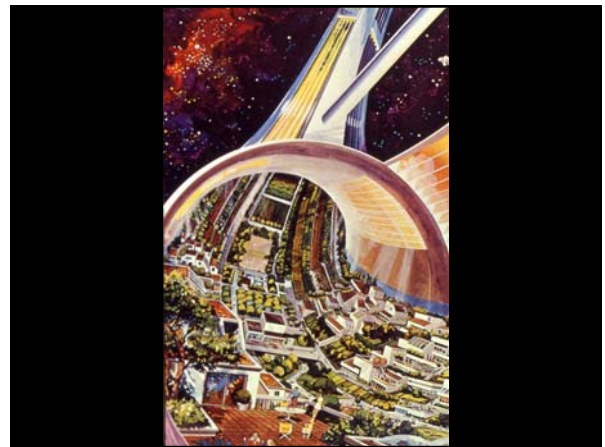
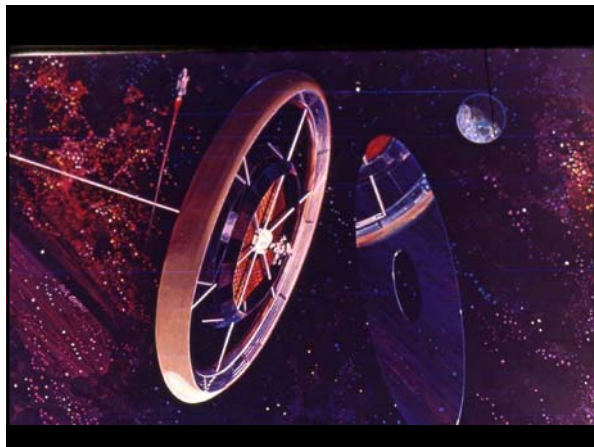
Total energy use on Earth  $\approx 4 \times 10^{13}$  w  
 $\approx 0.2$  milli-twit

Ice ages:  $-7C \sim 10$  milli-twit

CO<sub>2</sub> Greenhouse:  $3C \sim 4$  milli-twit

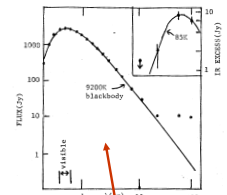
Major climate change with if energy input into lower atmosphere changes by a few 10's of milli-twit.

We are and will remain a milli-twit civilization unless we abandon planets



What would such a civilization look like?

- IR excess perhaps  $10^{-5} L_*$
- Will use hydrocarbon polymers
  - low temperature environment
- planar distribution



This is Vega

*They could afford to send interstellar beacons.*

*But since kinetic energy of a space colony moving at 0.01c is a few twit-days*

*They could also afford slow interstellar travel with a few centuries transit time*

*This probably doesn't sound very inviting to most of you.*

*Does it bother you that we've gone 60,000 miles since I've been talking to you?*

*Such travel would be colonizing*

- few centuries transit
- few centuries to grow the population from  $10^4$  to trillion at 6%/yr
- send out colonies to the next star in perhaps a 1000 years

*It only takes a few 10's of millions of years to colonize every suitable site in the Galaxy*

*This is less 1% the age of the Galaxy or about a day on the cosmic calender.*

*Where is the closest colonization site?*

*Here!*  
*Where are they?*



