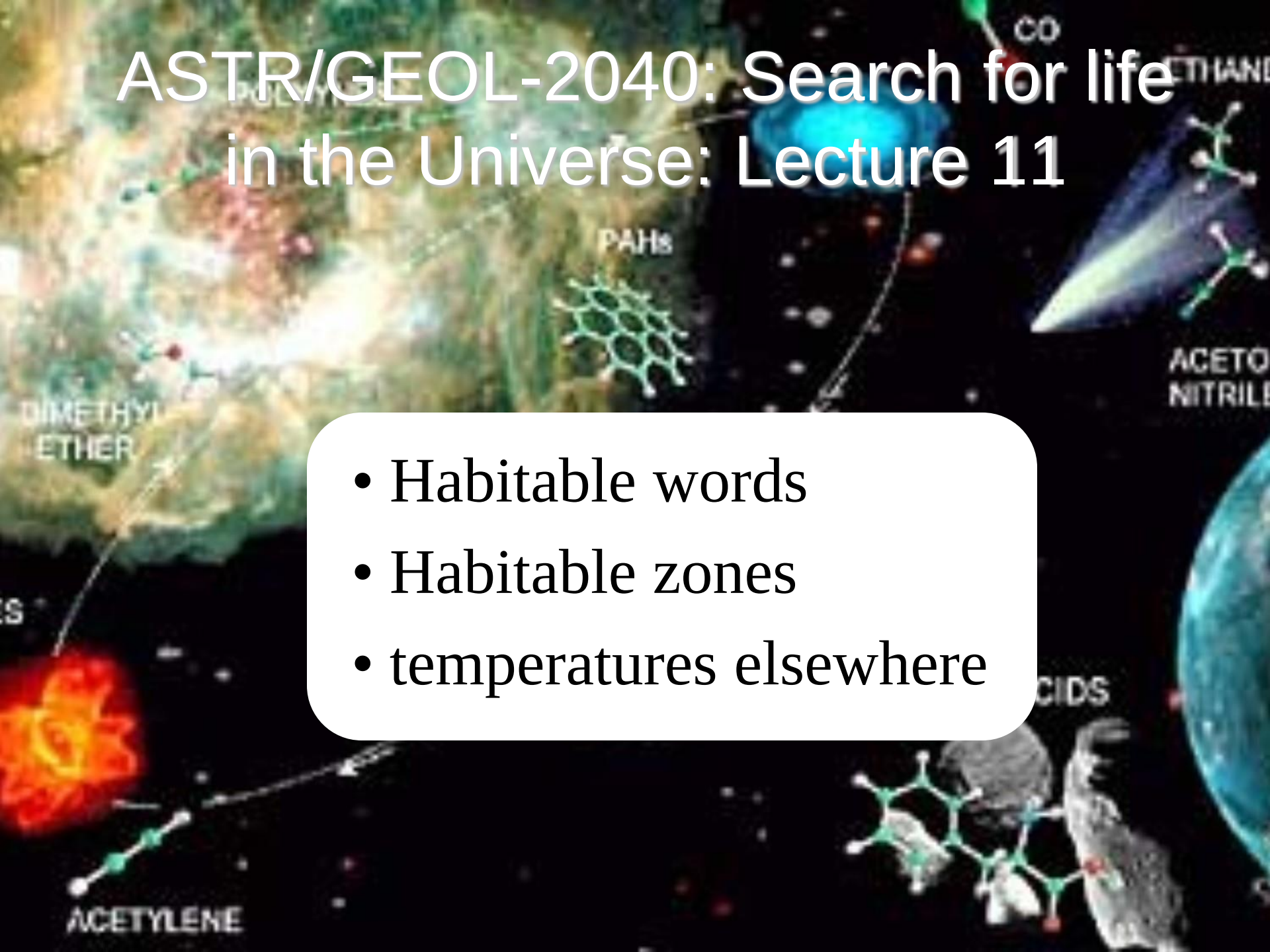
ASTR/GEOL-2040: Search for life in the Universe: Lecture 11

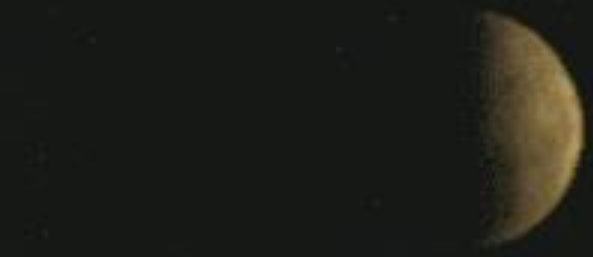


- Habitable words
- Habitable zones
- temperatures elsewhere

Background reading

- RGS pp.43 – 50
- Longstaff p. 352

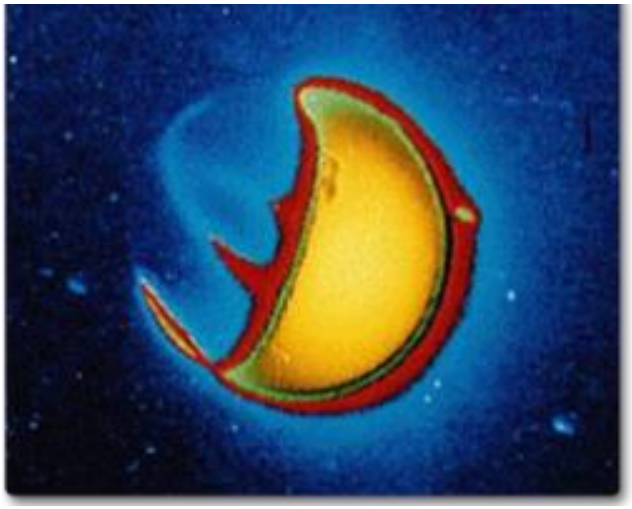
Habitable world



- Dec 16, 1992 Galileo
- Earth: today very different
- Liquid water
- Fluorescense UV → O_2
- Phytoplankton

