

enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.





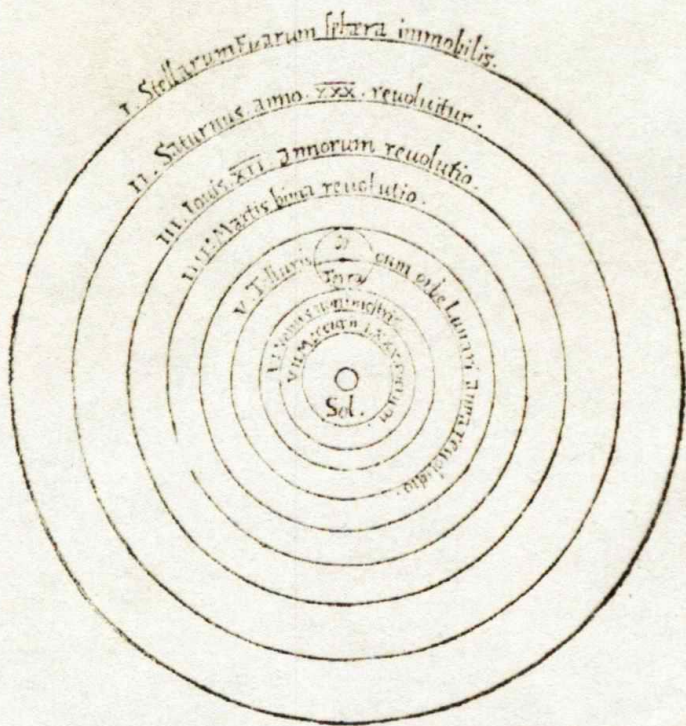
*“There are infinite worlds both like and unlike this world of ours...We must believe that in all worlds there are living creatures and planets and other things we see in this world.”*

*Epicurius*

*c. 300 B.C*

NICOLAI COPERNICI

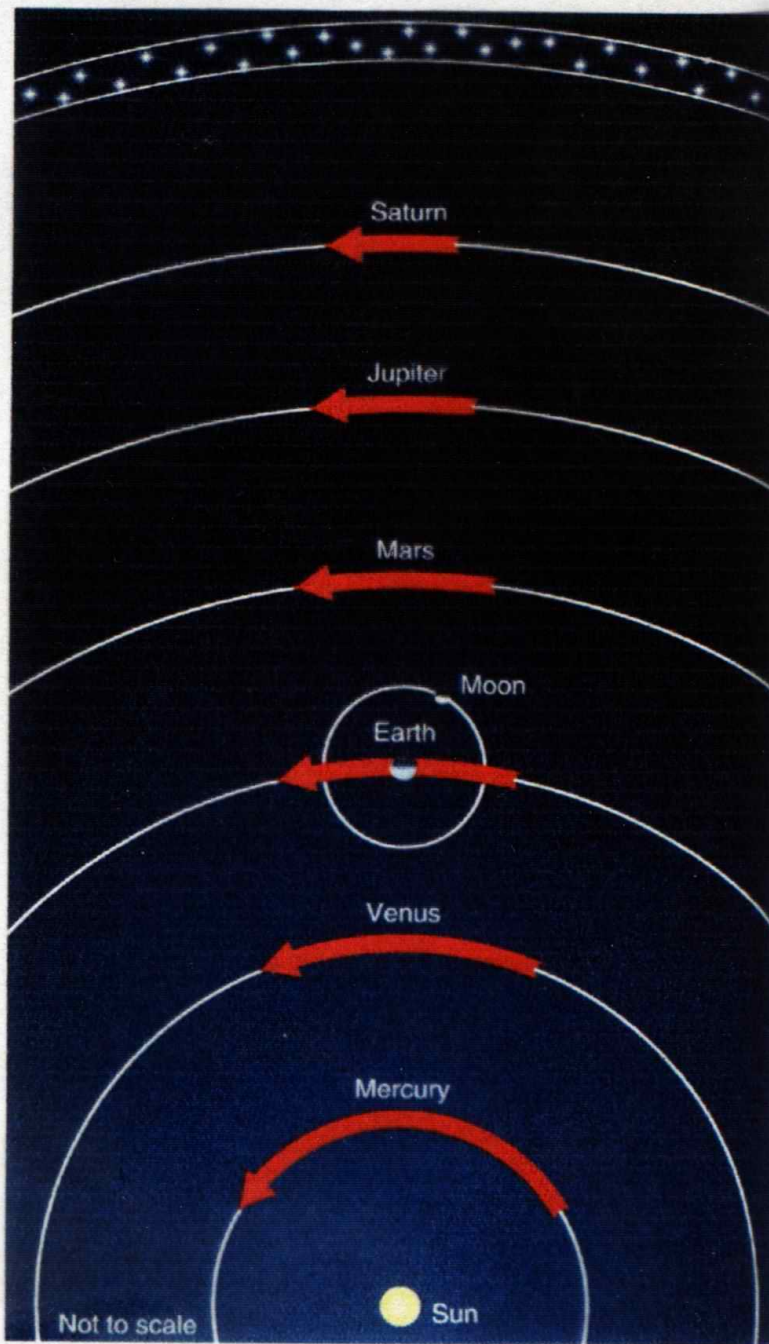
net, in quo terram cum orbe lunari tanquam epicyclo contineri diximus. Quo nō loco Venus nono mense reducitur. Sextum diebus locum Mercurius tenet, octuaginta dierum spacio circū currens. In medio uero omnium relictus Sol. Quis enim in hoc



pulcherrimo templo lampadem hanc in alio uel meliori loco poneret, quam unde rotum simul possit illuminare: Siquidem non inepte quidam lucernam mundi, alij mentem, alij rectorem uocant. Trimegistus uisibilem Deum, Sophoclis Electra intuentē omnia. Ita profecto tanquam in folio regali Sol residens circum agentem gubernat Altrorum familiam. Tellus quoque minime fraudatur lunari ministerio, sed ut Aristoteles de animalibus ait, maximam Luna cum terra cognationē habet. Cōcipit interea à Sole terra, & impregnatur anno partu. Inuenimus igitur sub

haec

a



b

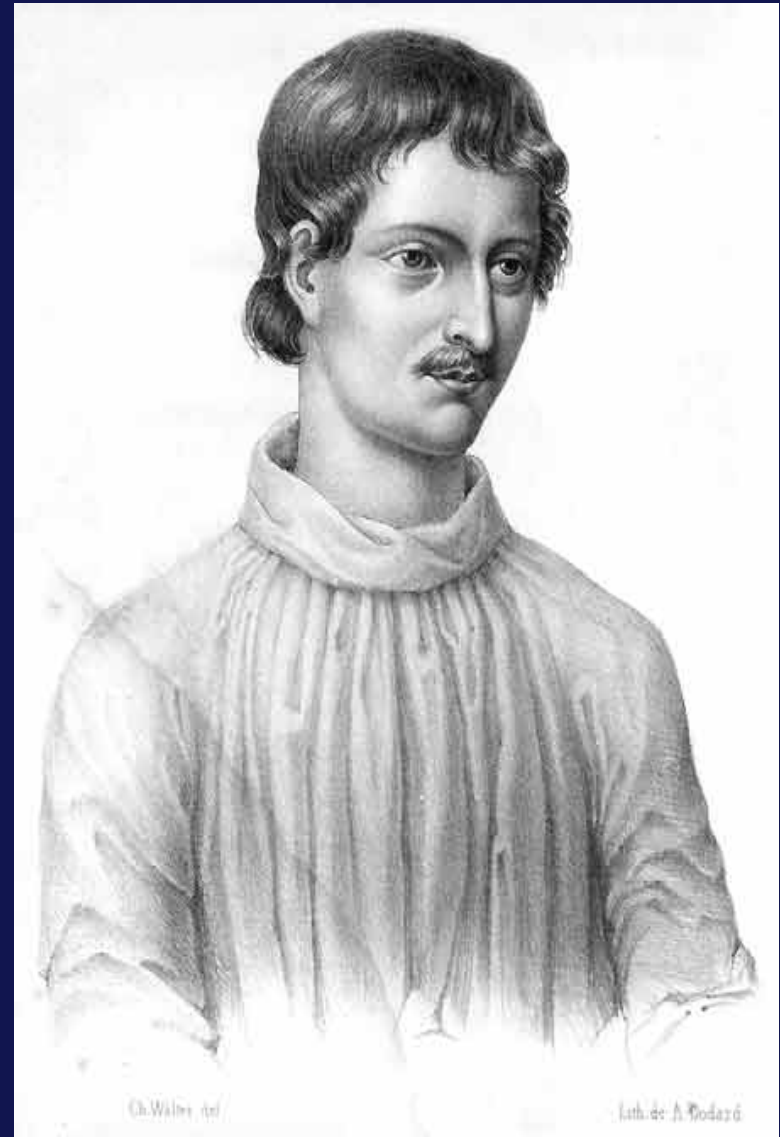


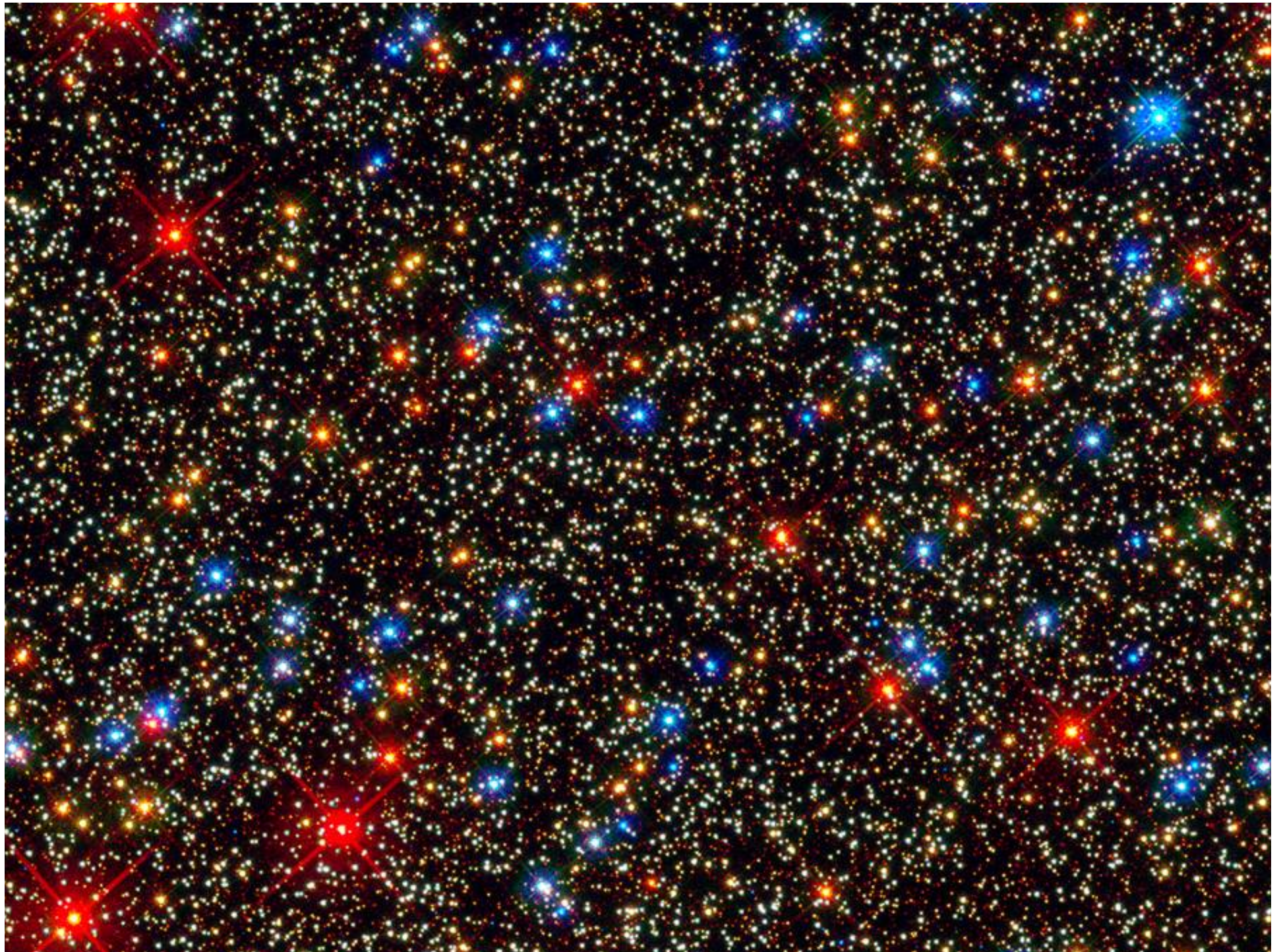
**1610 observation trumps ancient wisdom**

# 1584

*"There are countless suns and countless earths all rotating around their suns in exactly the same way as the seven planets of our system . . . The countless worlds in the universe are no worse and no less inhabited than our Earth"*

*Giordano Bruno  
in De L'infinito  
Universo E Mondi*

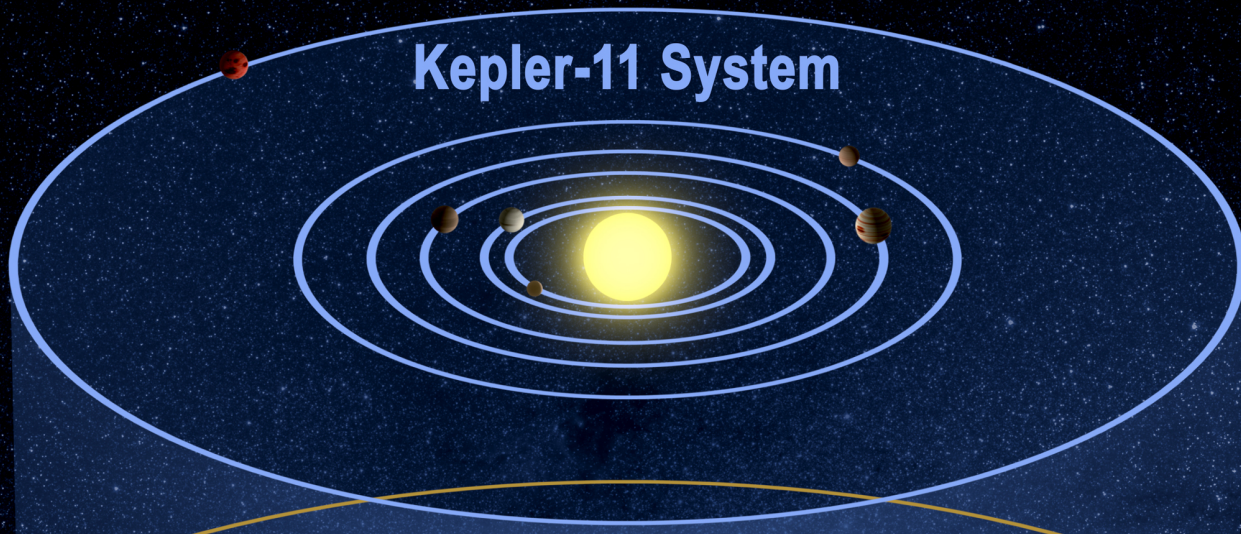








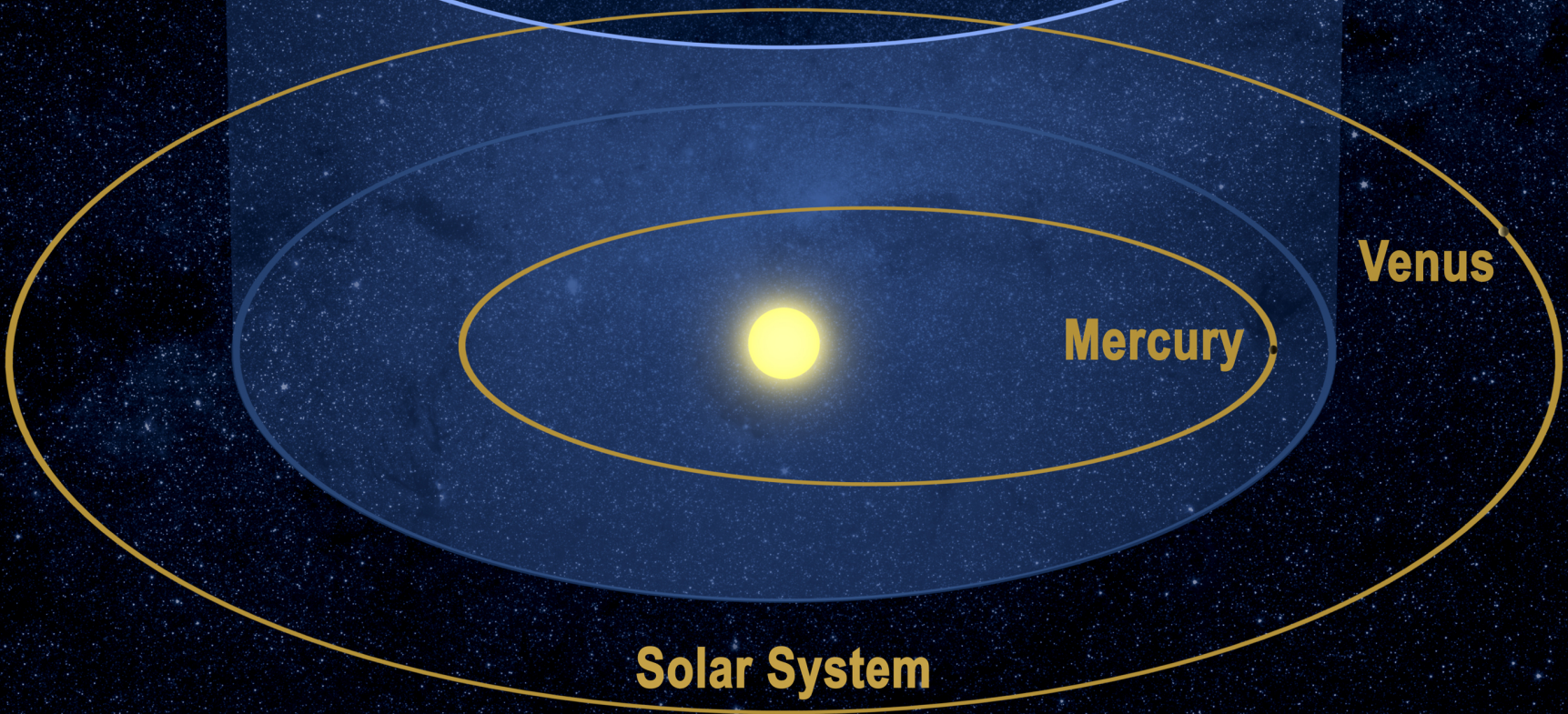
**Kepler-11 System**



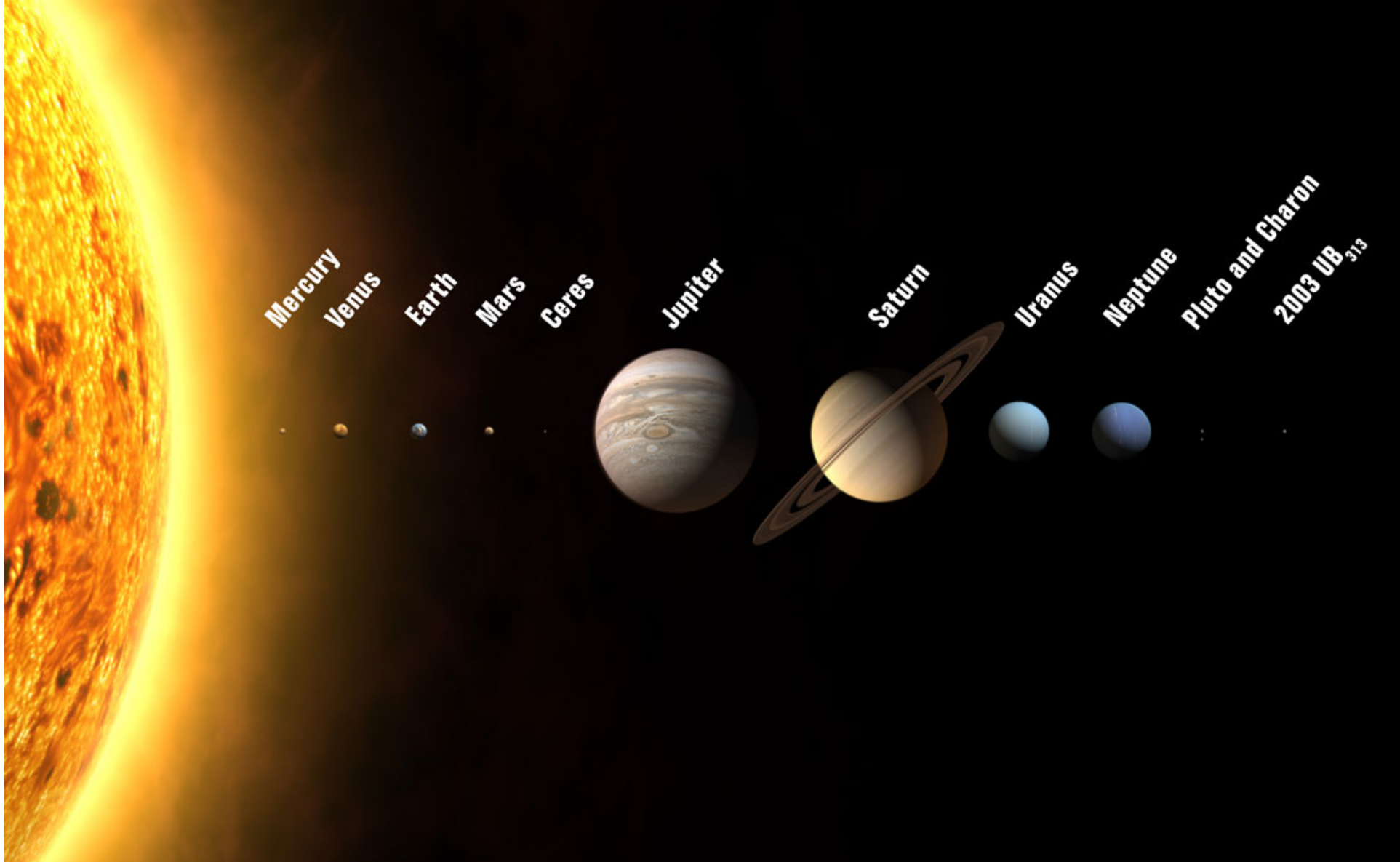
**Venus**

**Mercury**

**Solar System**







Mercury

Venus

Earth

Mars

Ceres

Jupiter

Saturn

Uranus

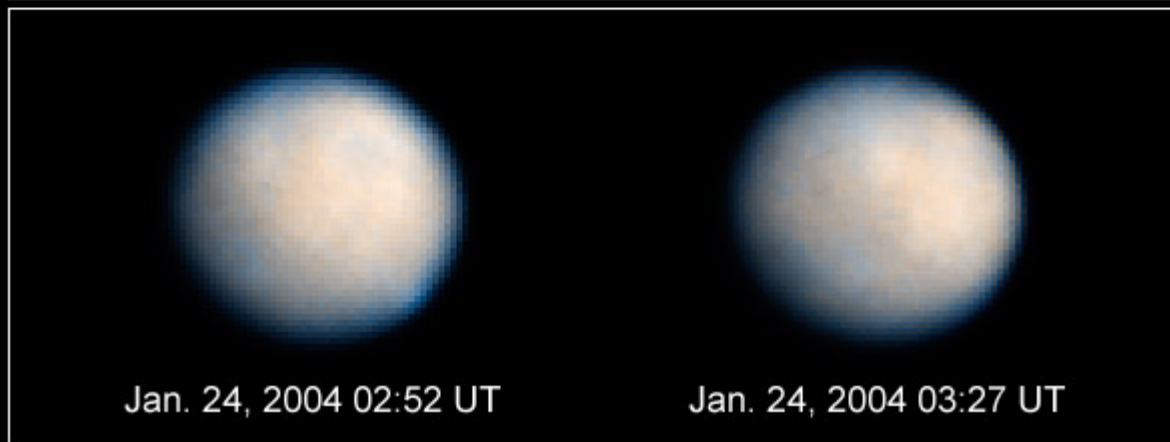
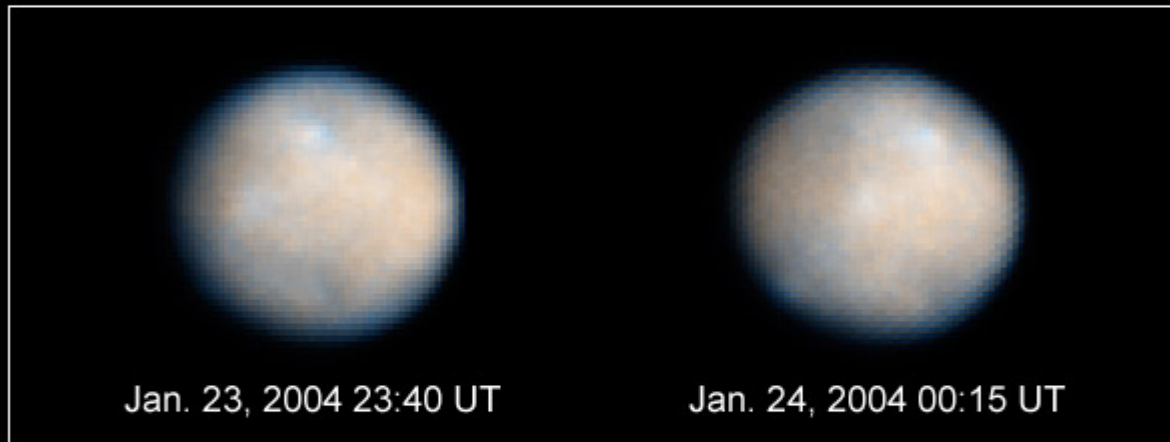
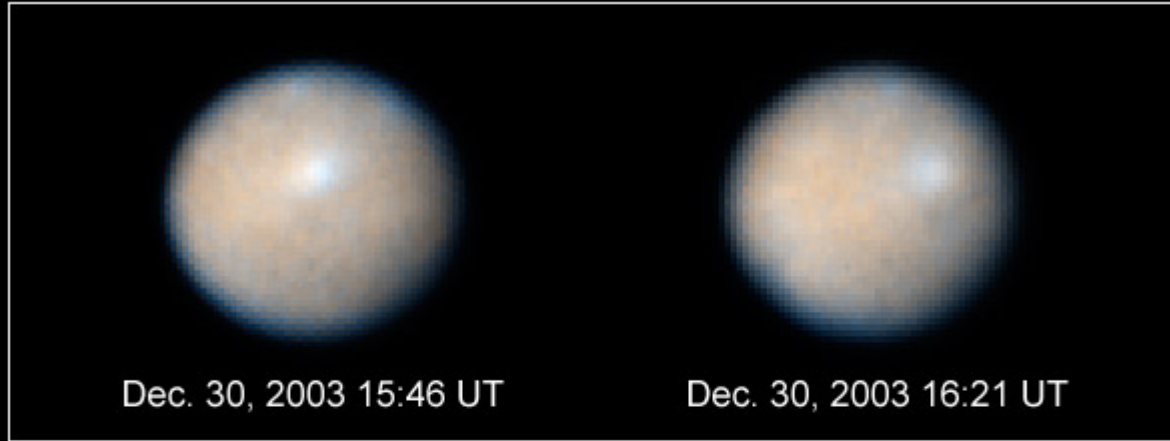
Neptune

