

Astrophysics Colloquium



Dr. Jorge Piekarewicz
Florida State University

Nuclear Astrophysics in the New Era of Multimessenger Astronomy

One of the overarching questions animating nuclear physics today is "How does subatomic matter organize itself". **Neutron stars** are cosmic laboratories uniquely poised to answer this fundamental question.

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EM waves

Neutrinos

Gravitational waves

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Multimessenger Astronomy

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Interlude 1 Talks

Humanity in the Solar System

Monday, November 4

Team 1: Keely Wiese, Caitlin Marat, Ryan Posthumus, Jonathan Peters

Team 2: Sam Omohundro, Gujie Shen, Giulia Eddy, Brian Wu

Team 3: Berk Donmez, Masaccio Braun, Nicholas Costa, Haowen Liu

Team 4: Yang Wang, Chumei Wei, Yehan Wu, Rongbiao Wang

Wednesday, November 6

Team 5: Jack Cone, Matt Wydra, Thomas Johnson, Matthew Cheng

Team 6: Sam Burrige, Drew Laird, Sal Rego, Thomas Olmsted

Team 7: Abigail Hartless, Caroline Kepler, Makiyah Rifenberg, Sophia Zaman

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Send me your PowerPoint or PDF talk by 8am Monday/Wednesday morning.

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Reminder (for everyone): Papers are due on Friday, November 8 (next week).

Today's Topics

Friday, November 1, 2019 (Week 9, lecture 25) – Chapters 14.4, 30.1-3, 16.

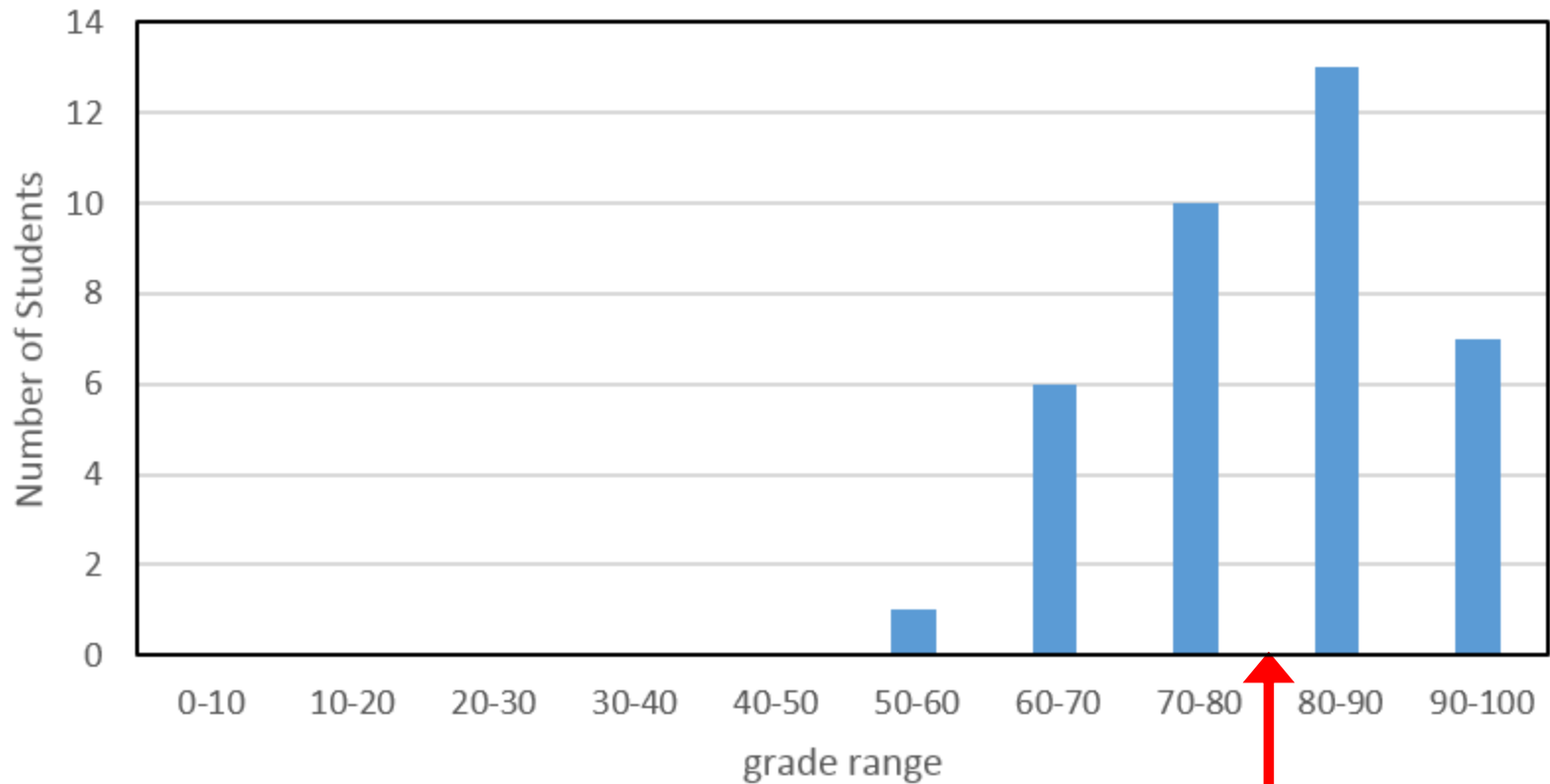
0. Midterm #2

1. Life in the Solar System?

3. Our Sun

Midterm Test #2

Midterm #2: Histogram of Grades



Average = 80

Median = 81

High Score = 97

What is Life ?