Earth's color

- Fluorescense in UV → O_2
  - Apollo 16, 50-150 nm
  - Worked with film



Swedish | Greek | Finnish | English - detected | English | Finnish | Greek | Translate

plant × | φυτό

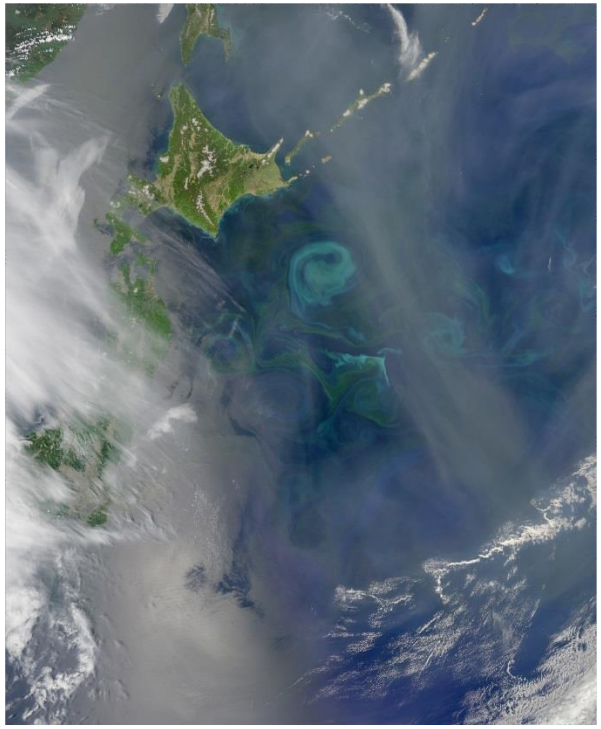
Phytoplankton

The name comes from the Greek words φυτόν (*phyton*), meaning "plant", and πλαγκτός (*planktos*), meaning "wanderer" or "drifter".[1] Most phytoplankton are too small to be individually seen with the unaided eye.

drifter
wanderer
× | άσκοπα περιφερόμενος
περιπλανώμενος

Phytoplankton reflects green

- Important in modern times:
  - 50-85% of worlds O_2
  - Fe as nutrient



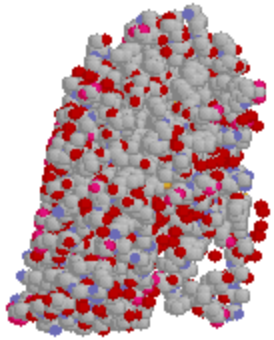
Diatoms

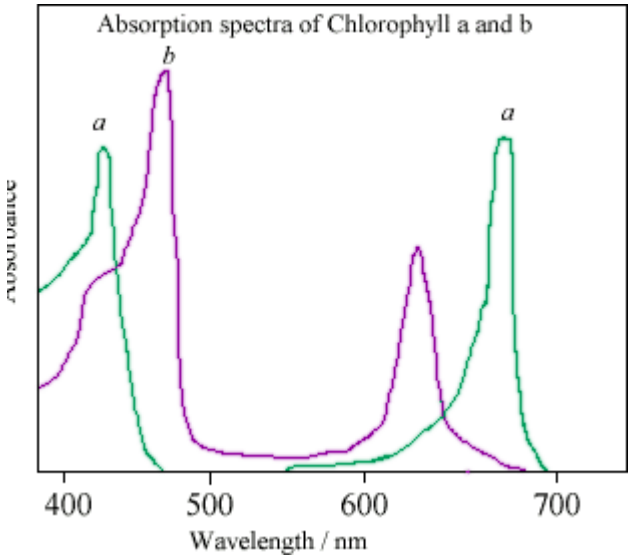
- Unicellular
- 2-200 μm
- eukarya

chain. A unique feature of diatom cells is that they are enclosed within a cell wall made of silica (hydrated silicon dioxide) called a frustule.[7] These frustules show a wide diversity in form, but are usually almost bilaterally symmetrical, hence the group name. The symmetry is not perfect since one