Pluto and Charon

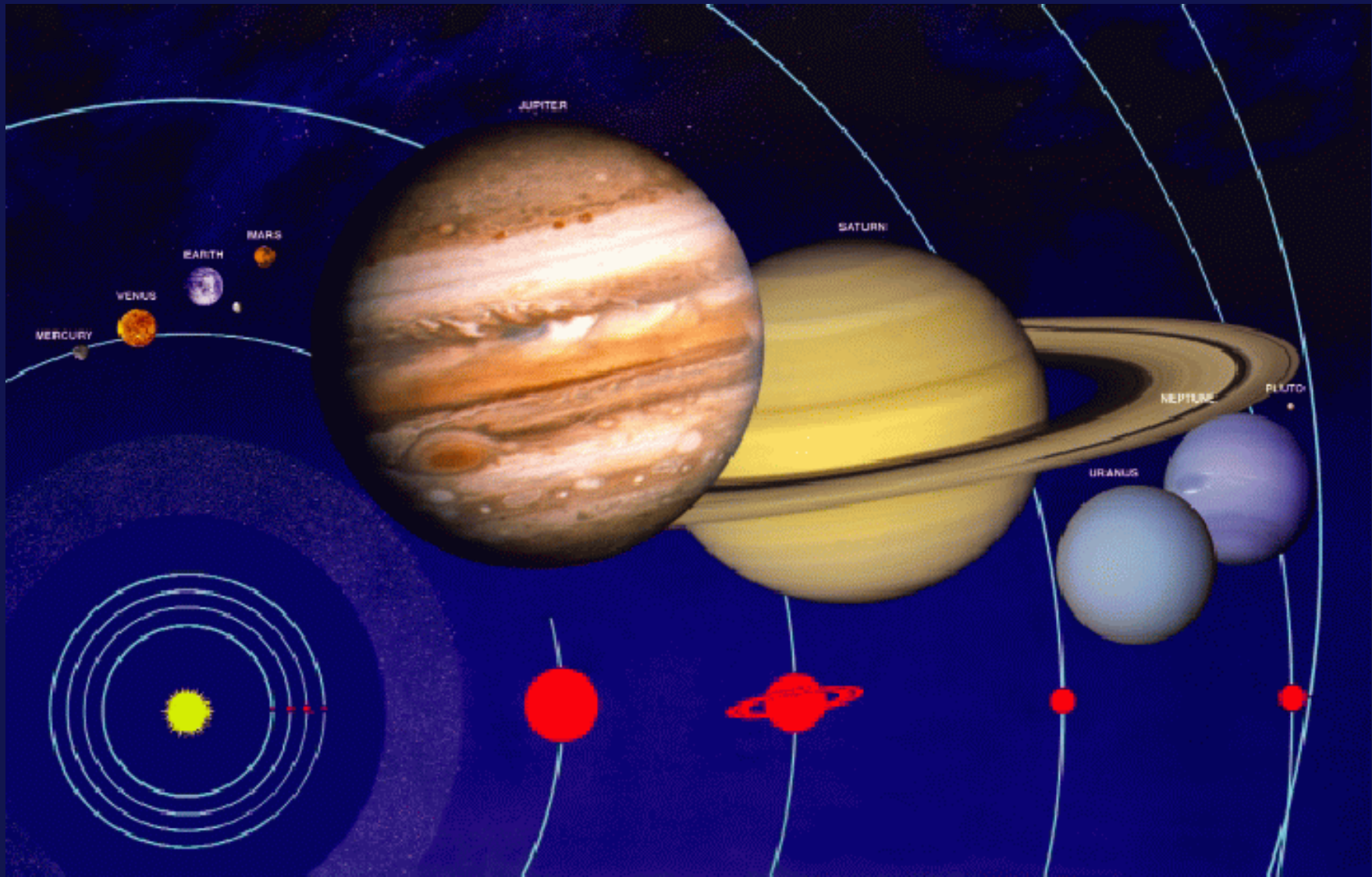
2003 UB<sup>313</sup>

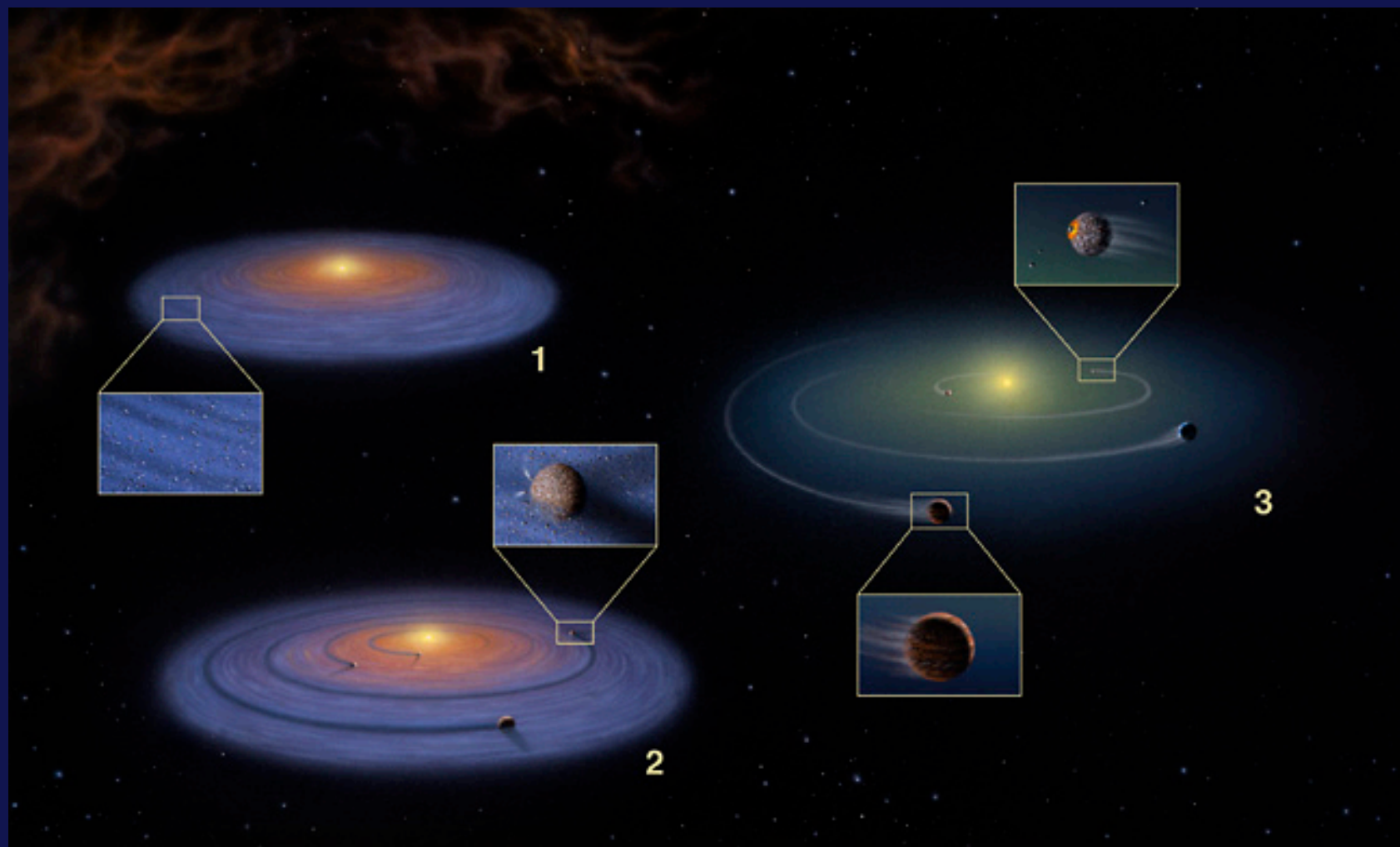
Ceres

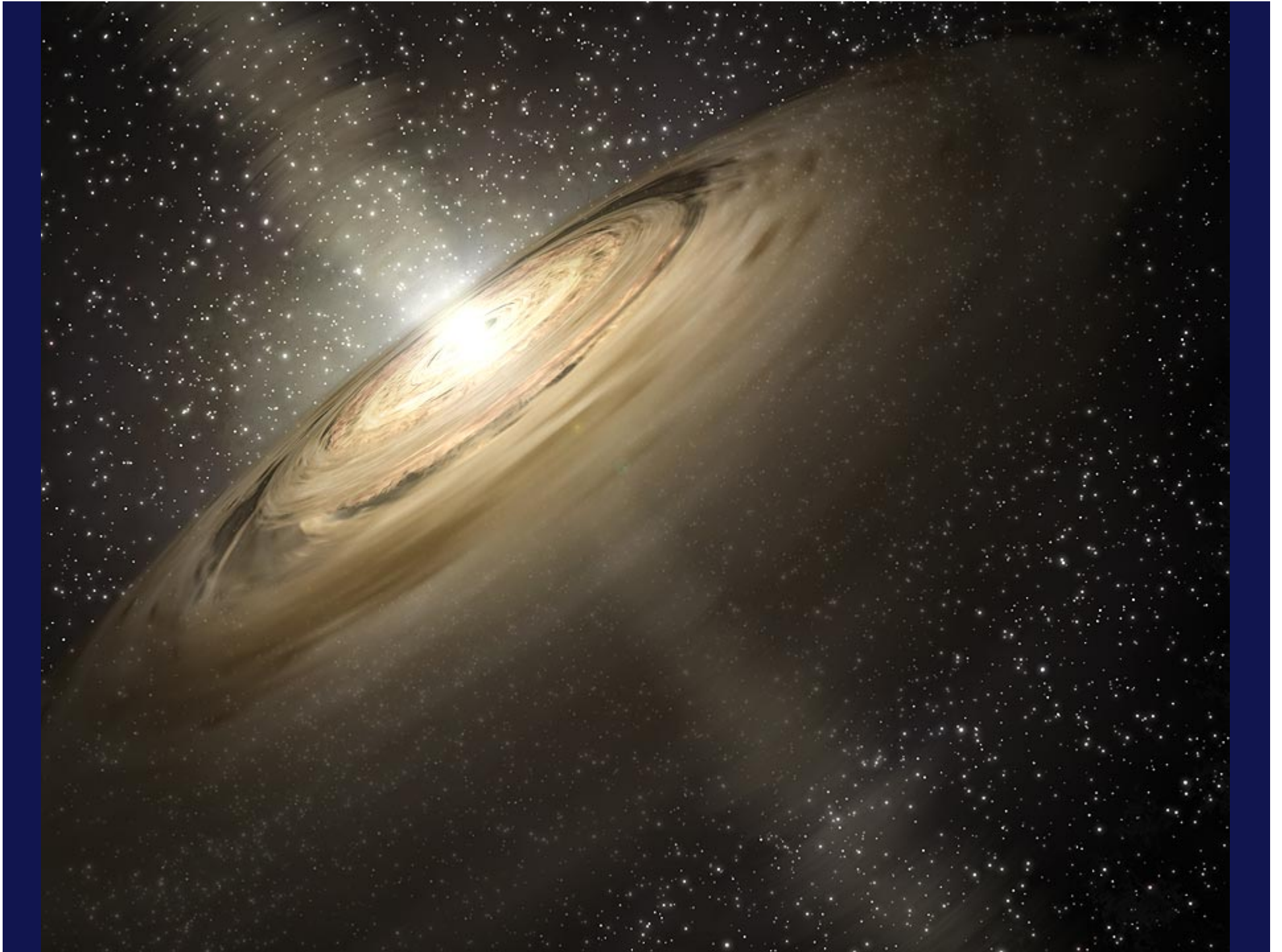
Hubble Space Telescope • ACS/HRC



# *Solar System Architecture*

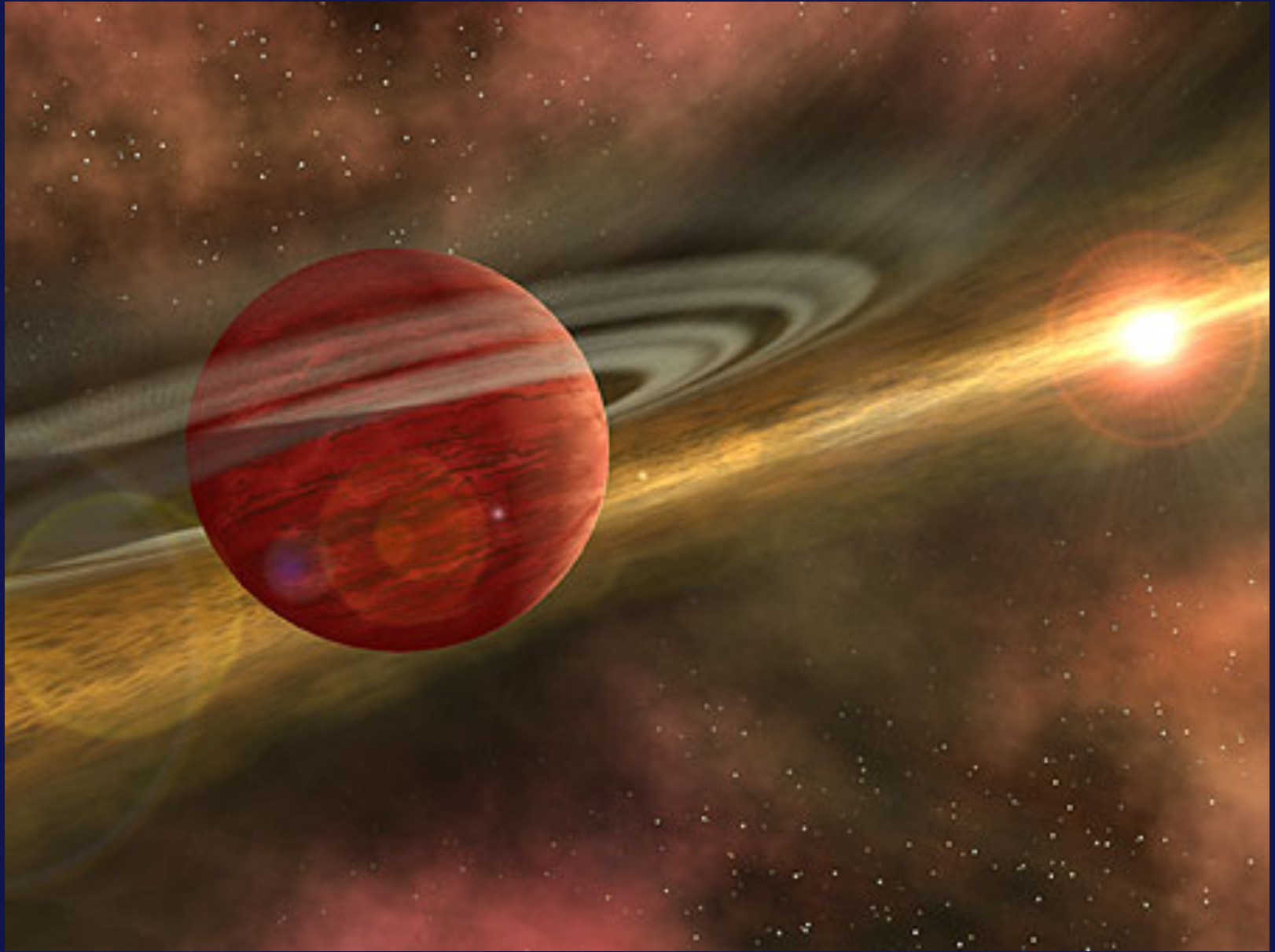




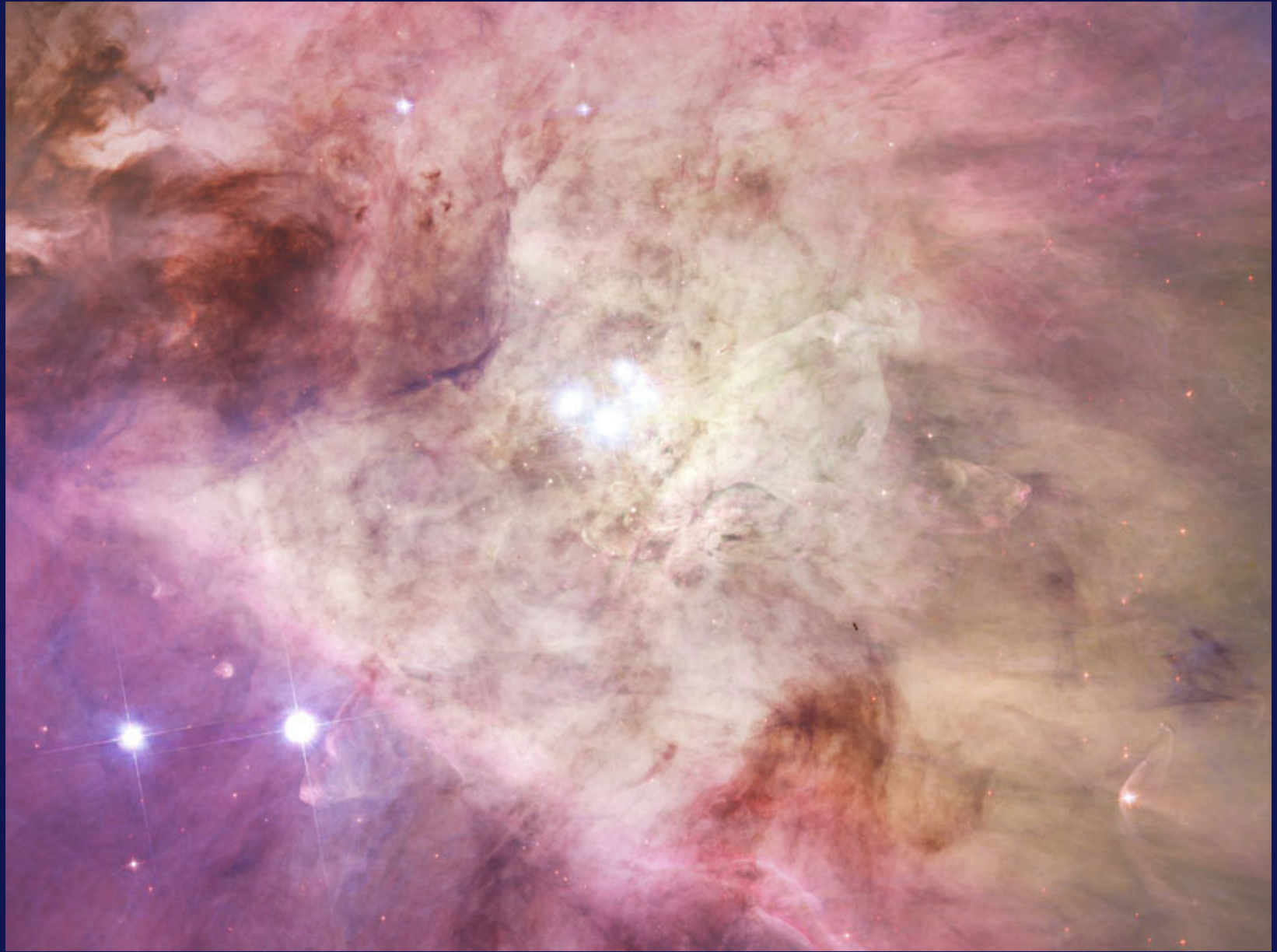


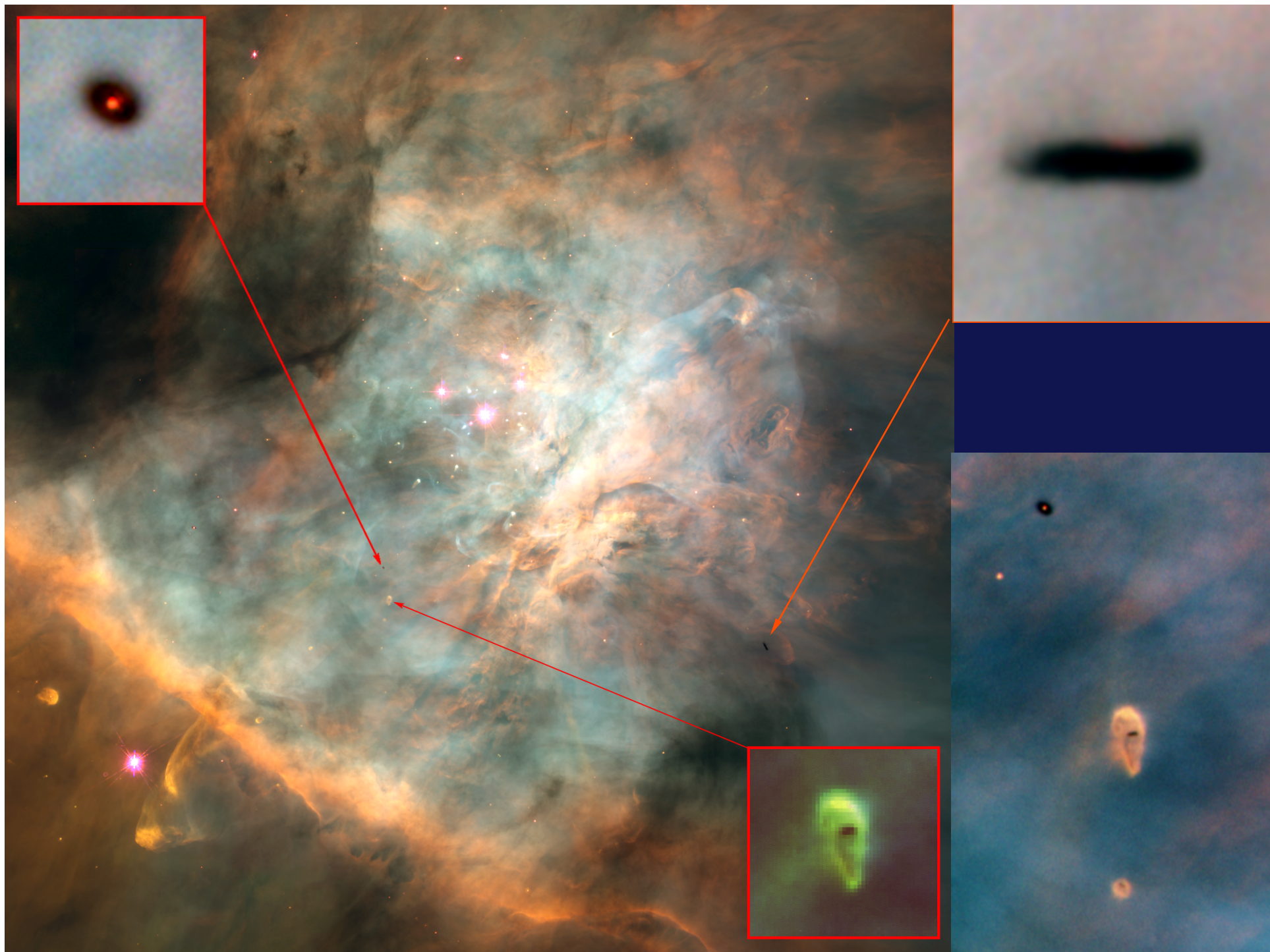


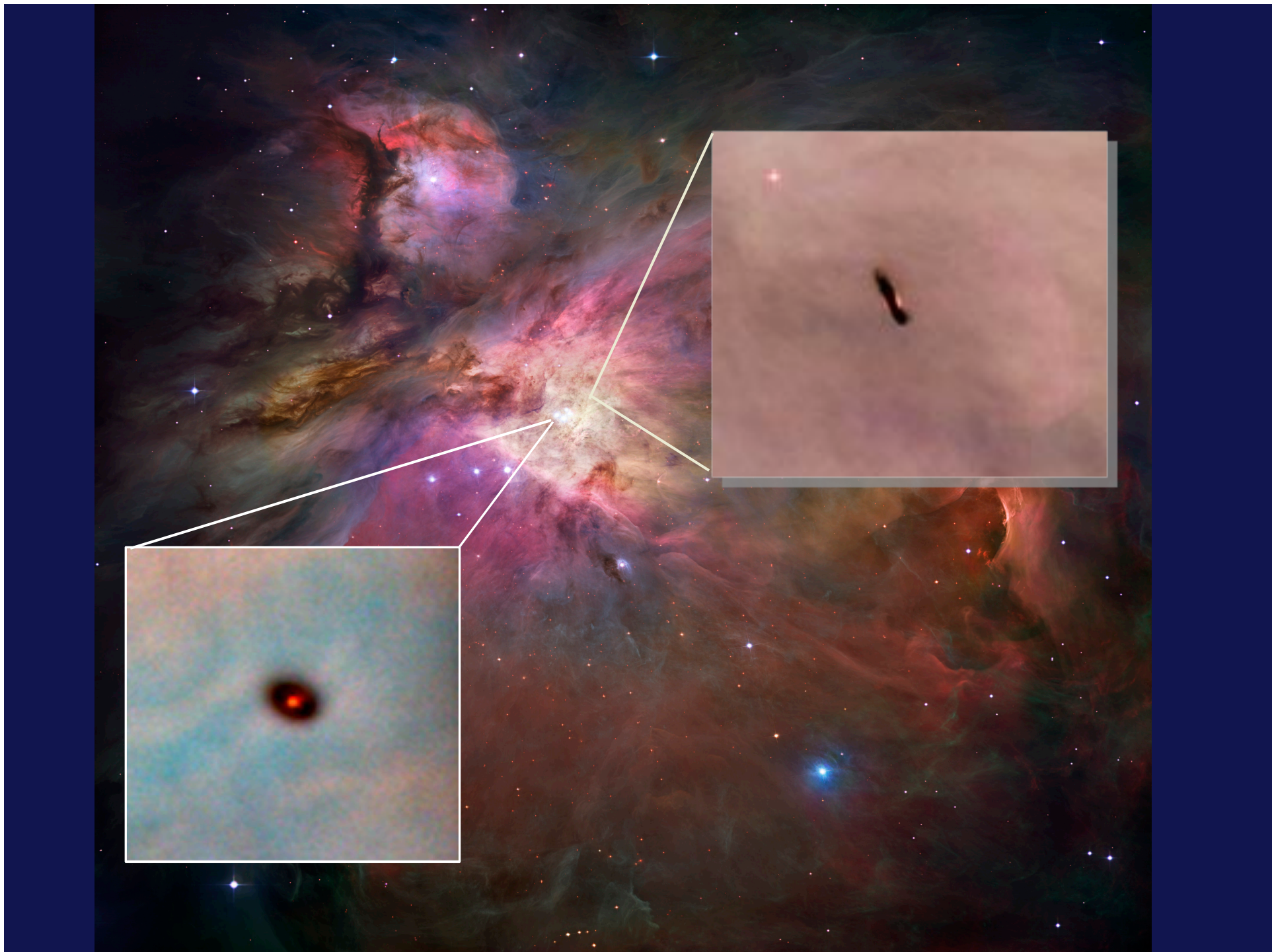


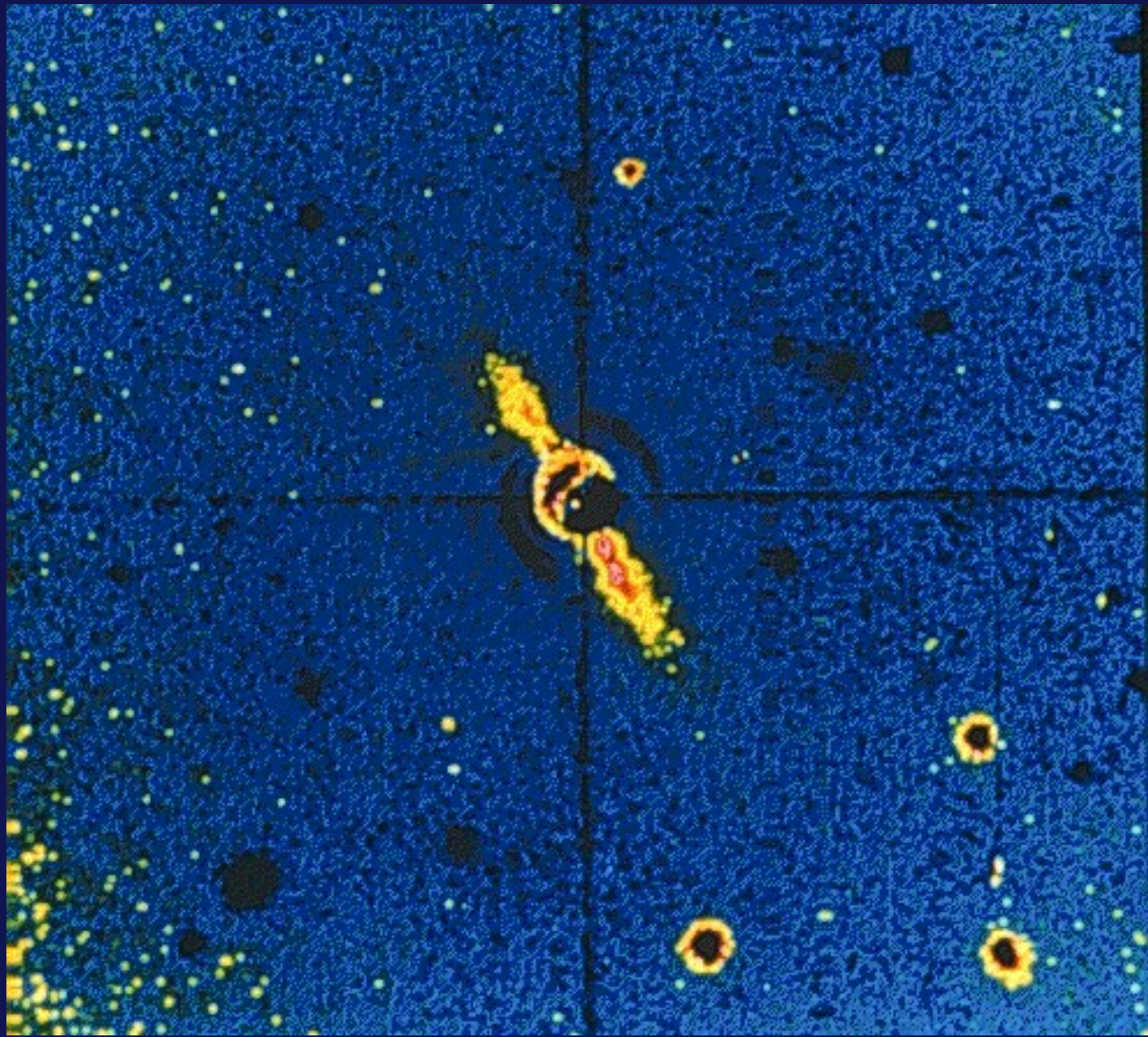


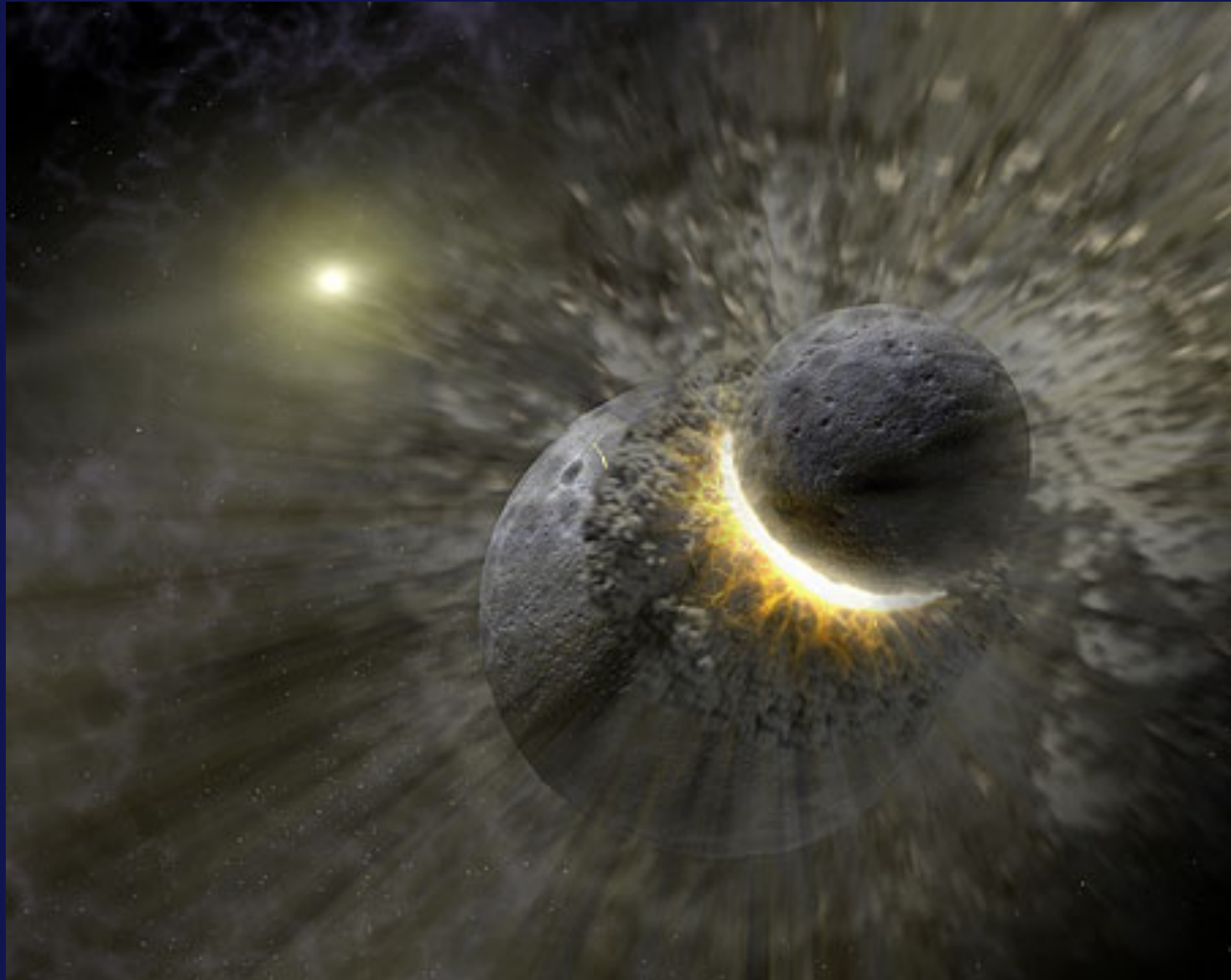


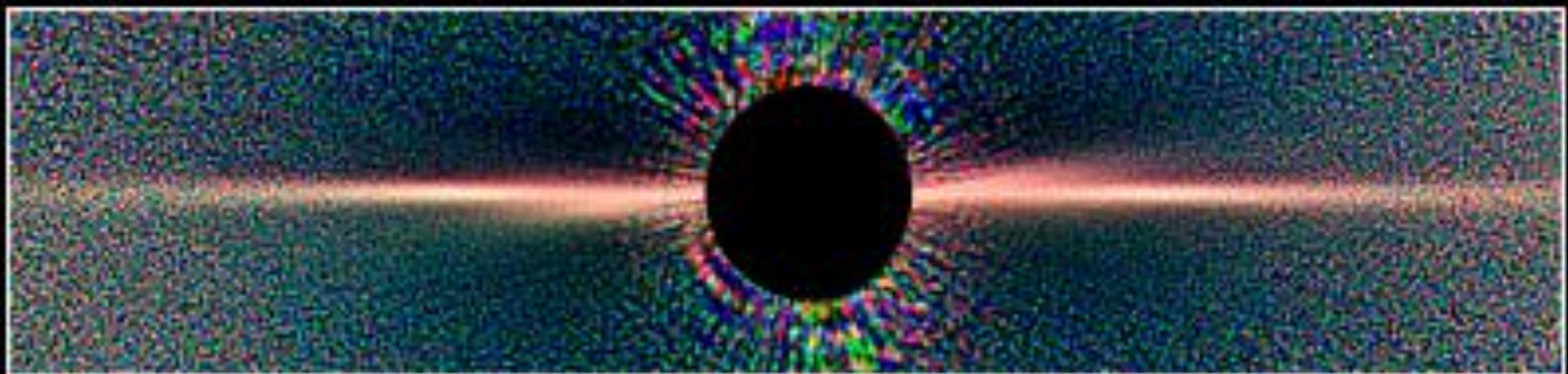






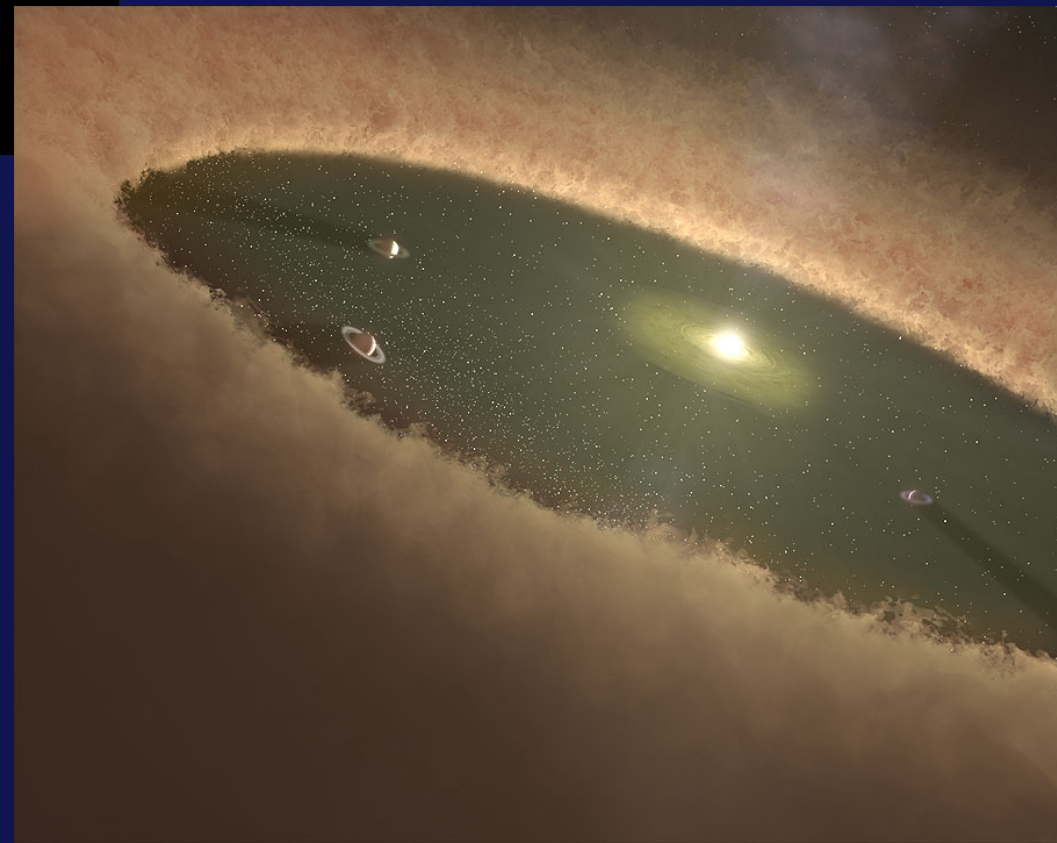
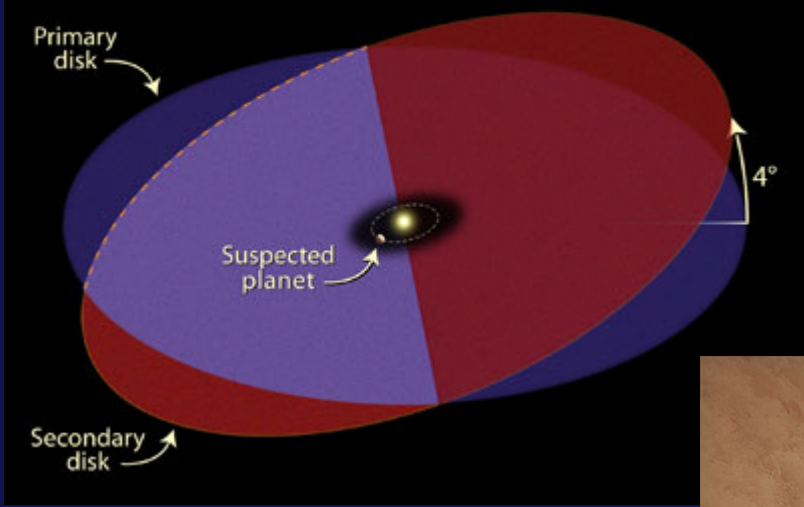






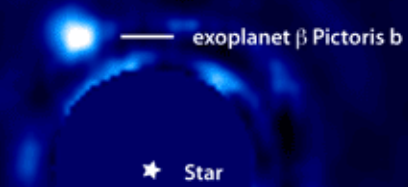


# Double disk around Beta Pictoris



November 2003

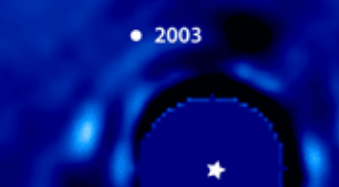
L' band - 3.8  $\mu\text{m}$



October 2009

L' band - 3.8  $\mu\text{m}$

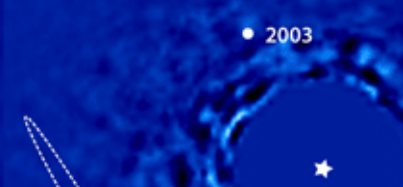
• 2003



March 2010

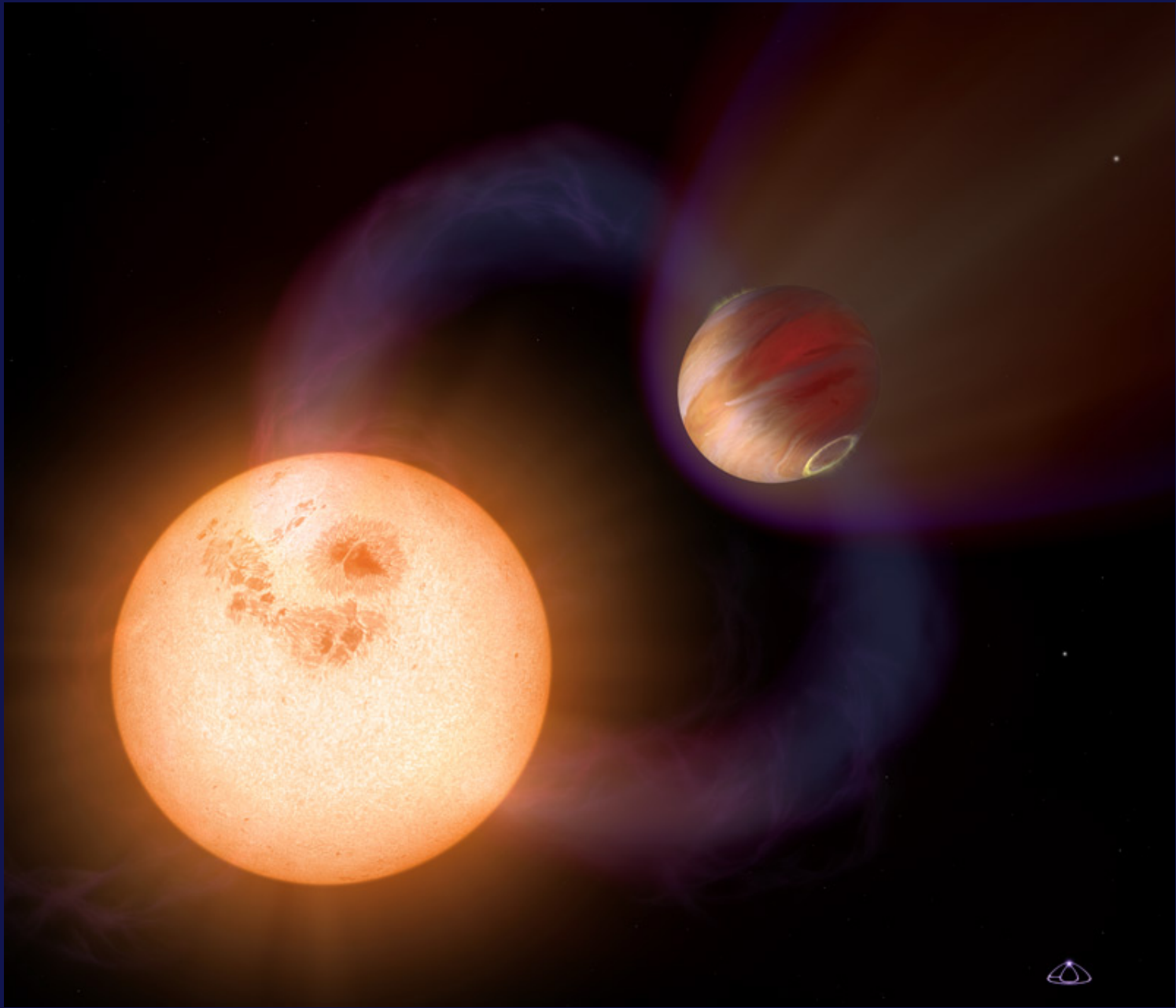
Ks band - 2.18  $\mu\text{m}$

• 2003



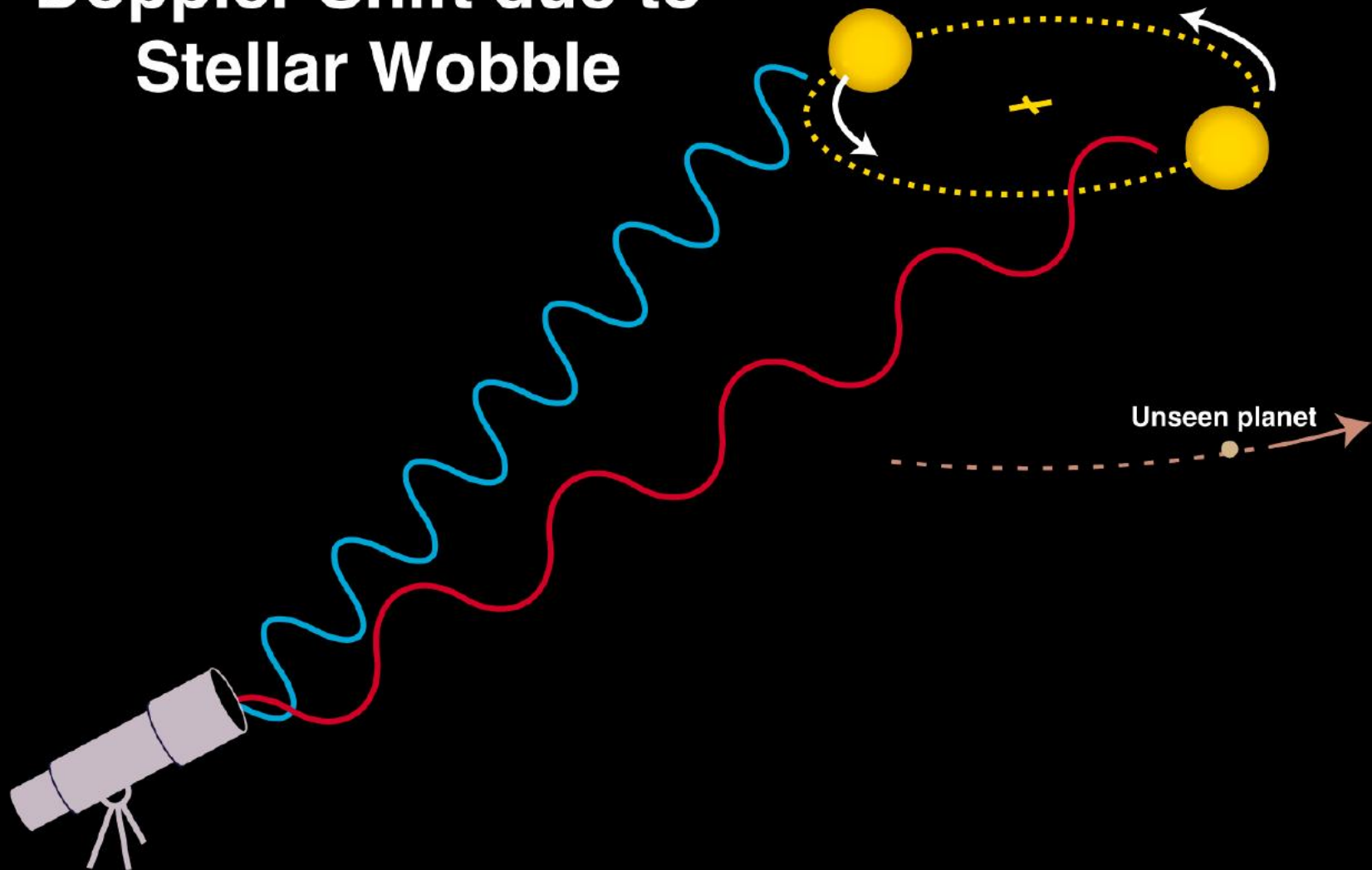
Saturn's orbit

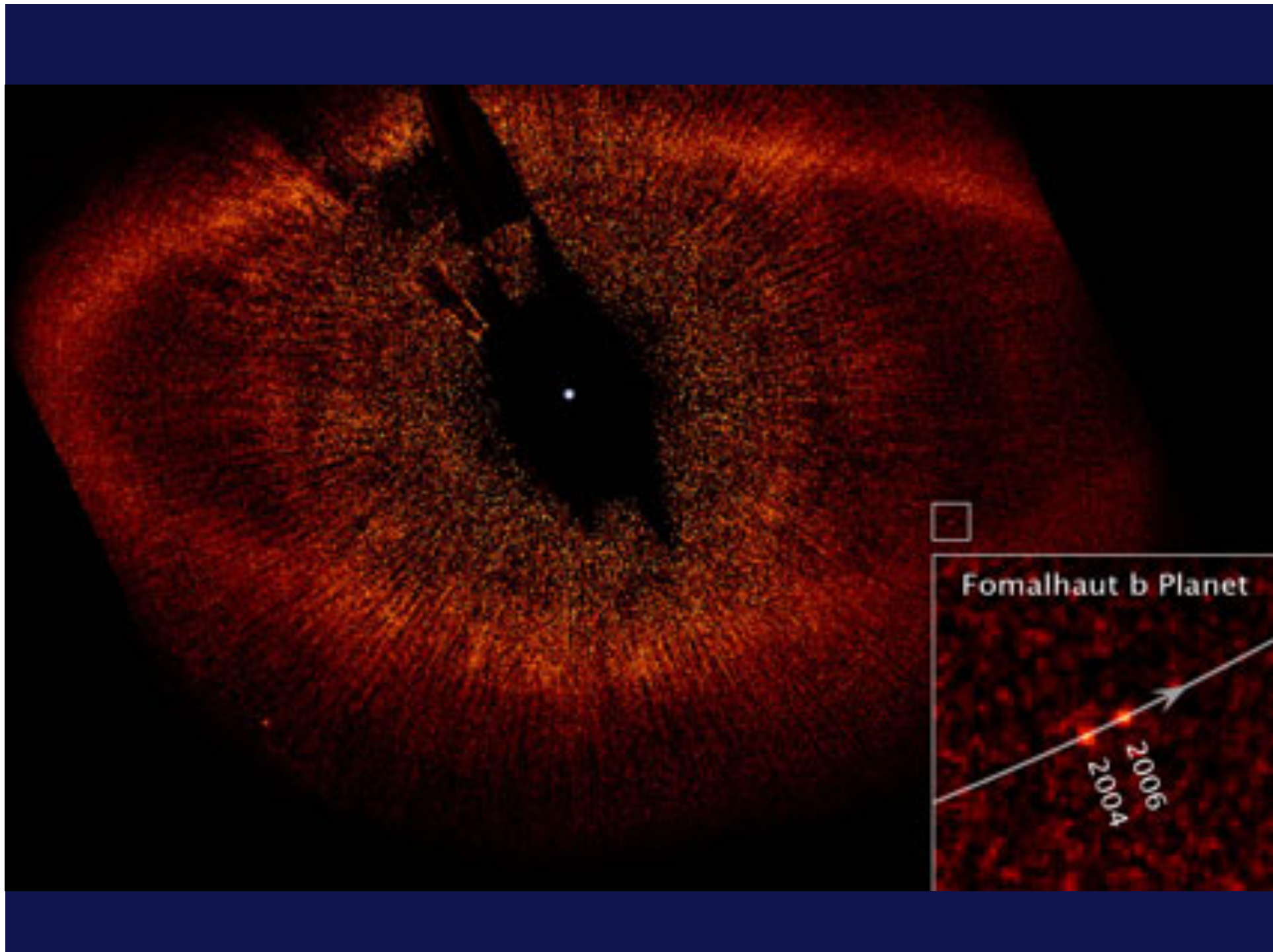
400 mas  
7.8 AU

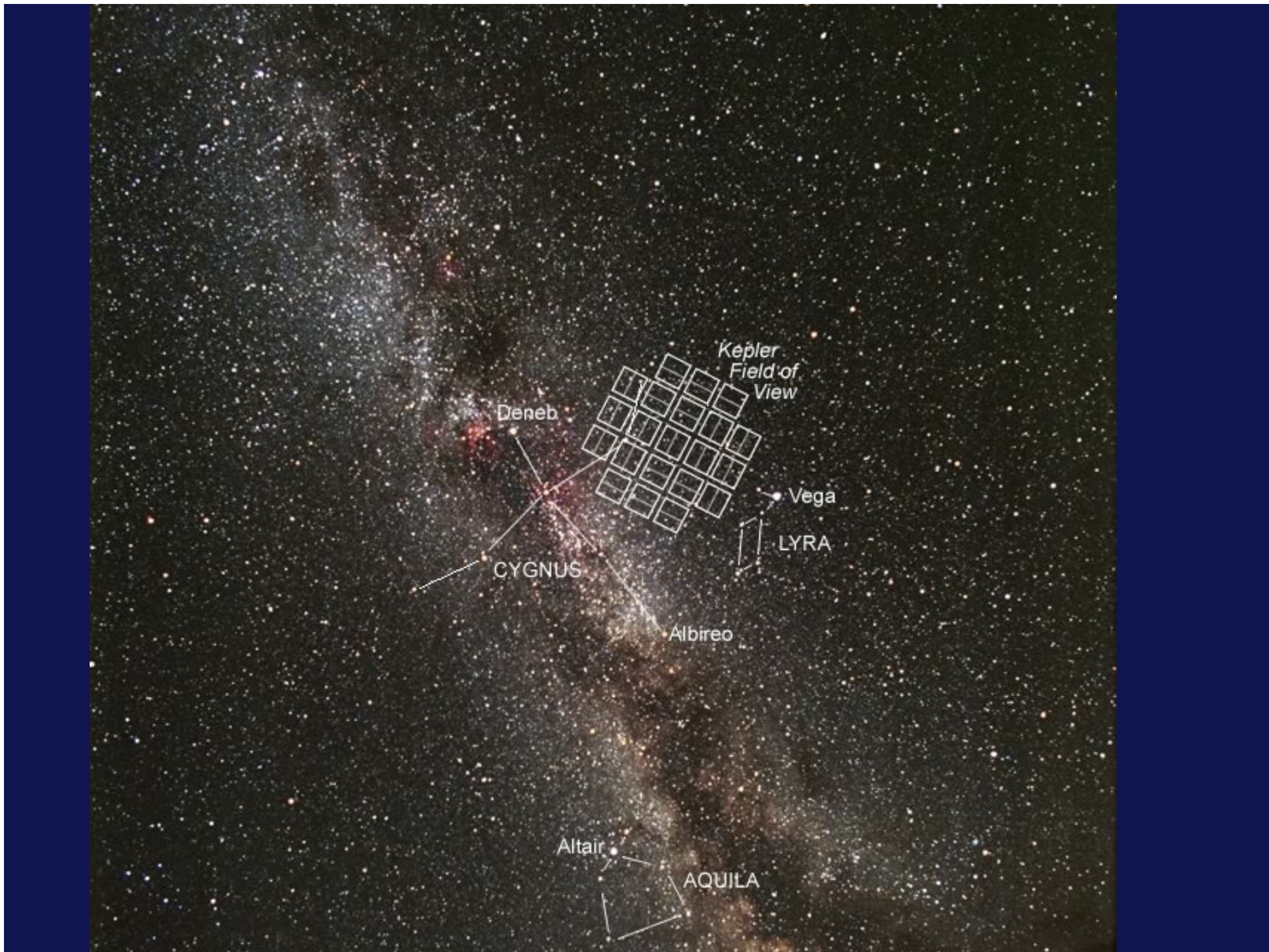


# Planet Detection

Doppler Shift due to  
Stellar Wobble

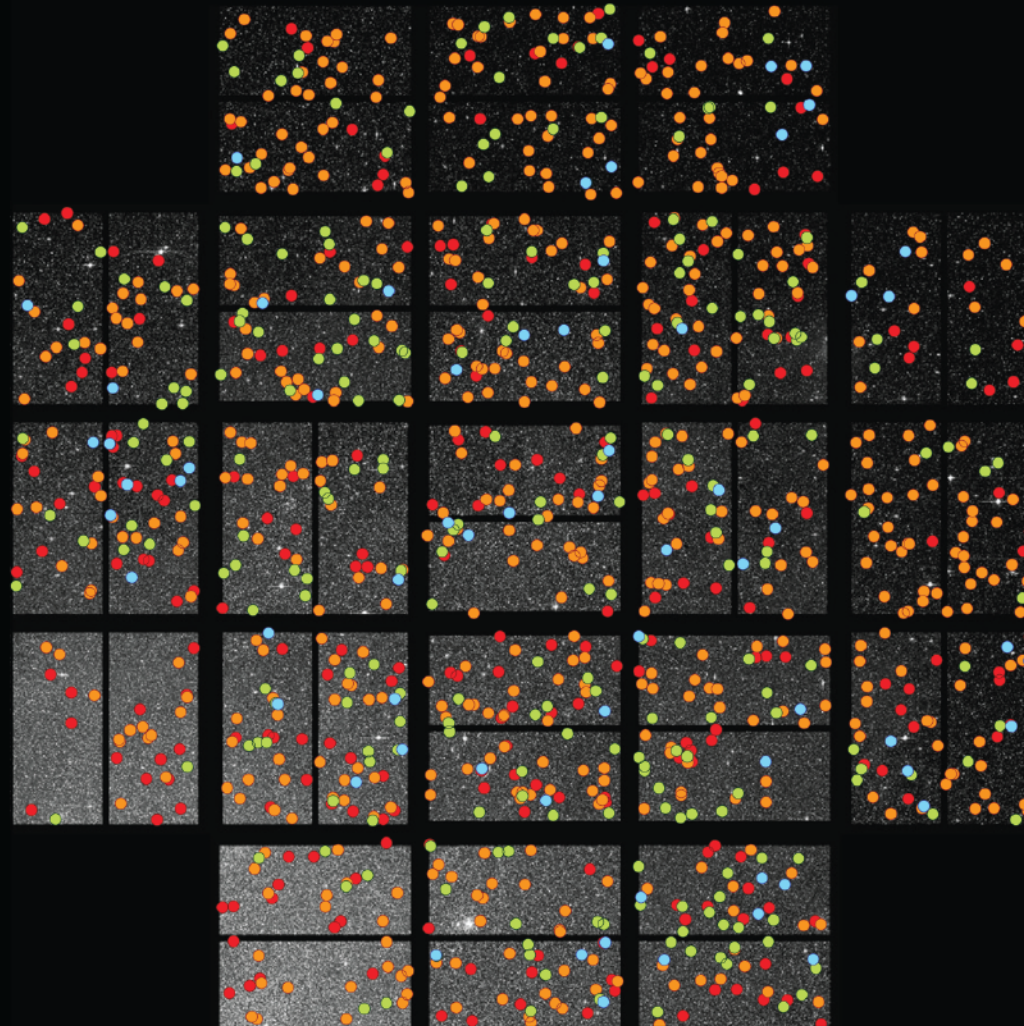






# Locations of Kepler Planet Candidates

- Earth-size
- Super-Earth size  
1.25 - 2.0 Earth-size
- Neptune-size  
2.0 - 6.0 Earth-size
- Giant-planet size  
6.0 - 22 Earth-size

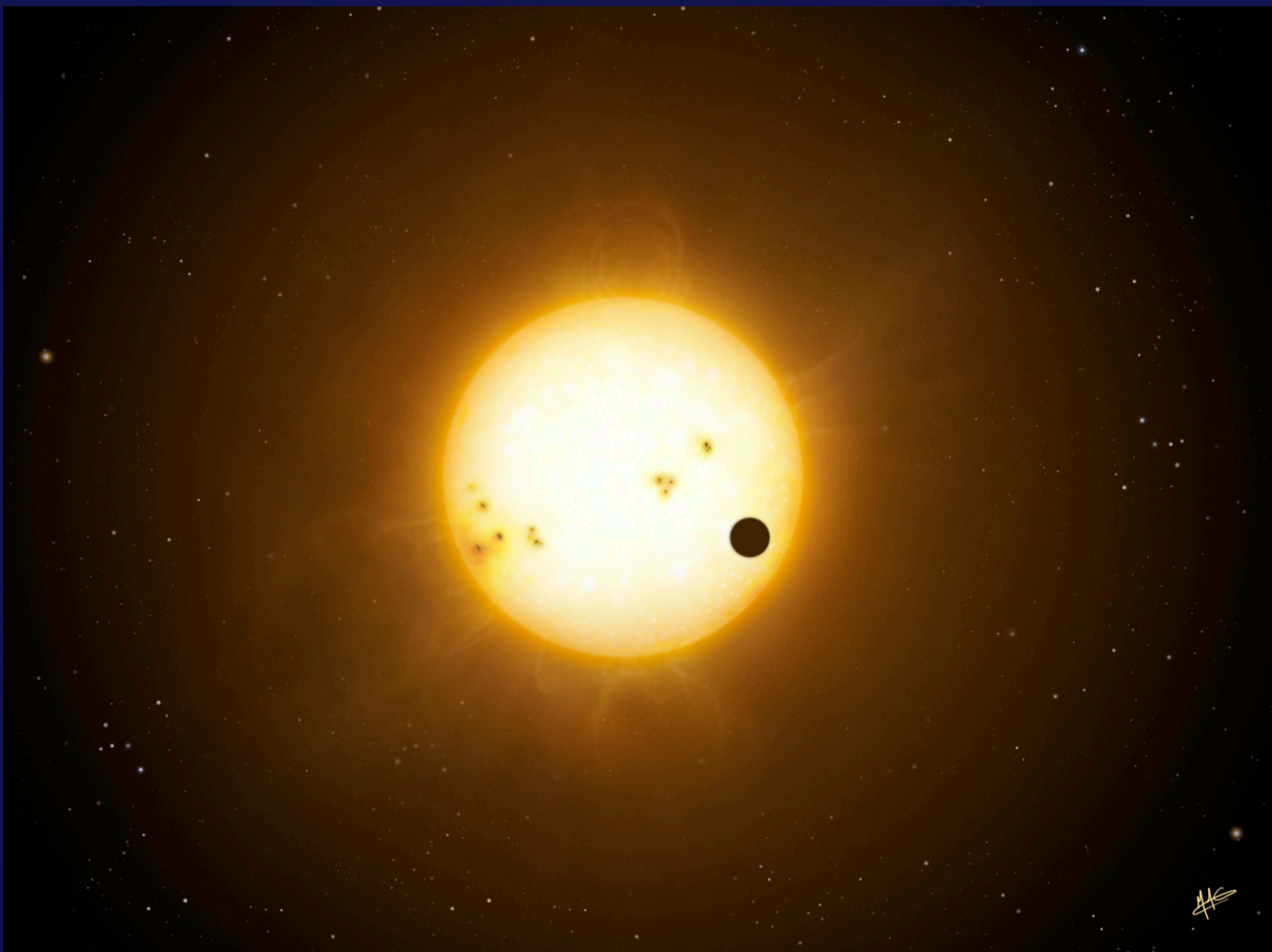




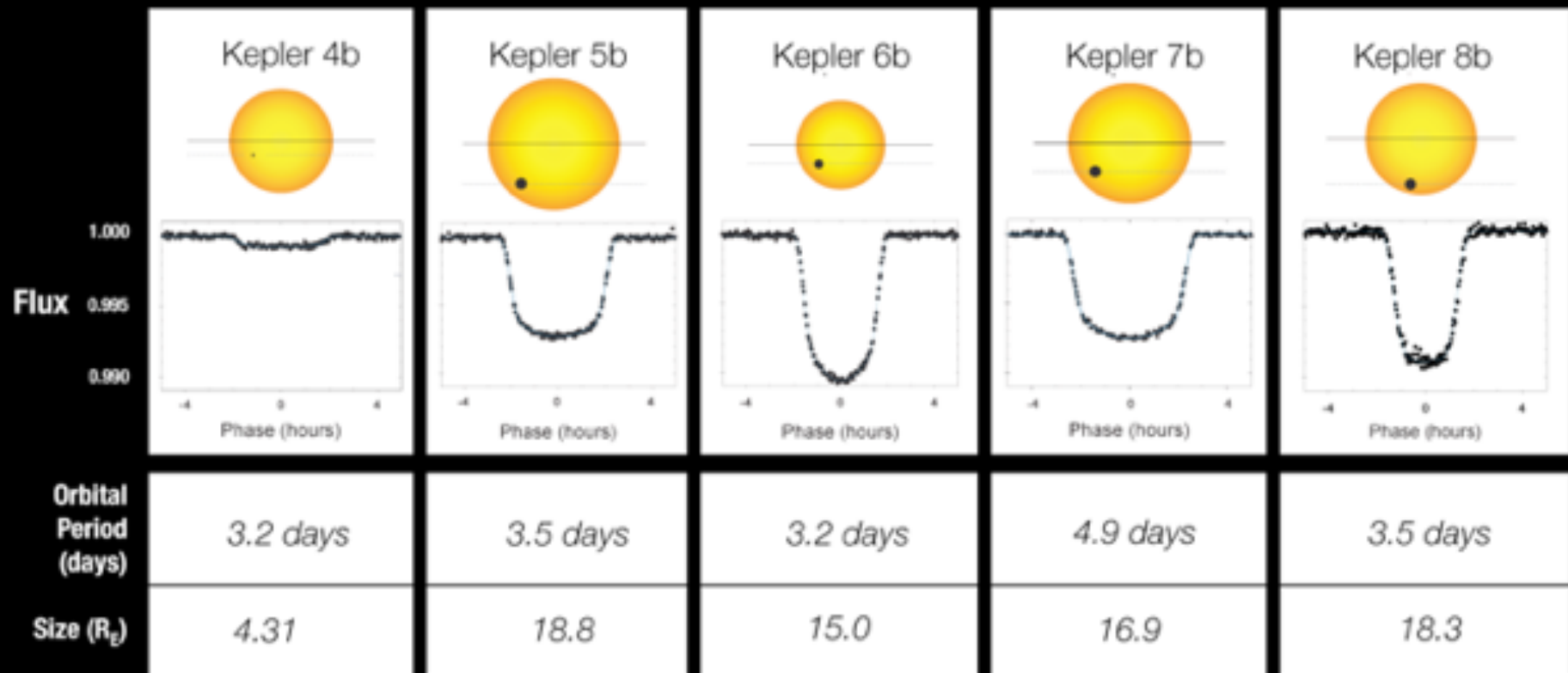
*“My God it’s  
full of,  
... planets!”*

SWEEPS  
HST ACS/WFC  
K. Sahu (STScI)  
F814W I  
F555W V





# Transit Light Curves

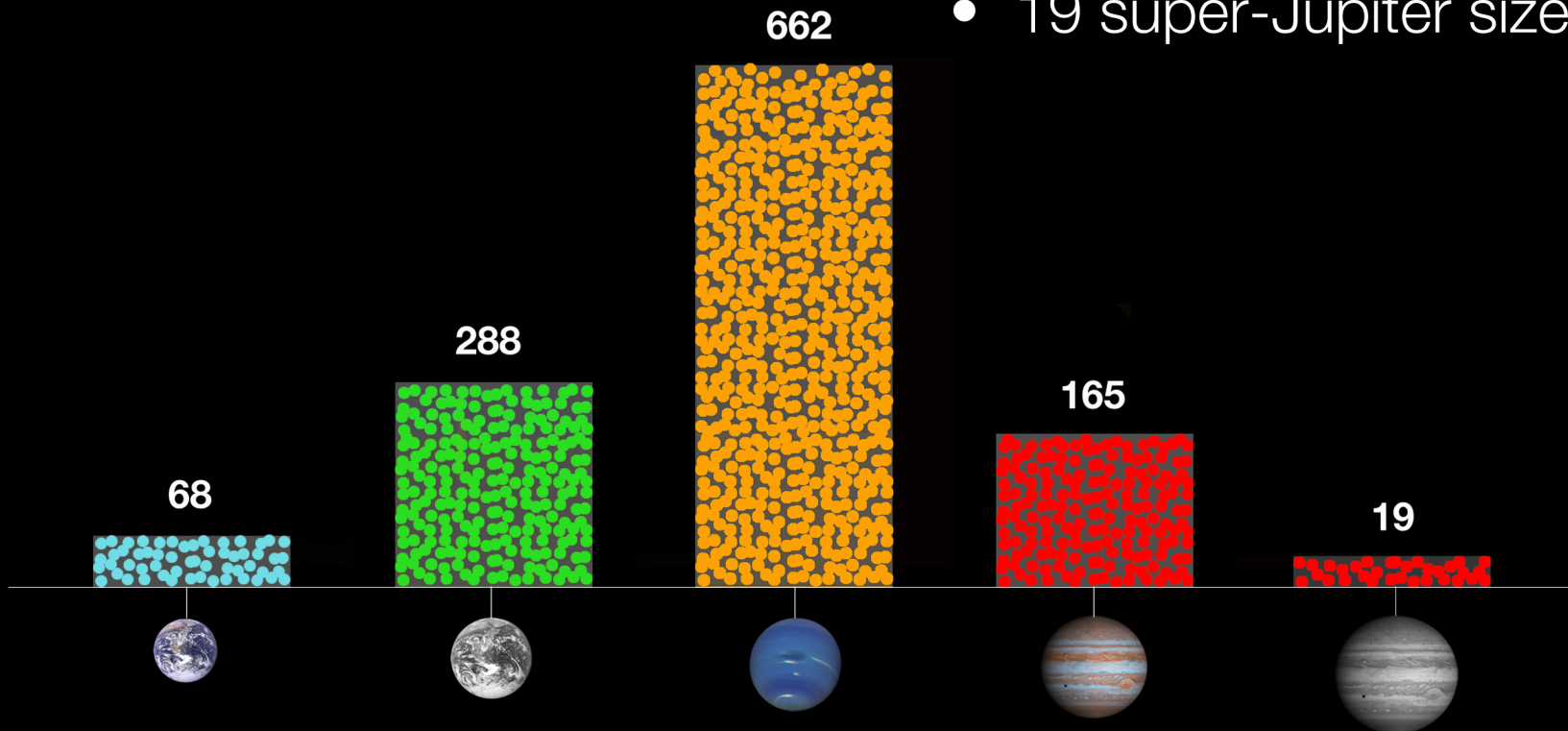


*1:10,000 ratio*



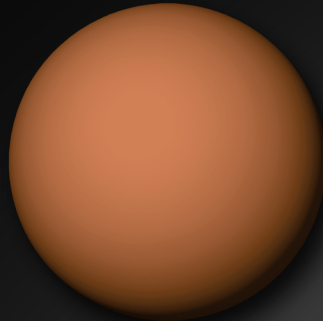
# Numbers of Planet Candidates

- 68 Earth-size
- 288 super-Earth size
- 662 Neptune size
- 165 Jupiter size
- 19 super-Jupiter size