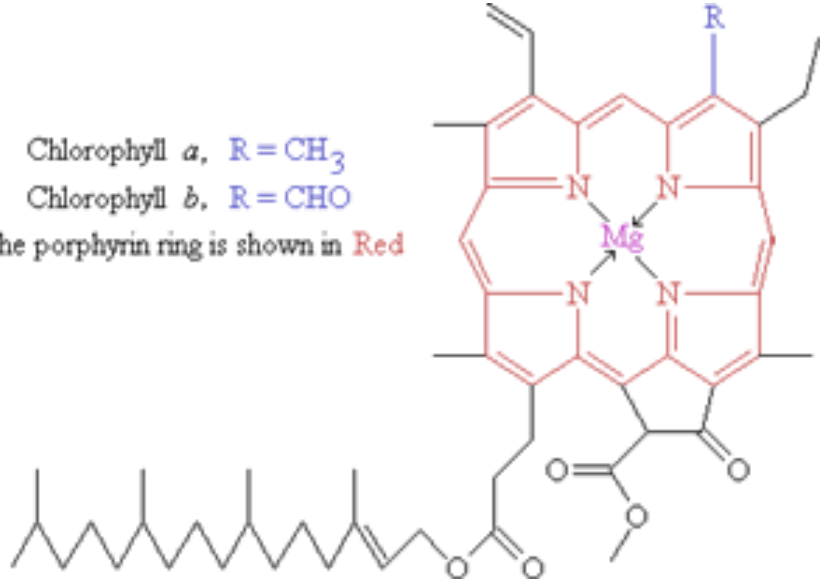
Chlorophyll

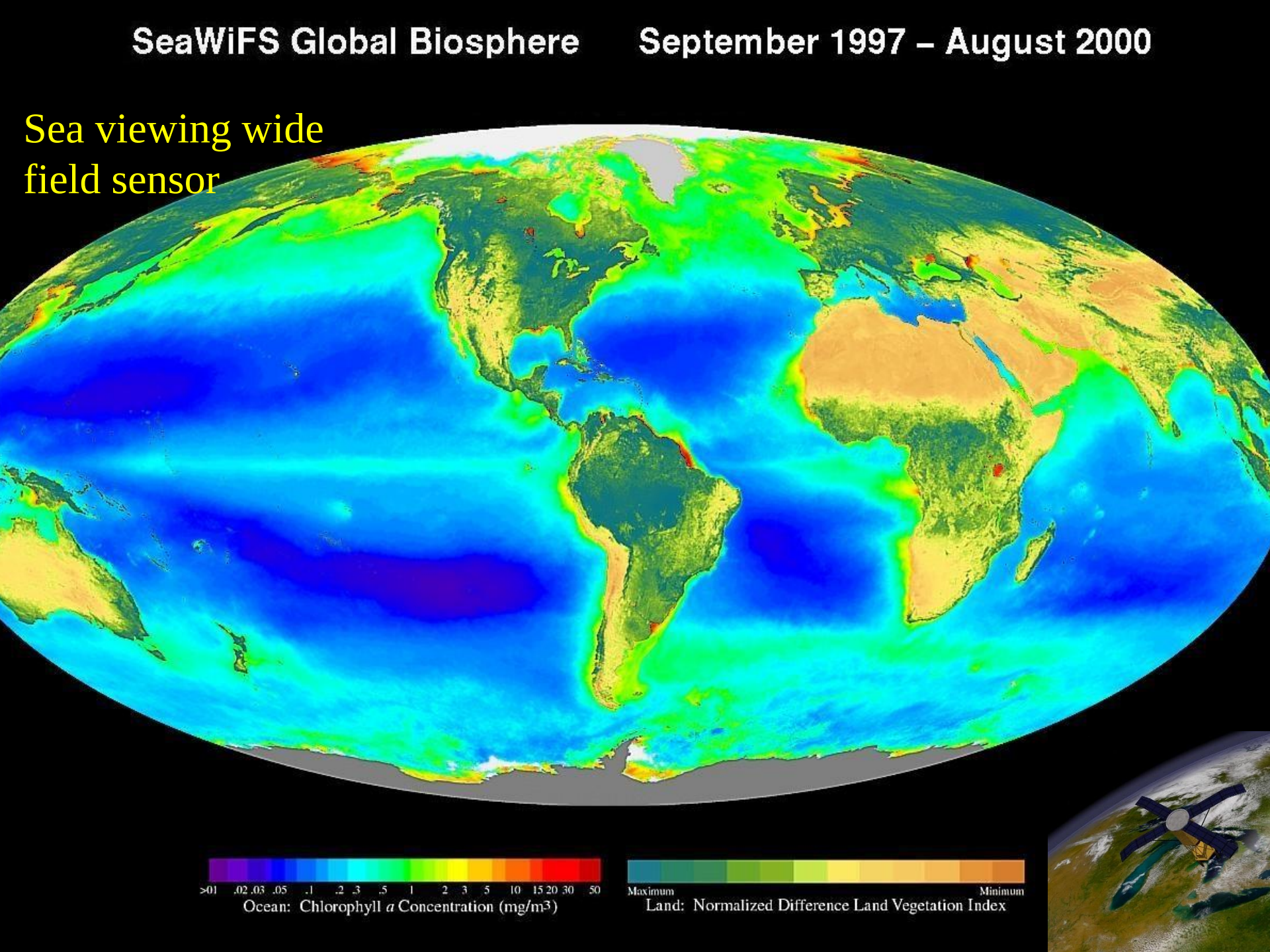
- Two types
  - a & b
- red & blue
  - Complement





Chlorophyll *a*, R = CH_3
Chlorophyll *b*, R = CHO
The porphyrin ring is shown in Red