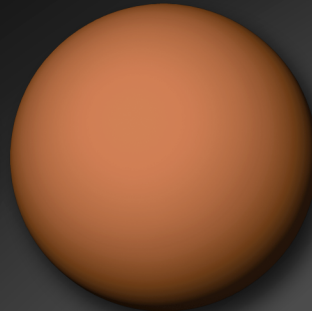
# Planet Sizes

Kepler-7b



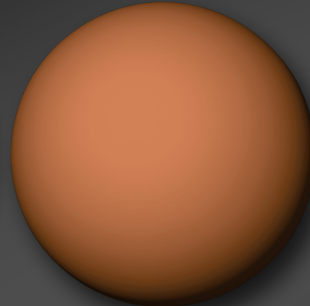
16.52  $R_E$

Kepler-5b



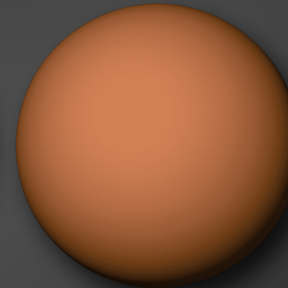
16.00  $R_E$

Kepler-8b



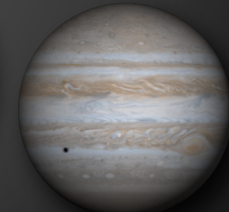
15.86  $R_E$

Kepler-6b



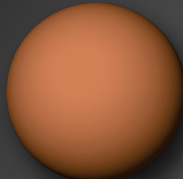
14.79  $R_E$

Jupiter



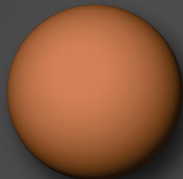
11.2  $R_E$

Kepler-9b



9.4  $R_E$

Kepler-9c



9.2  $R_E$

Kepler-4b



3.99  $R_E$

Kepler-9d



1.64  $R_E$

Kepler-10b



1.42  $R_E$

Earth



Kepler-11b



1.97  $R_E$

Kepler-11c



3.15  $R_E$

Kepler-11d



3.43  $R_E$

Kepler-11e



4.52  $R_E$

Kepler-11f

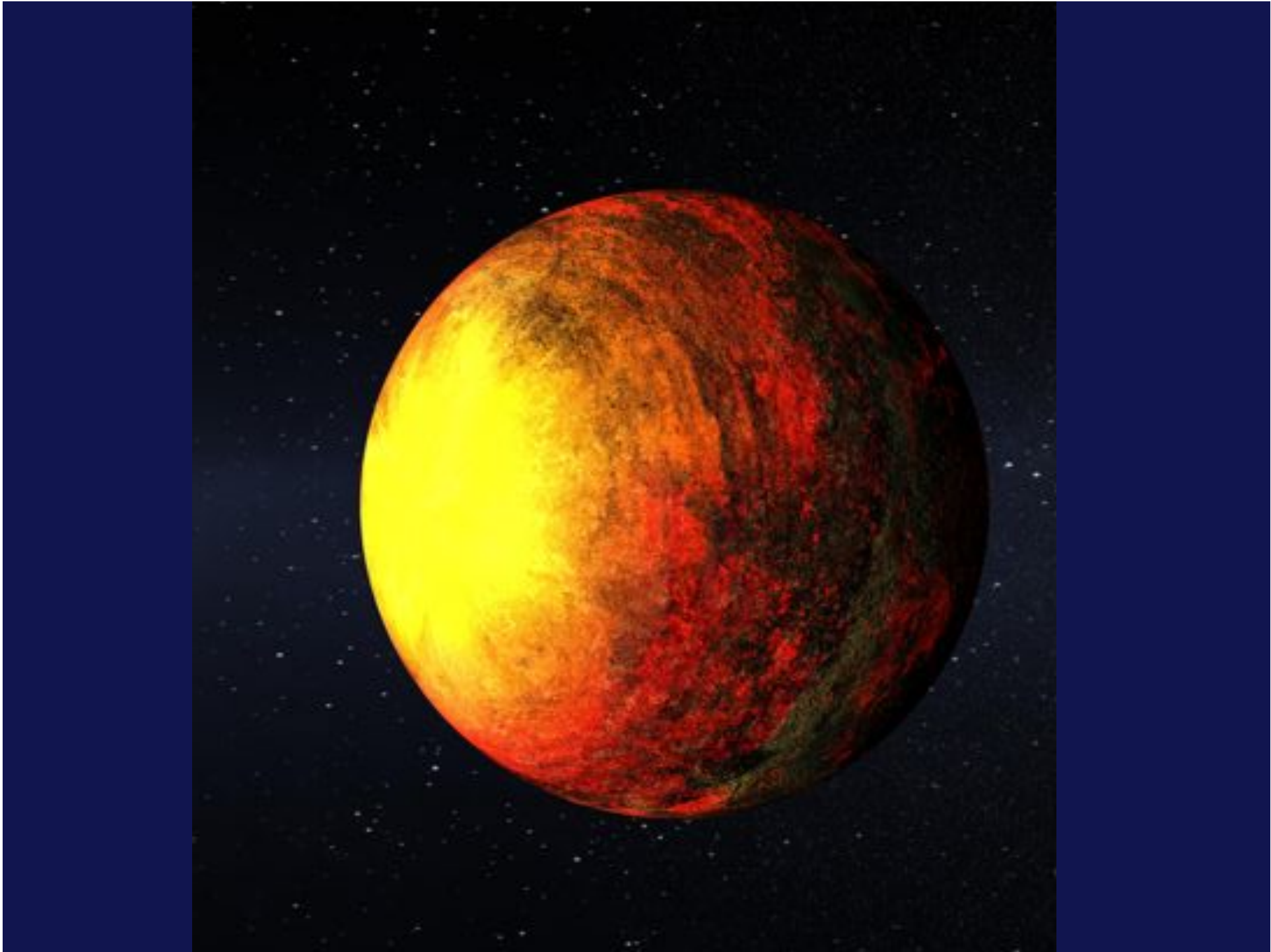


2.61  $R_E$

Kepler-11g



3.66  $R_E$





Find more articles on [kepler-10 b earthlike](#)

## First rocky planet discovered: NASA spots tiny Earth-like planet, too hot for life

January 10, 2011 by Kerry Sheridan

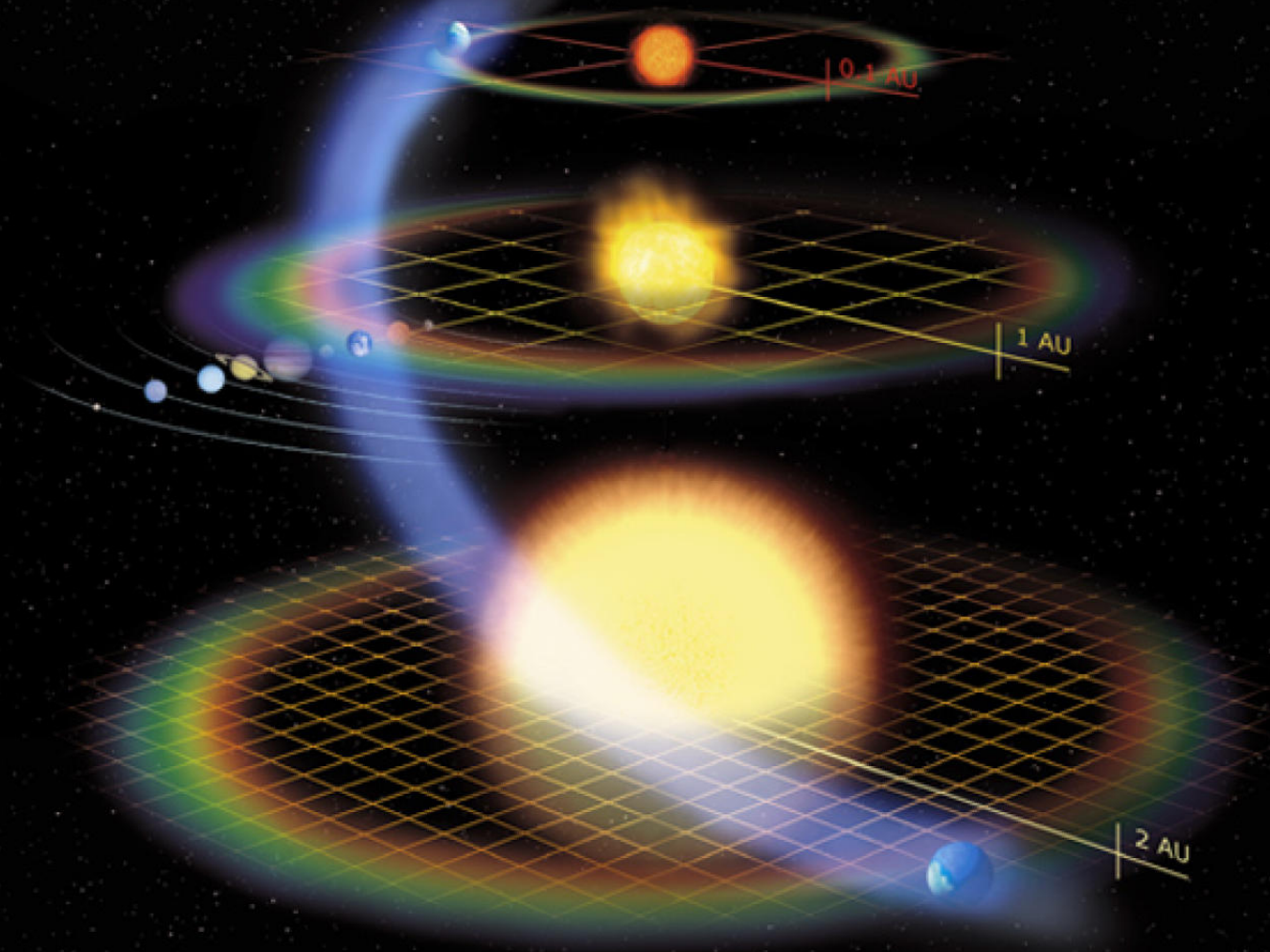


 [Enlarge](#)

The smallest-ever planet outside our solar system has been spotted by NASA's Kepler spacecraft, seen here in a 2009 artist conception, -- a rocky planet similar in size to the Earth, the US space agency said on Monday.



## *Habitable Zones Around K, G, F Stars*







# Found: An Earthlike Planet, at Last

By **MICHAEL D. LEMONICK** Wednesday, Sep. 29, 2010

## Related

### Photos

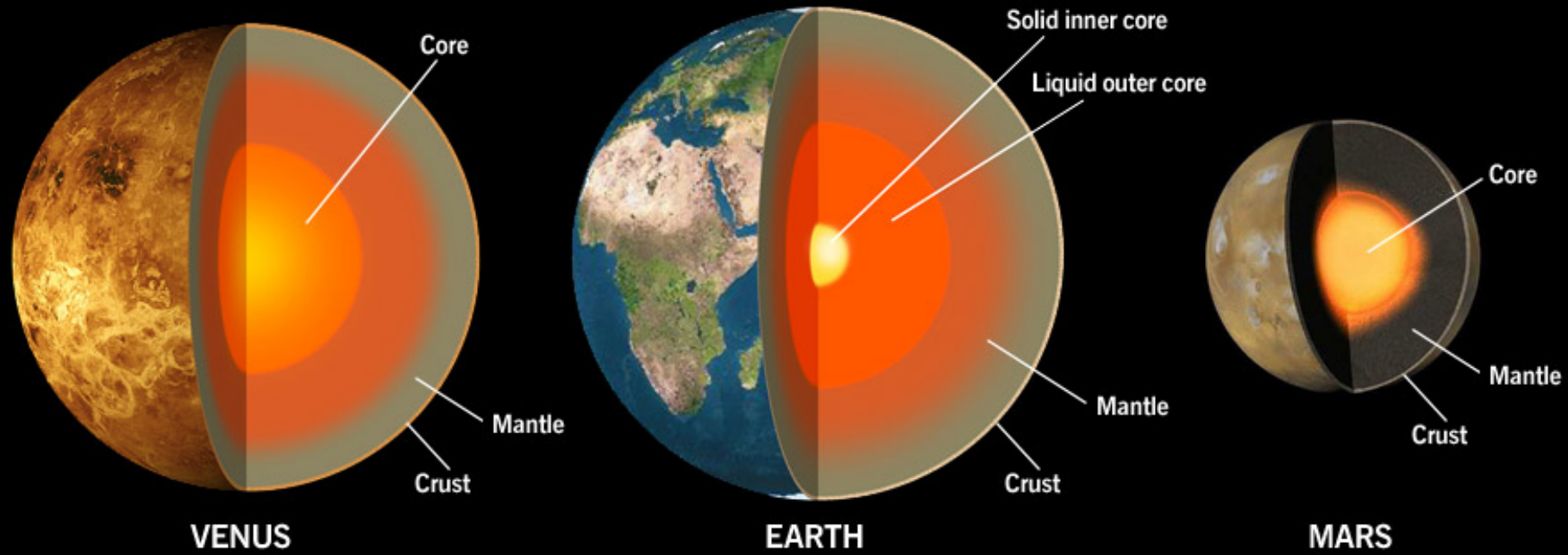


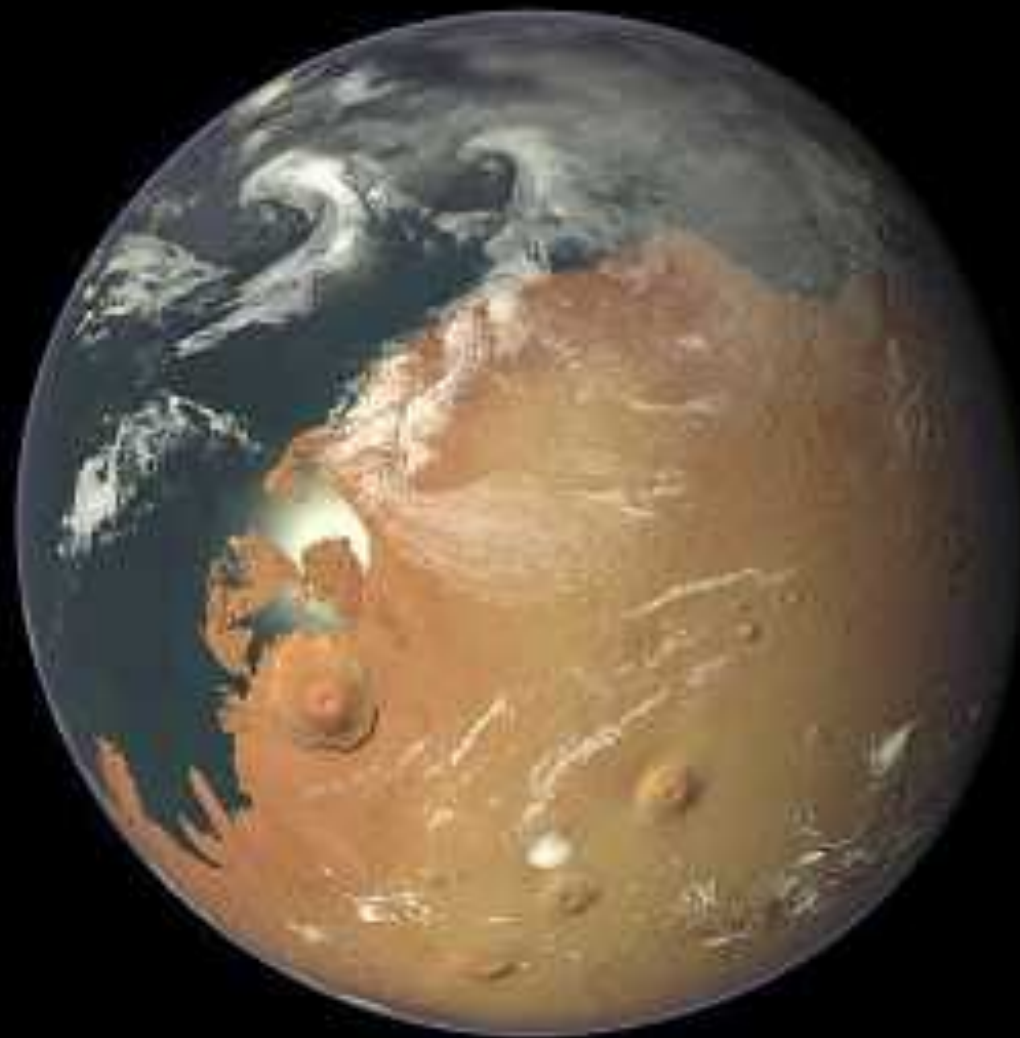
Planet Earth: An Illustrated History

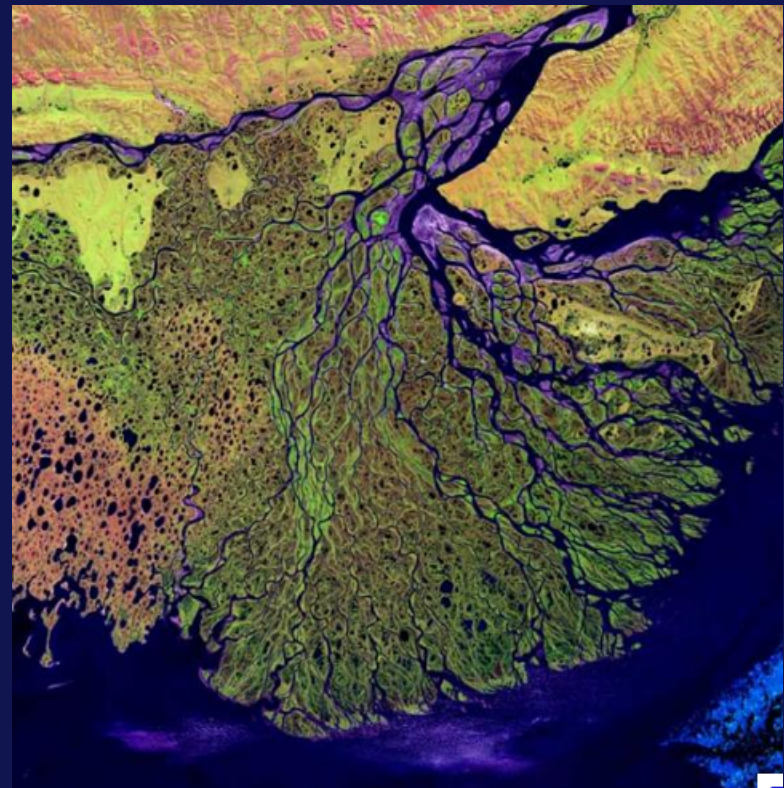
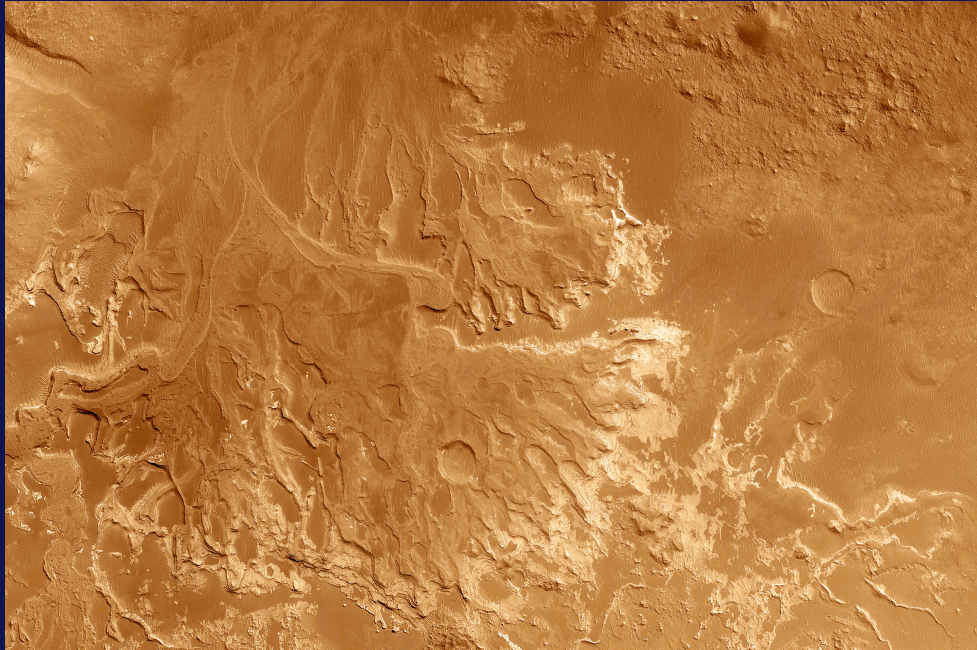
### Photos



An artist's conception shows the inner four planets of the Gliese 581 system and their host star  
Lynette Cook







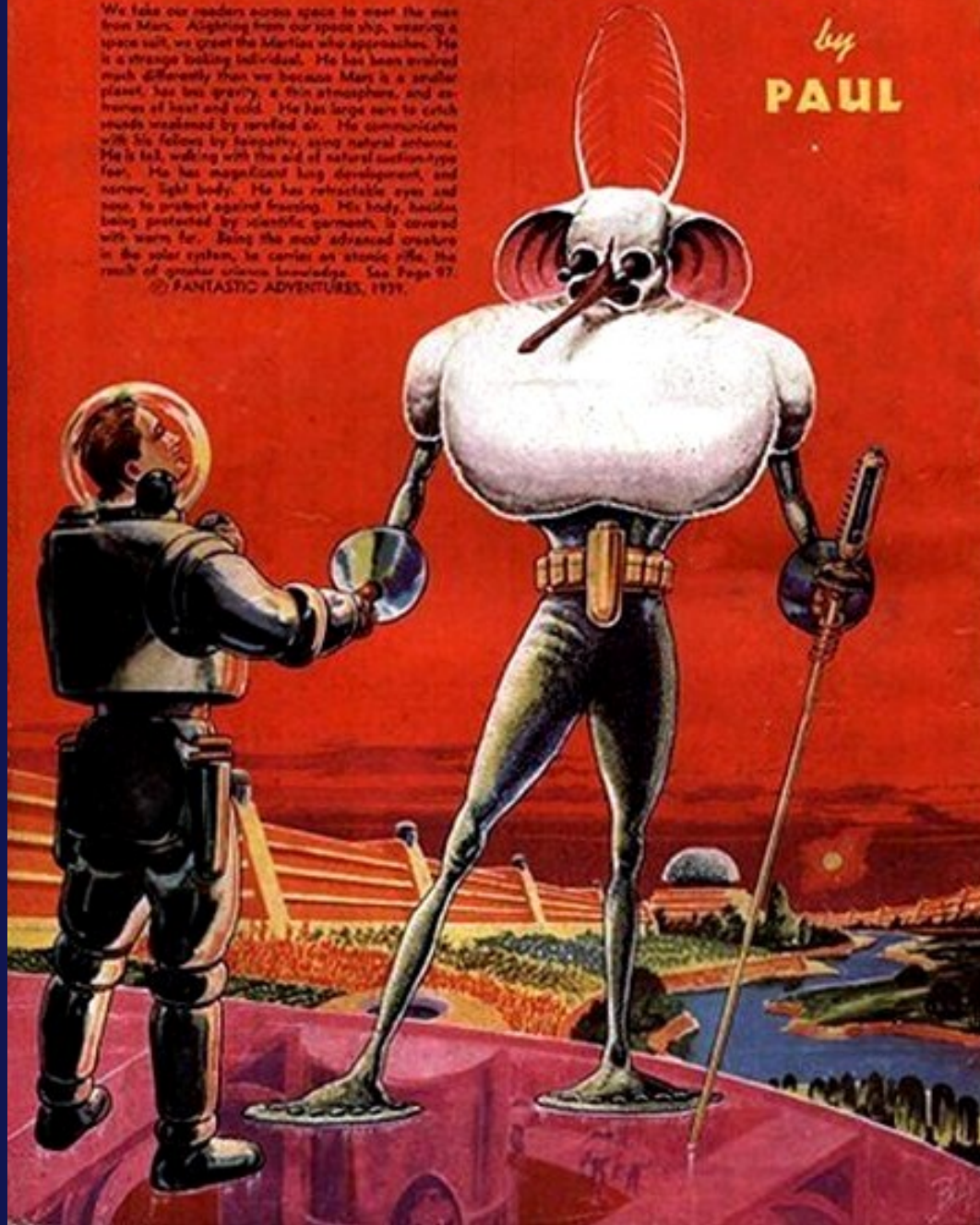
Lena River  
Basin,  
Siberia

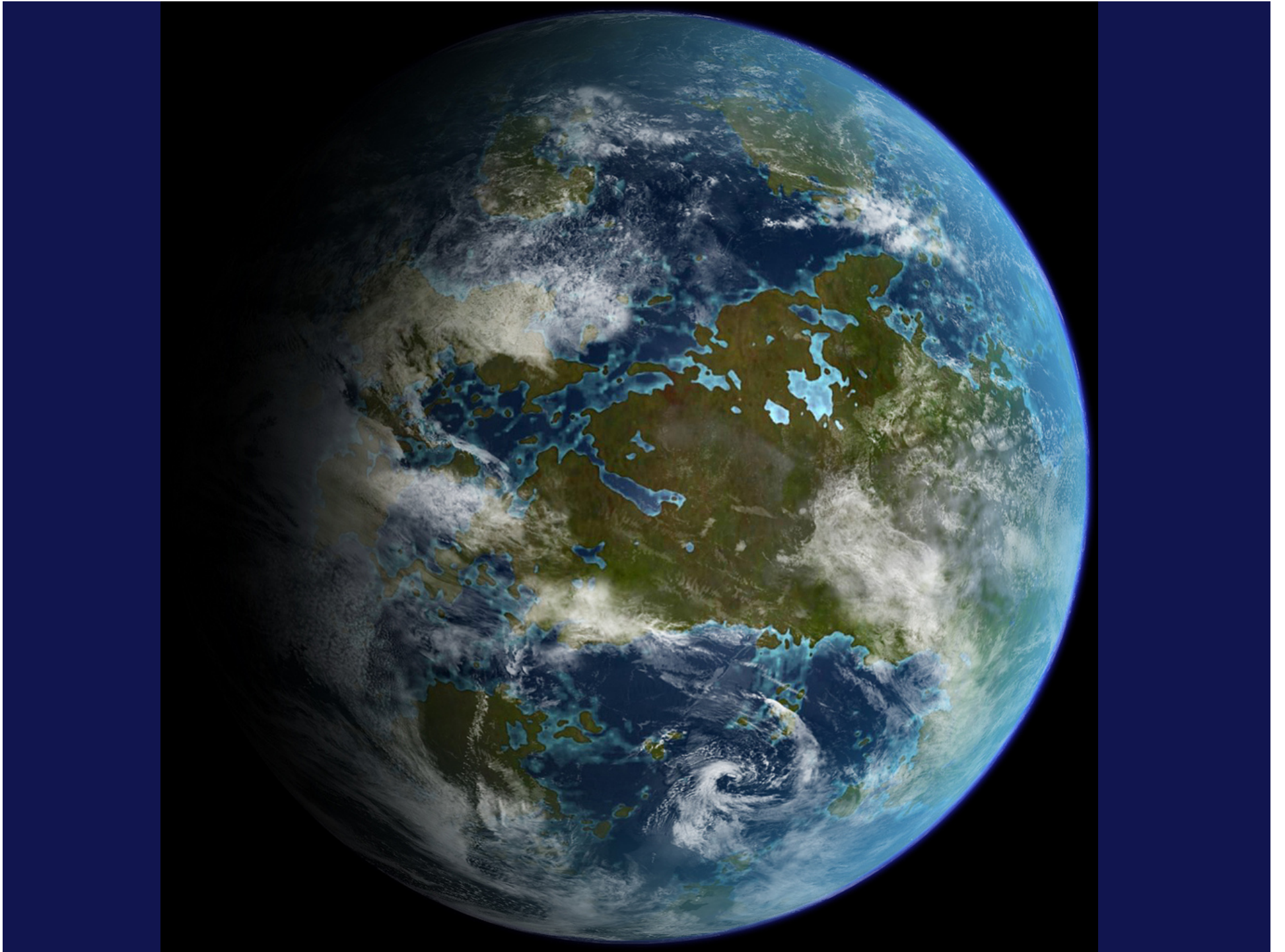
# The MAN from MARS

We take our readers across space to meet the man from Mars. Alighting from our space ship, wearing a space suit, we greet the Martian who approaches. He is a strange looking individual. He has been evolved much differently than we because Mars is a smaller planet, has less gravity, a thin atmosphere, and extremes of heat and cold. He has large ears to catch sounds weakened by rarefied air. He communicates with his fellows by telepathy, using natural antennae. He is tall, walking with the aid of natural suction-type feet. He has magnificent lung development, and narrow, light body. He has retractable eyes and nose, to protect against freezing. His body, besides being protected by scientific garments, is covered with warm fur. Being the most advanced creature in the solar system, he carries an atomic rifle, the result of greater scientific knowledge. See Page 97.

© FANTASTIC ADVENTURES, 1937.

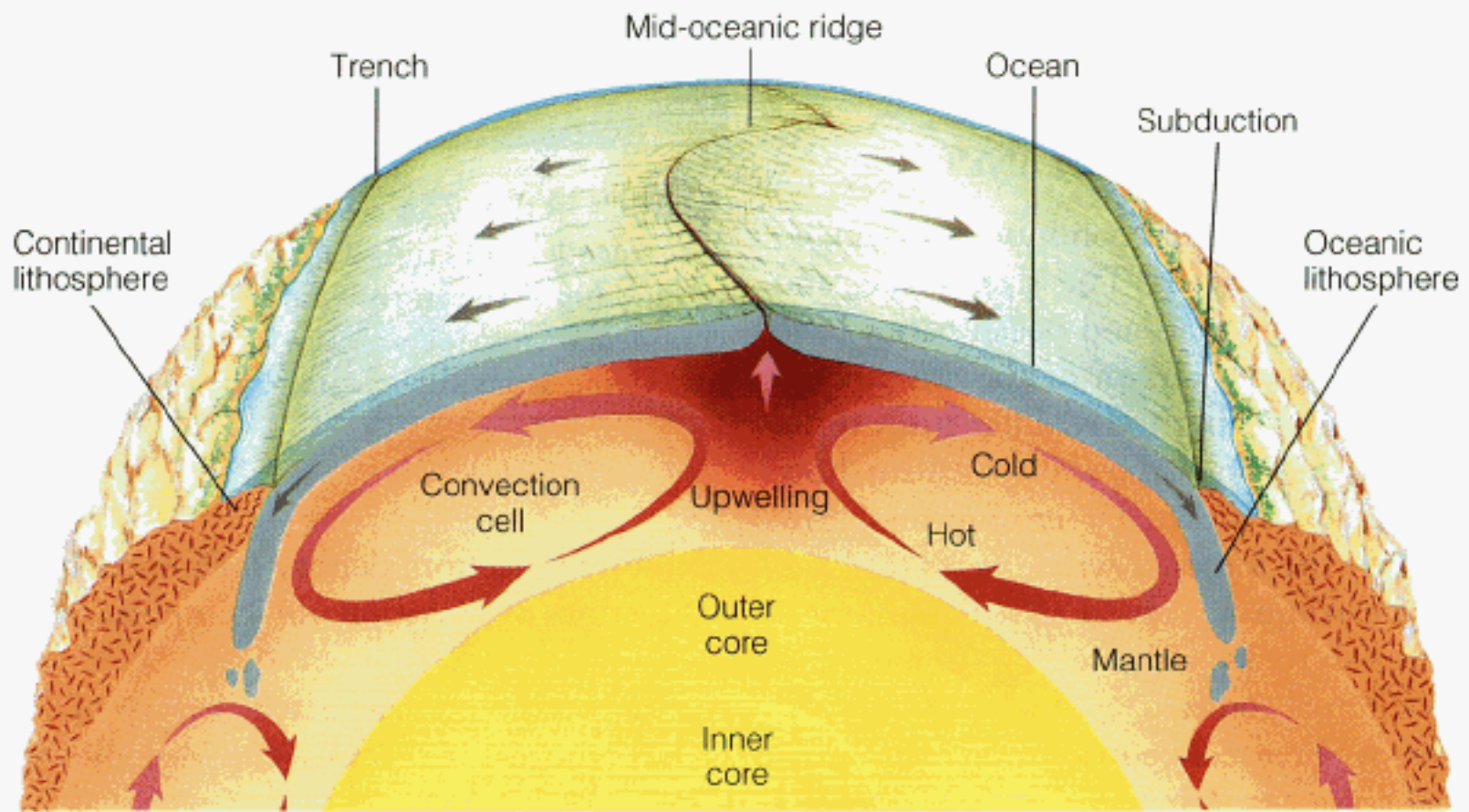
by  
**PAUL**





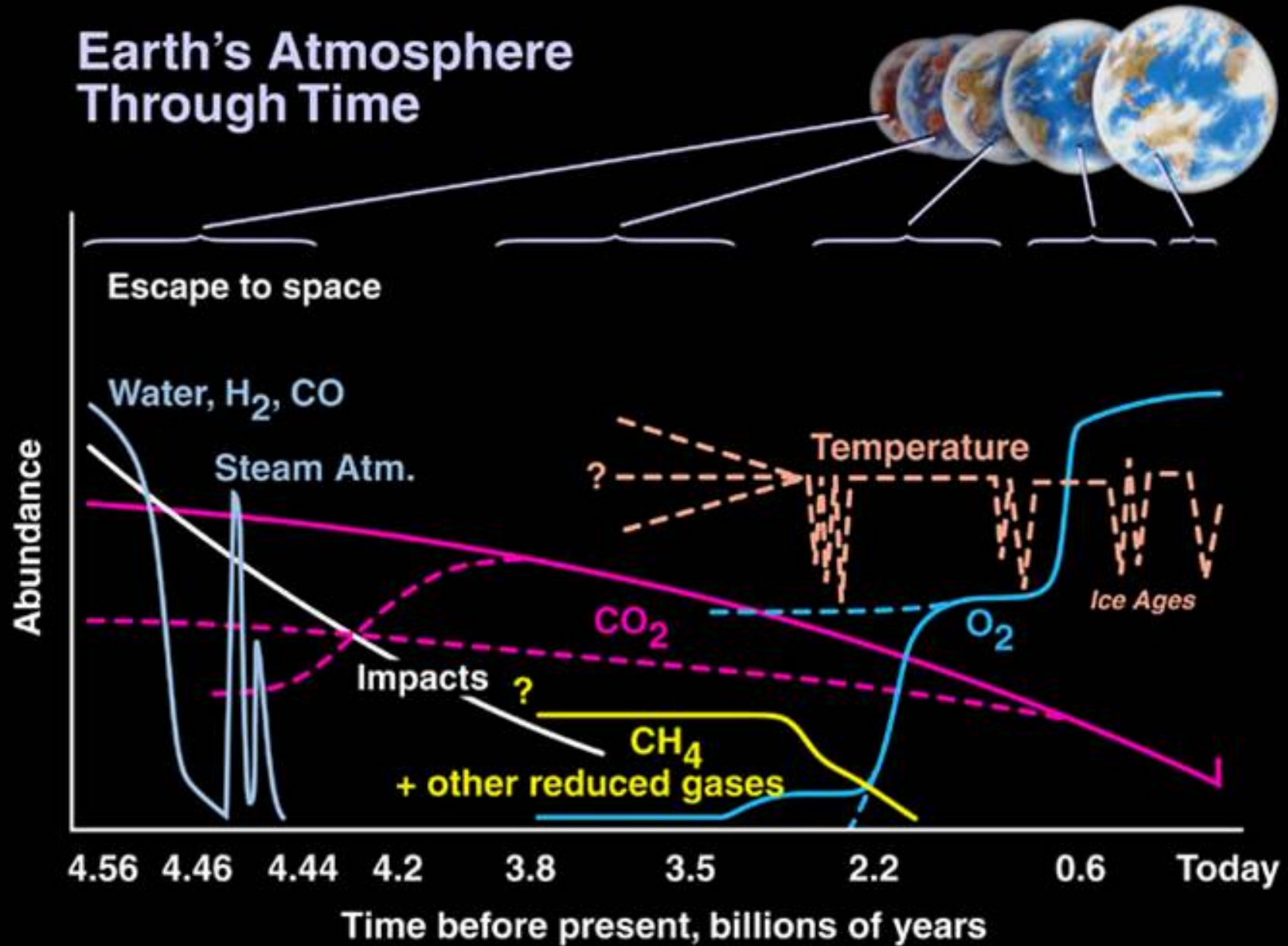








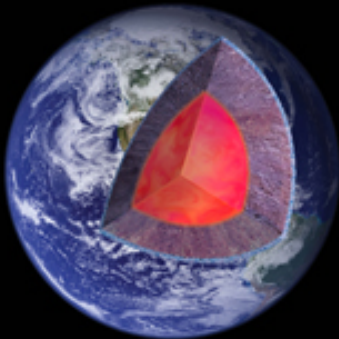
# Earth's Atmosphere Through Time



# Earth Compared with Two "Super Earths"

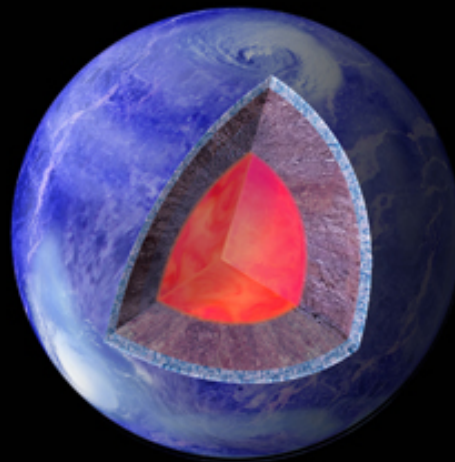


1  
Earth Mass



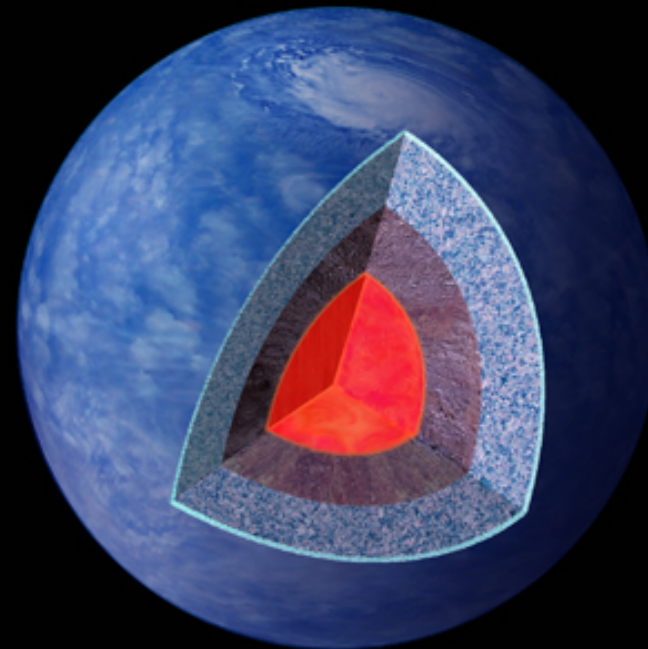
1  
Earth Radius

3  
Earth Masses

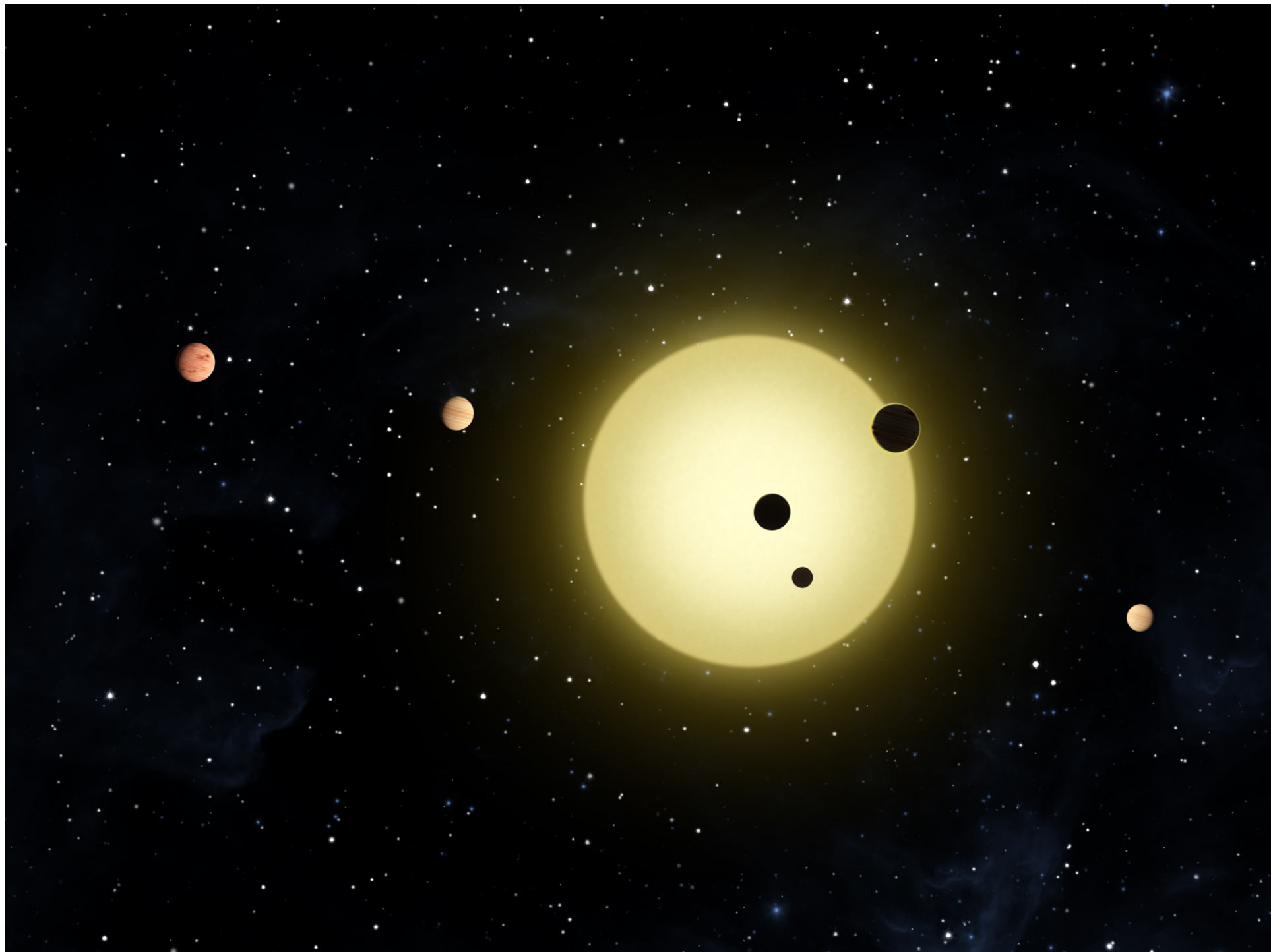


1.4  
Earth Radii

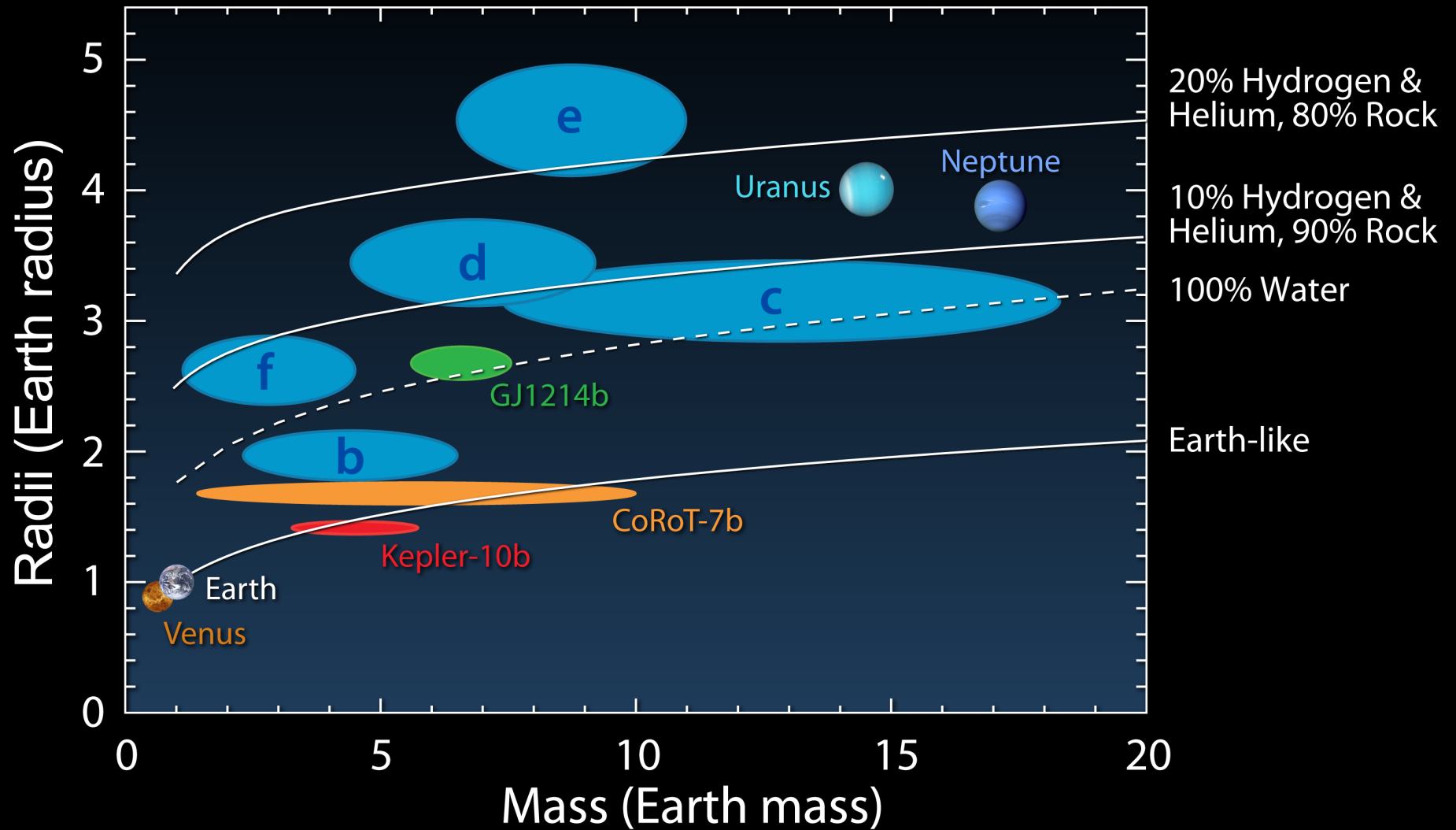
6  
Earth Masses

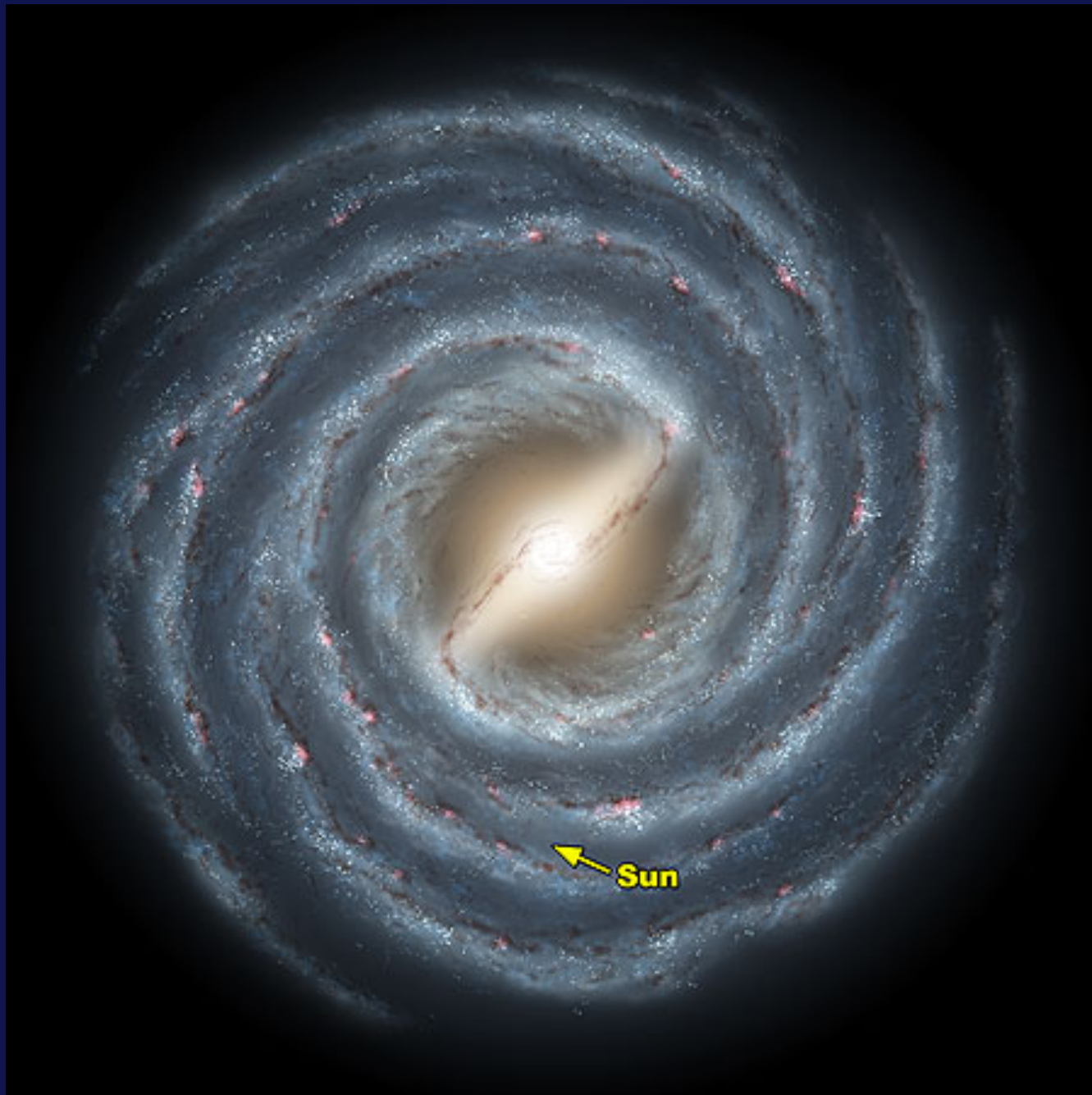


1.9  
Earth Radii



# Composition of Kepler-11 Planets





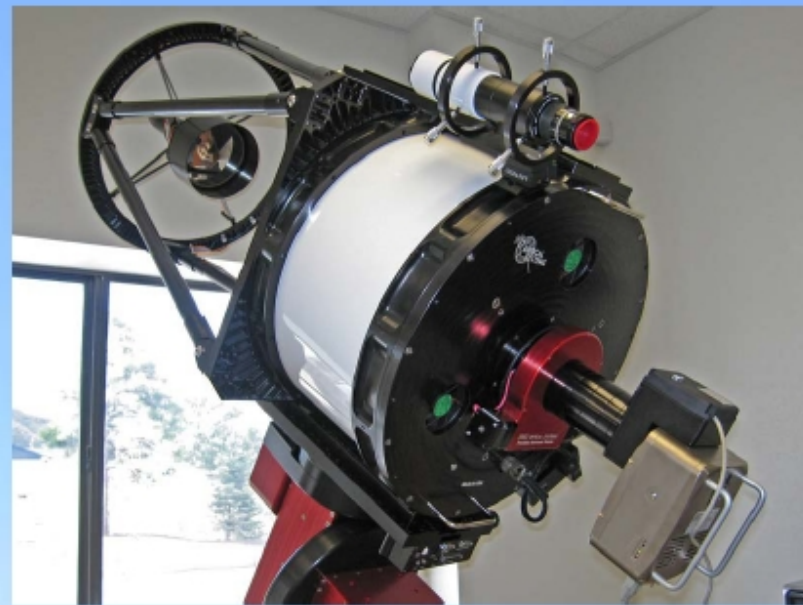


# The MEarth Project

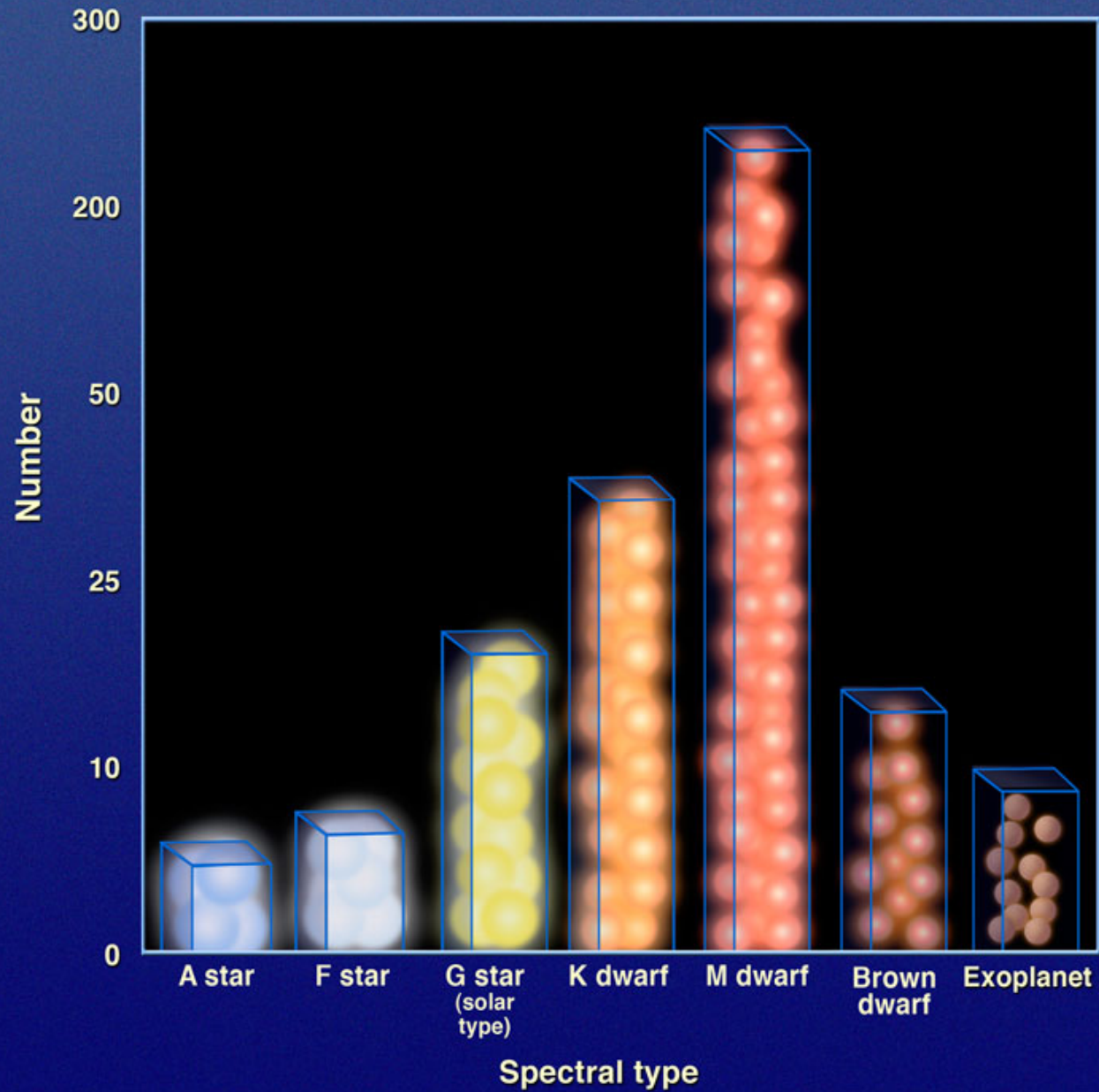
Charbonneau et al.



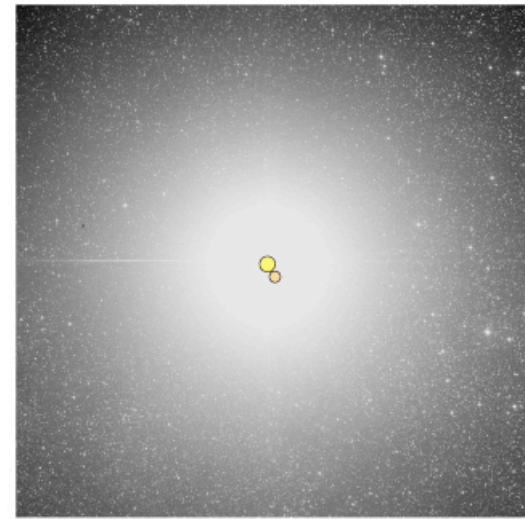
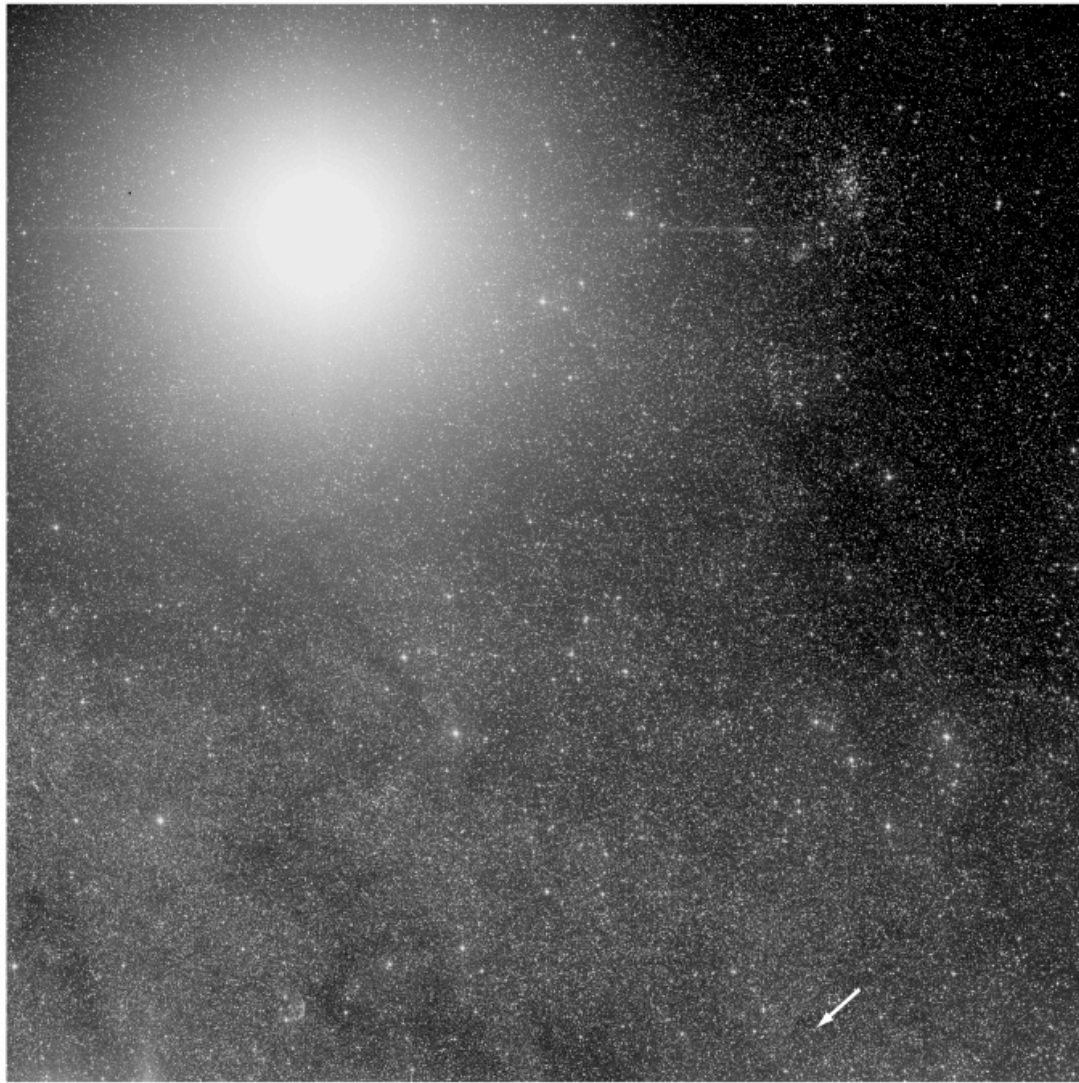
- Using 8 X 16-inch telescopes to survey the 2000 nearest M-dwarfs for rocky planets in their habitable zones
- Converted an existing abandoned building on Mt Hopkins, AZ
- Fully operational; southern version planned
- **These planets will be amenable to spectroscopic follow-up to search for atmospheric biomarkers**



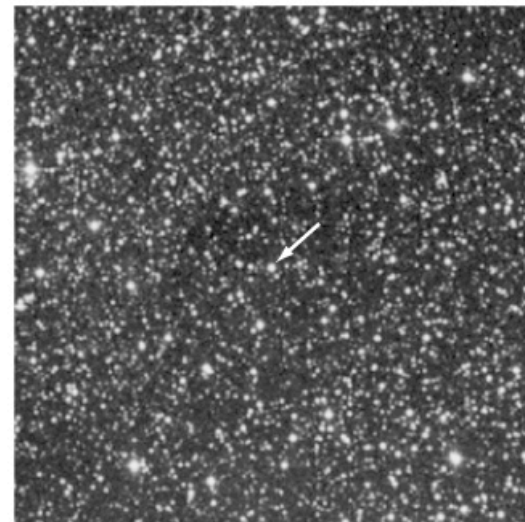
## An inventory of stars within 32 light-years' distance from Earth







$\alpha$  Cen A & B



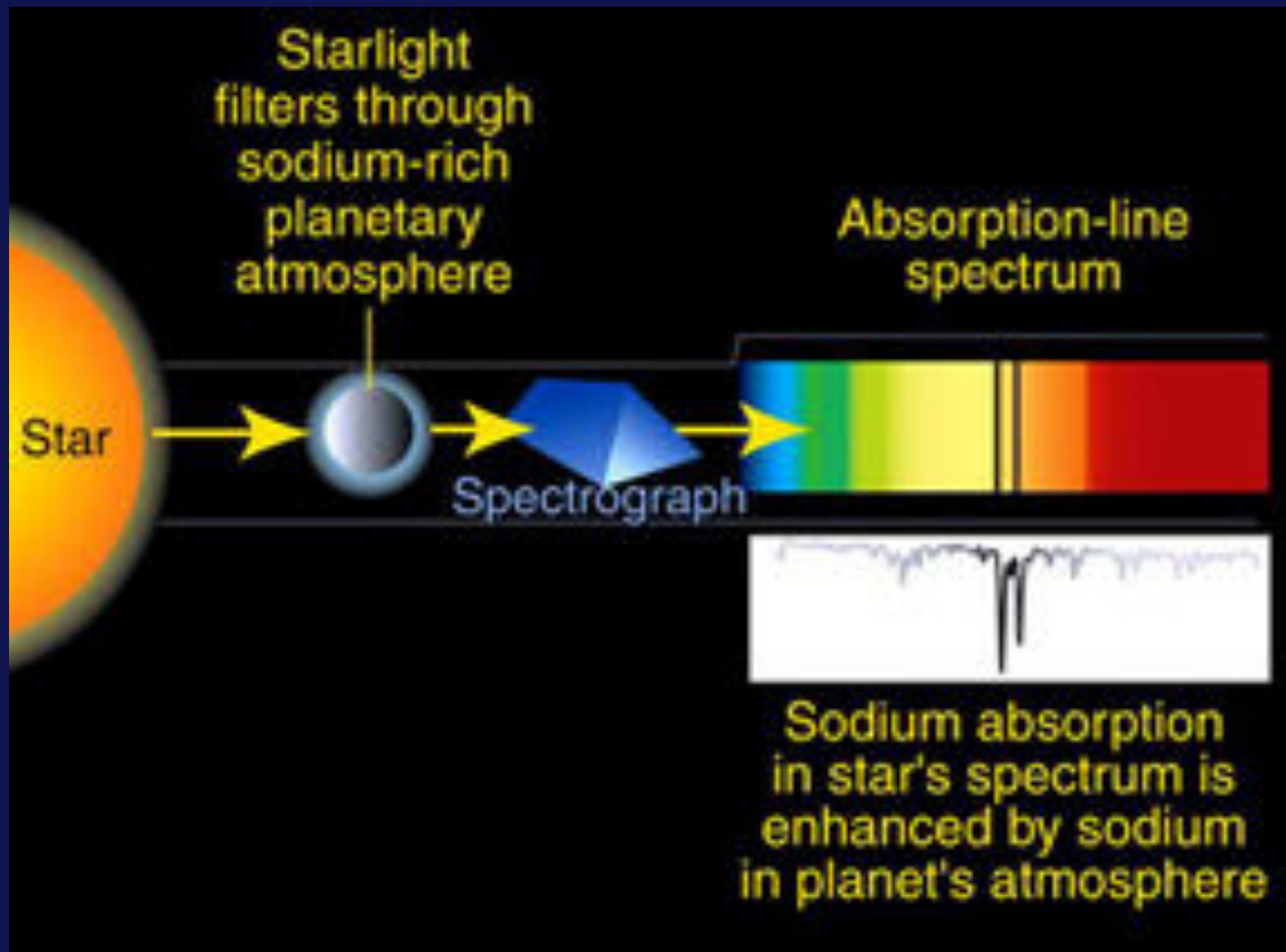
Proxima

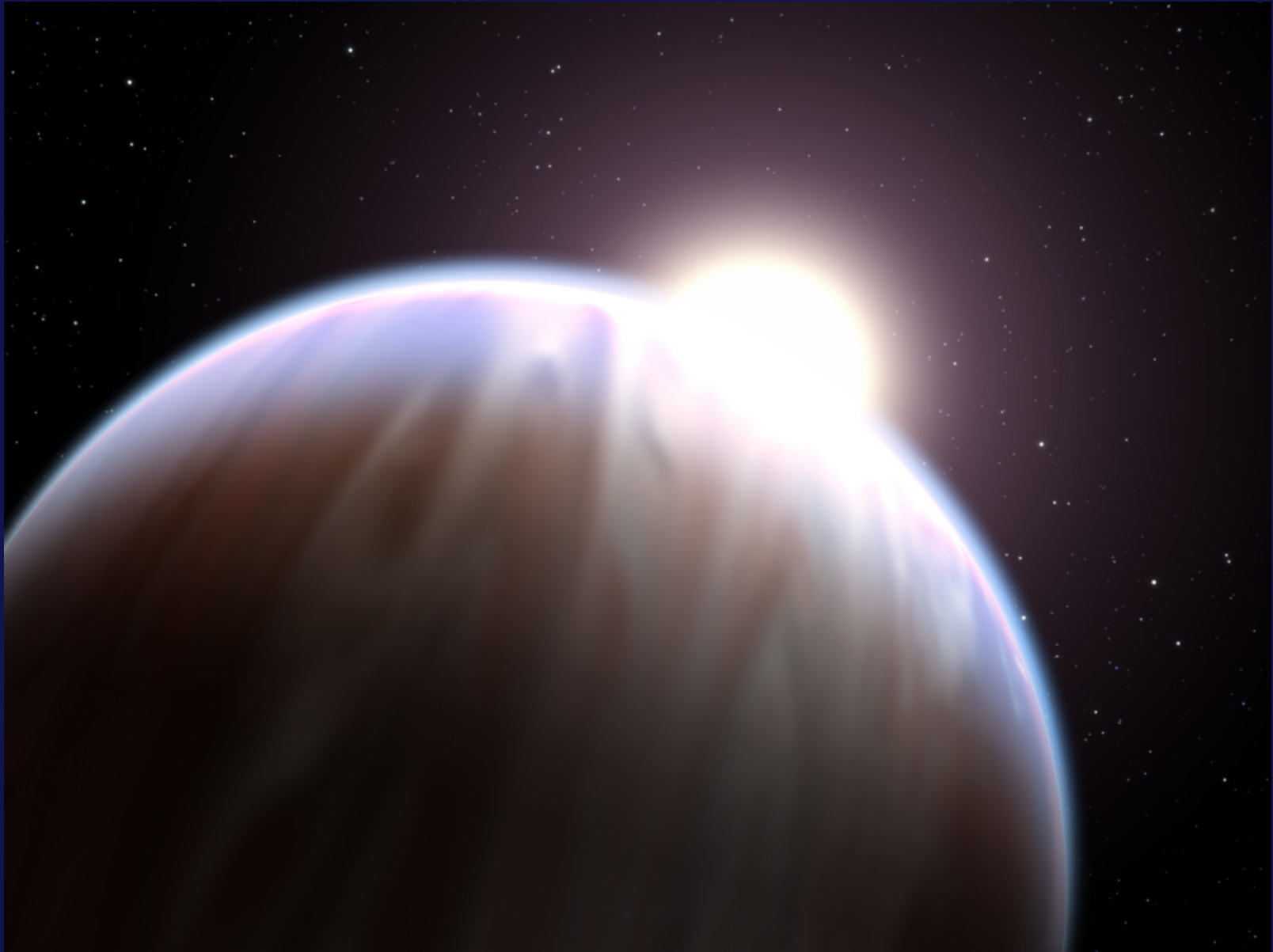
The Triple Stellar System Alpha Centauri  
(ESO 1-m Schmidt Telescope)

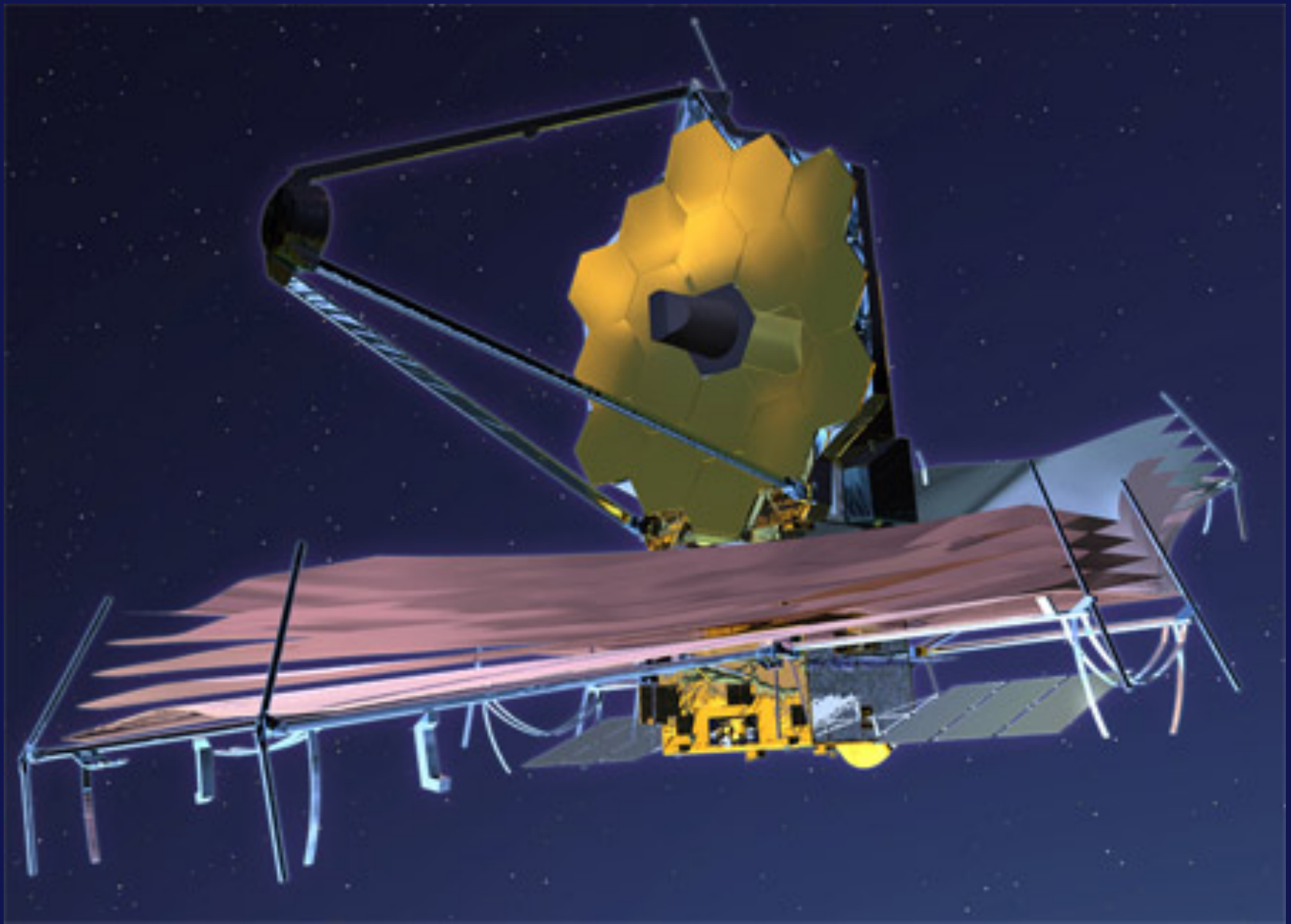
ESO PR Photo 07a/03 (15 March 2003)

© European Southern Observatory

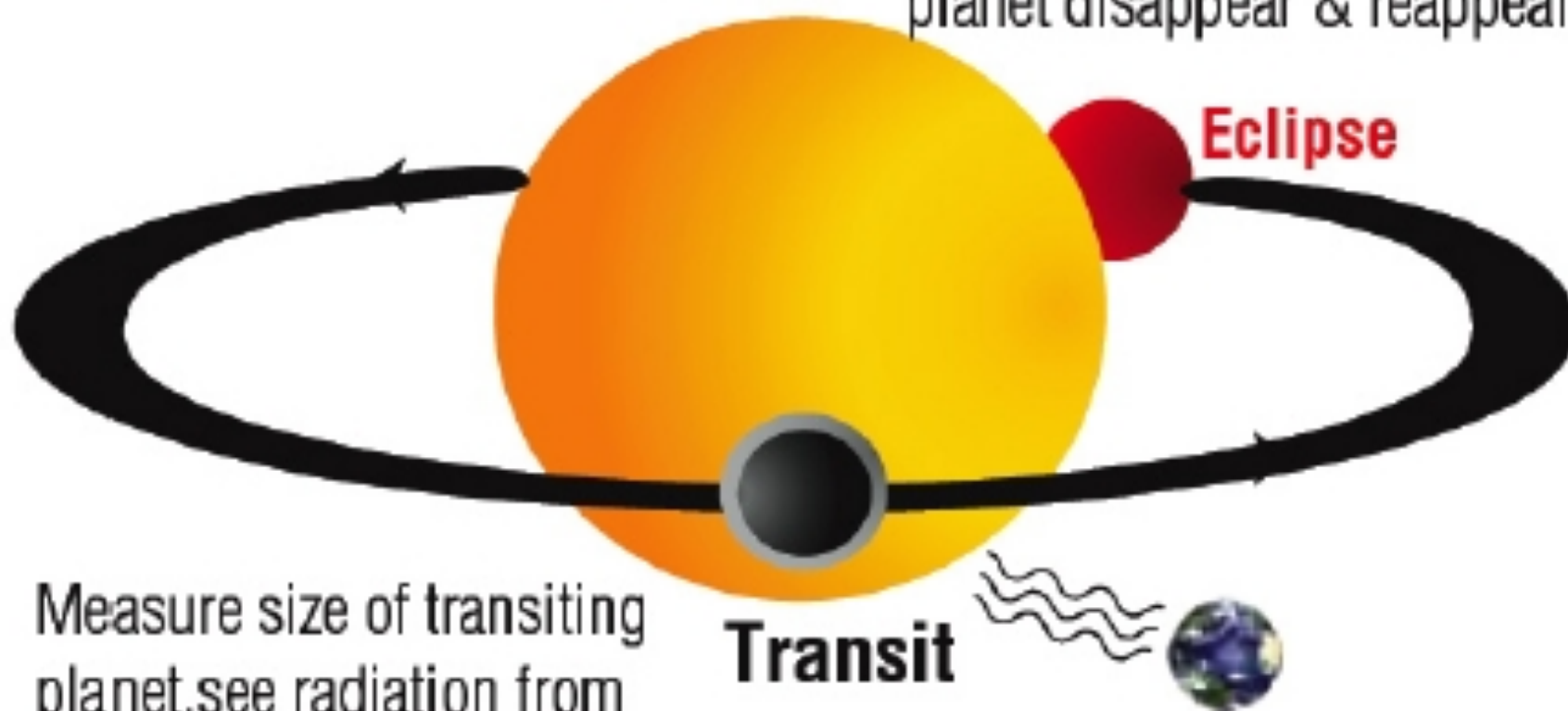








See thermal radiation from planet disappear & reappear



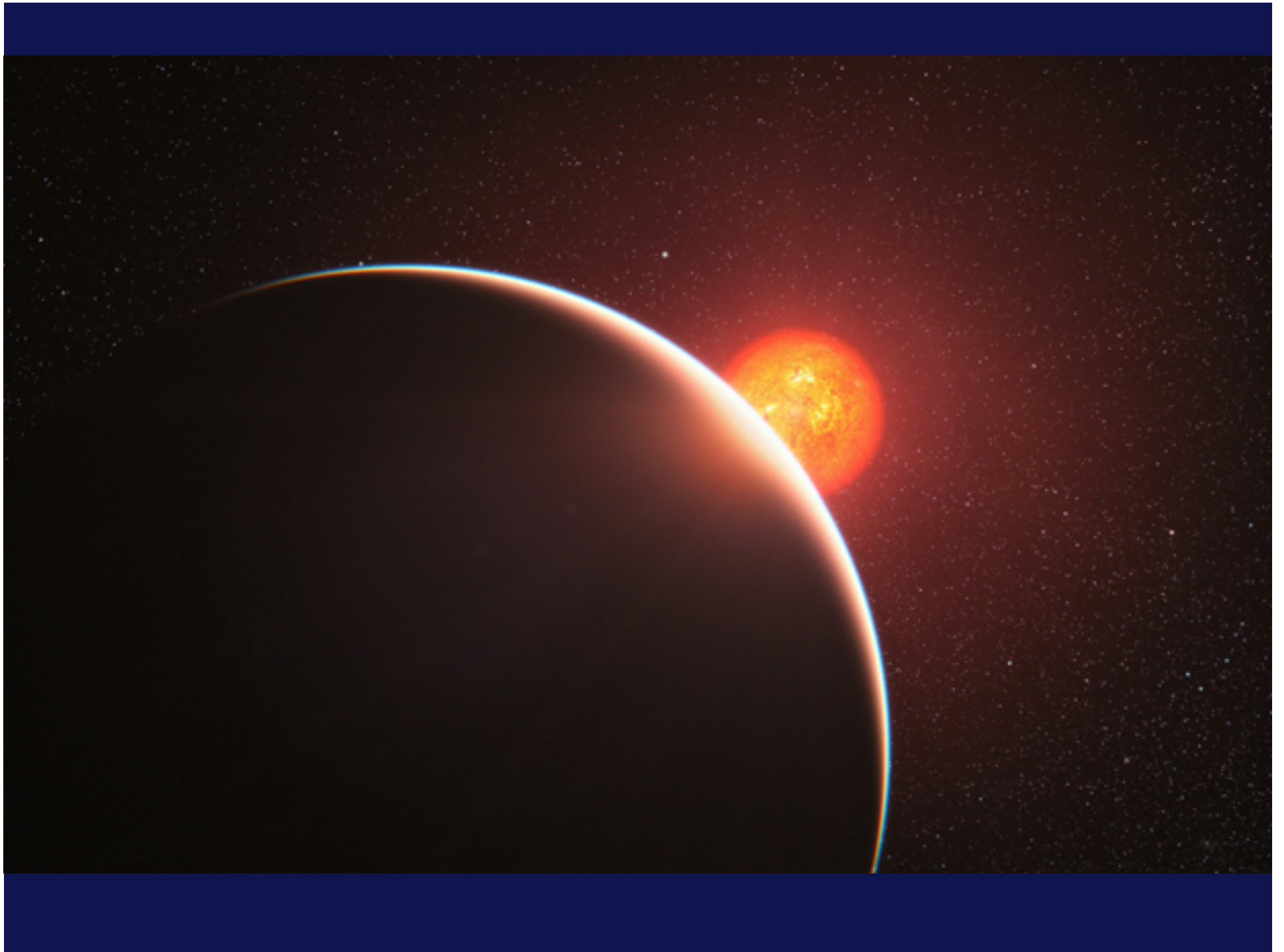
Measure size of transiting planet, see radiation from star transmitted through the planet's atmosphere

**Transit**

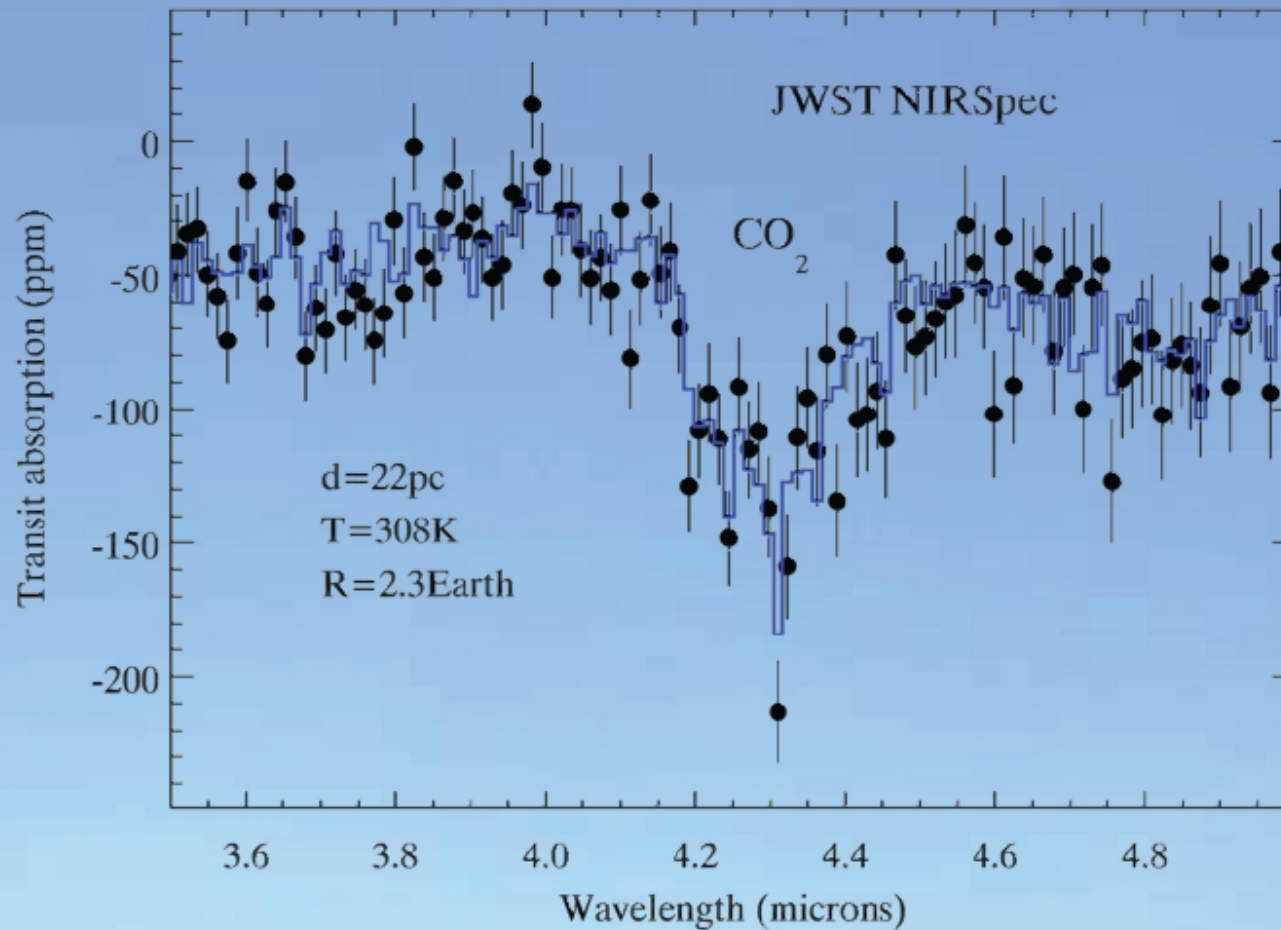
Gravitational tug of unseen planets alters transit times

TRA0009

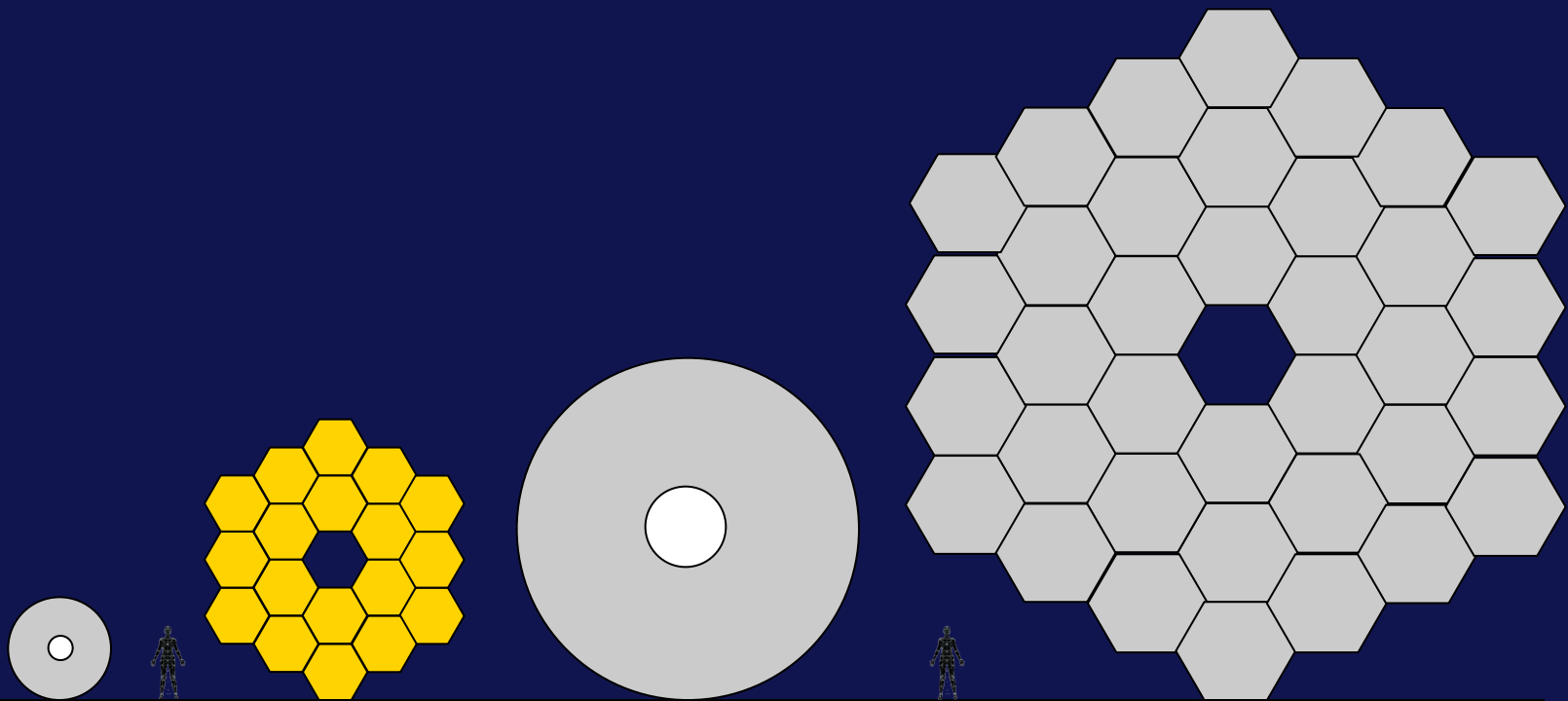




# Example of carbon dioxide in a habitable SuperEarth



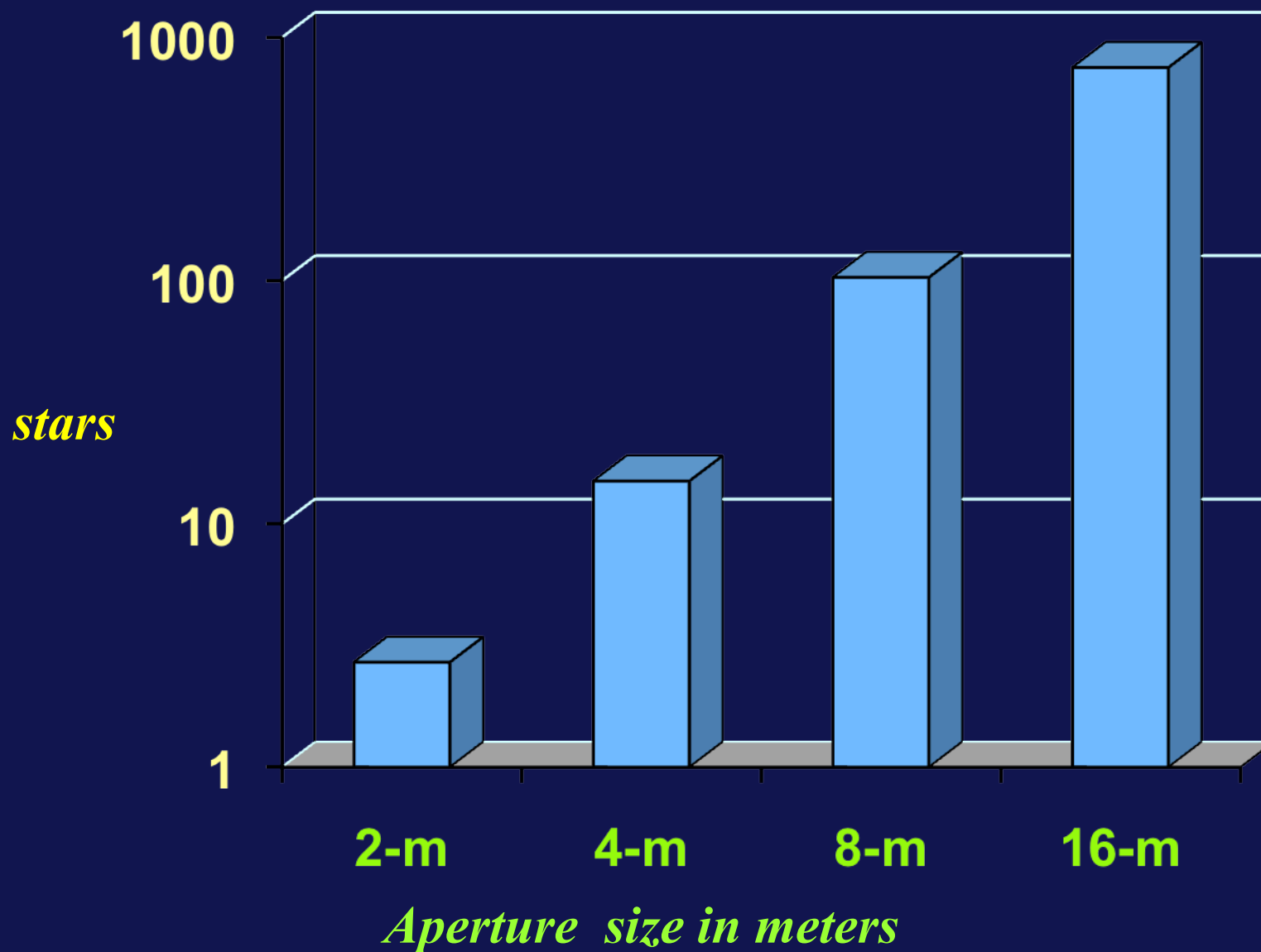
**An optical/near-infrared space telescope with a filled aperture of at least 8-meters will probably be required to definitively answer the question “Are we alone?”**