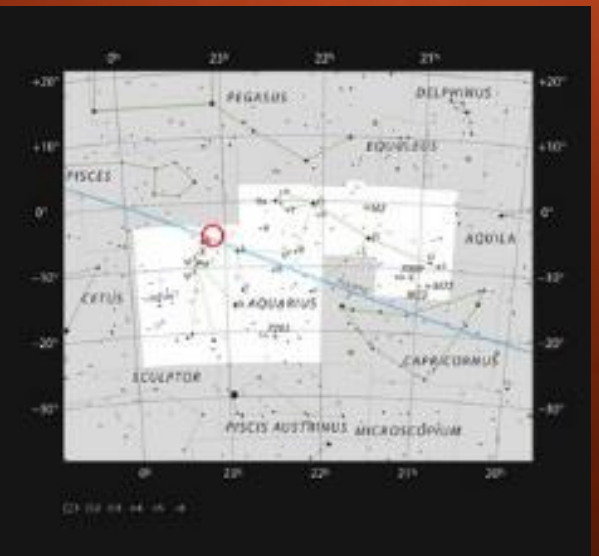

SeaWiFS Global Biosphere
September 1997 – August 2000
Sea viewing wide field sensor
>01 .02 .03 .05 .1 .2 .3 .5 1 2 3 5 10 15 20 30 50
Ocean: Chlorophyll a Concentration (mg/m3)
Maximum
Minimum
Land: Normalized Difference Land Vegetation Index

Defining habitable planet

- Special reference to our world
- Land & oceans
- O_2 continuously regenerated
- Some O_3 protects from UV
- Liquid water → habitable zone (HZ)

Motivation: TRAPPIST-1

- M8 star
- 7 terrestrial planets



m=18.8, 12 pc = 39 ly

2017/08/31

2017/08/31

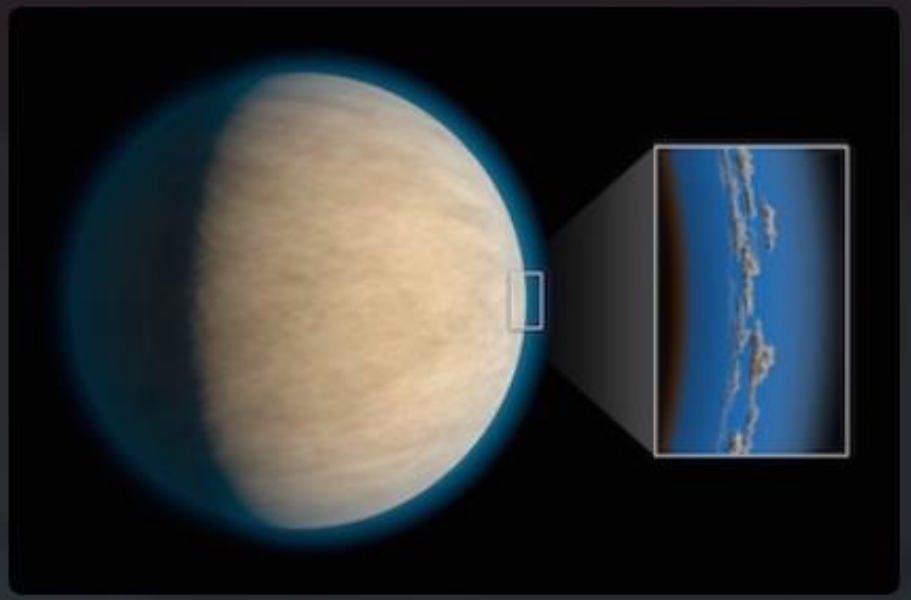
BOURRIER ET AL.

The ultraviolet flux of TRAPPIST-1 is monitored with *Hubble*. This suggests the outer planets could keep an atmosphere, and some oceans.