***HST 2.4-m JWST 6.5-m ATLAST 8-m***

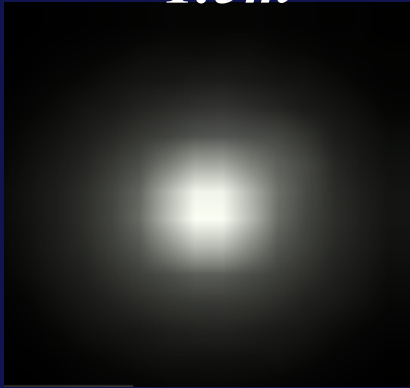
***ATLAST 16-m***

## Number of FGK stars in 100 light-year search radius



# *Coronagraph performance vs. telescope aperture*

*1.5m*



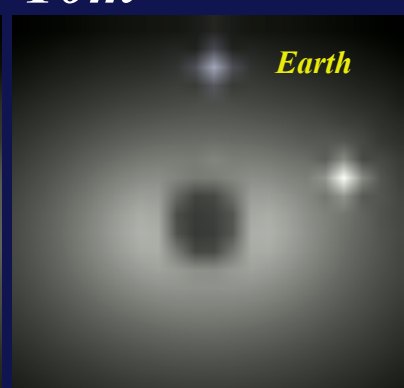
*2.4m*



*4m*

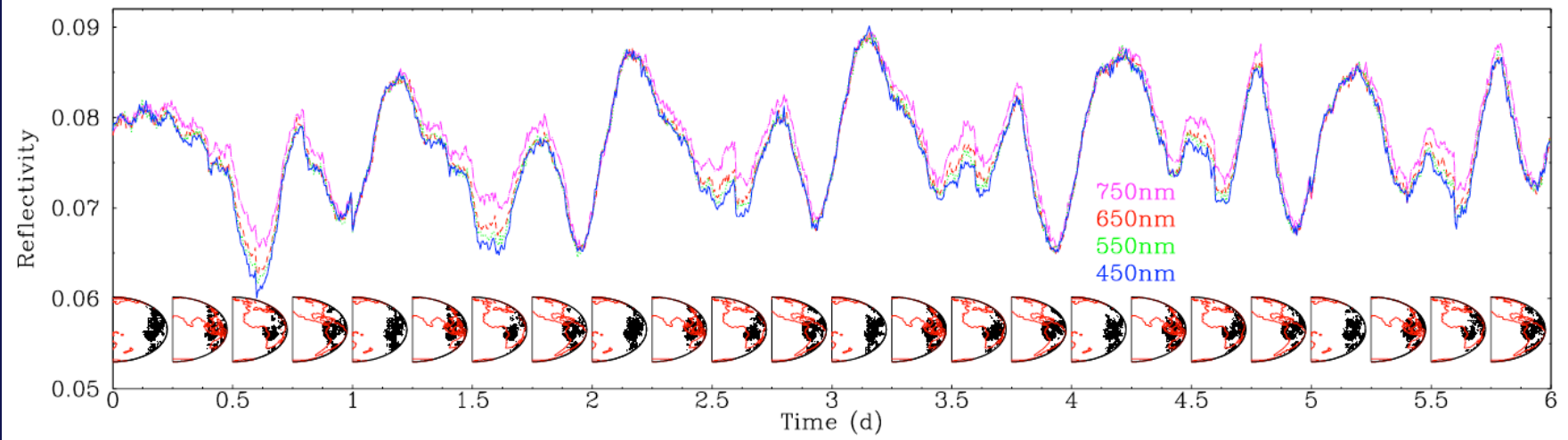


*10m*

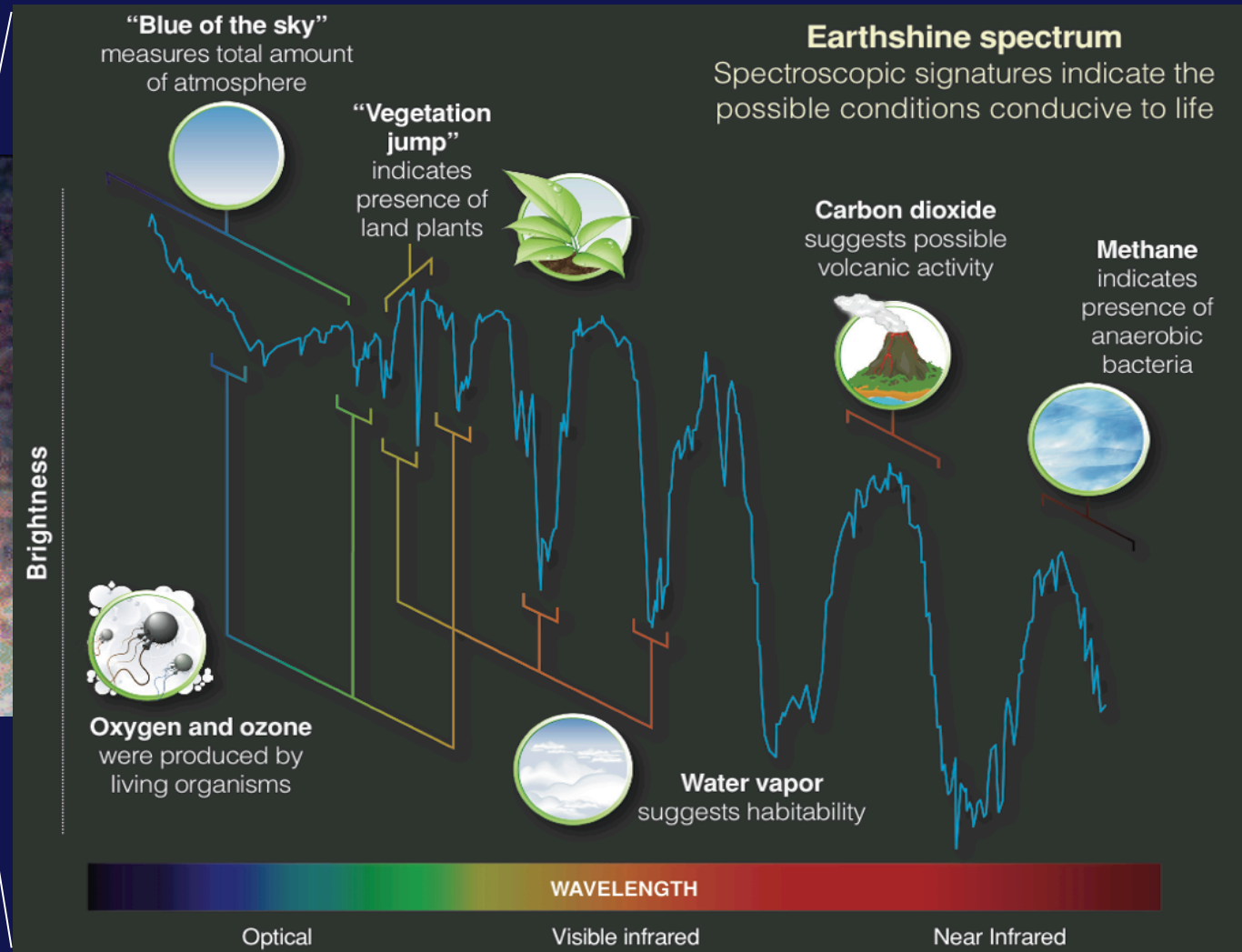


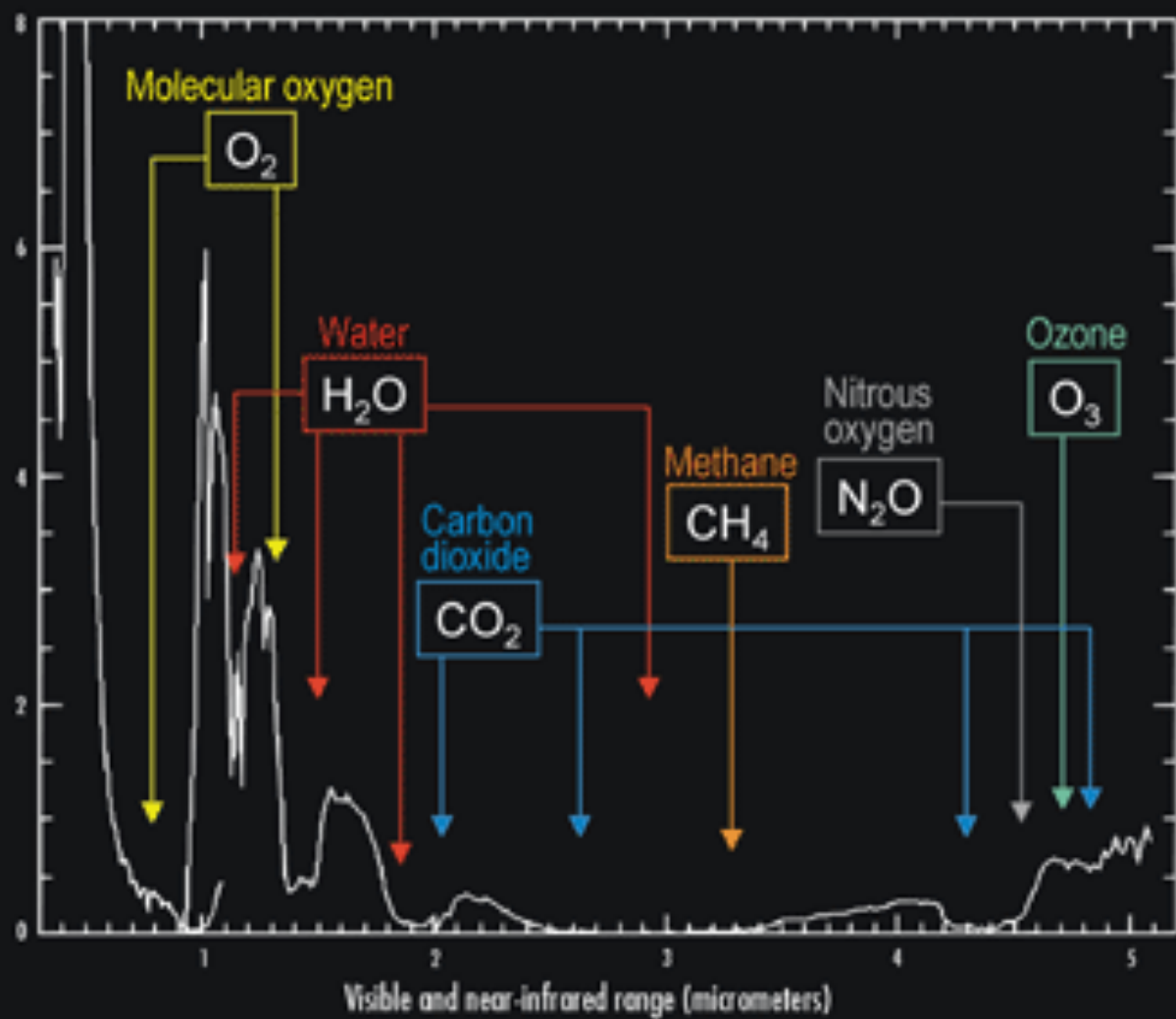
*Earth*

*Venus*



# *the faint trace of life*

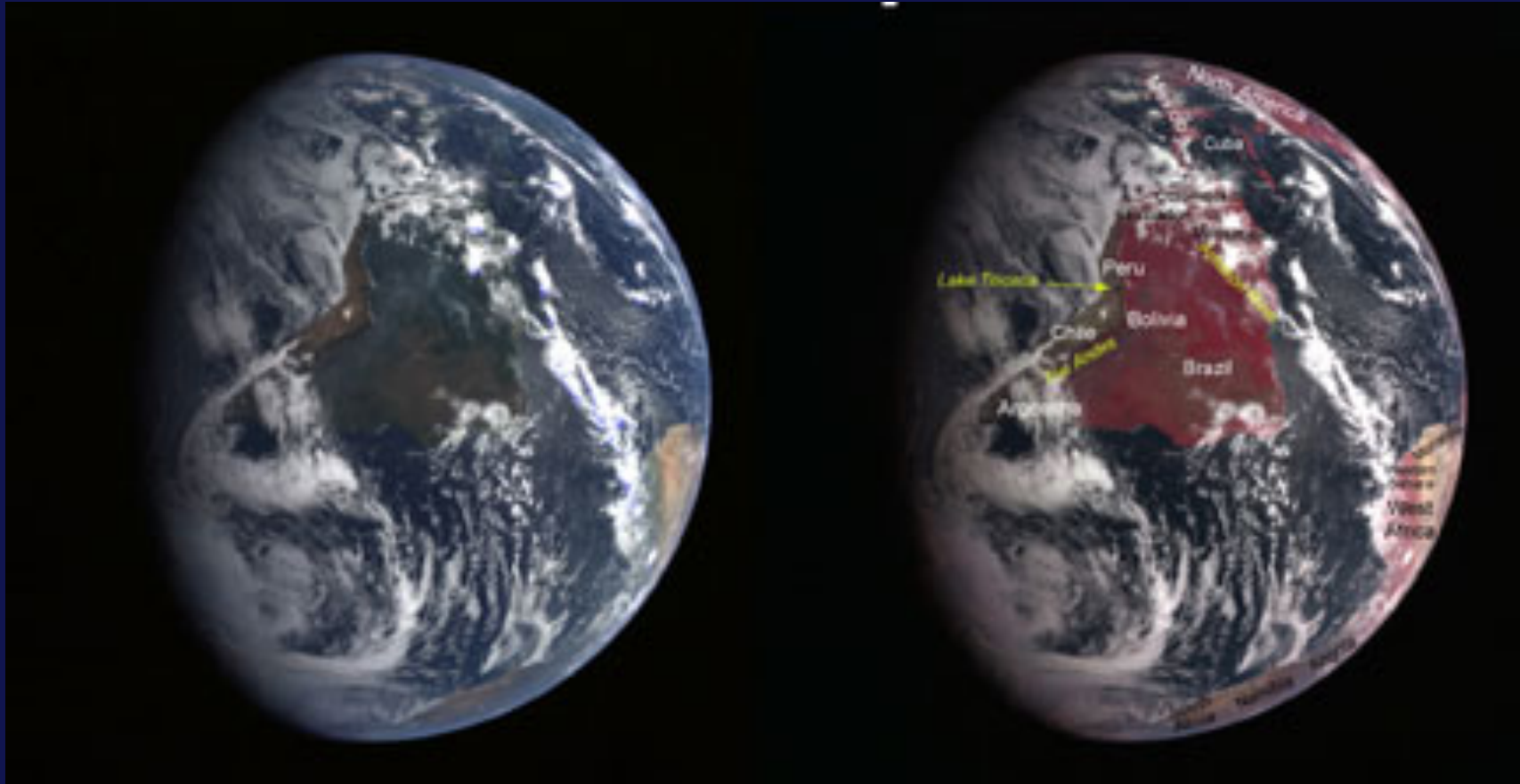




Composition of the Earth by the Mars Express OMEGA Spectrometer  
3 July, 2003

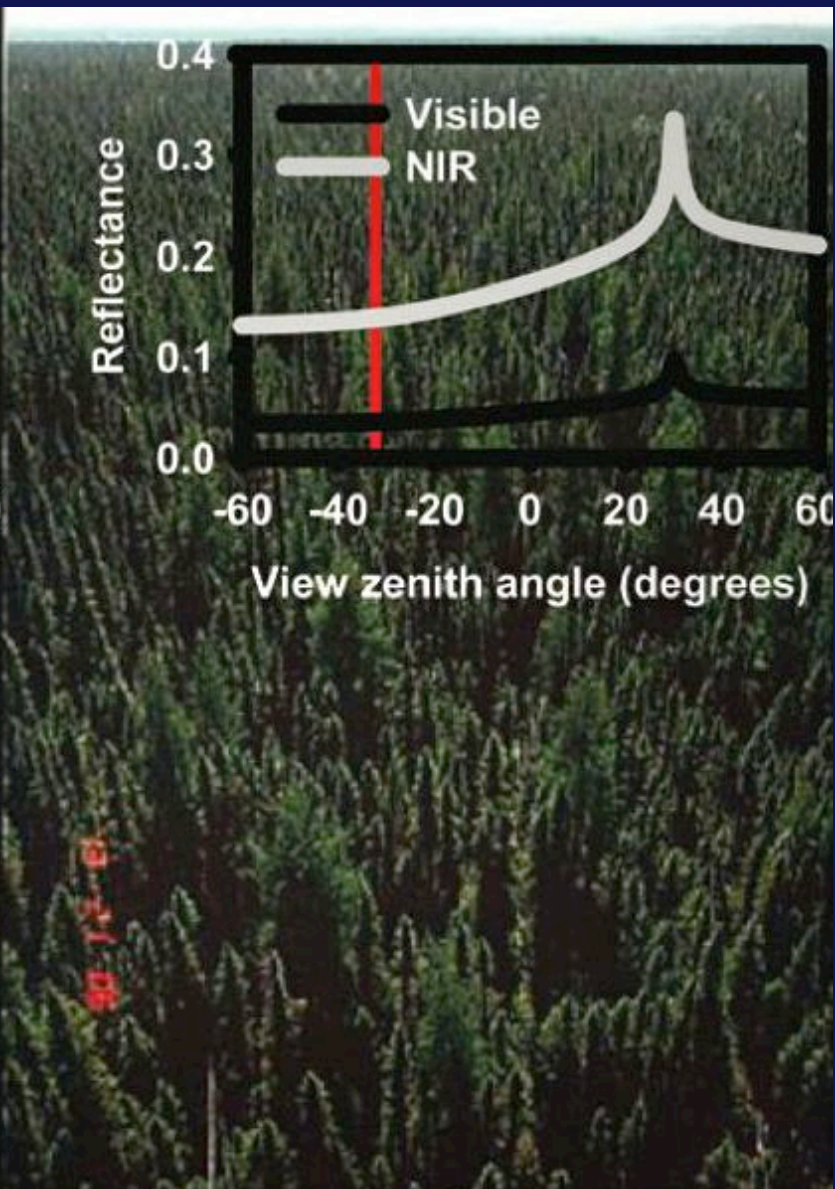
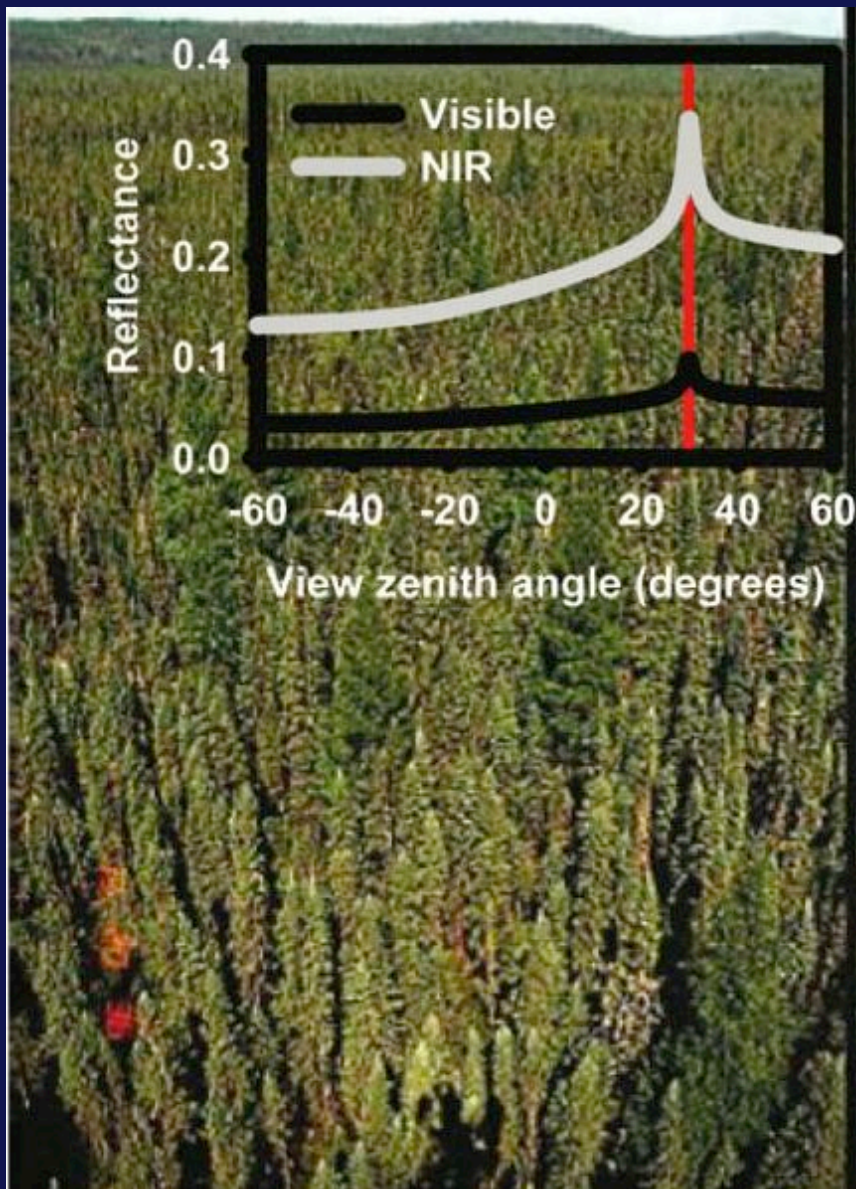


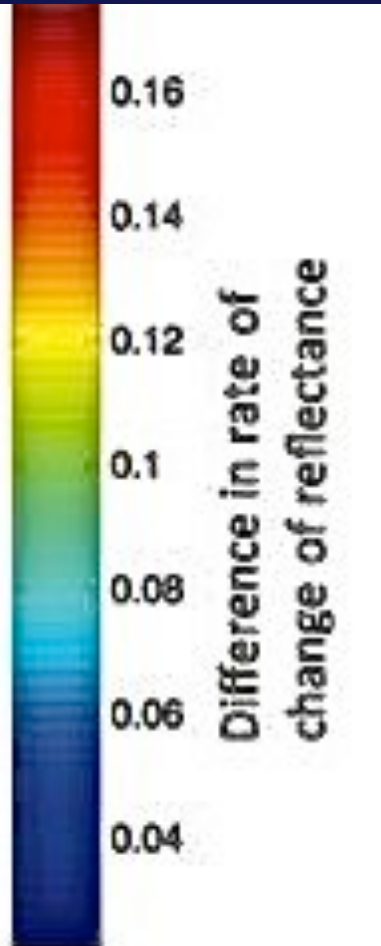
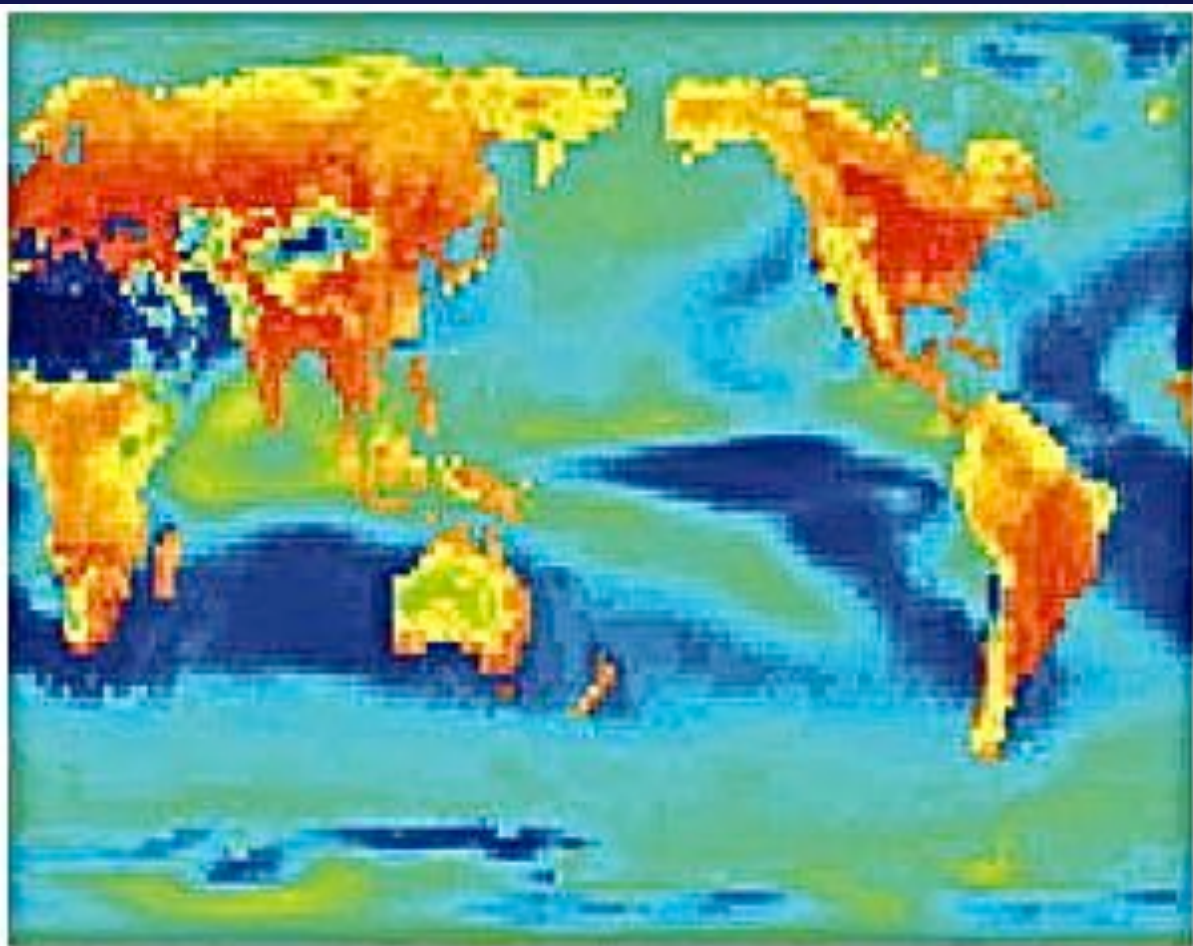


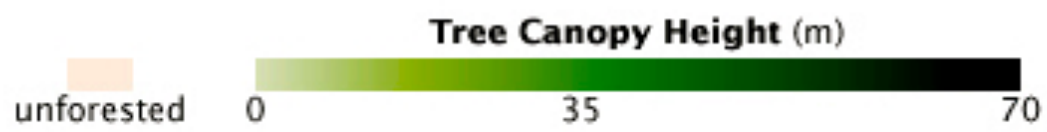
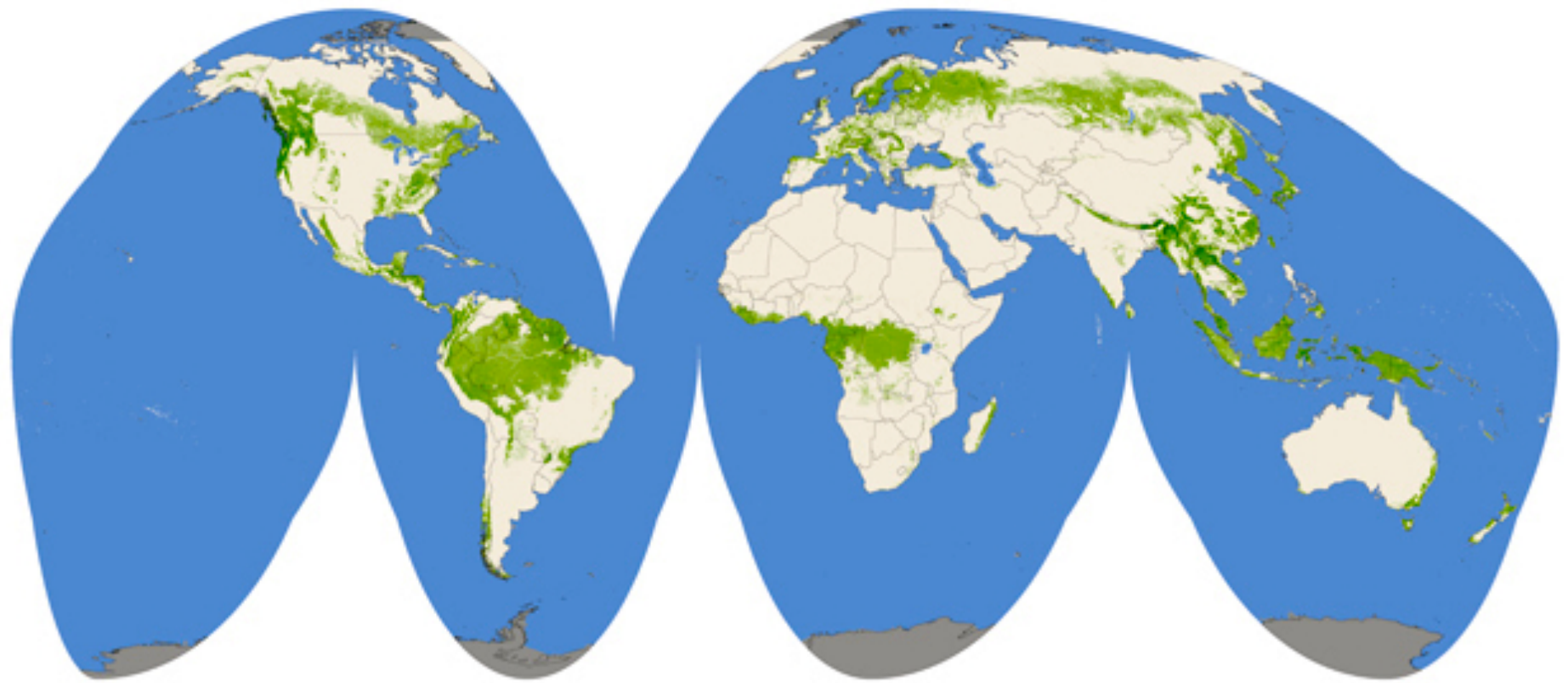


The "red edge" is a well-known signature of chlorophyll, which appears green to us only because our eyes aren't very sensitive at the red end of the visible spectrum.











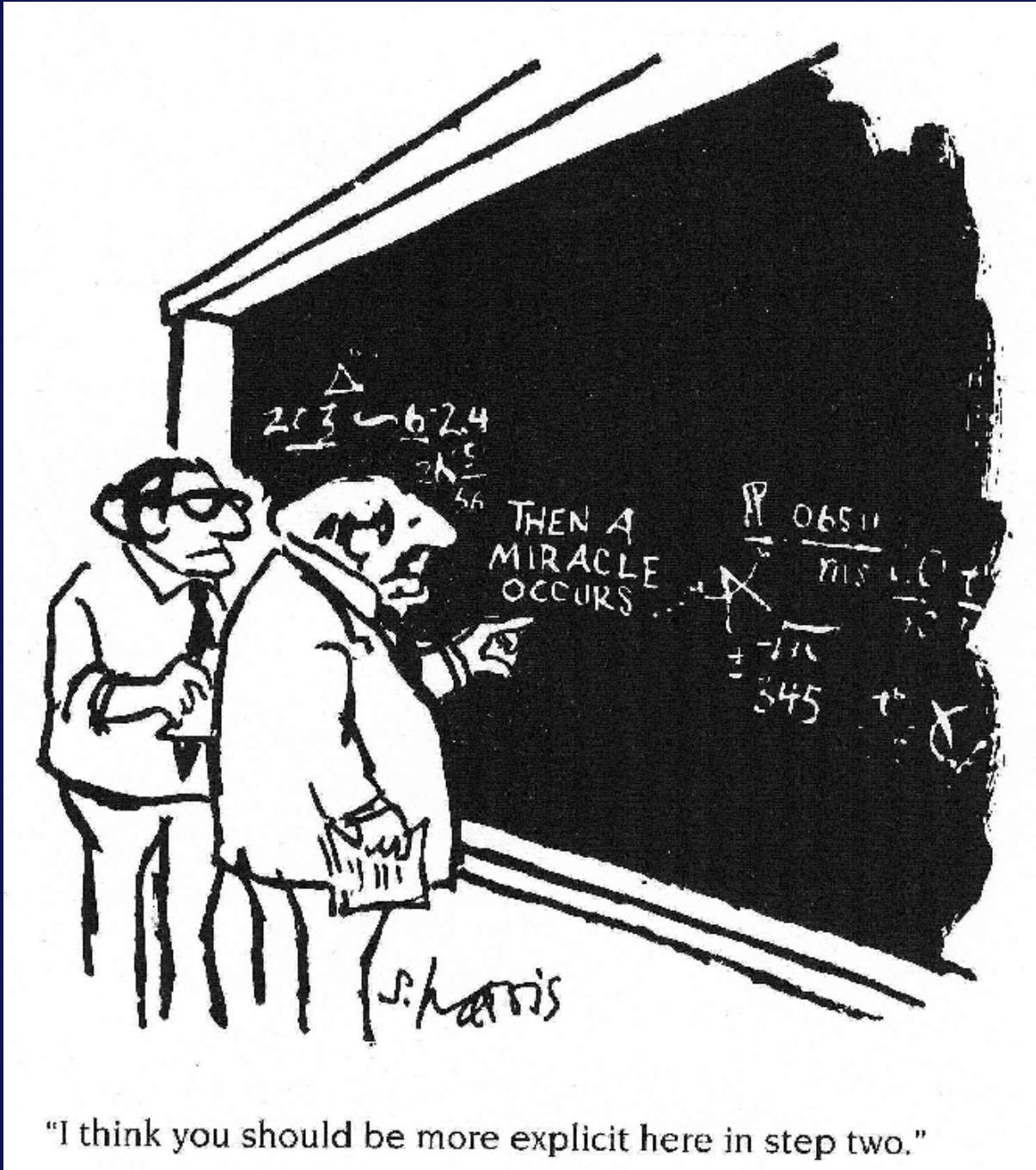


(c) Oscar Gonzalez H.  
[www.fotoil.com](http://www.fotoil.com)



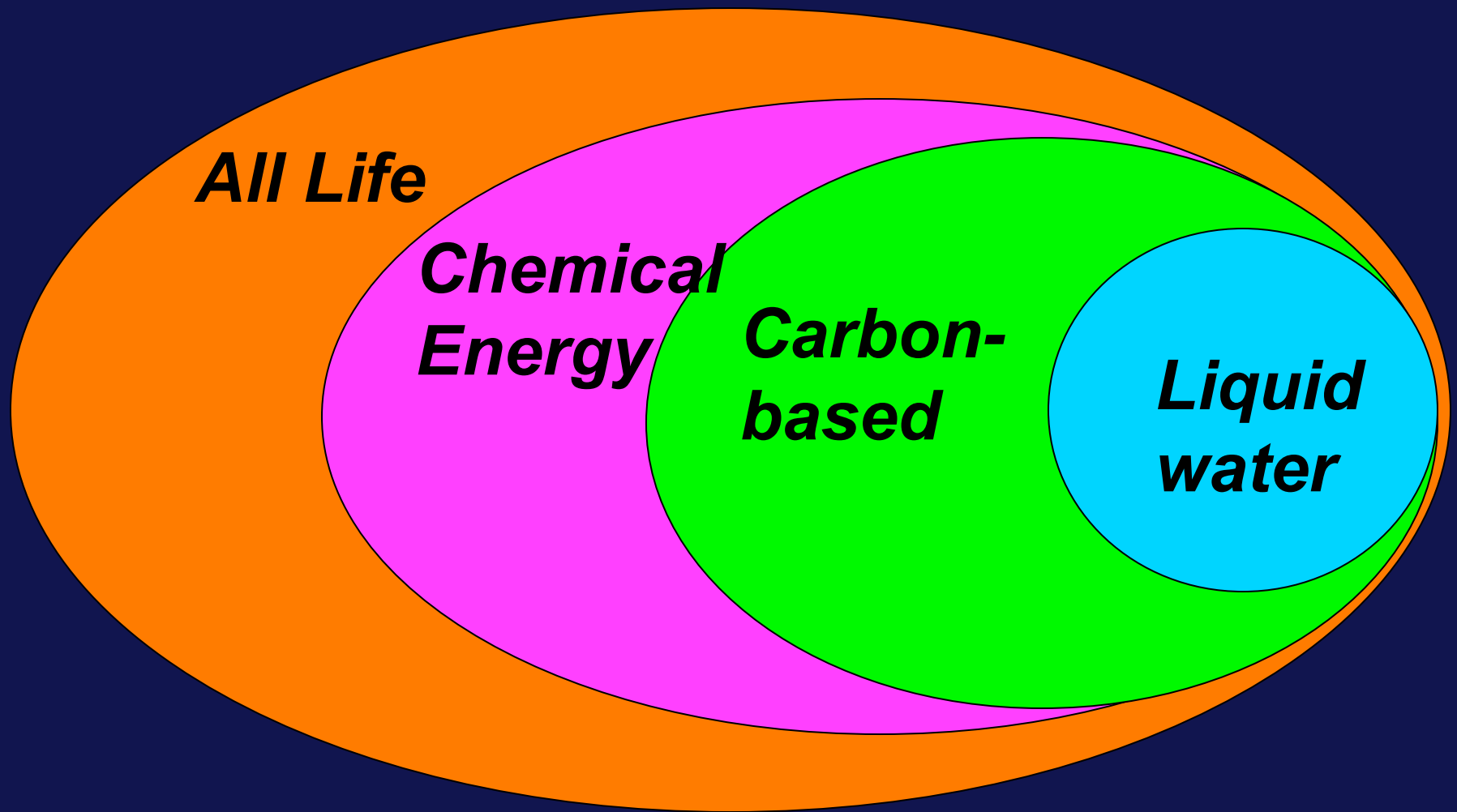


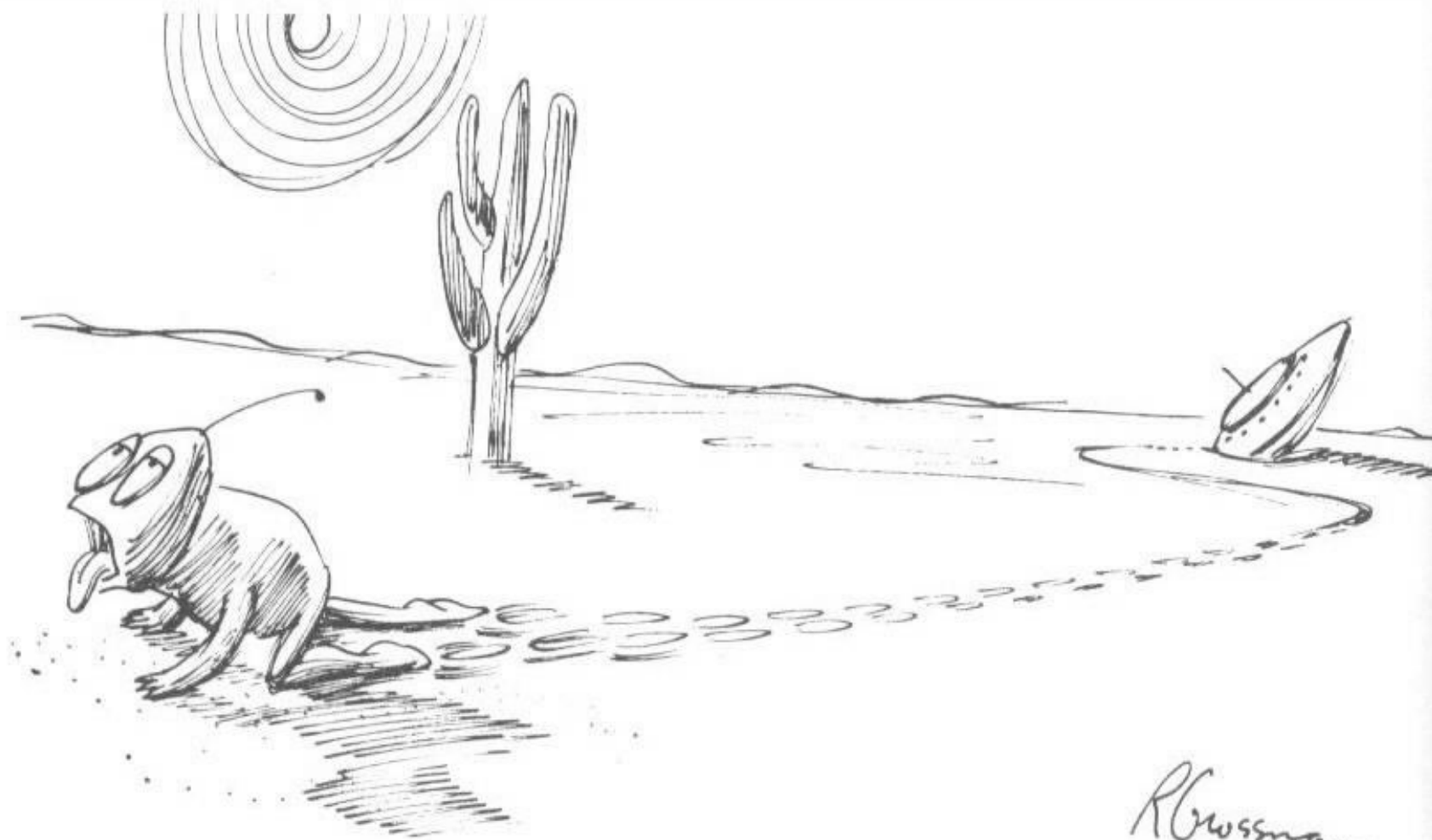




"I think you should be more explicit here in step two."

# Life in the Universe





R. Grossman

*"Ammonia! Ammonia!"*

Drawing by R. Grossman; © 1962.  
The New Yorker Magazine, Inc.

• *A thermodynamic disequilibrium*

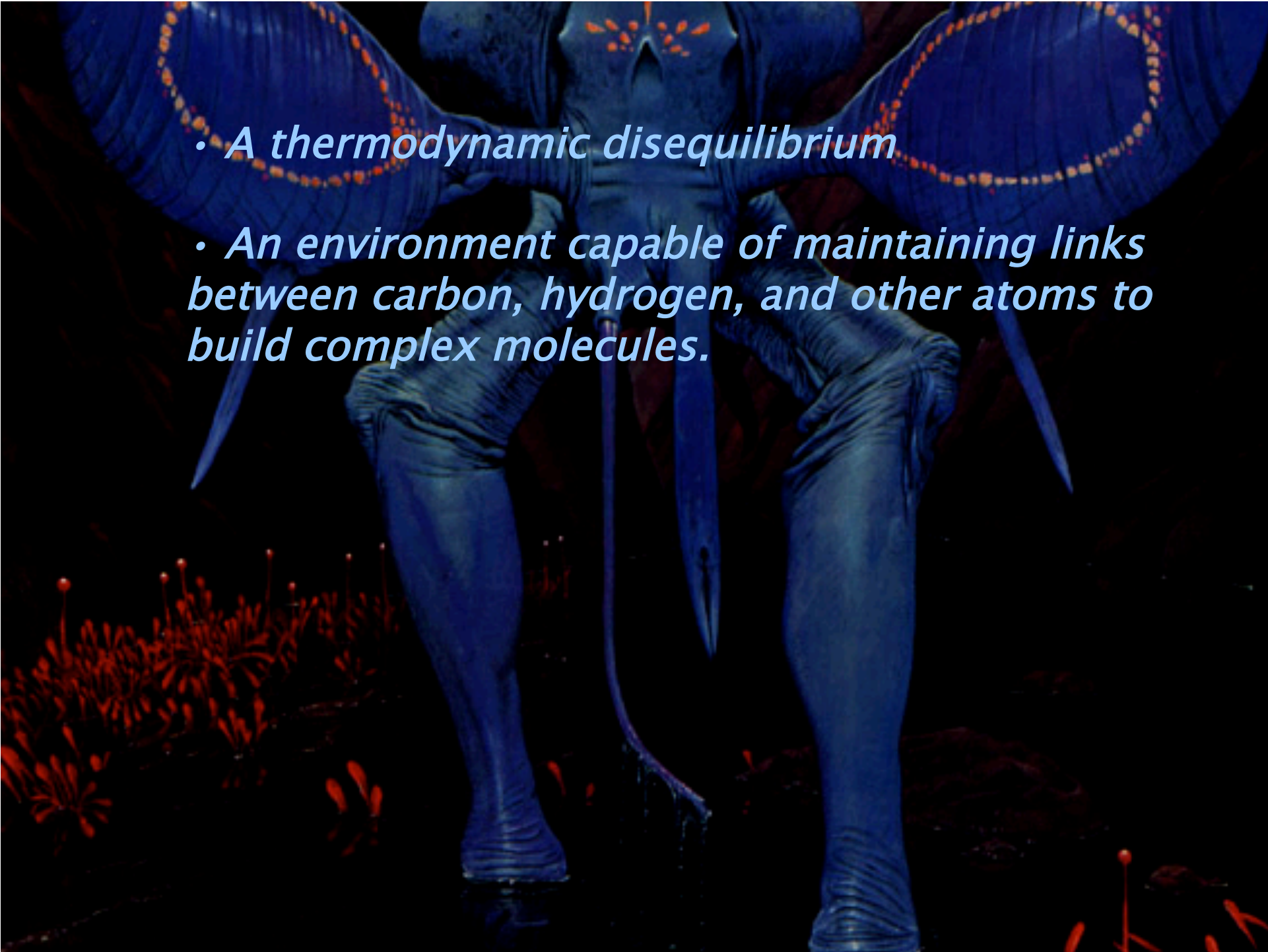


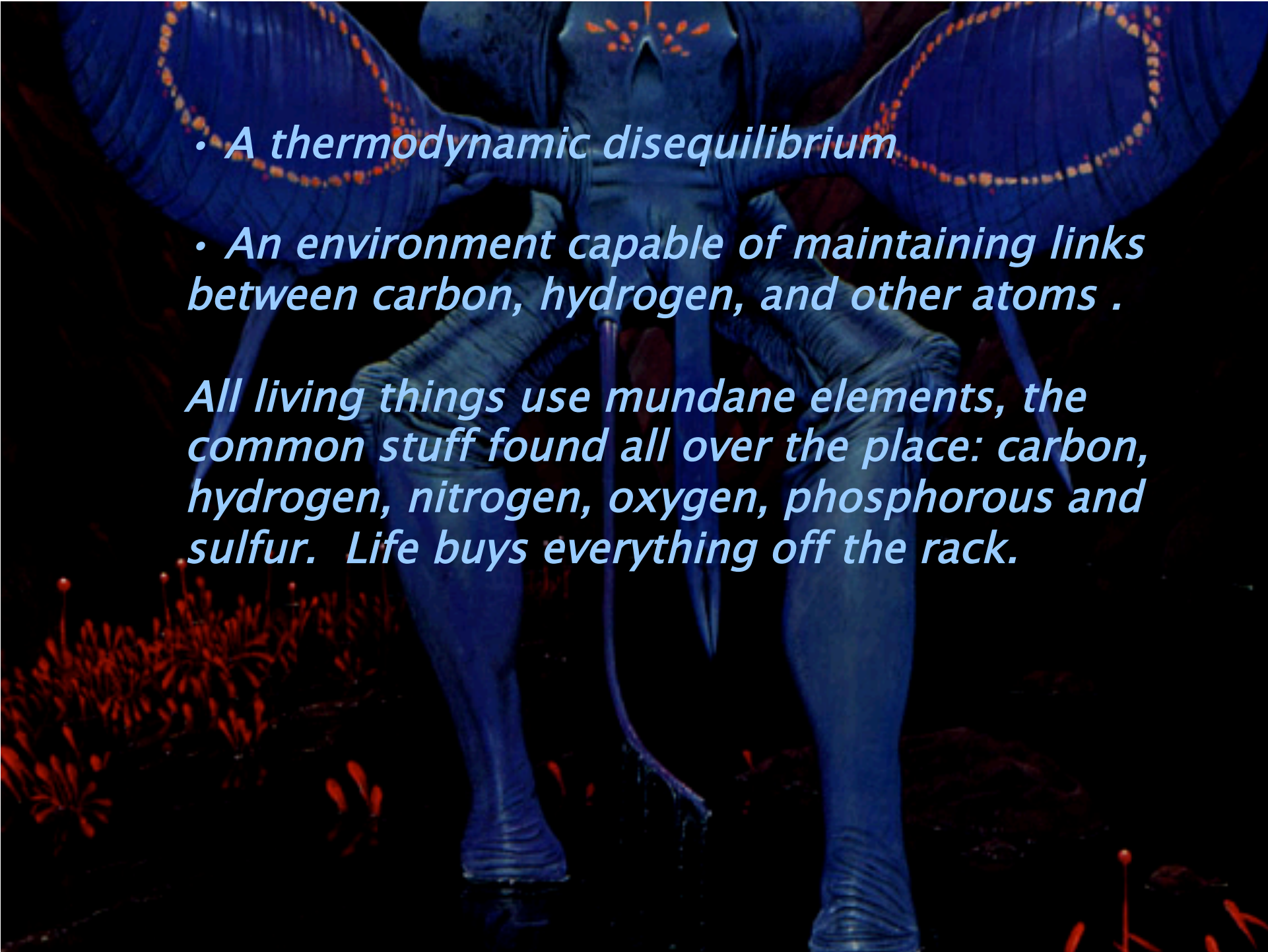




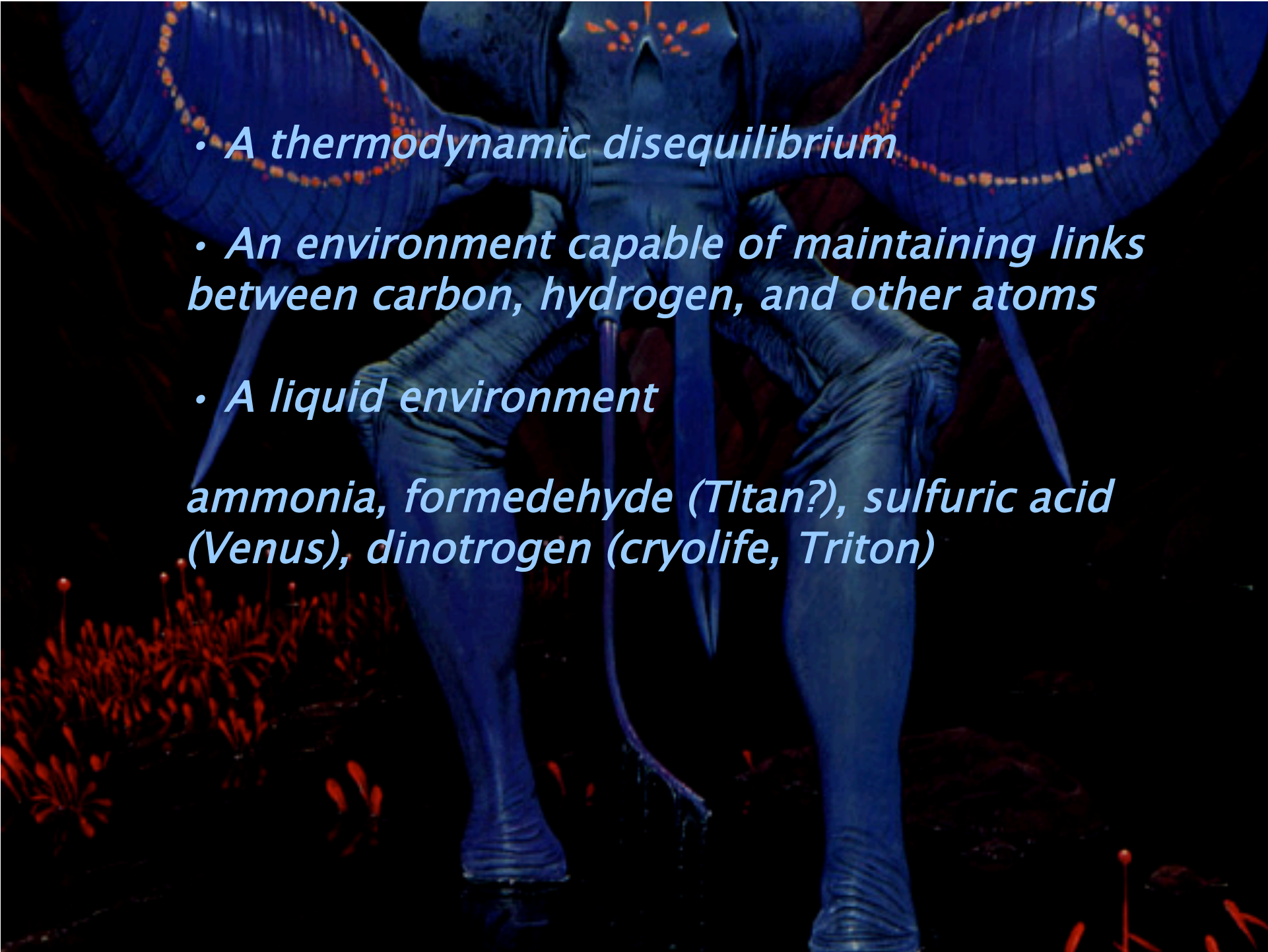
• *A thermodynamic disequilibrium  
star, molten interior, impact melt,*



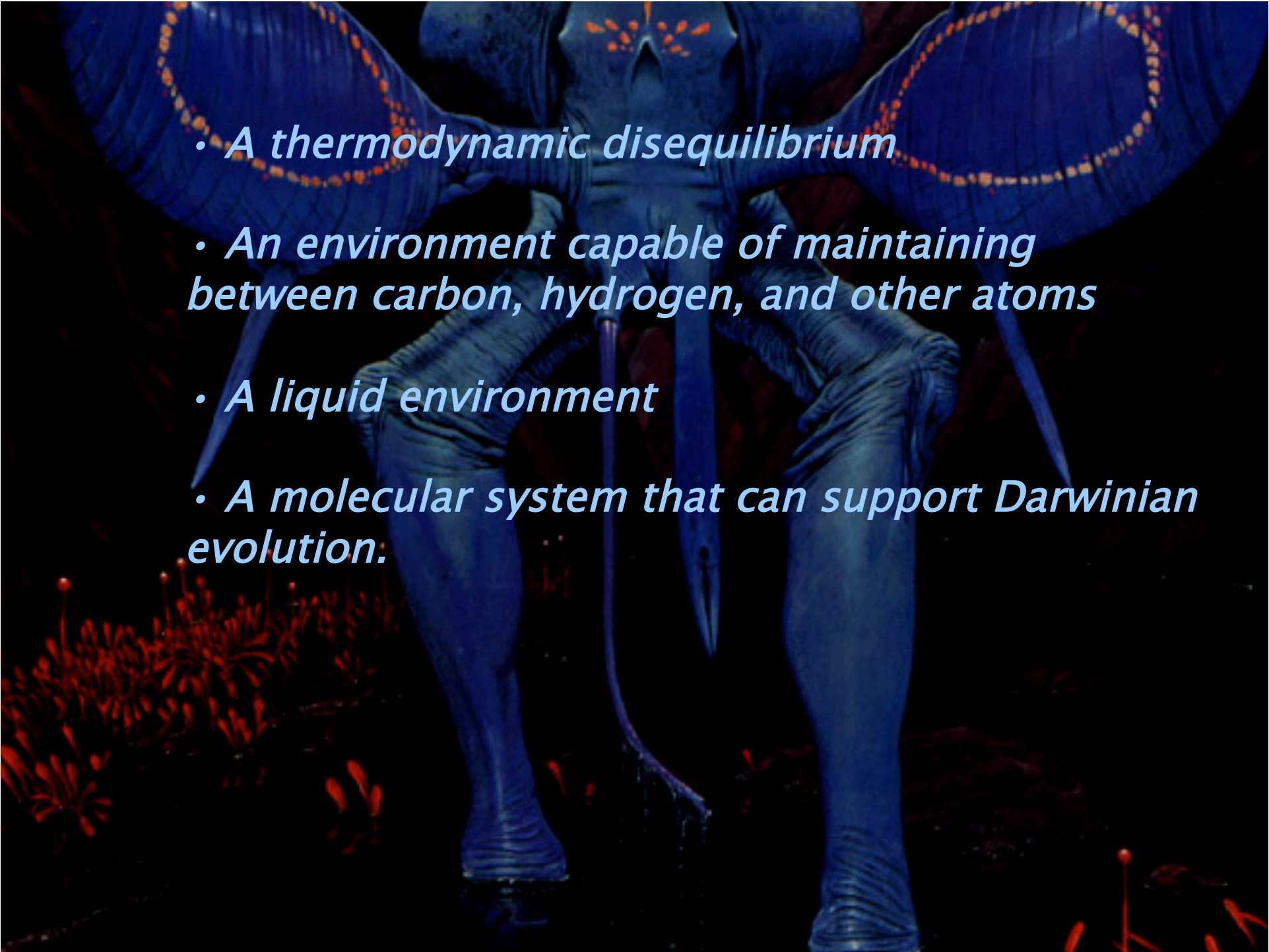
- 
- *A thermodynamic disequilibrium*
  - *An environment capable of maintaining links between carbon, hydrogen, and other atoms to build complex molecules.*