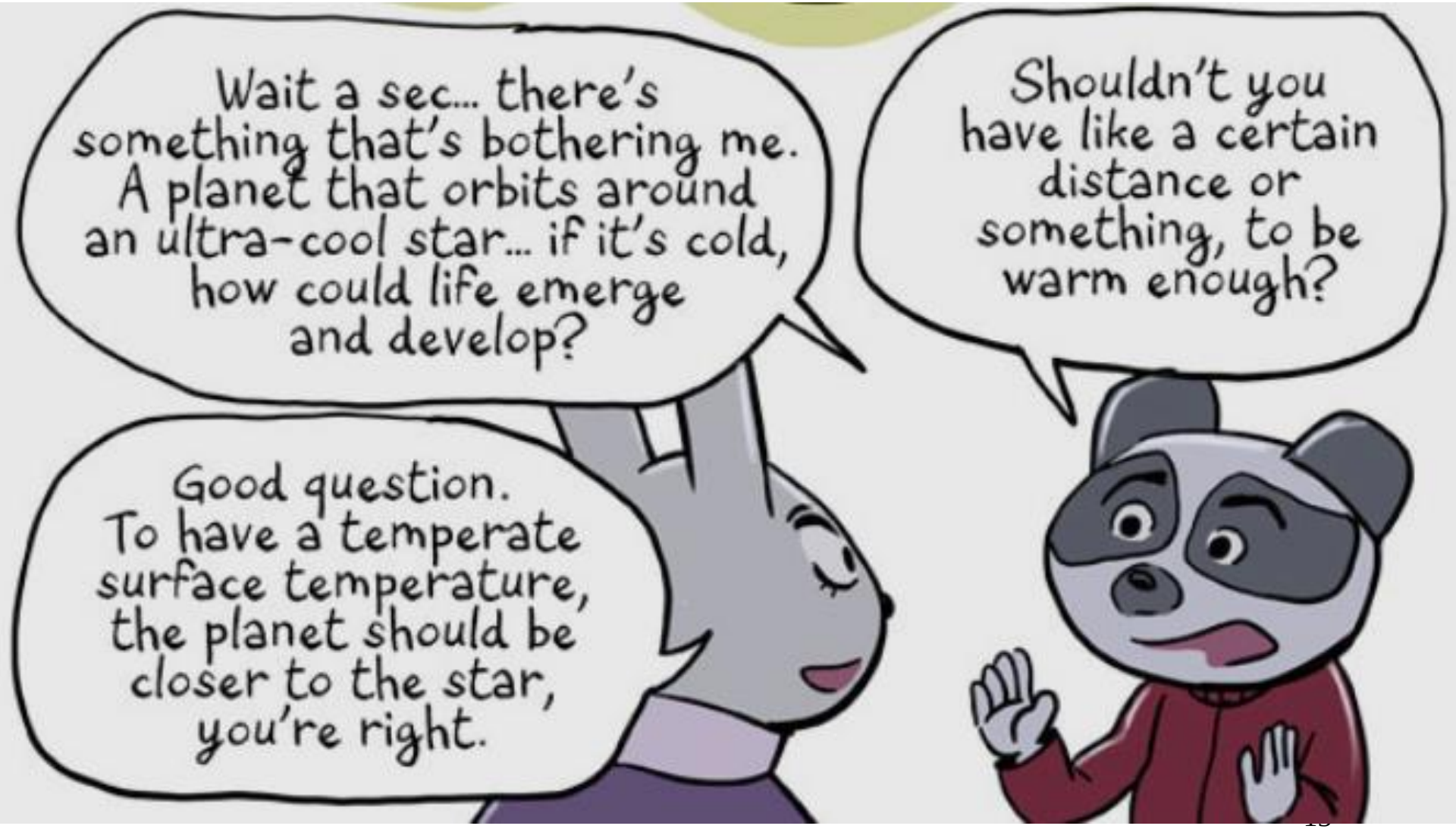
2017/08/14

MORLEY ET AL.

Models for the atmospheres of several terrestrial planets, including TRAPPIST-1's, confirm that we will be able to study them using *JWST*. Exciting!



Trappist-1: an ultra-cold star



TRAPPIST-1 vs Sun

Illustrations

TRAPPIST-1 System	b	c	d	e	f	g	h
Orbital Period *days*	1.51 *days*	2.42 *days*	4.05 *days*	6.10 *days*	9.21 *days*	12.35 *days*	~20 *days*
Distance to Star *Astronomical Units (AU)*	0.011 *AU*	0.015 *AU*	0.021 *AU*	0.028 *AU*	0.037 *AU*	0.045 *AU*	~0.06 *AU*
Planet Radius *relative to Earth*	1.09 R_{earth}	1.06 R_{earth}	0.77 R_{earth}	0.92 R_{earth}	1.04 R_{earth}	1.13 R_{earth}	0.76 R_{earth}
Planet Mass *relative to Earth*	0.85 M_{earth}	1.38 M_{earth}	0.41 M_{earth}	0.62 M_{earth}	0.68 M_{earth}	1.34 M_{earth}	–

Solar System Rocky Planets	Mercury	Venus	Earth	Mars
Orbital Period *days*	87.97 *days*	224.70 *days*	365.26 *days*	686.98 *days*
Distance to Star *Astronomical Units (AU)*	0.387 *AU*	0.723 *AU*	1.000 *AU*	1.524 *AU*
Planet Radius *relative to Earth*	0.38 R_{earth}	0.95 R_{earth}	1.00 R_{earth}	0.53 R_{earth}
Planet Mass *relative to Earth*	0.06 M_{earth}	0.82 M_{earth}	1.00 M_{earth}	0.11 M_{earth}

List of potentially habitable exoplanets

From Wikipedia, the free encyclopedia

For a more generic list, see List of exoplanets.

This article needs to be **updated**. Please update this article to reflect recent events or newly available information. *(February 2017)*

Object	Star	Star type	Mass ($M_\oplus$)	Radius ($R_\oplus$)	Flux ($F_\oplus$)	T_{eq} (K)	Period (days)	Distance (ly)	Ref
Earth	Sun	G2V	1.00	1.00	1.00	255	365.24	-	
Proxima Centauri b	Proxima Centauri	M6Ve	≥1.3	0.8 – 1.1 – 1.4	0.65	234	11.186	4.22	[11]
Gliese 667 Cc	Gliese 667 C	M3V	≥3.8	1.1 – 1.5 – 2.0	0.88	277	28.143 ± 0.029	23.62	[12] [13]
Kepler-442b	Kepler-442	K?V	8.2 – 2.3 – 1.0	1.34	0.70	233	112.3053	1291.6	[13]

Object	Star	Star type	Mass ($M_\oplus$)	Radius ($R_\oplus$)	Flux ($F_\oplus$)	T_{eq} (K)	Period (days)	Distance (ly)	Ref
Trappist-1e	Trappist-1	M8V	0.62	0.92	-	251	6.1	39	[24]
Trappist-1f	Trappist-1	M8V	0.68	1.04	-	219	9.2	39	[24]
Trappist-1g	Trappist-1	M8V	1.34	1.13	-	199	12.3	39	[24]

What determines Earth's temperature?

- . . . . .
- . . . .
- . . . .

What determines Earth's temperature?

- . . . . .
- . . . .
- . . . .

If each of you got the same amount of money
how much will each of you have?