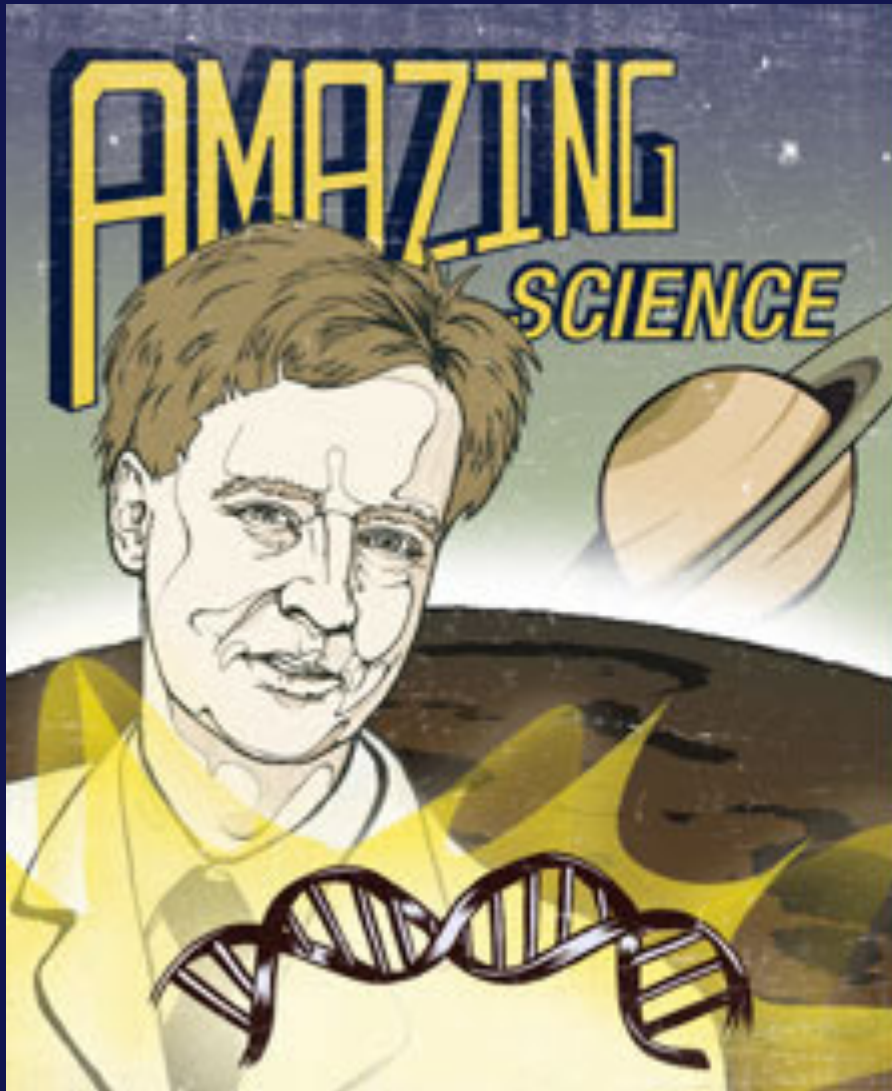
- 
- *A thermodynamic disequilibrium*
  - *An environment capable of maintaining links between carbon, hydrogen, and other atoms .*

*All living things use mundane elements, the common stuff found all over the place: carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Life buys everything off the rack.*

- 
- *A thermodynamic disequilibrium*
  - *An environment capable of maintaining links between carbon, hydrogen, and other atoms*
  - *A liquid environment*

*ammonia, formaldehyde (Titan?), sulfuric acid (Venus), dinitrogen (cryolife, Triton)*

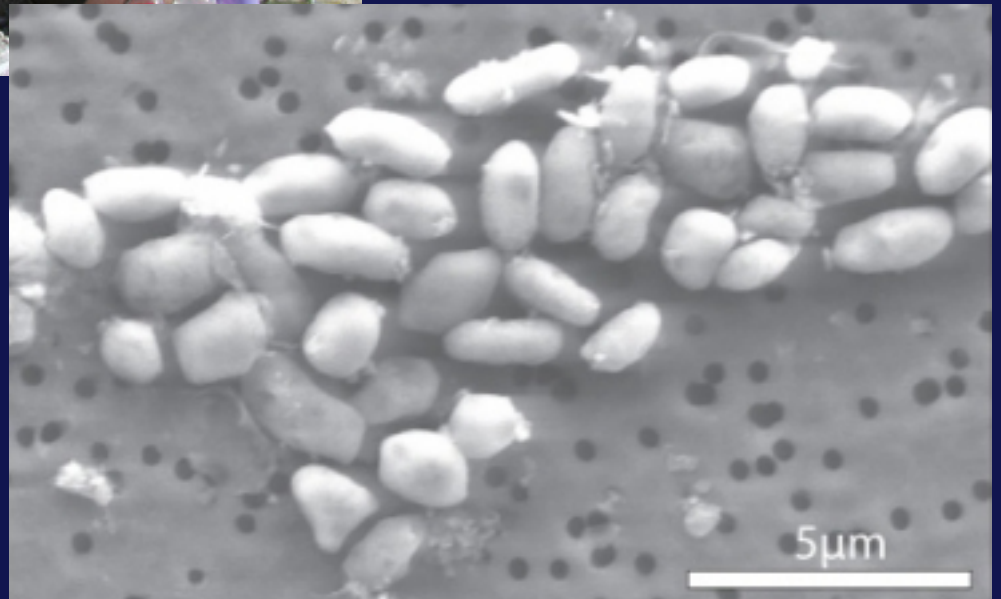
- 
- *A thermodynamic disequilibrium*
  - *An environment capable of maintaining between carbon, hydrogen, and other atoms*
  - *A liquid environment*
  - *A molecular system that can support Darwinian evolution.*



A Formula  
For Life

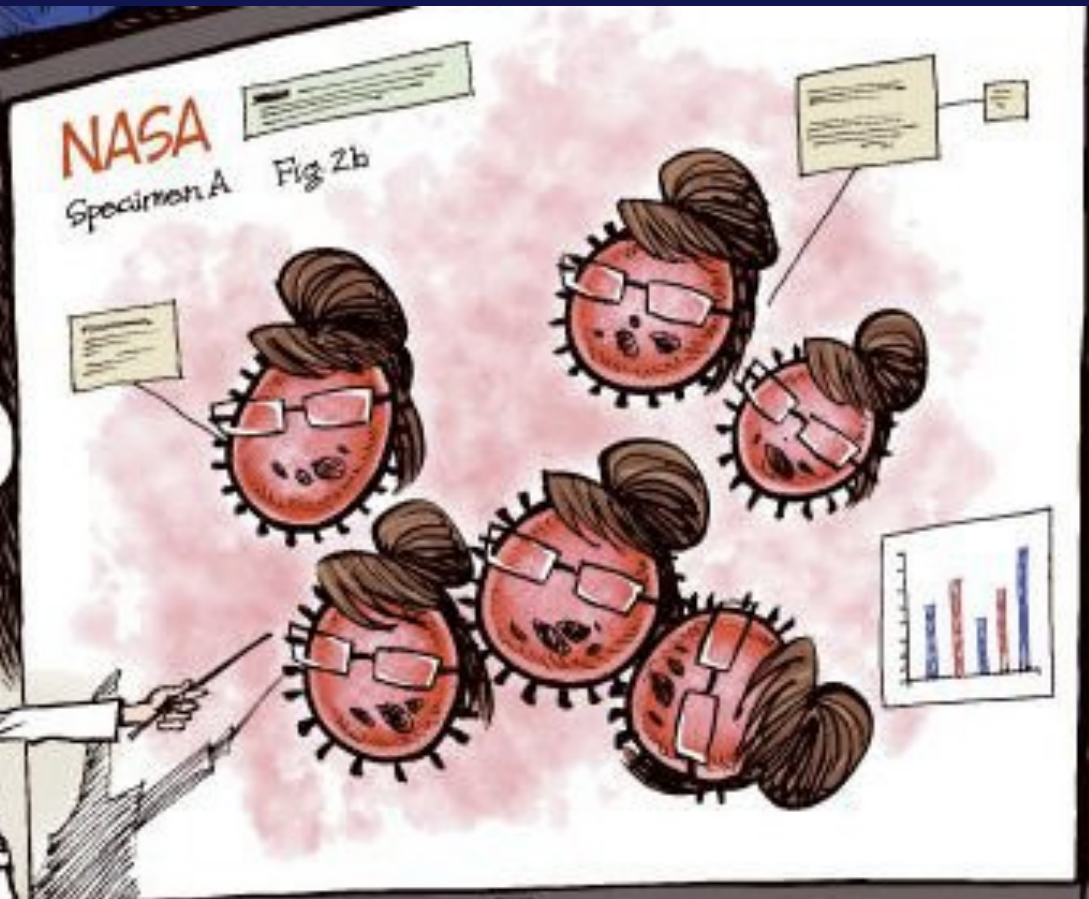
---

The Benner group has worked to identify molecular structures likely to be universal features of living systems regardless of their genesis, and not likely products of non-biological processes



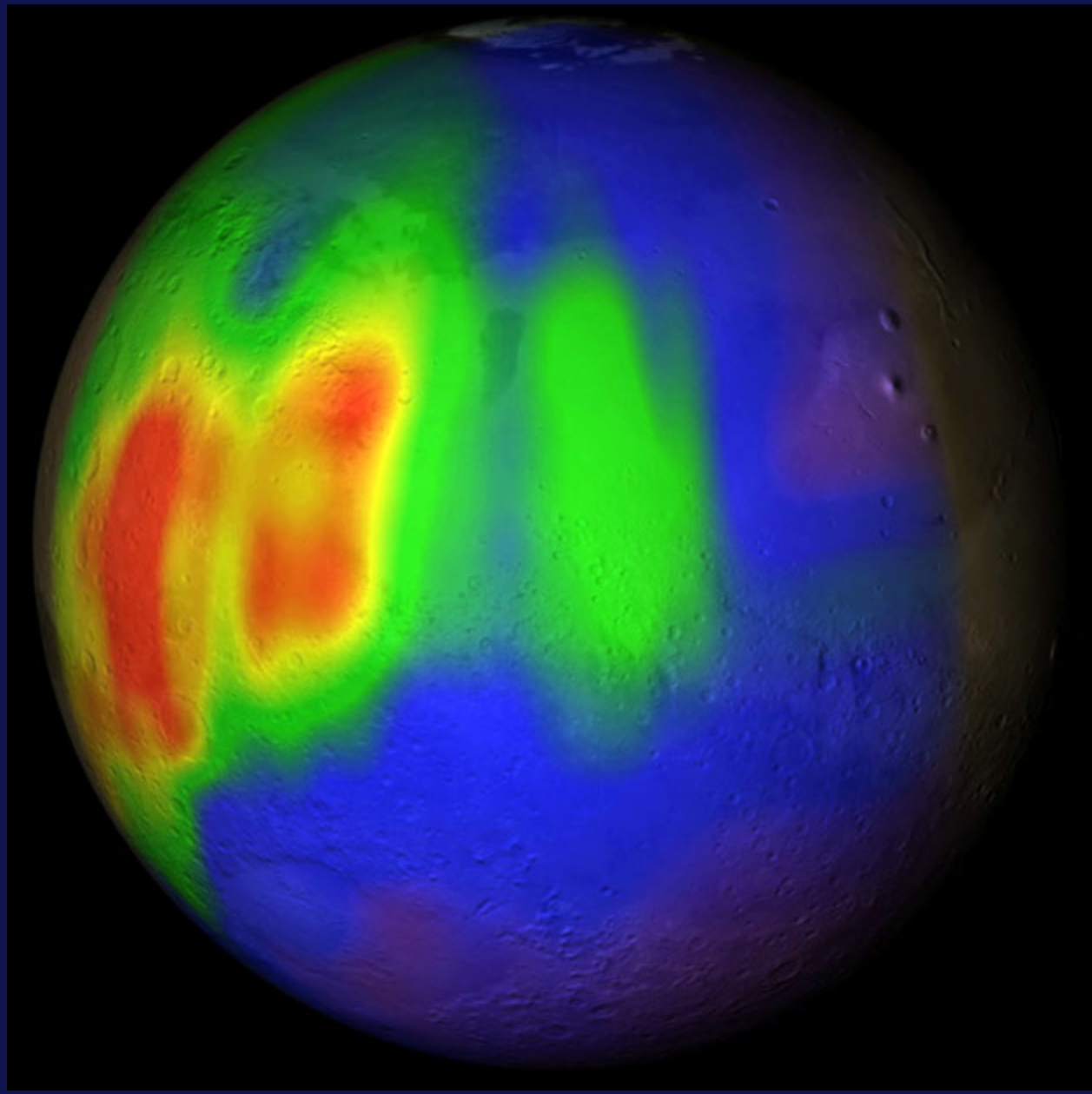
WE DISCOVERED  
A LIFEFORM WHOSE  
VERY **D.N.A.** IS  
COMPOSED OF  
**POISON**....

WE'RE CALLING IT,  
"**SARAH PALINELLA**."

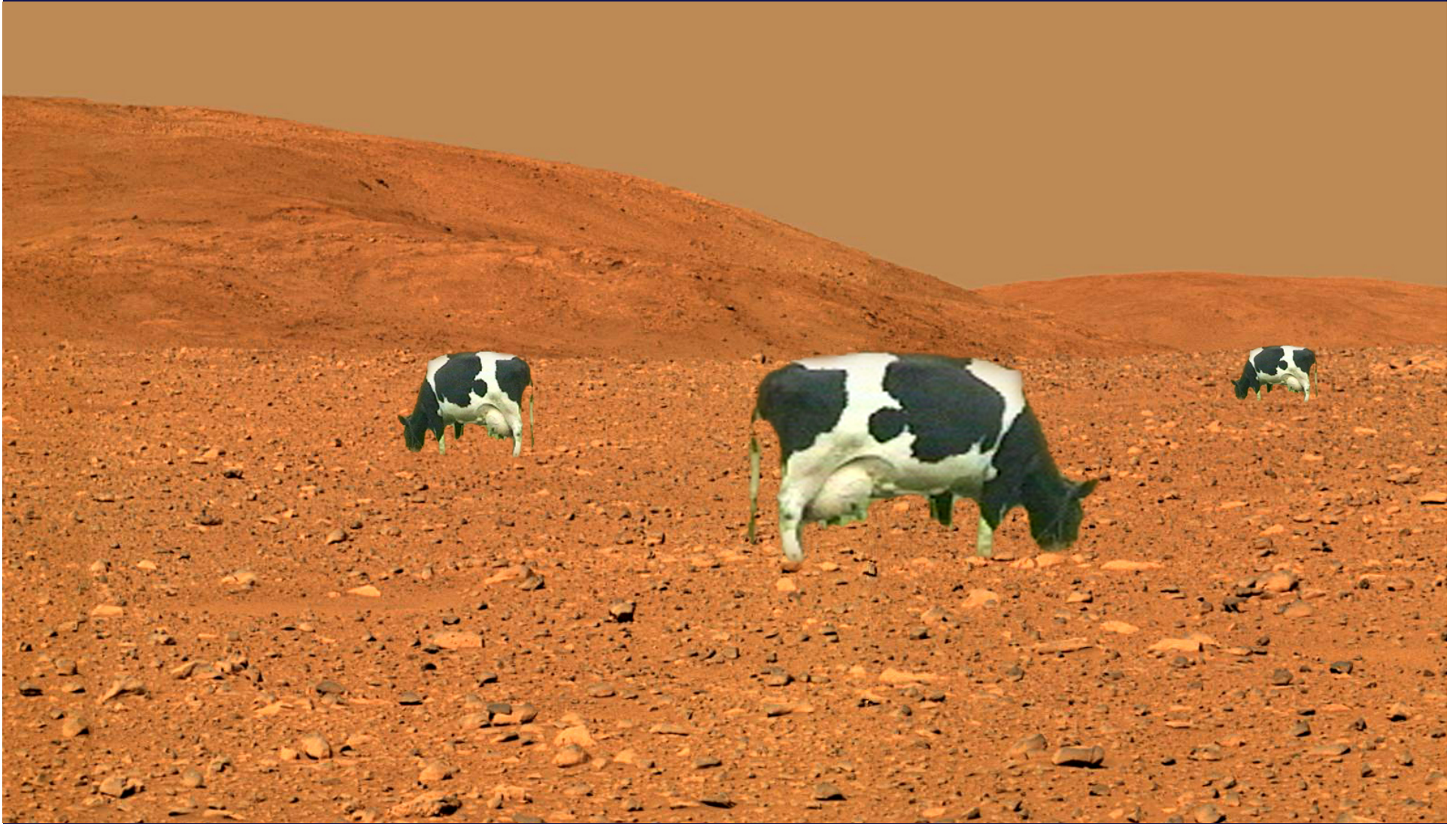




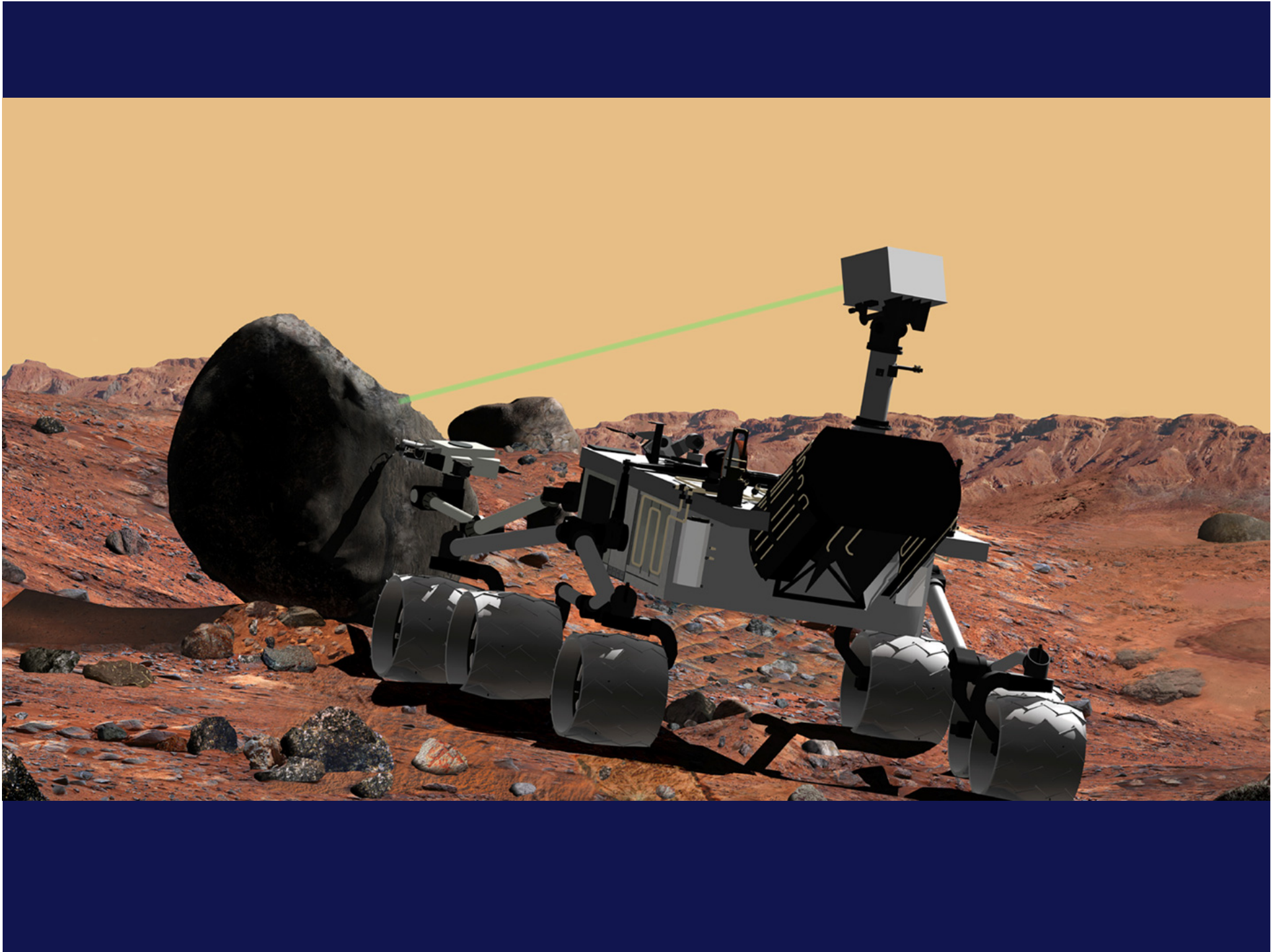




# *Source of Martian Methane?*

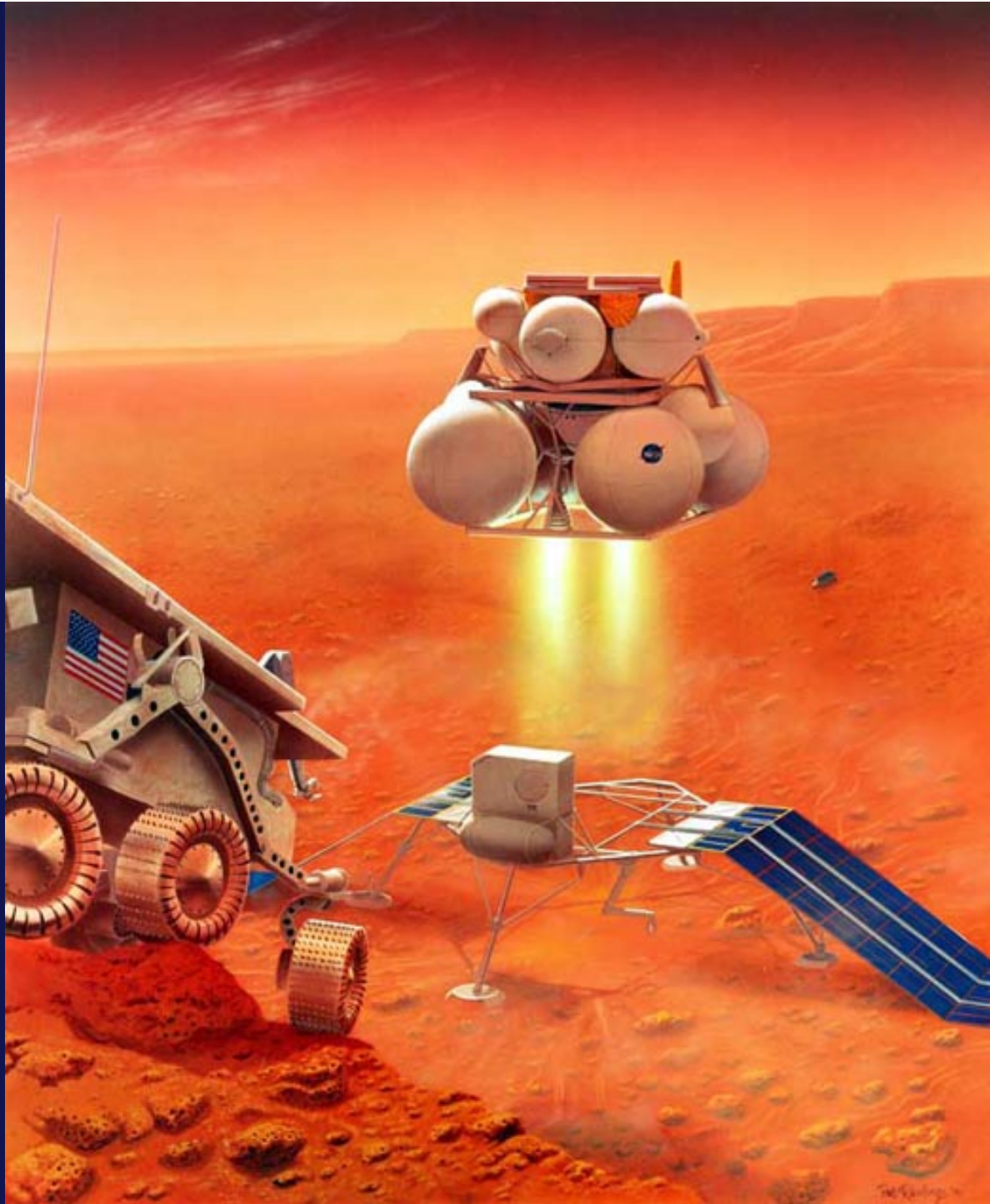






**STRANGE  
BREED  
OF CATS  
FOUND  
ON MARS!**











**CLASSICS**  
*Illustrated*

Featuring Stories by the  
World's Greatest Authors

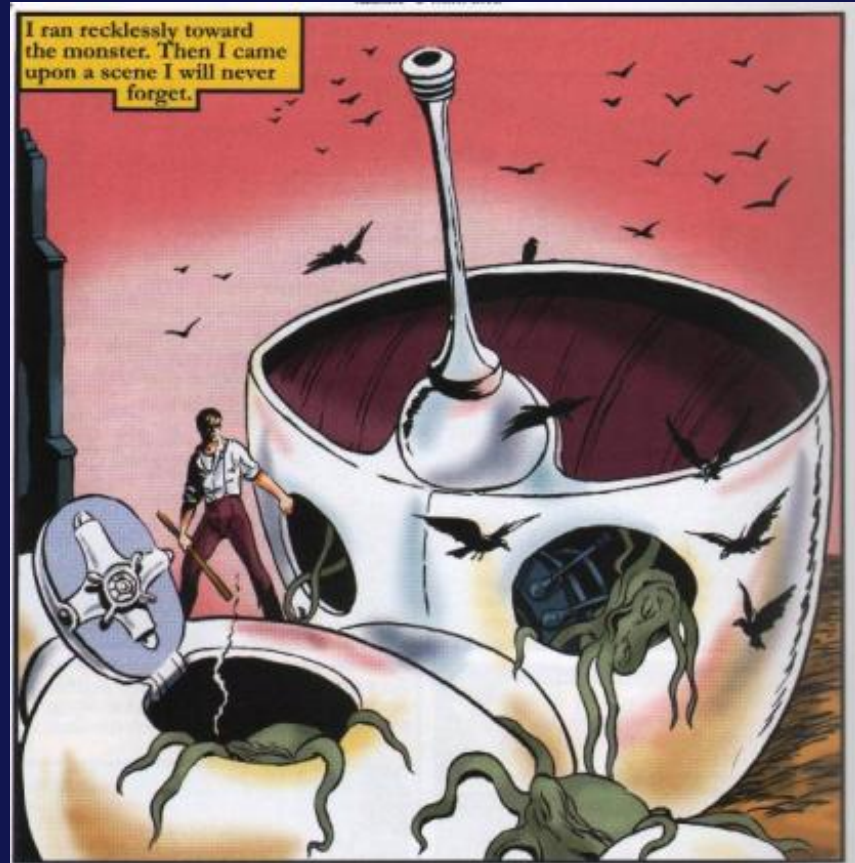
# THE WAR OF THE WORLDS

By H.G. WELLS

No. UK.  
1 £2.99



ISBN 978-1-906814-01-4





**Gaspra**  
(12 mi)



**Eros**  
(21 mi)



**Ida**  
(36 mi)

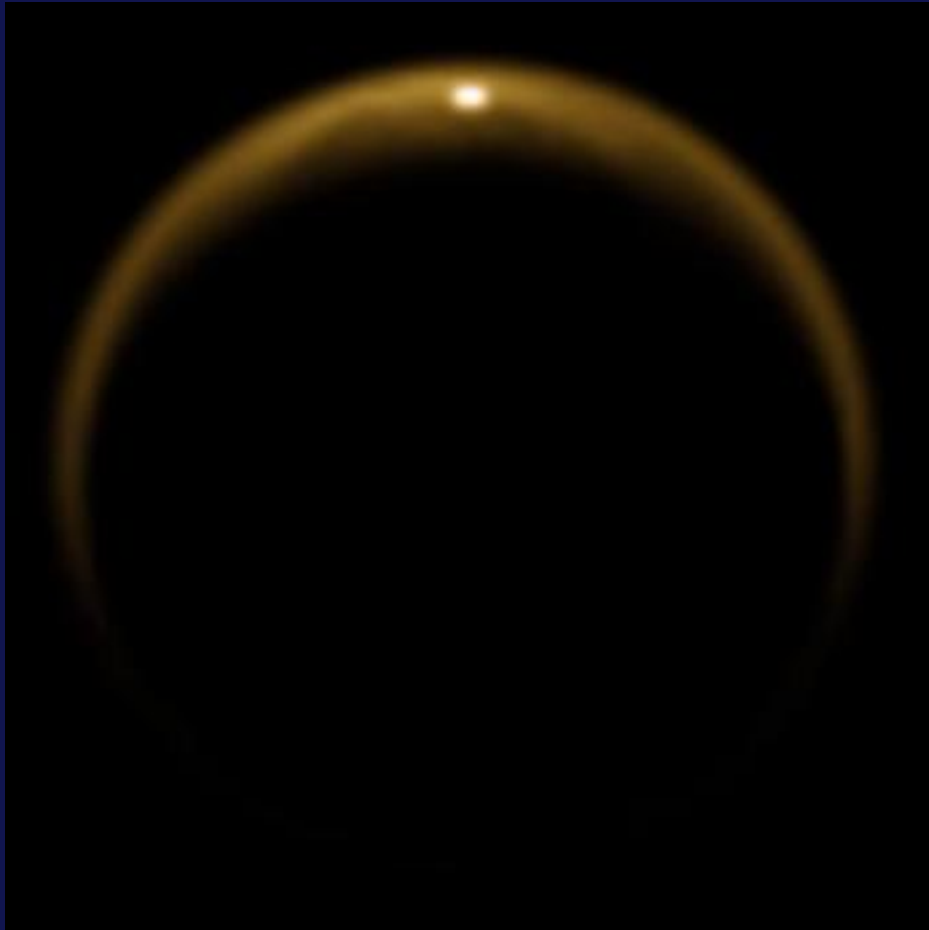
**Vesta**  
(329 mi)



**Ceres**  
(597 mi)

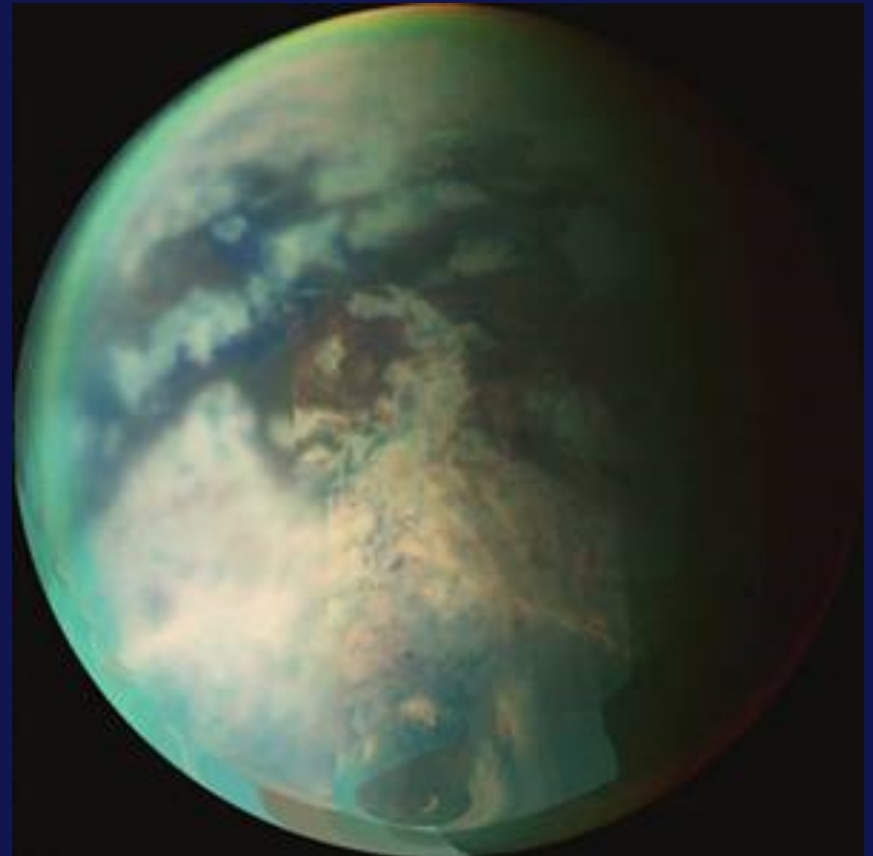


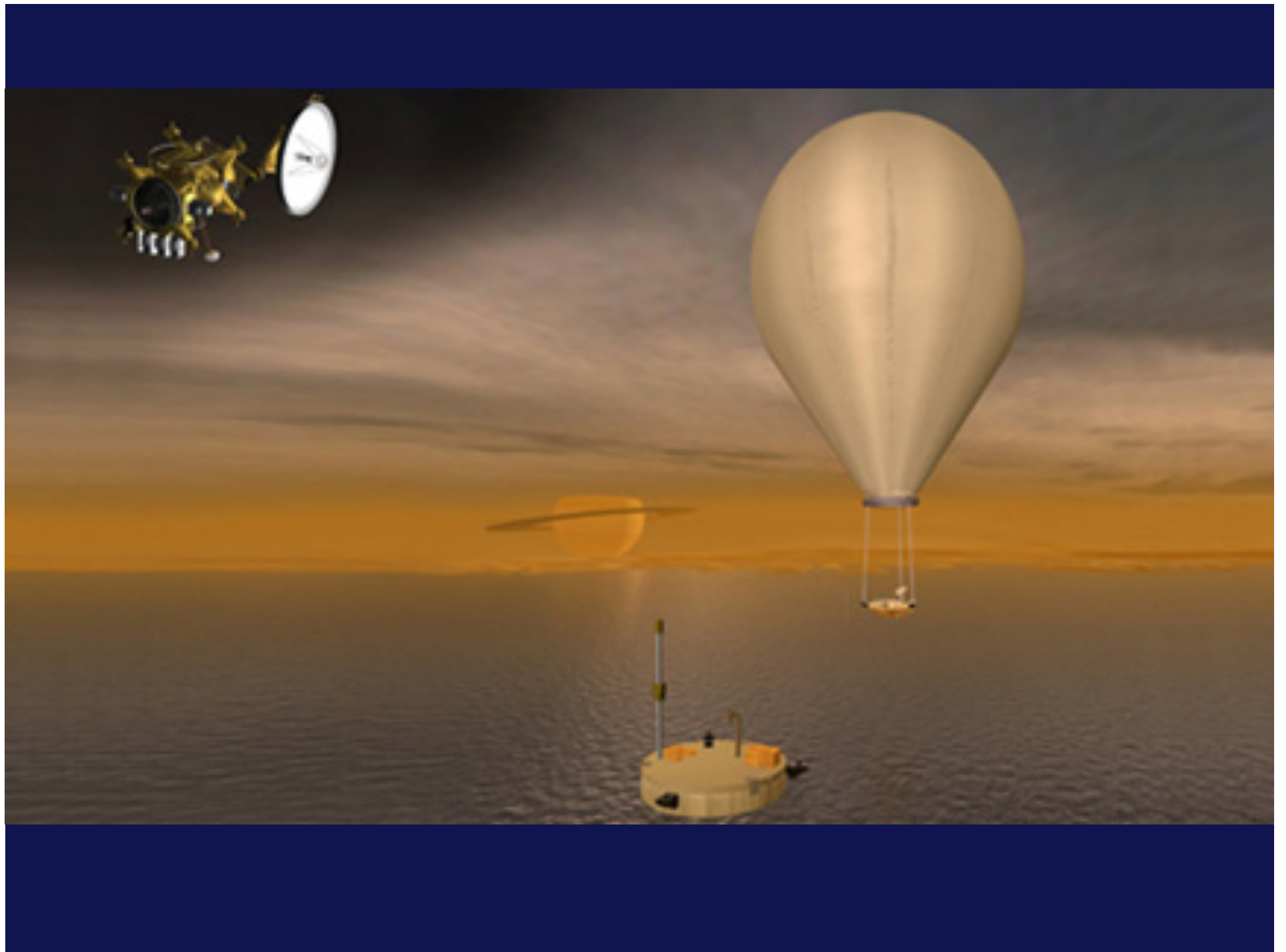
*Image credits: Gaspra, Ida: Galileo (NASA/JPL); Eros: NEAR Shoemaker (JHU/APL).  
Vesta and Mars images: HST (NASA/STScI).*



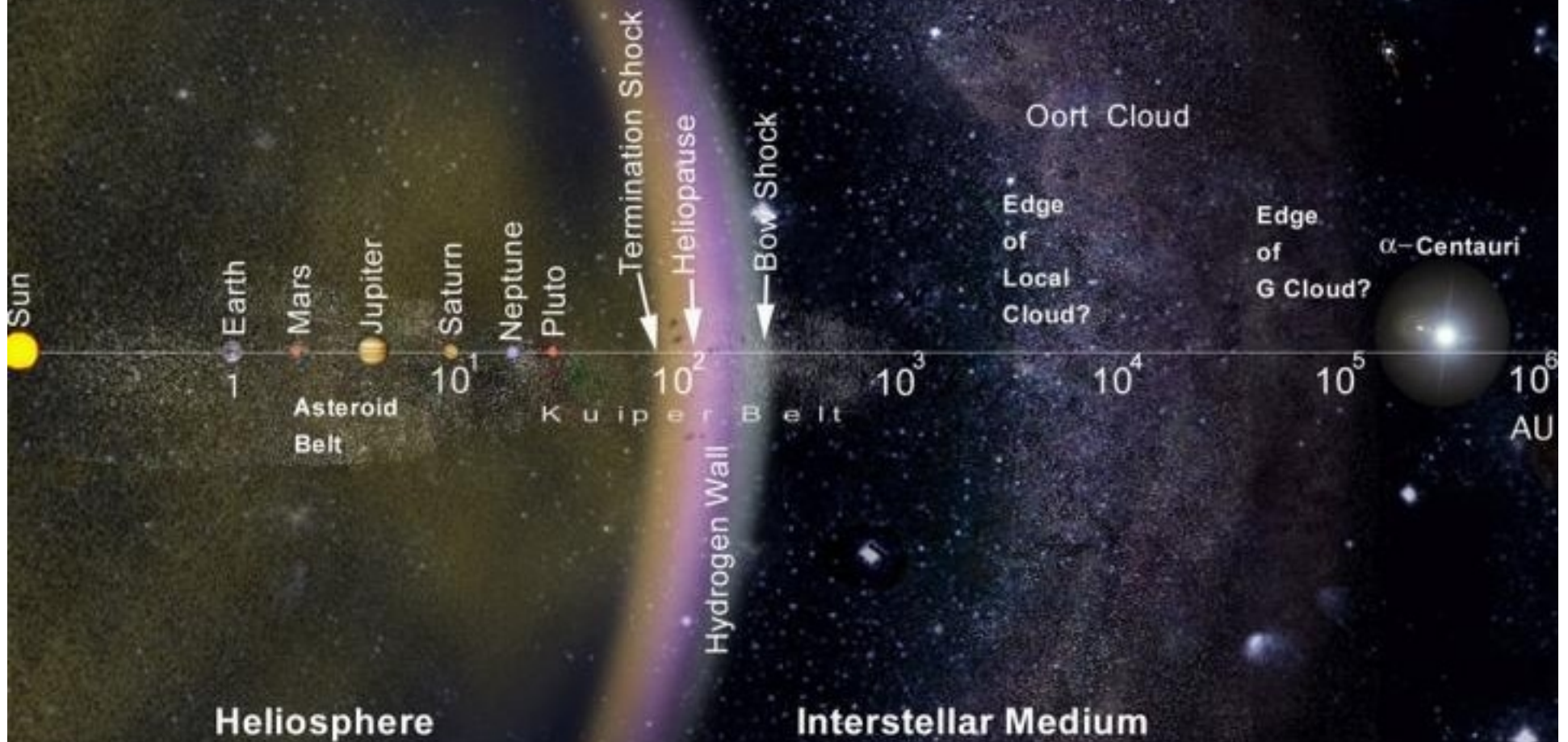
There isn't as much ethane in Titan's atmosphere as expected. Could Methanogens be eating it?

Or could a strange non-biological process be at work?

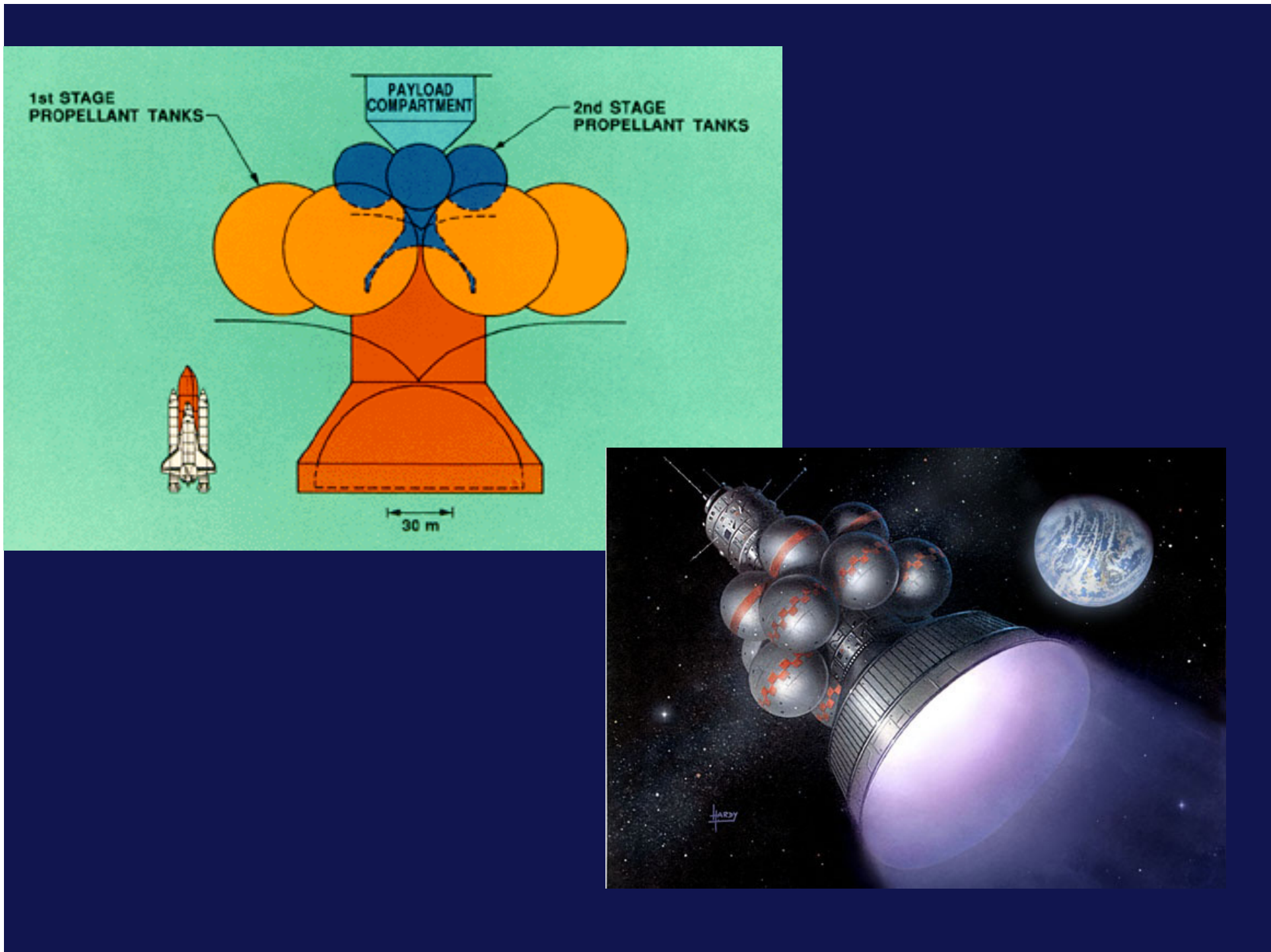




# Interstellar Distances - In Perspective



Source: R. Mewaldt & P. Liewer, JPL

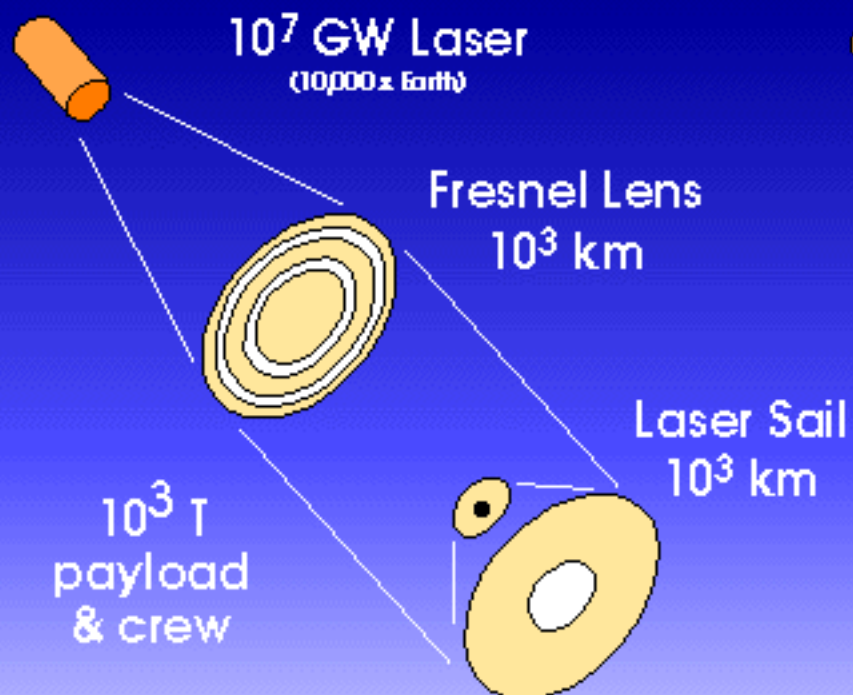


# Beamed Propulsion Concepts

## Laser Light Sail

1984...

R. Forward, et al

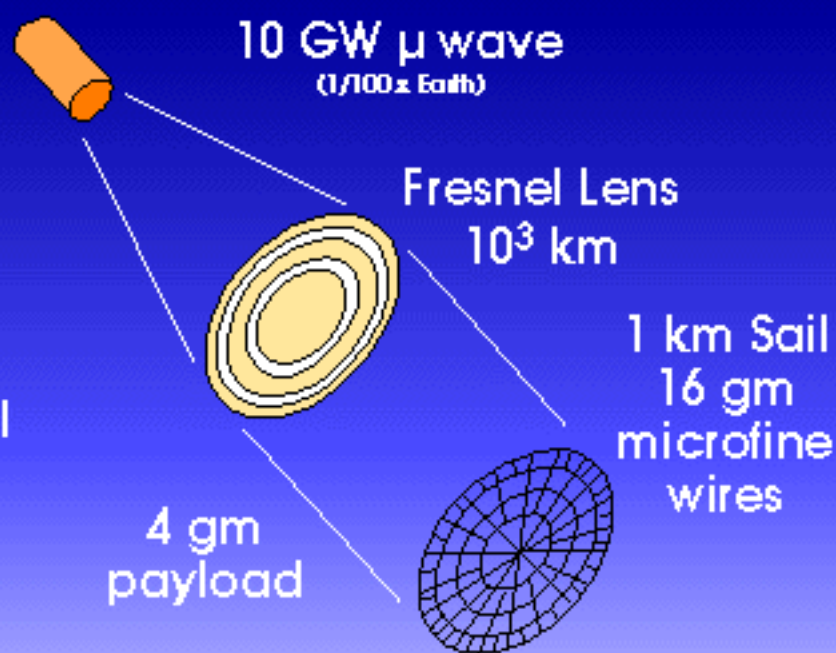


**10 YEARS one way**

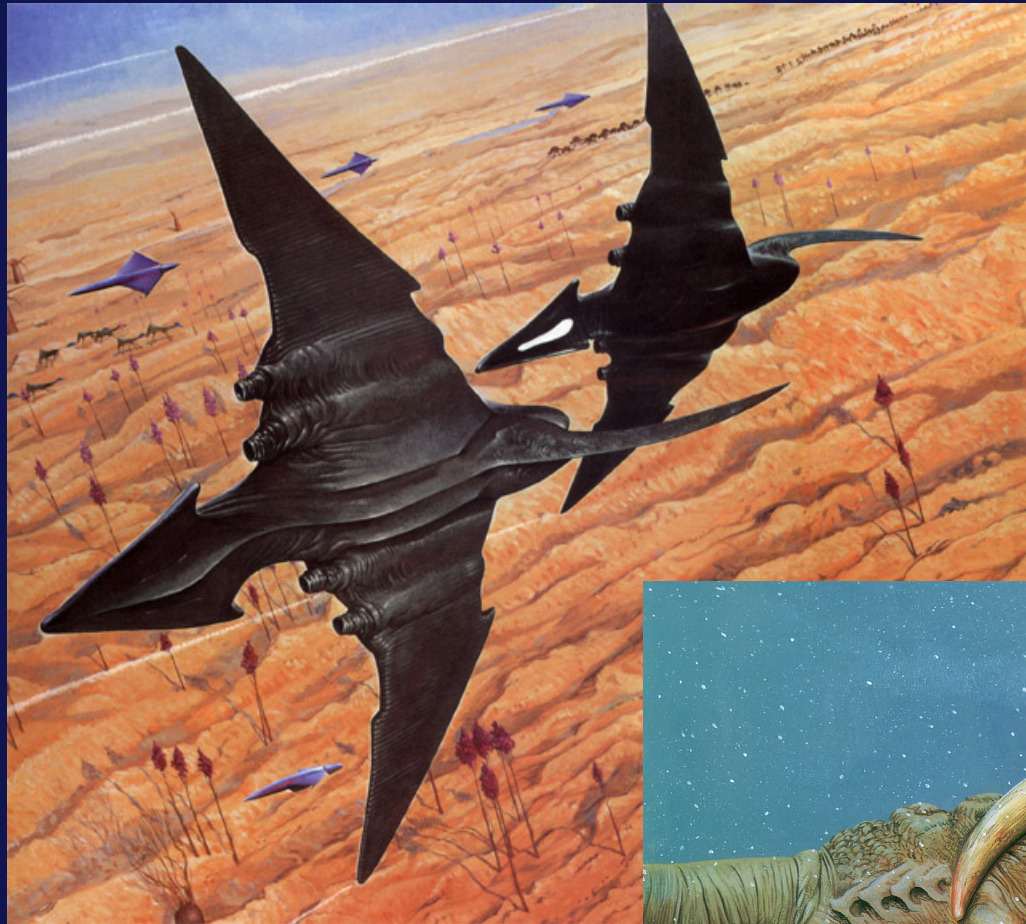
## Star Warp

1985

R. Forward



**20 YEARS one way**





































































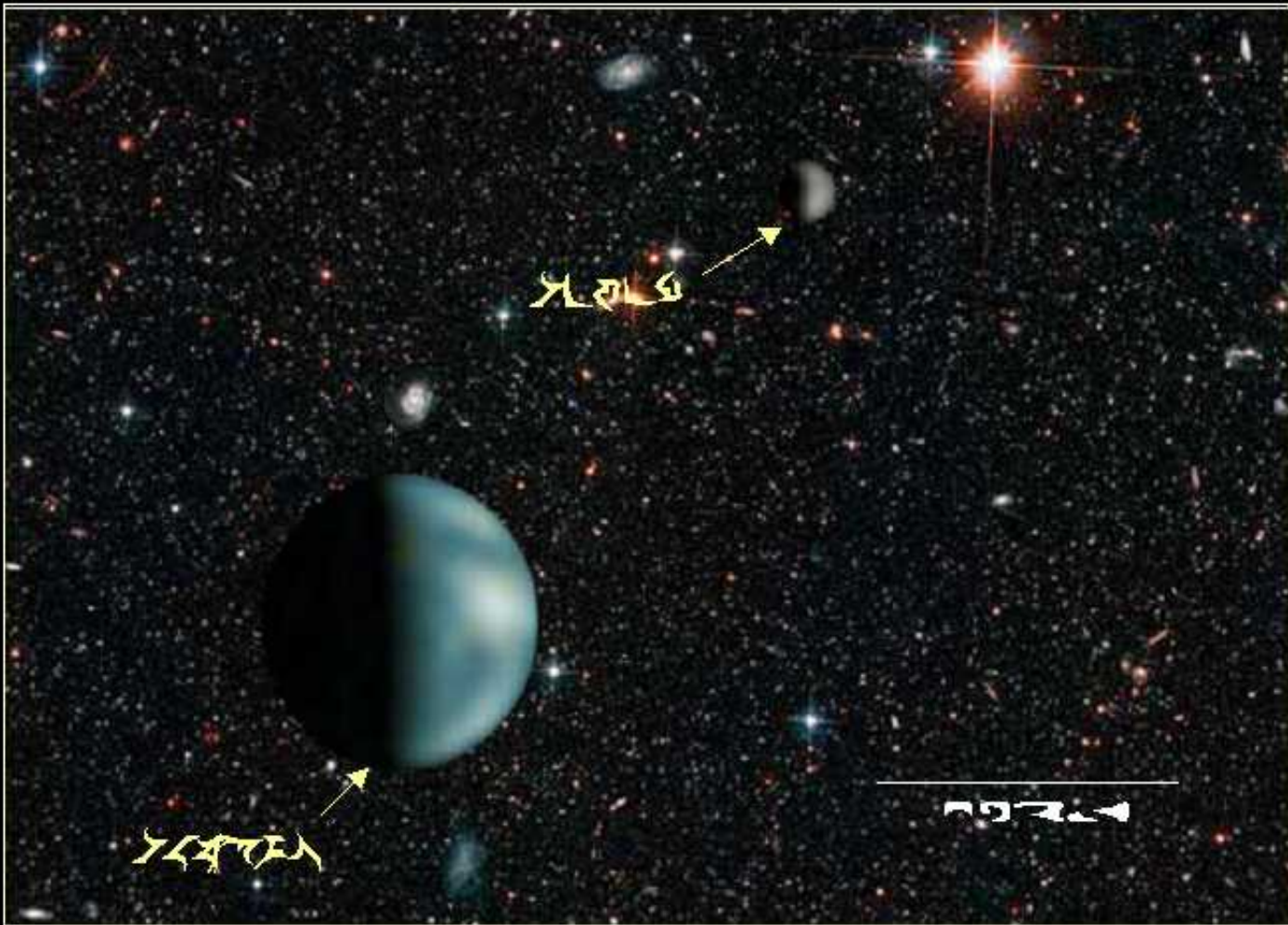




**EPSILON  
ERIDANI**

**TAU CETI**

**Project  
Ozma  
began  
searching  
in 1960**

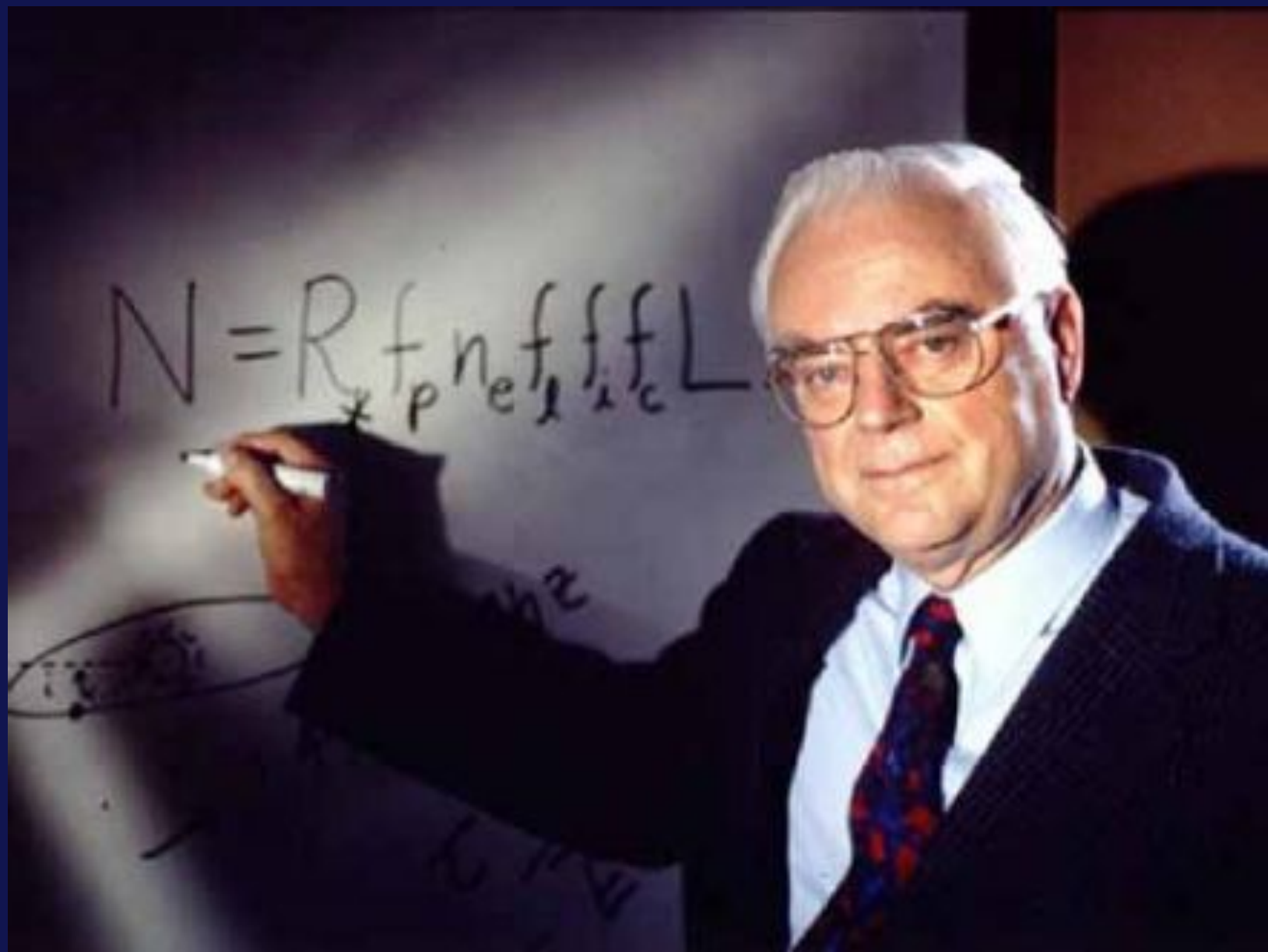


שבתאי  
 הירח



אנו מודים לך על שיתוף הפעולה והתמיכה במיזם זה.





## DRAKE EQUATION

$$N = R \times f_s \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

- R average rate of star formation
- $f_s$  fraction of good stars that have planetary systems
- $n_e$  number of planets around these stars within an “ecoshell”
- $f_l$  fraction of those planets where life develops
- $f_i$  fraction of living species that develop intelligence
- $f_c$  fraction of intelligent species with communications technology
- L lifetime of the “communicative phase”

## *THE OBSERVABLE DRAKE EQUATION*

$$*ETL = N_p \times F_{TP} \times FP_w \times FP_L*$$

*ETL = Planets with extraterrestrial life in the Galaxy*

*N<sub>p</sub> = Number of exoplanets*

*F<sub>tp</sub> = Fraction of terrestrial planets*

*FP<sub>w</sub> = Fraction of terrestrial planets with water*

*FPL = Fraction of terrestrial planets with carbon-based life*

# October 1, 1993



***Nevada  
Senator  
Richard  
Bryan (D)***

*saying "The great Martian chase has finally come to an end. As of today, millions have been spent and we have yet to bag a single little green fellow. Not a single Martian has said 'take me to your leader', and not a single flying saucer has applied for FAA approval. It may be funny to some, except the punchline includes a \$12.3 million price tag to the taxpayer."*

# Project Phoenix: 1994 - 2004

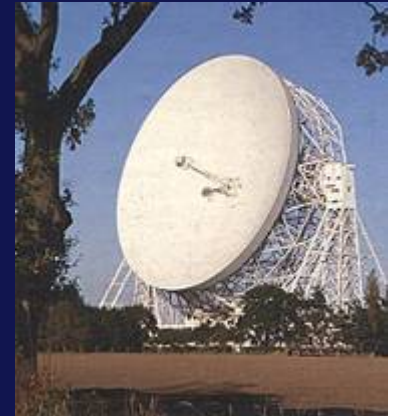
Mopra



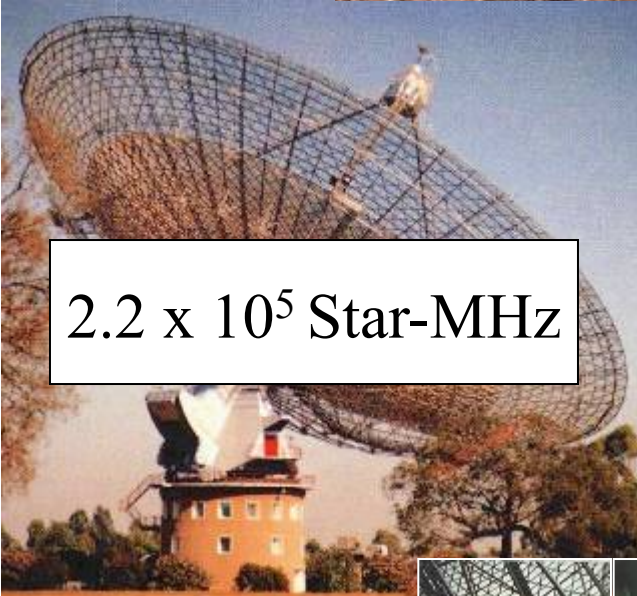
Woodbury



Lovell



Parkes



140 Ft.



Arecibo



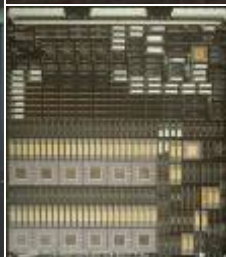
$2.2 \times 10^5$  Star-MHz

$2.9 \times 10^5$  Star-MHz

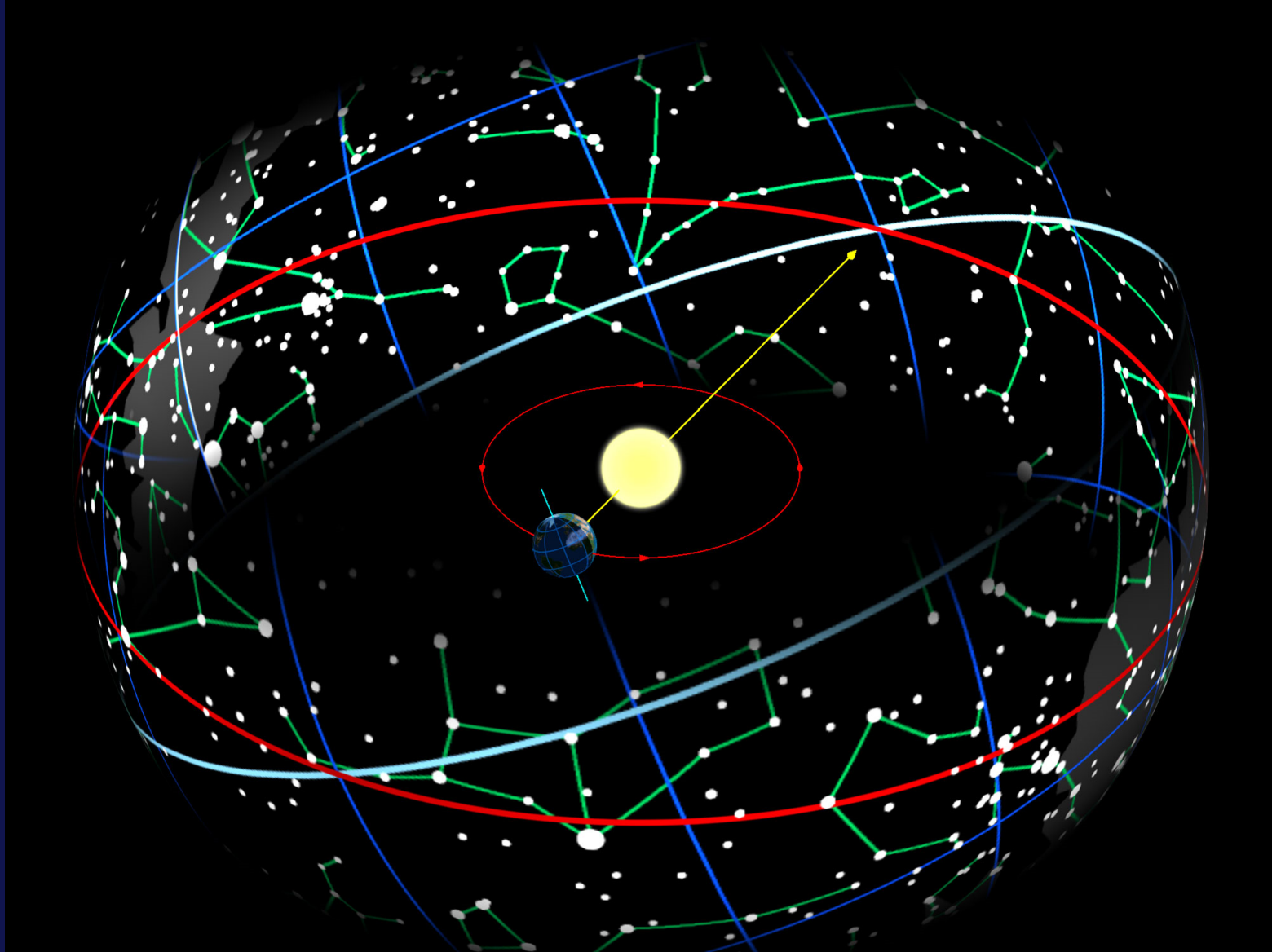
$4.8 \times 10^5$  Star-MHz

NSS: PCs  
+ accelerators

NASA-derived  
TSS: full custom



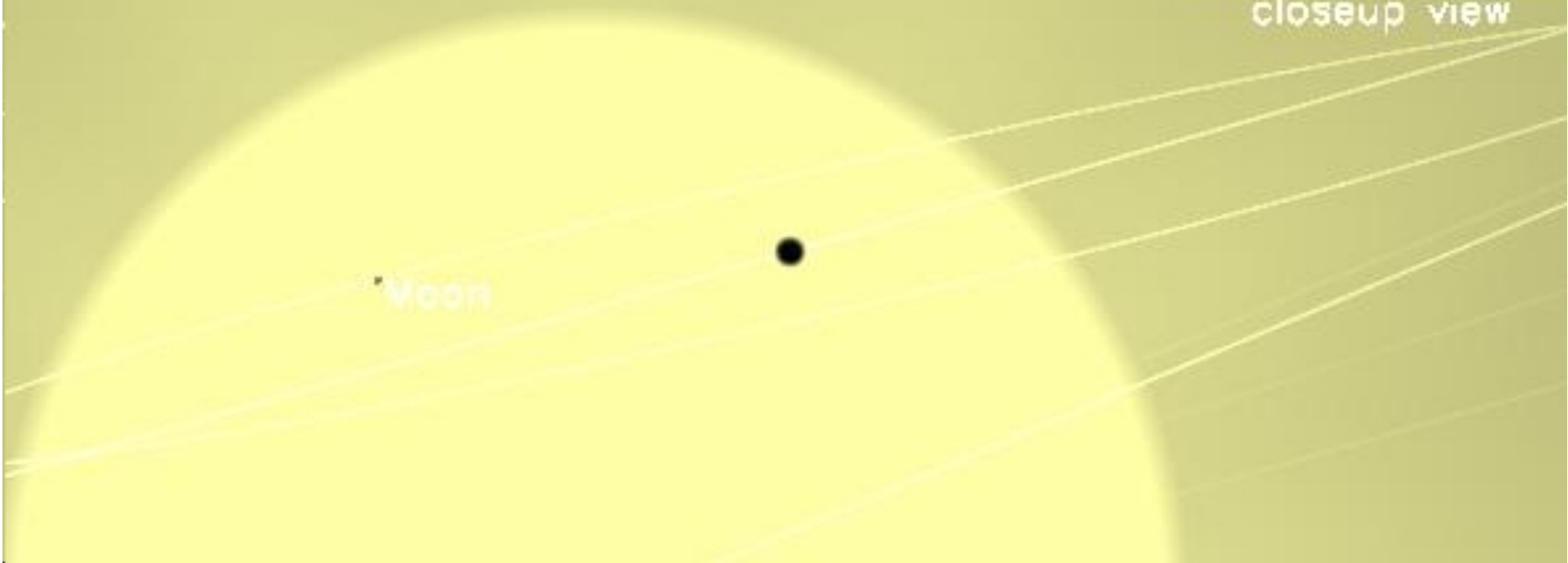




The Earth as seen from Mars  
10 Nov 2084 09:00 GMT  
30.00 min field of view



closeup view





# Tomorrow: Low Frequency SETI Eavesdropping on ET TV

## LOFAR

*First LOFAR station*



*Dense core site  
for six stations*



# Expand The Galactic Exploration

OSETI

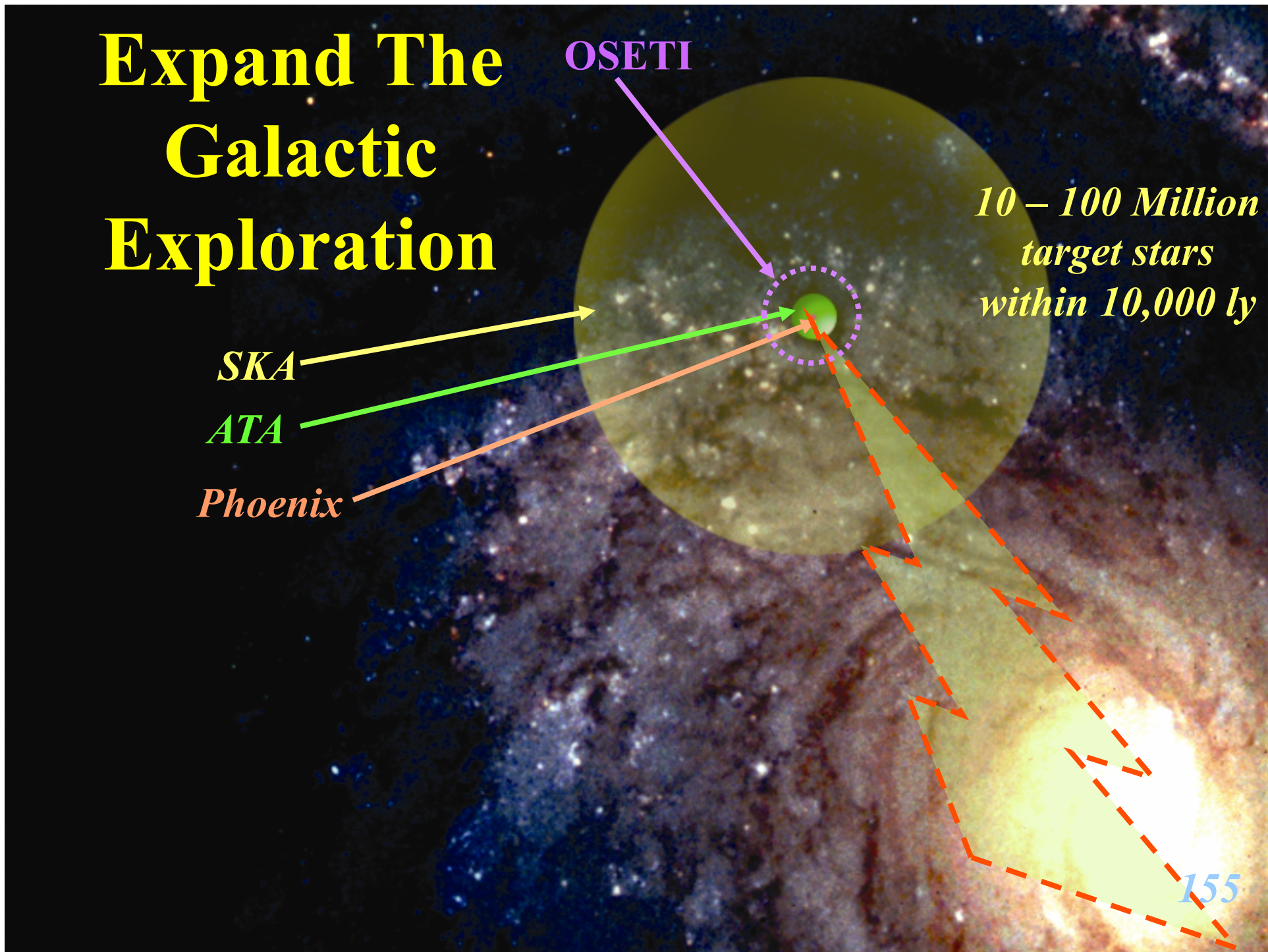
*10 – 100 Million target stars within 10,000 ly*

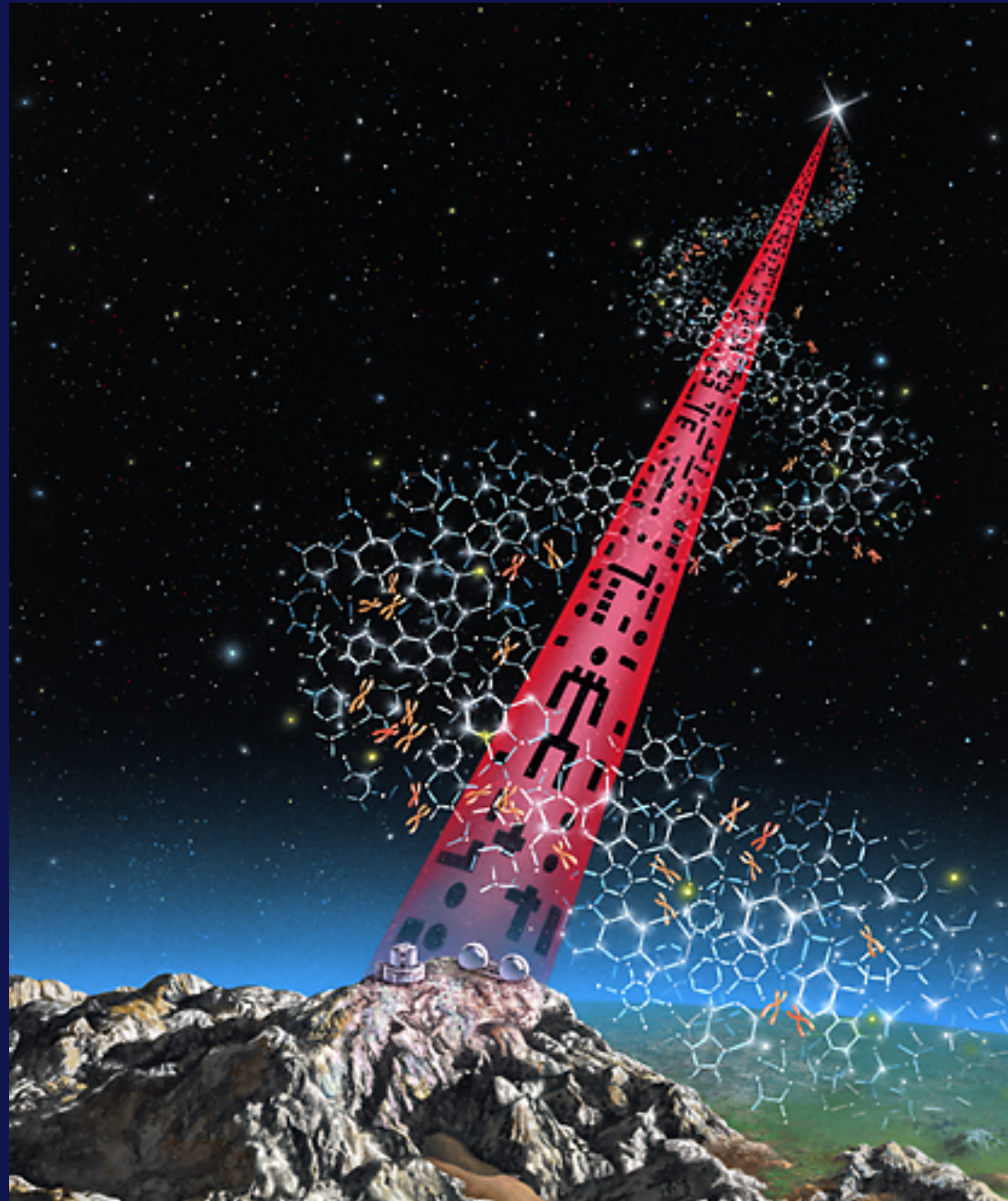
*SKA*

*ATA*

*Phoenix*

155

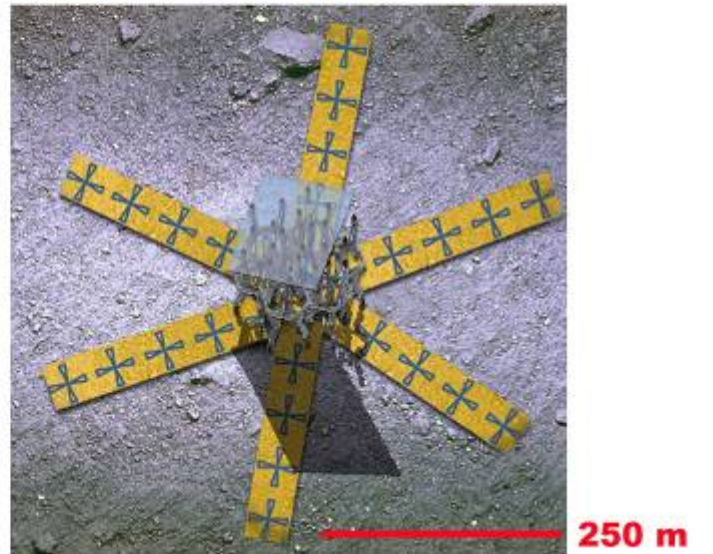
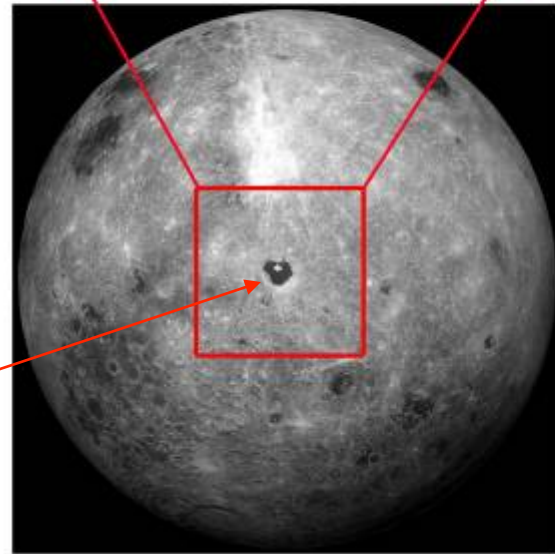
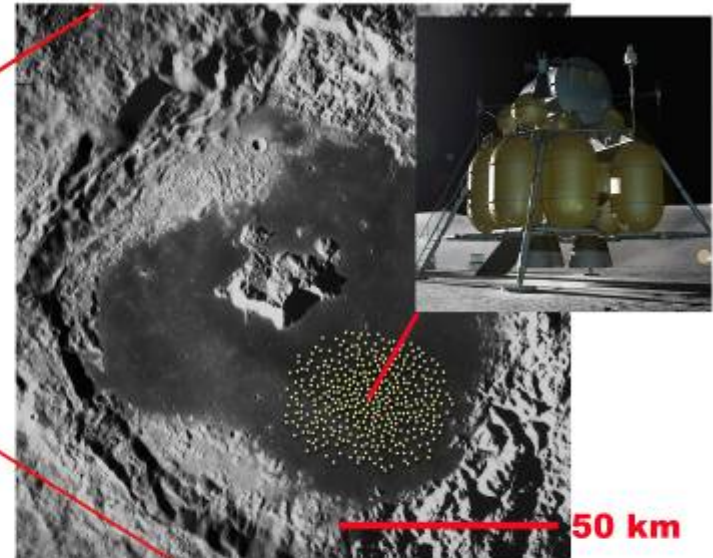
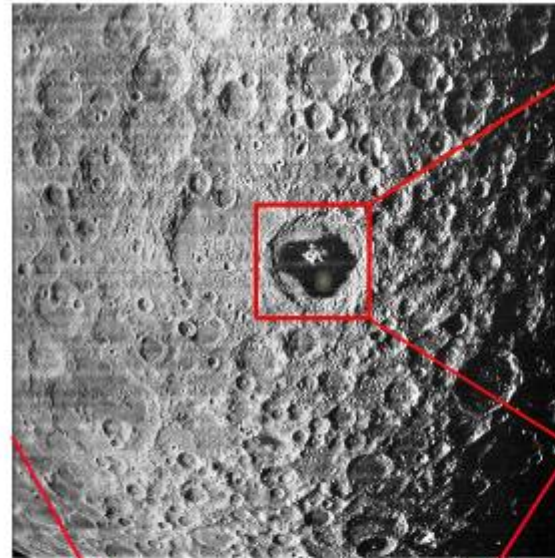




# Dark Ages Lunar Interferometer

*No ionosphere*

*10-100 MHz*



*Tsiolkovsky  
Crater*

# Should We Broadcast?

Who Should Speak For Earth?

What Should They Say?

*Transmission requires:*

*Long term commitment*

*Global cooperation and coordination*

*Smile :) Humans are naive and fragile. We are not evolved to understand everything. We are children in a vast and mysterious universe.*

*Tommy  
Adelaide, Australia*

*Hey I'm Katelyn. I just want to know what's with all the abductions? If you need a volunteer, please take my brothers! Take your pick. I thank you in advance. x*

*Katelyn Tepper  
Horsham, Australia*

*We come in peace. If you are out there, please respond. We want to be friends. We are all different and we can't wait to meet you! From the children of Earth.*

*Class4M  
Castle Cove Public School, Australia*

*All our petty disputes, disagreements and wars fade into insignificance when we consider our tiny world's place in the cosmos.*

*Silvio Zarb  
Melbourne, Australia*

*What do you see when you look up into the sky? Do you feel small and lonely, just like us? From now on, I can assure you one thing: you are not alone. Be happy.*

*Sergio Camalich  
Hemrosillo, Mexico*

*What I've learnt: believe in yourself, believe in others, keep confidences, that family matters, you get what you give, dare to dream and don't forget to laugh.*

*Patty  
Melbourne, Australia*

*We are but children with so much still to learn; troubled by fears and nightmares but also elated by our hopes and dreams. We hope one day to be friends.*

*Wilson da Silva  
Sydney, Australia*

*If you come to Earth look into: music, the beach, ice cream, hugs, family, love, dancing, cheese, trampolines, friendship, books and dreams. Just for a start.*

*Tamasin  
Richmond, Australia*

*Hi there: Sorry about "The Outer Limits"; hope you enjoyed "I Love Lucy". Have you got all our missing socks? Love, Earth*

*Fred Mason  
Roberts Creek, Australia*

*"These are not the droids you're looking for."*

*Don  
Denton, TX, United States*

*"We are all lying in the gutter, but some of us are looking at the stars..." - Oscar Wilde*

*Jeff N  
Sydney, Australia*

*Hope you receive this message as it could mean the start of something magnificent. With awe and respect from Earth.*

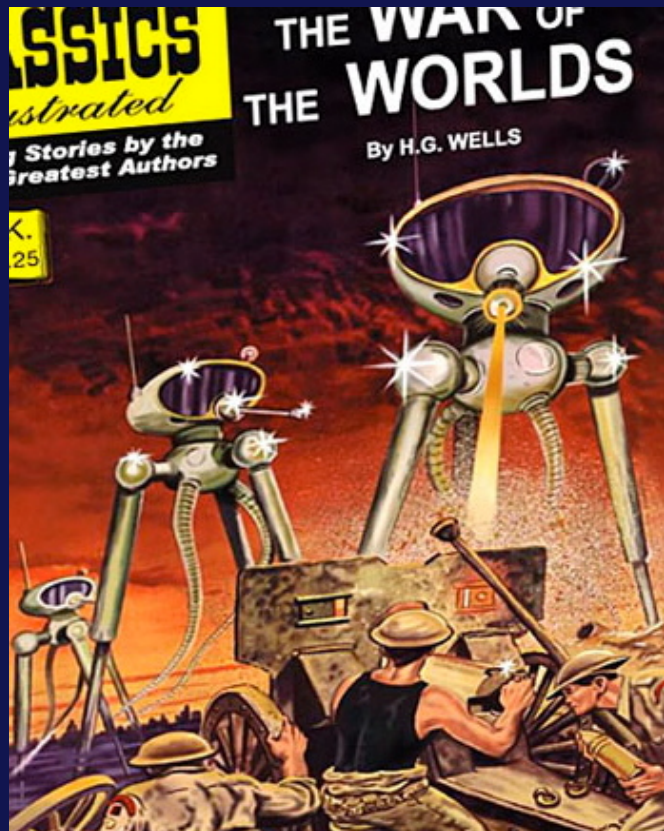
*Theresa  
Canberra, ACT, Australia*

*You are cordially invited to an Interplanetary BBQ. 6.00pm, 4th October, 2452 at my place BYO Meat and Beer. RSVP: Year 2100 Cheers*

*Daniel Edmonds  
Melbourne, Australia*

*Hi from Patrick & Emily of Earth. We all wonder if there's life elsewhere in the Universe. But one thing is certain - We're never alone when we have each other.*

*Patrick  
Sydney, Australia*



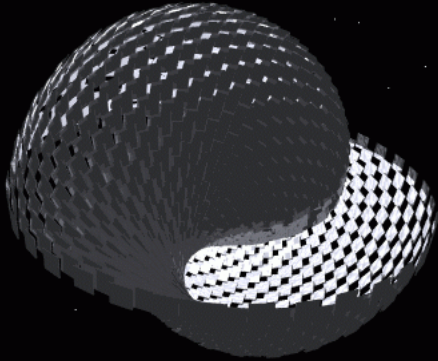






©2000 Barahal [www.bigalienents.com](http://www.bigalienents.com)

# Dyson Sphere

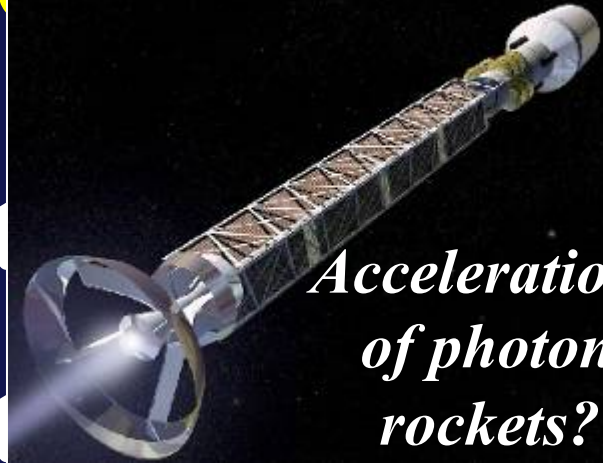


# Asteroid mining



Ida & Dactyl

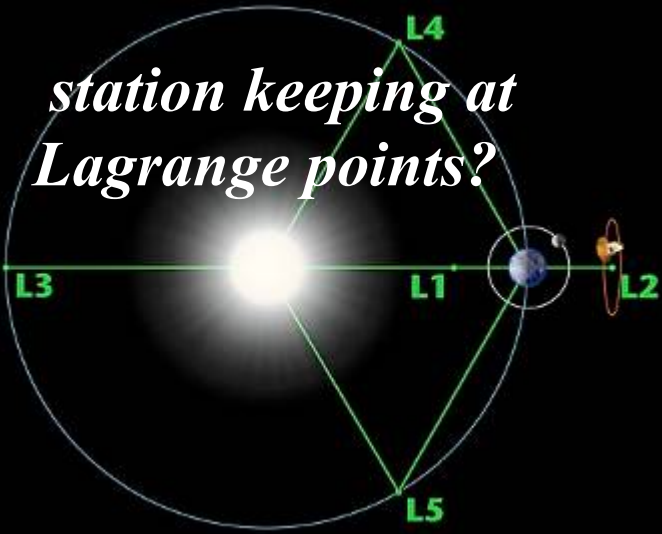
# Gamma-ray Bursts



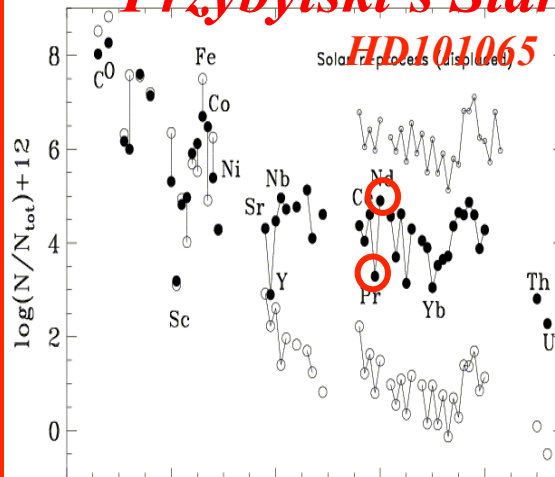
Accelerations of photon rockets?

- Magic?

station keeping at Lagrange points?



# Przybylski's Star

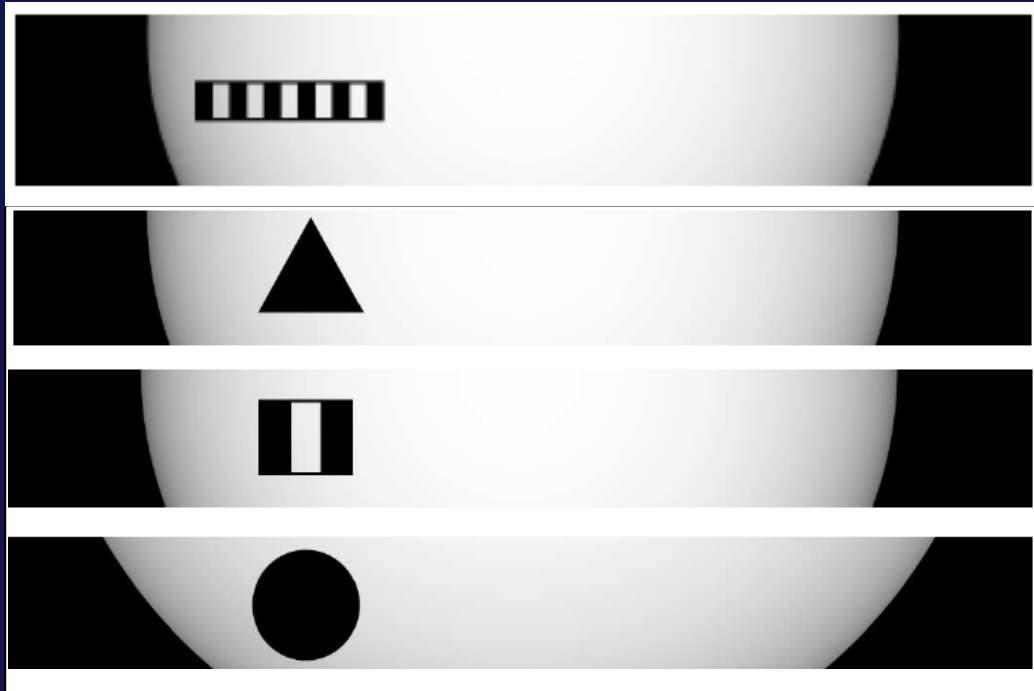


Fissile waste dump?

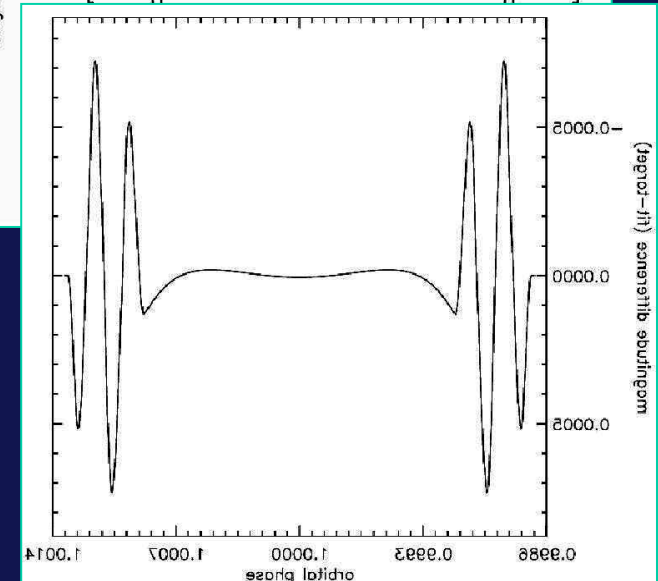
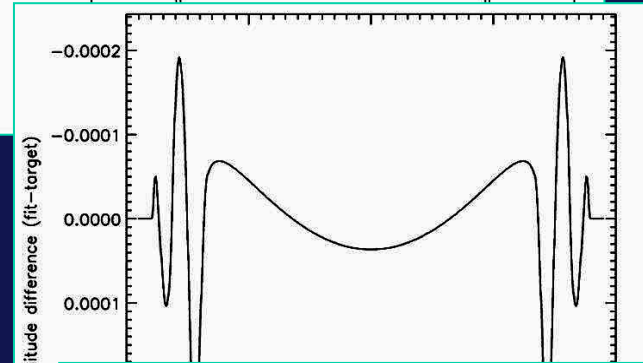
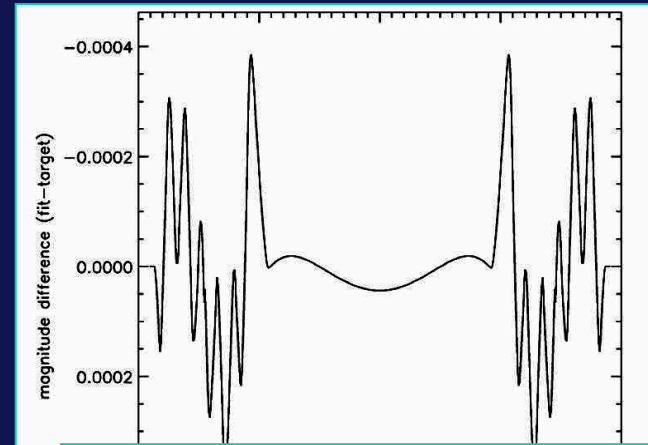
Tritium Line @ 1512 MHz (21 cm analog) Not near SNR

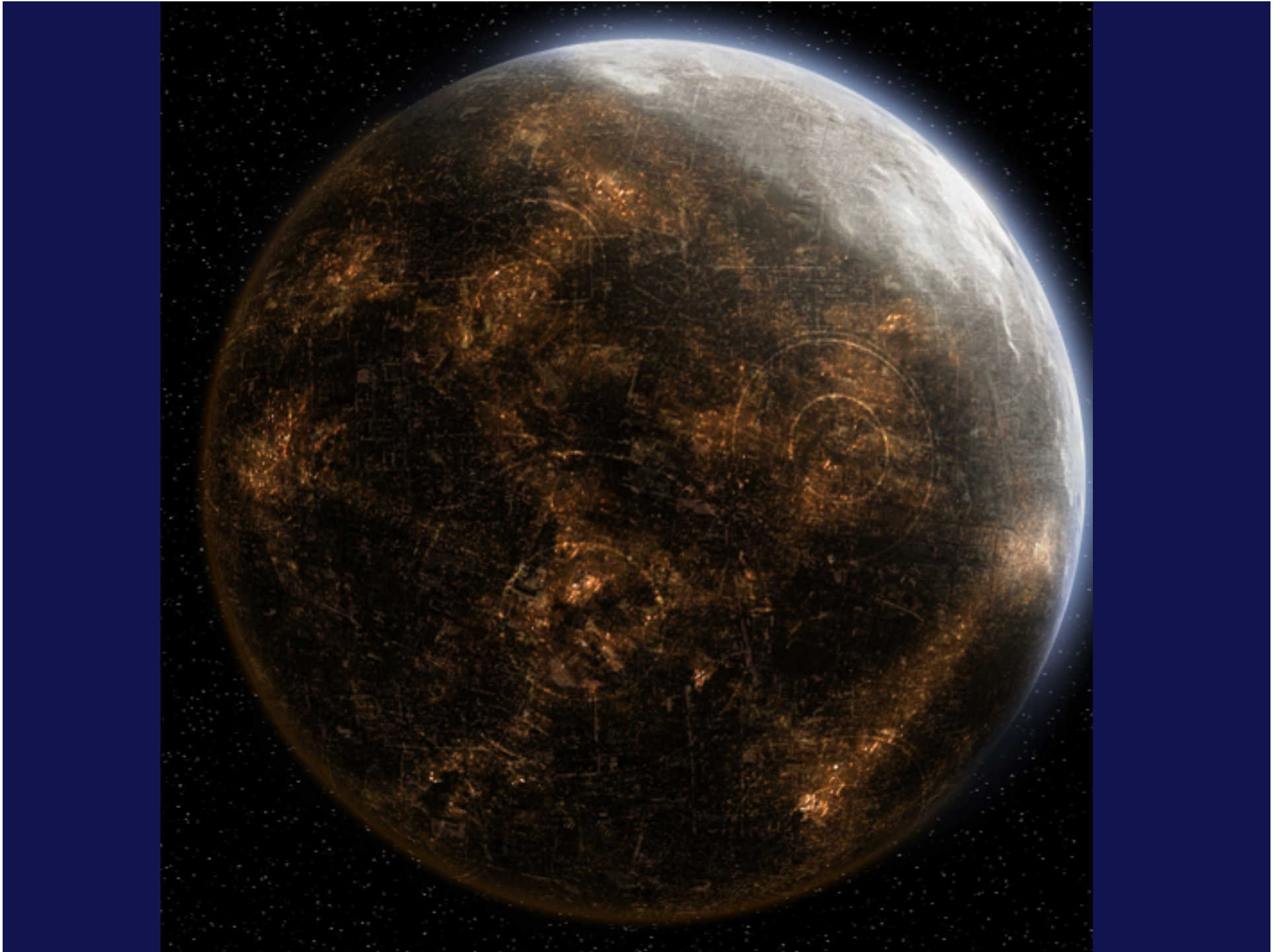
Leakage from fusion plant?