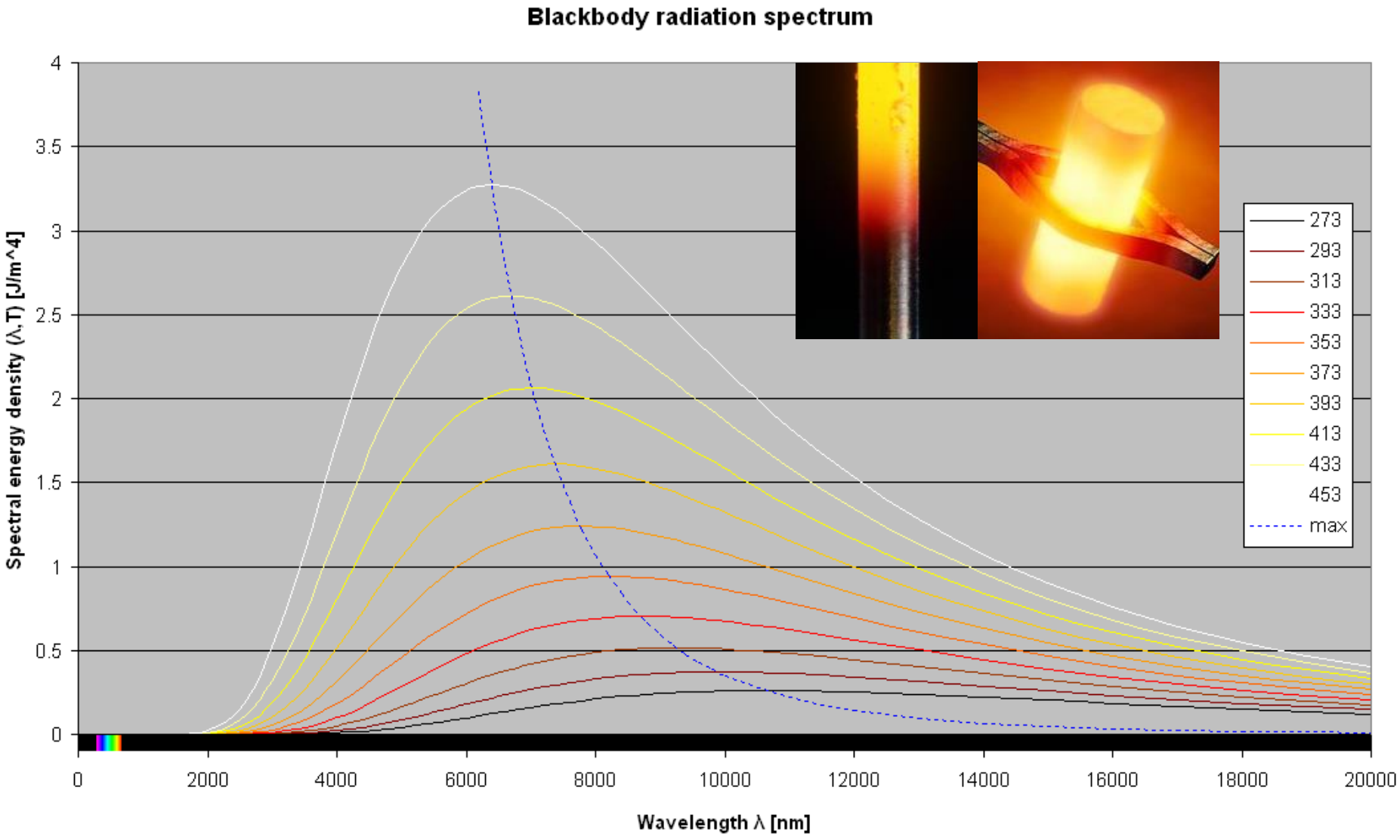
The Earth loses more energy when

A. the surface is cold

B. the surface is hot

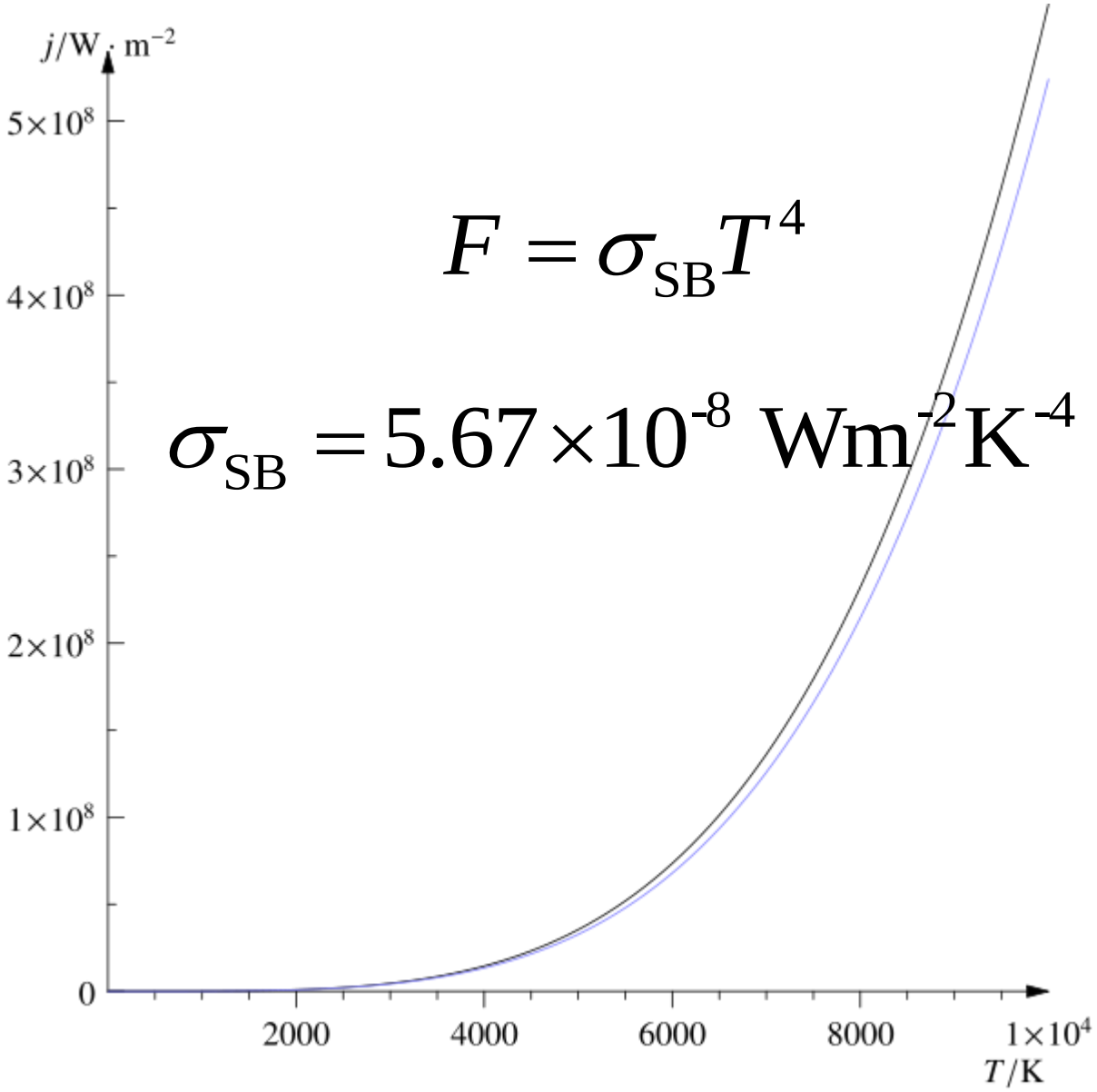
C. neither: it loses a fixed amount

Color of “black” body



The hotter, the more

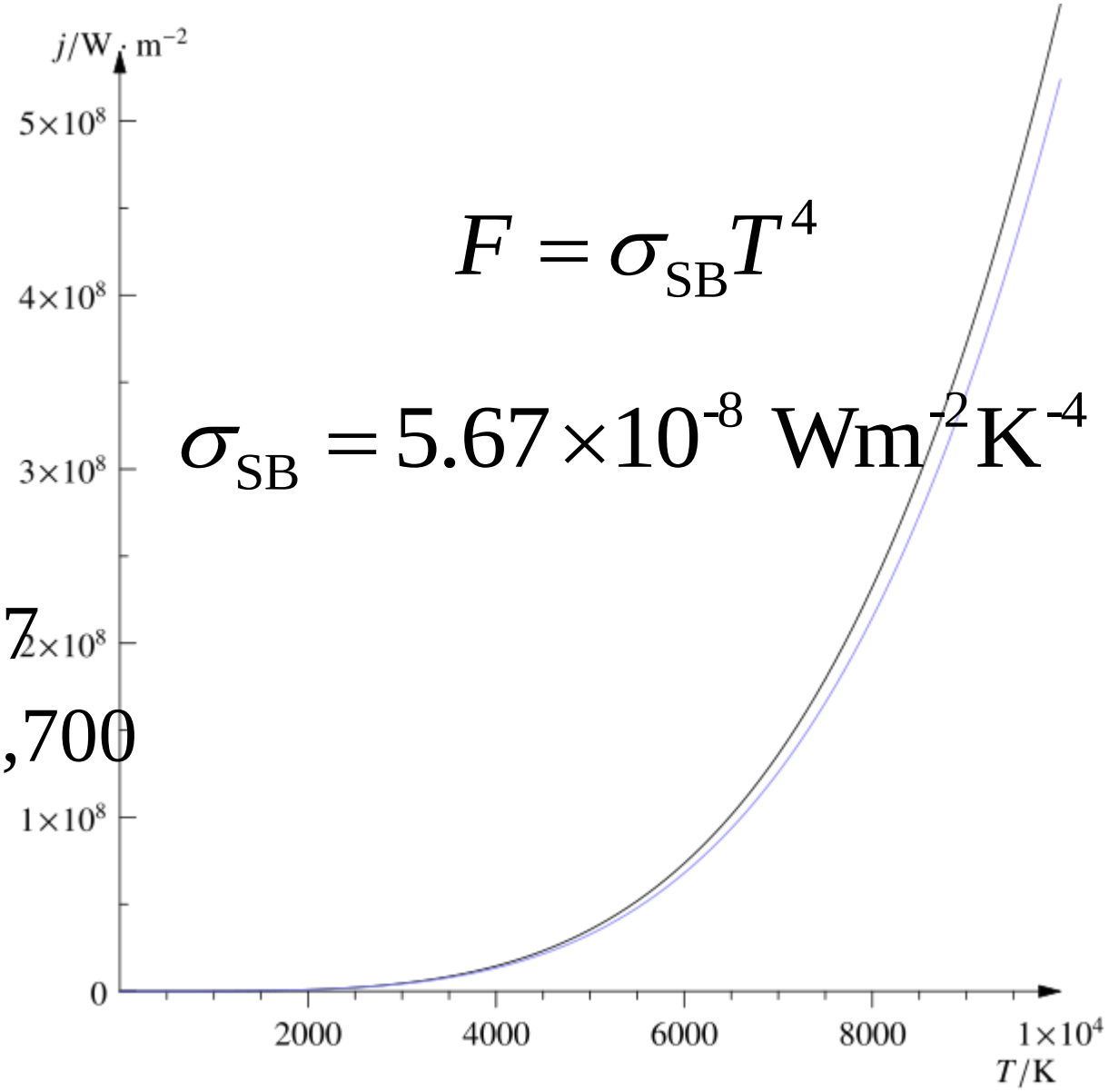