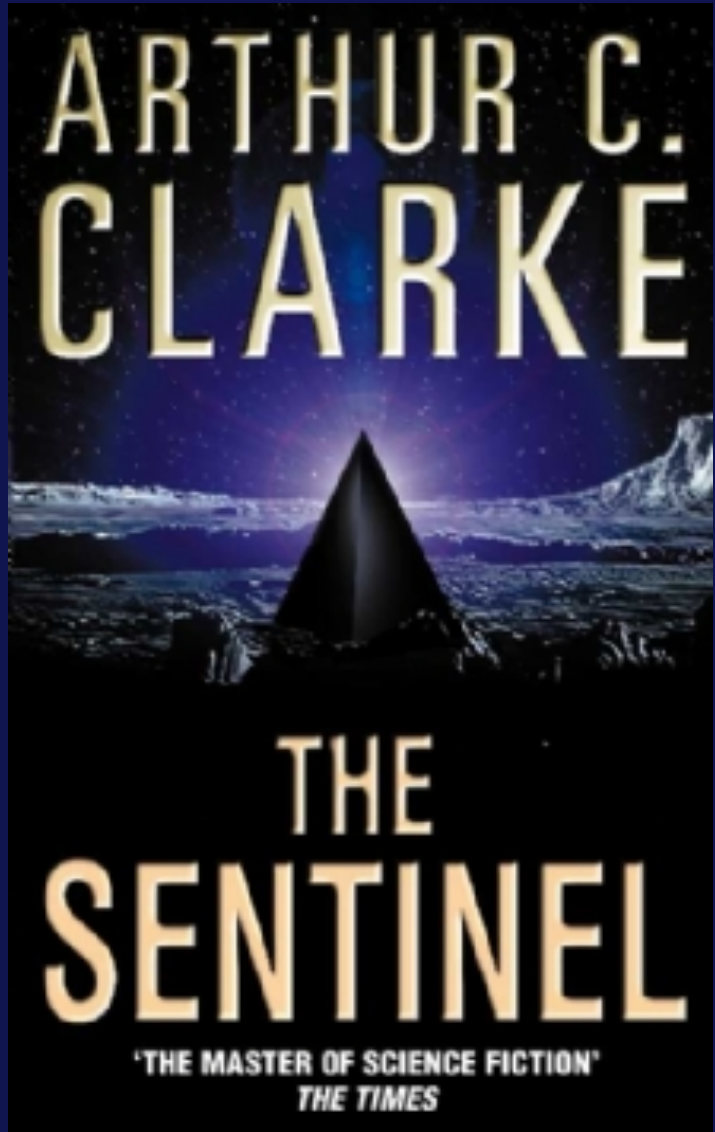




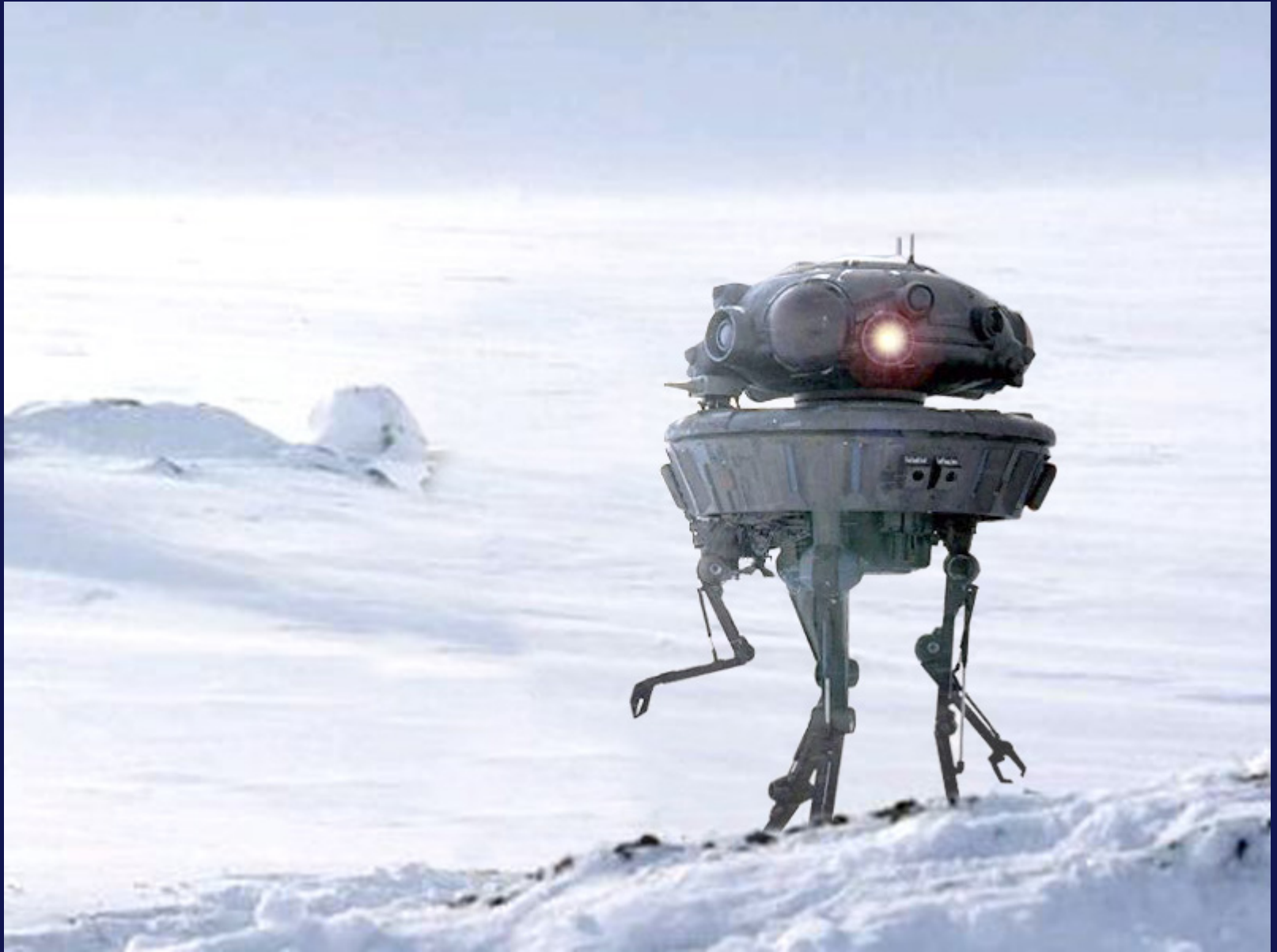
*L.F. A. Arnold (2005)*





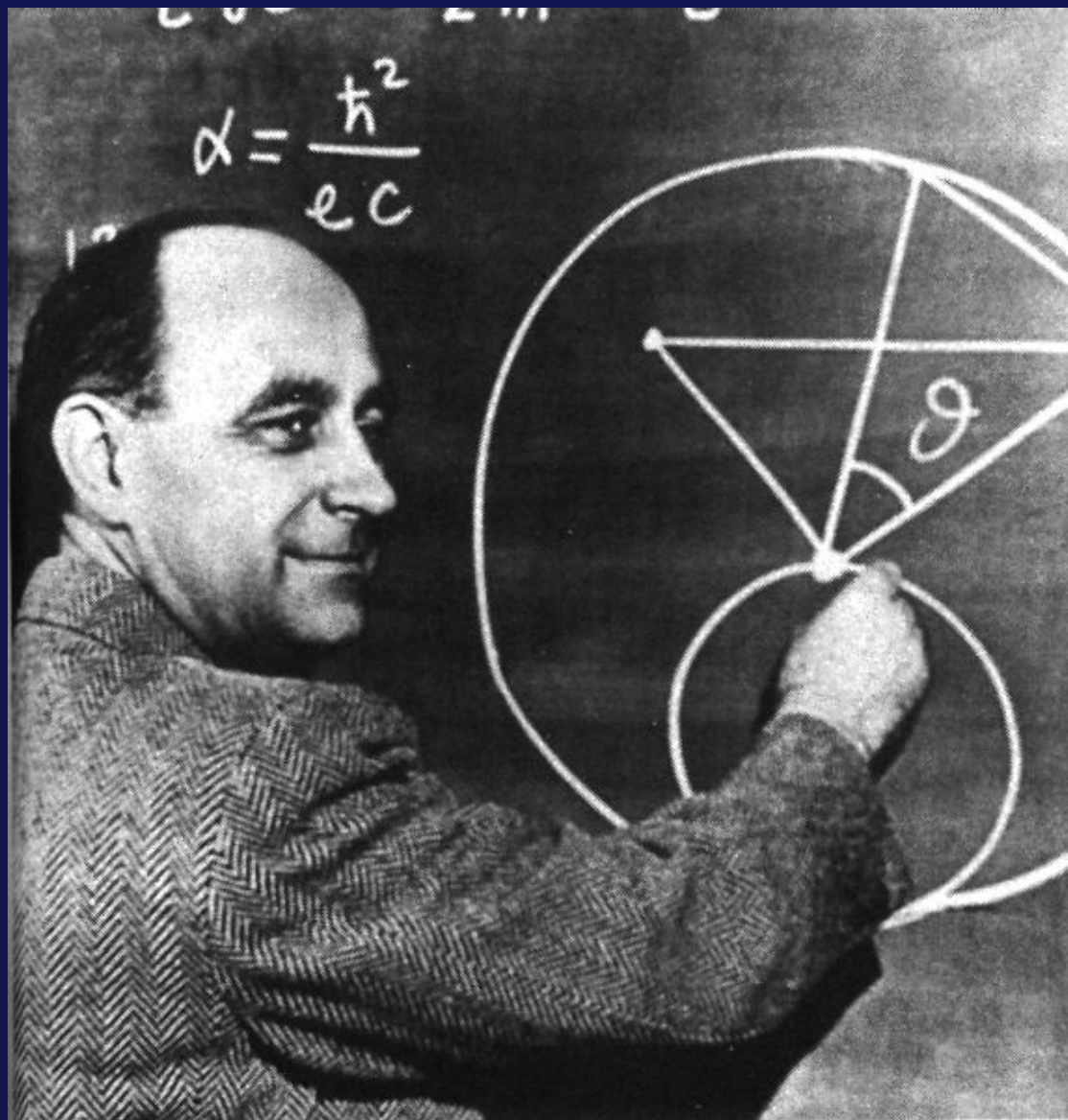








# Enrico Fermi 1950



# FERMI PARADOX

*if the rise of advanced civilizations and space colonization are at all likely, aliens should have been to Earth by now.*

*Yet there is no sign of them.*

*Does this imply that aliens do not exist or that space colonization may be undesirable?*

*Maybe There's nothing paradoxical about it.  
It's just ignorance.*

# FERMI'S RATIONALIZATION

*Our descendants will travel out to the nearby stars.*

*Colonies planted around these stars would be expected soon to expand further in a wave, spreading through the entire galaxy in less than a hundred million years*

*Other intelligent civilizations must have gotten a head start on us and should long since have filled the galaxy.*

**Where Are They ??**

# Where Are They ??

- Zoo Hypothesis – they stay away from us

# Where Are They ??

- Zoo Hypothesis – they stay away from us
- Ant Farm Hypothesis – they are too advanced to be interested in us.

# Where Are They ??

- Zoo Hypothesis – they stay away from us
- Ant Farm Hypothesis – they are too advanced
- Dr. Strangelove Hypothesis

# Where Are They ??

- Zoo Hypothesis – they stay away from us
- Ant Farm Hypothesis – they are too advanced
- Dr. Strangelove Hypothesis
- AI Hypothesis – Mecca replaces Org



# Where Are They ??

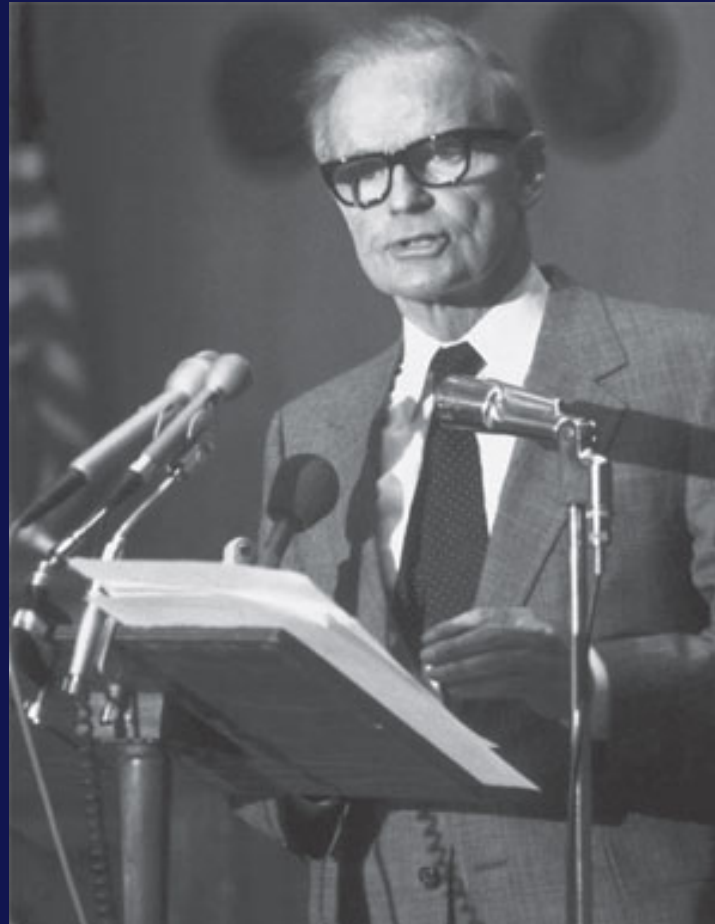
- Zoo Hypothesis – they stay away from us
- Ant Farm Hypothesis – they are too advanced
- Dr. Strangelove Hypothesis
- AI Hypothesis – *Mecca* replaces *Org*
- Space travel too expensive or difficult

# Where Are They ??

- Zoo Hypothesis – they stay away from us
- Ant Farm Hypothesis – they are too advanced
- Dr. Strangelove Hypothesis
- AI Hypothesis – Mecca replaces Org
- Interstellar travel too expensive or difficult
- They lack curiosity

# Where Are They ??

- Proxmire Effect



You're serious then.

They're made out of meat.

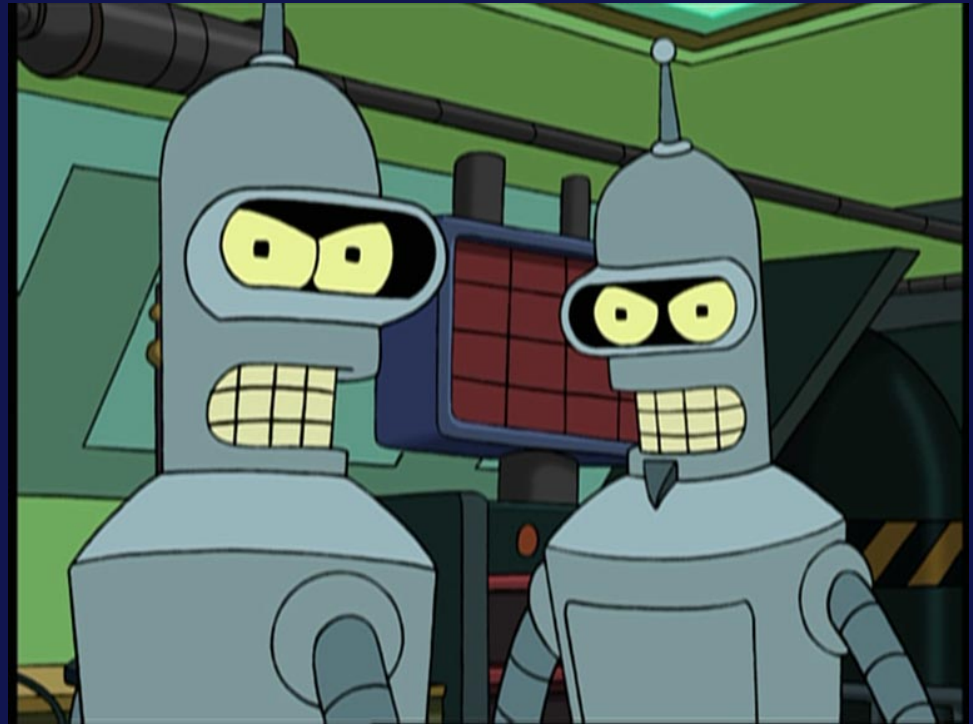
Yes. They are indeed made out meat. And they've been trying to get in touch with us for almost a hundred of their years."

"So what does the meat have in mind."

"First it wants to talk to us. Then I imagine it wants to explore the universe, contact other sentients, swap ideas and information."

."It seems harsh, but there is a limit. Do we really want to make contact with meat?"

"I agree one hundred percent. What's there to say?" `Hello, meat. How's it going?'





# THE RAMIFICATIONS OF CONTACT

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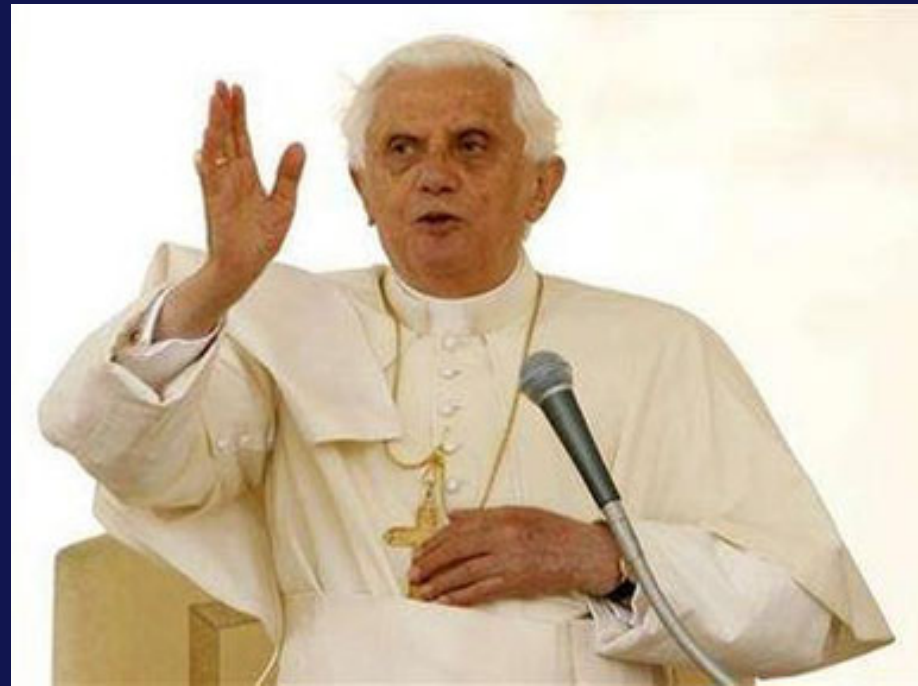
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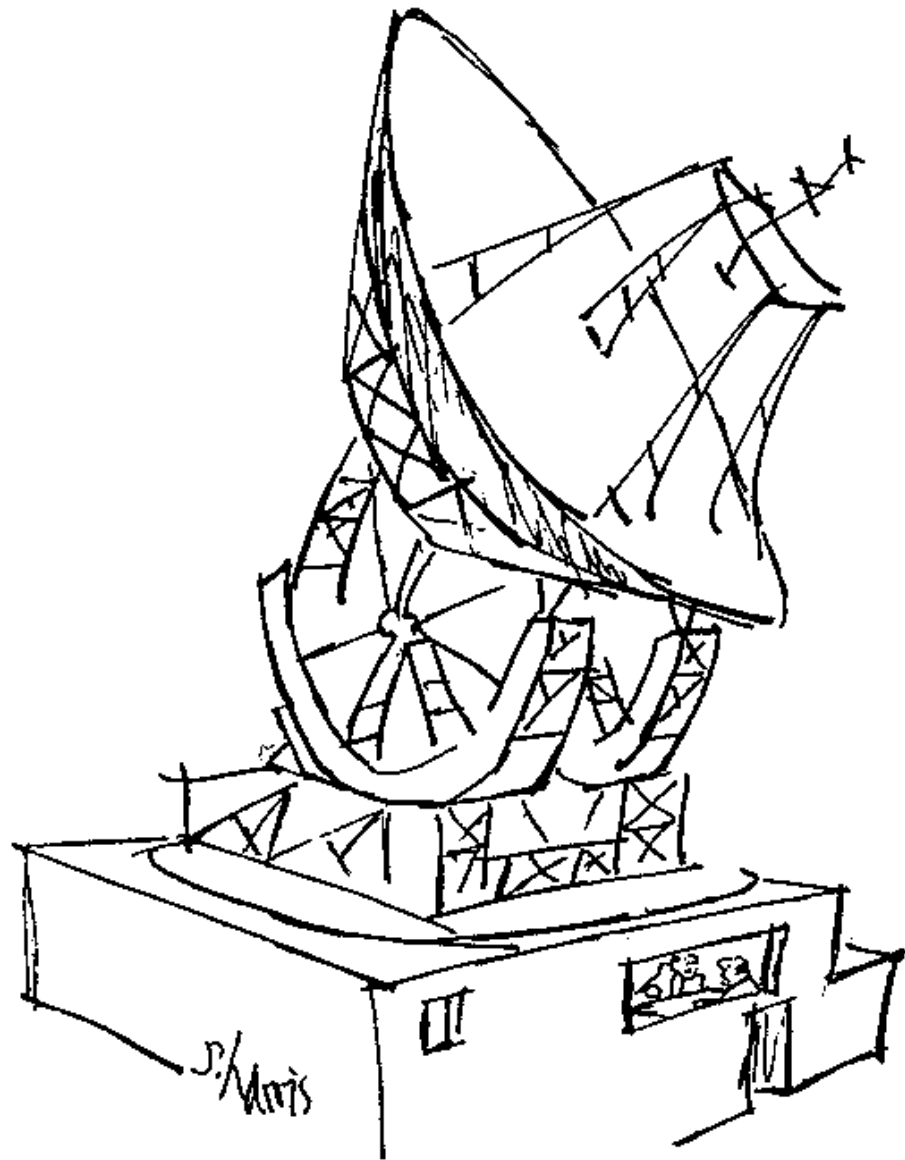
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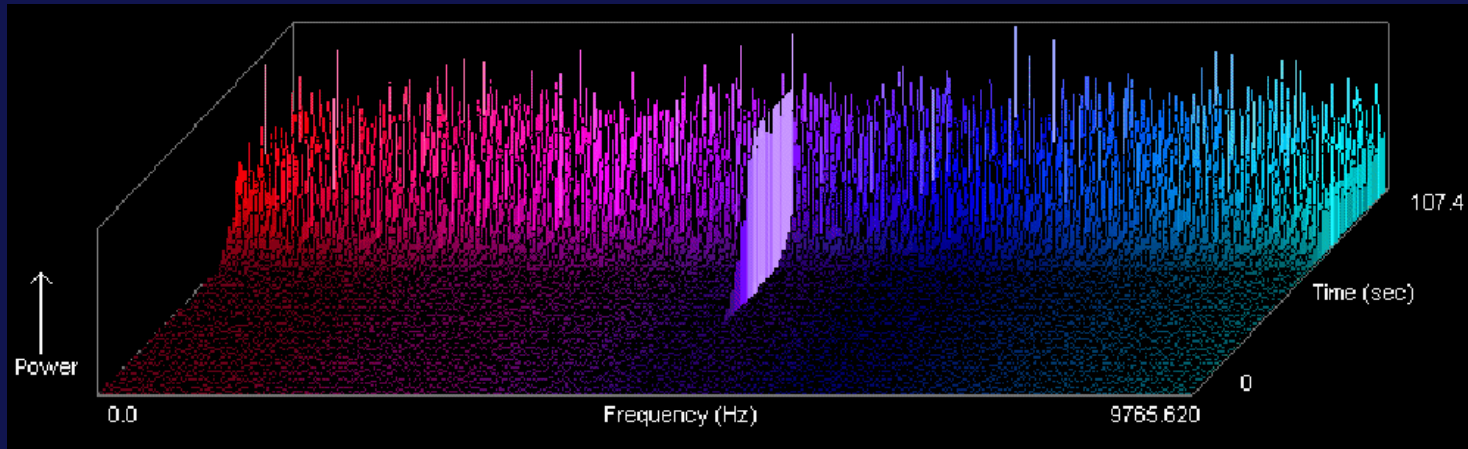
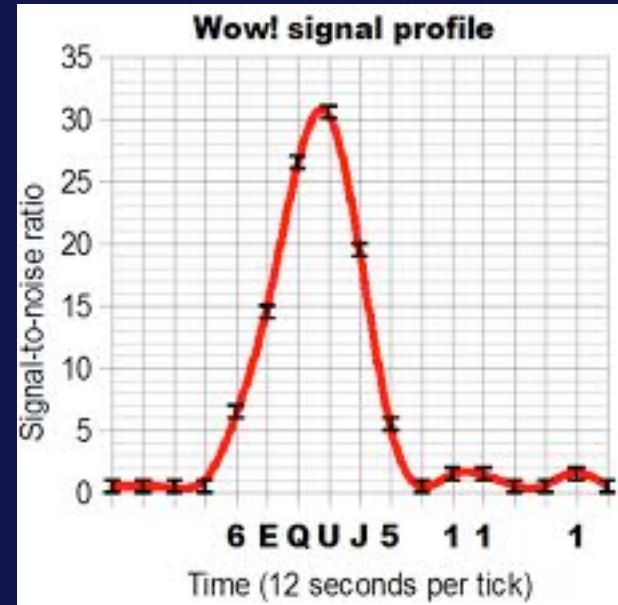
- Historical precedent (Copernicus, Darwin, etc.) suggests a gradual change in world view rather than a dramatic upset in the daily conduct of society.

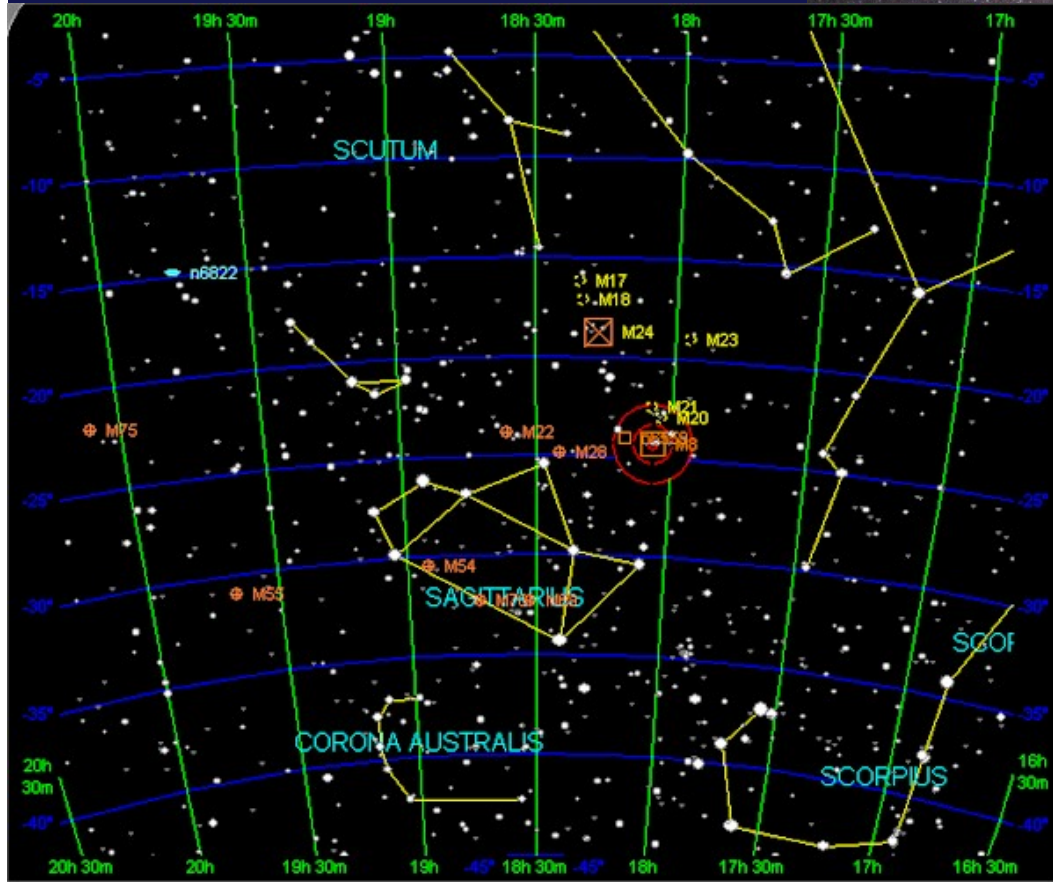


**“As I understand it, they want an immediate answer. Only trouble is, the message was sent out 3 million years ago.”**

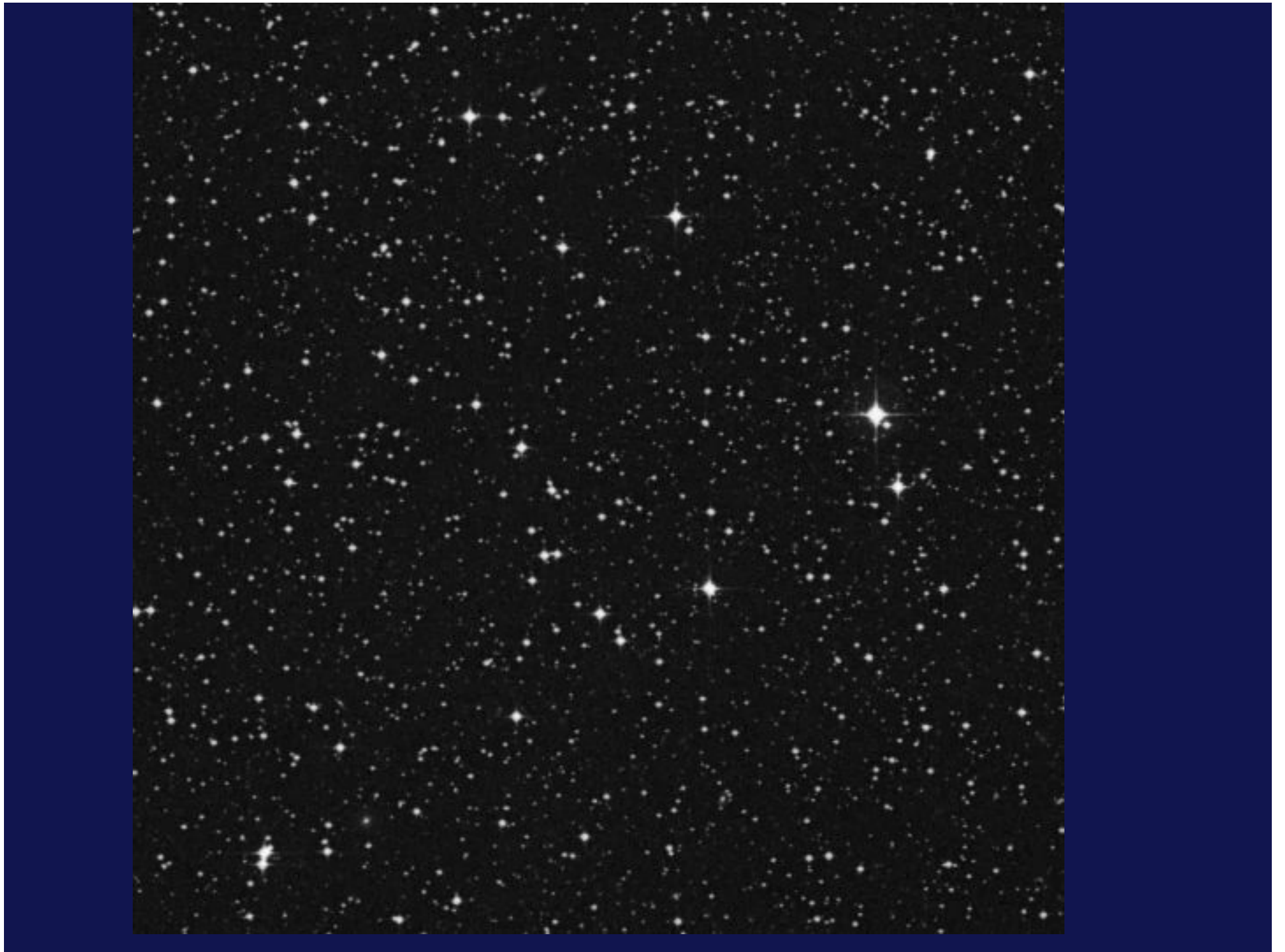
Wow!

1		2		1	4	3
1	16	1		1		1
1	11	1		1		11
	1				3	1
6	2				31	
1E	24	3	12	1	21	1
Q	1	16	1	2	1	1
U	3	1			3	1
2J	1	31	3	11	1	1
5	1				1	1
	14	1		113	2	11
1	3	1		1		11
1	4			1		11
	4	1	1	1	11	111
	1			1		2
1	1	1			11	1
						14









WE'VE SEARCHED DOZENS OF THESE FLOOR TILES FOR SEVERAL COMMON TYPES OF PHEROMONE TRAILS.

IF THERE WERE INTELLIGENT LIFE UP THERE, WE WOULD HAVE SEEN ITS MESSAGES BY NOW.



THE WORLD'S FIRST ANT COLONY TO ACHIEVE SENTIENCE CALLS OFF THE SEARCH FOR US.

















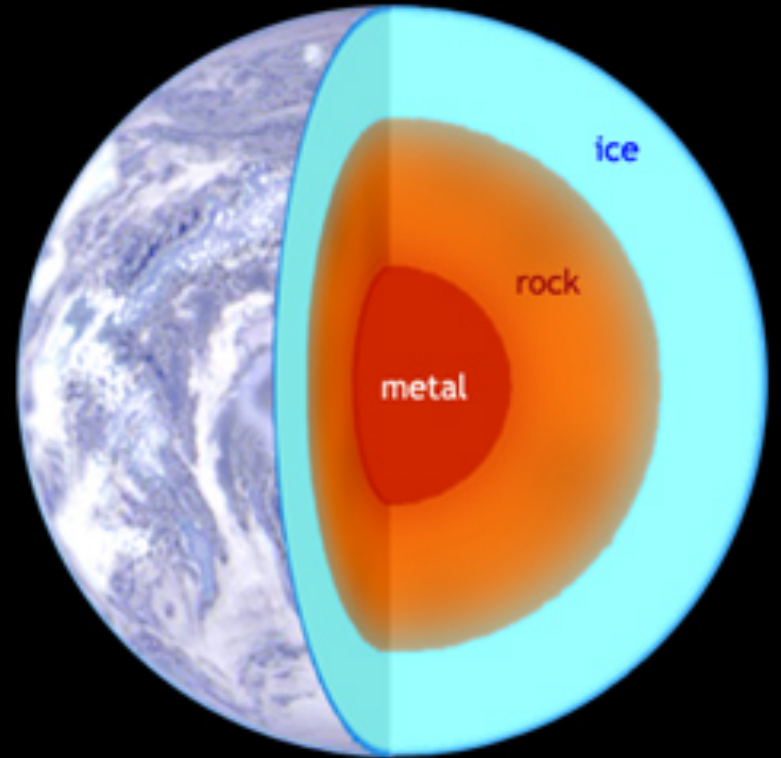
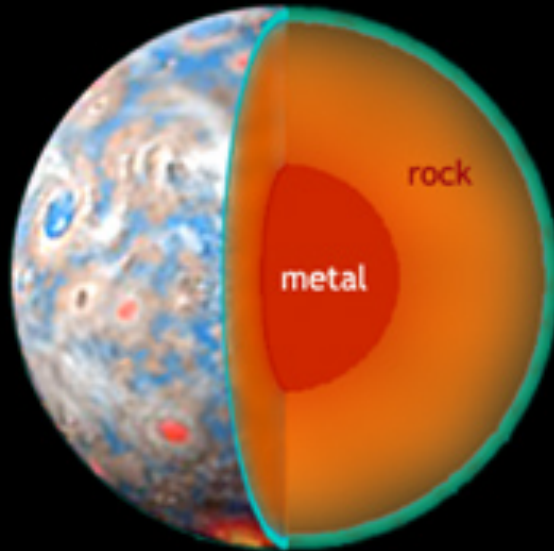
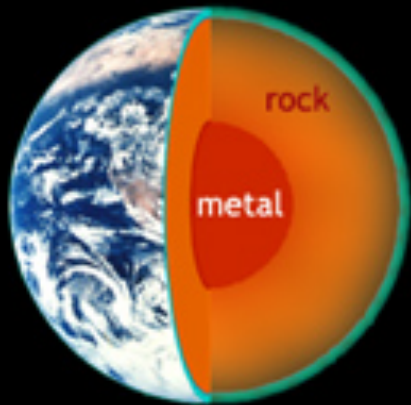


# *Earth Masses*

1

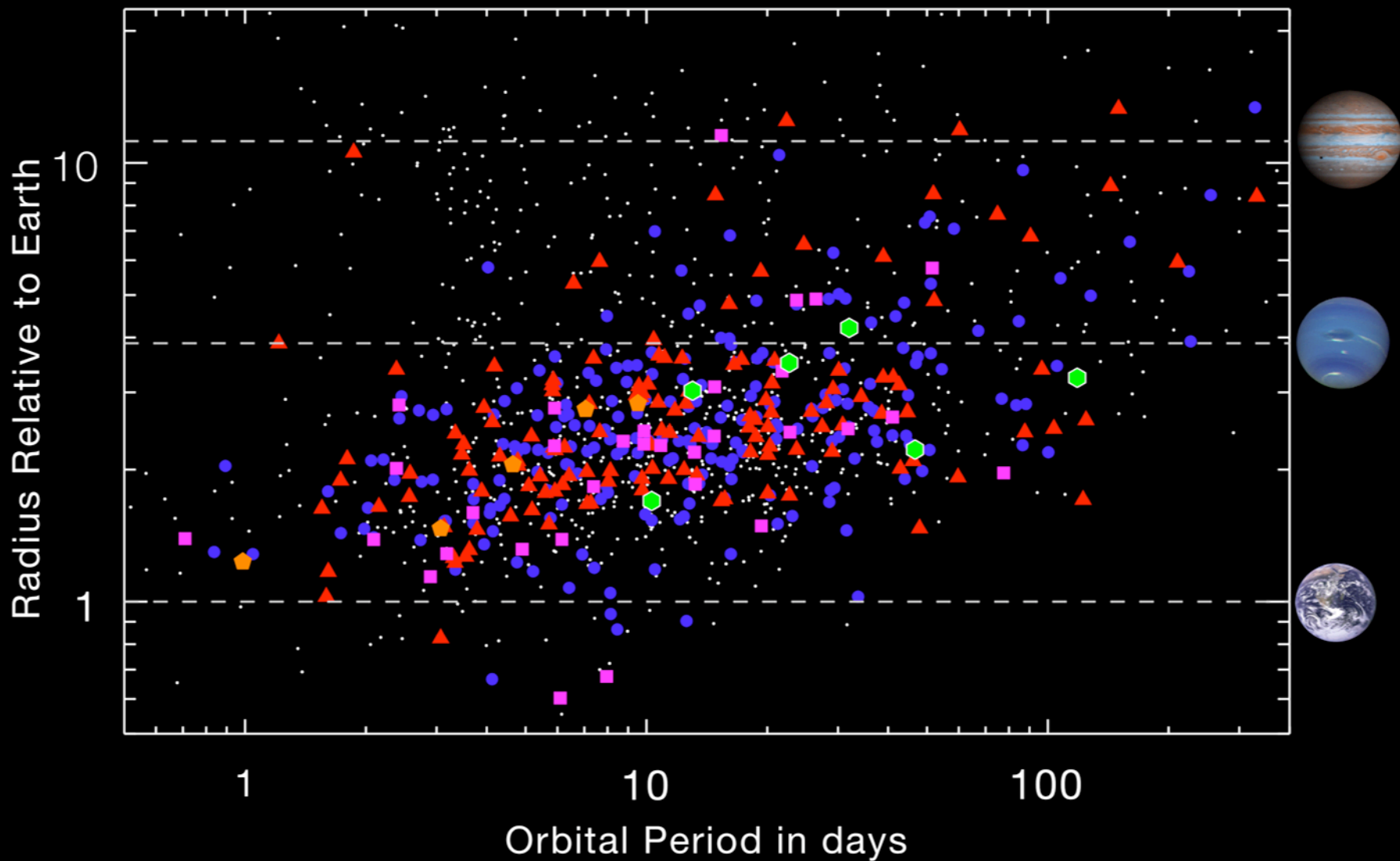
3

6

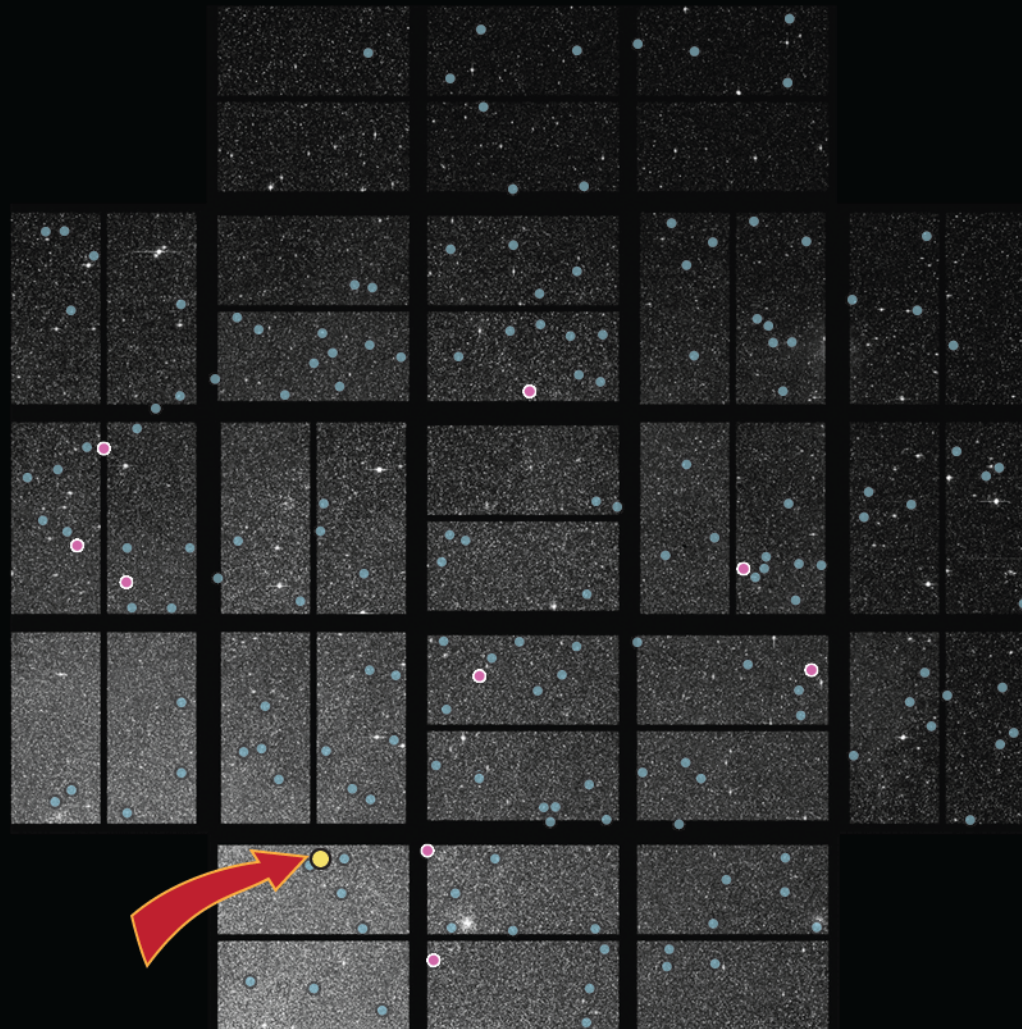


***SUPER-EARTHS***

# Candidate Multi-Planet Systems



# Kepler-11: Six Planets



Jack's presentation

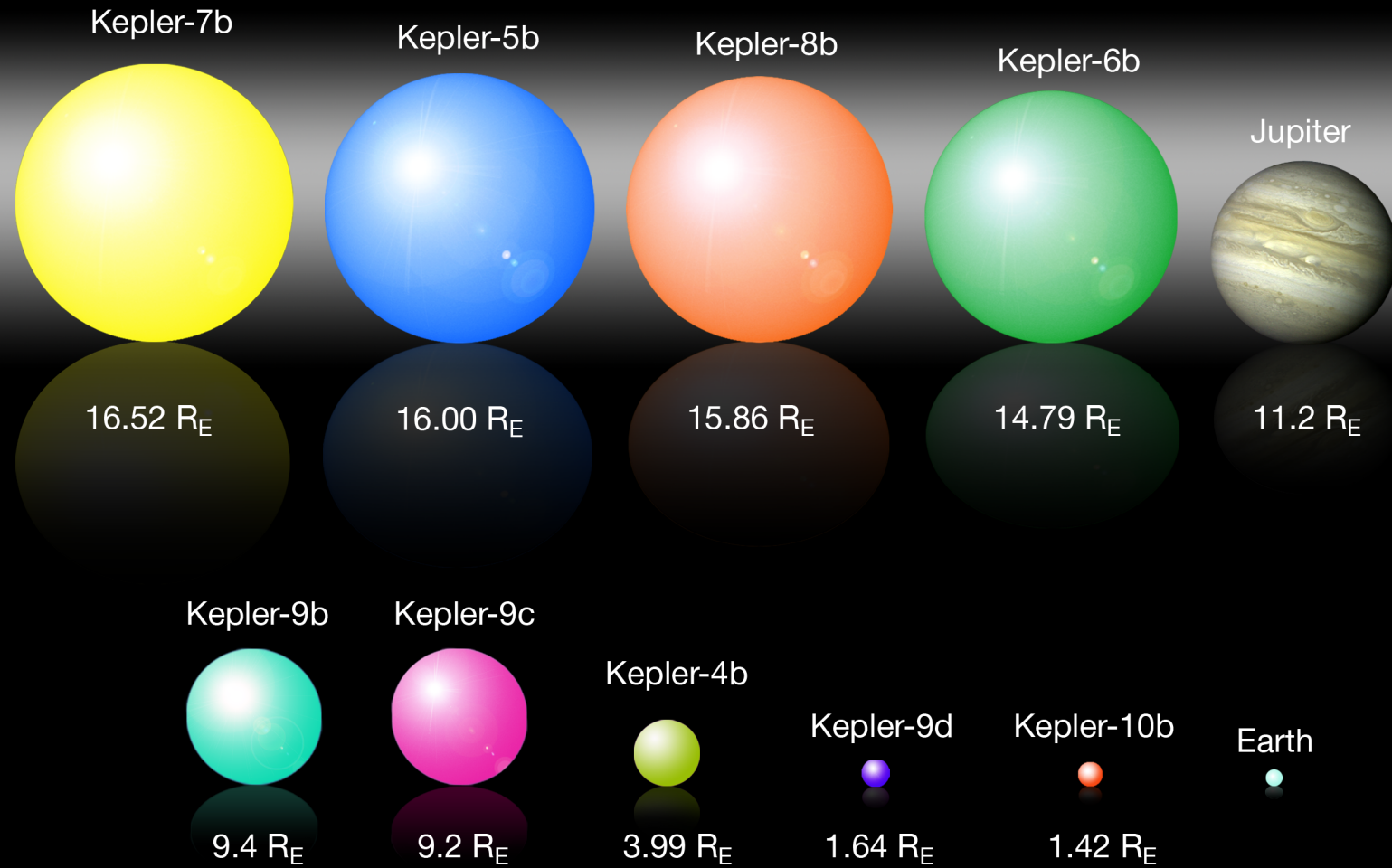
Play animation now

# Summary

- Kepler-11 is a surprisingly flat system of six planets.
- The five inner planets comprise the most closely-spaced planetary system known.
- The planets are mid-sized: 2-5 times as large as Earth.
- Most have low densities, implying mixtures of solids and light gases.



# Planet Size

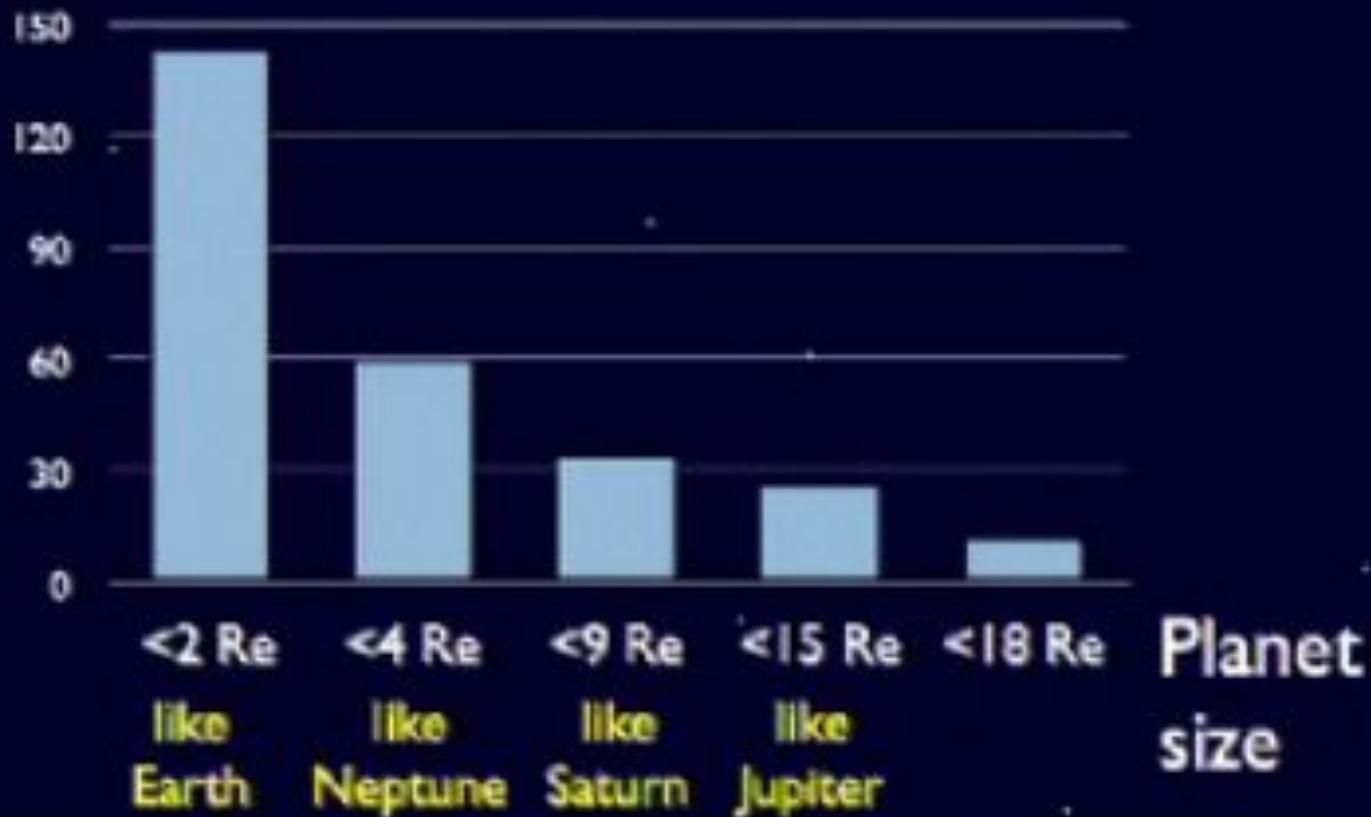




July 2010

Planet number

Total: ~1160\*





**EARTH**



5000 km  
(3107 mi)

**GLIESE 581 C**