- 100 K
- 1000 K
- 10,000 K



$$F = \sigma_{SB} T^4$$

$$\sigma_{SB} = 5.67 \times 10^{-8}\ \mathrm{Wm^{-2}K^{-4}}$$

The hotter, the more



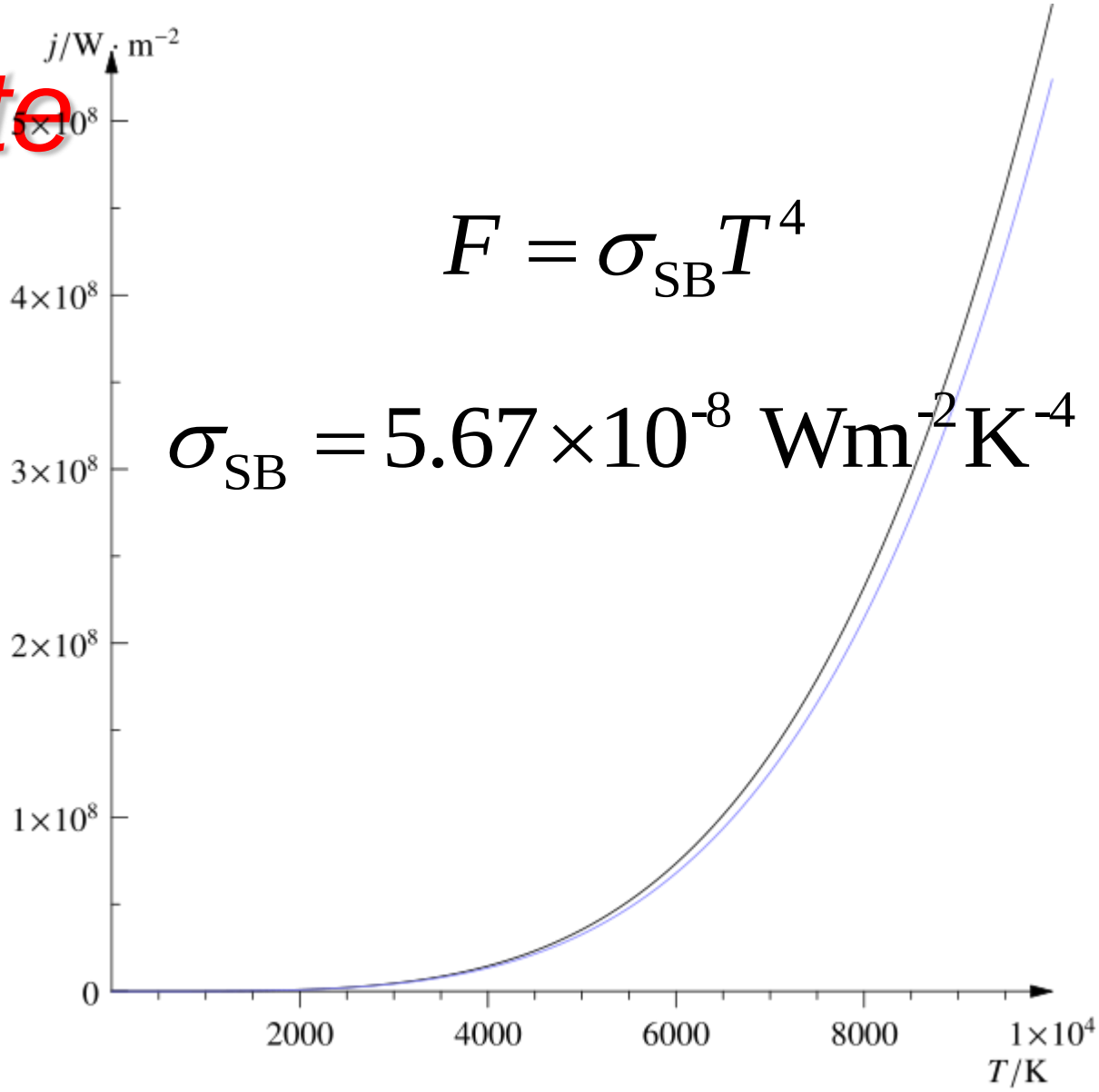
$$F = \sigma_{SB} T^4$$

$$\sigma_{SB} = 5.67 \times 10^{-8}\ \mathrm{Wm^{-2}K^{-4}}$$

- 100 K → 5.67
- 1000 K → 56,700
- 10,000 K →

Intermediate numbers

- 100 K
- 178 K
- 316 K
- 562 K
- 1000 K
- 10,000 K



$$F = \sigma_{SB} T^4$$

$$\sigma_{SB} = 5.67 \times 10^{-8}\ \mathrm{Wm^{-2}K^{-4}}$$

Next time

- Finish temperature calculation
- Carbon cycle
- Plate tectonics
- pp. 50 - 53