Definitions of Life (biology) – *there are many definitions (no consensus)*

Definition 1

Life is considered a characteristic of something that preserves, furthers or reinforces its existence in the given environment [*Wikipedia*].

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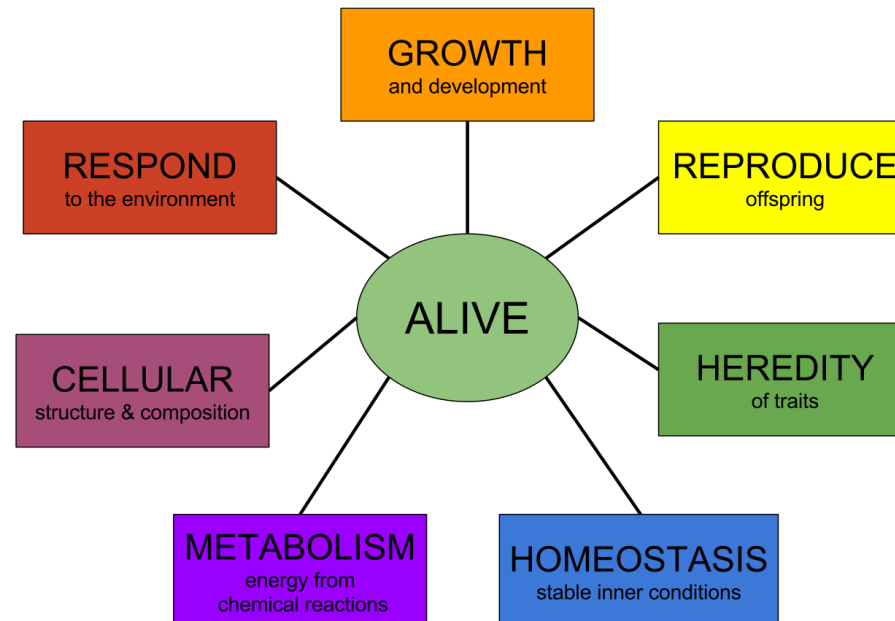
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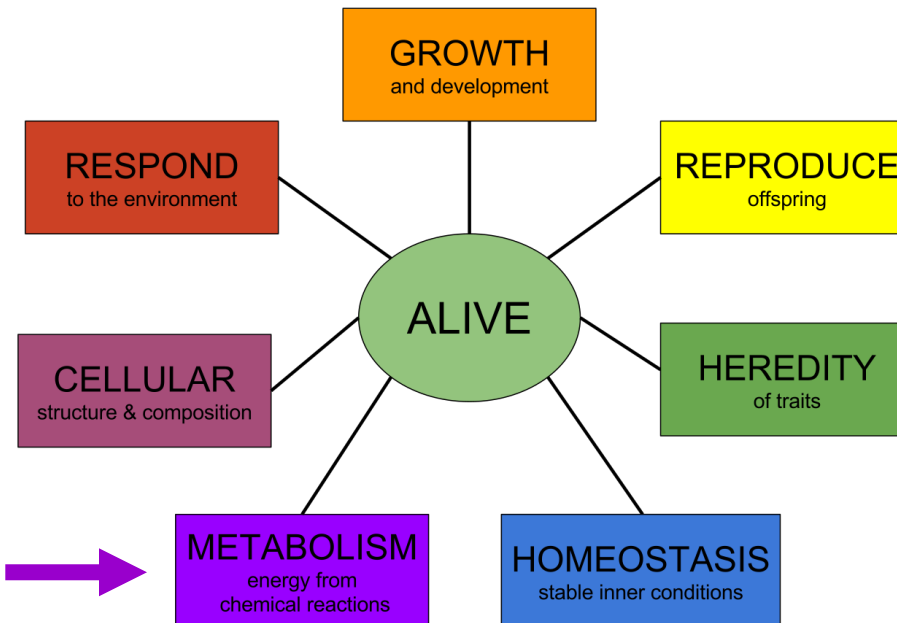
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Life is a self-sustained chemical system capable of undergoing Darwinian evolution [Wikipedia].

Life requires specific environmental conditions →
... Also, life can modify its environment.



Life requires an energy source →

What are the environmental requirements for Earth-style Life?

Ingredients for Earth-style life

- **Liquid water** (solvent).
- Carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur.
- **Temperature range: -25° C to 120° C.**
- Not too much ionizing radiation.
- **An energy source:** solar energy, chemical energy, heat.

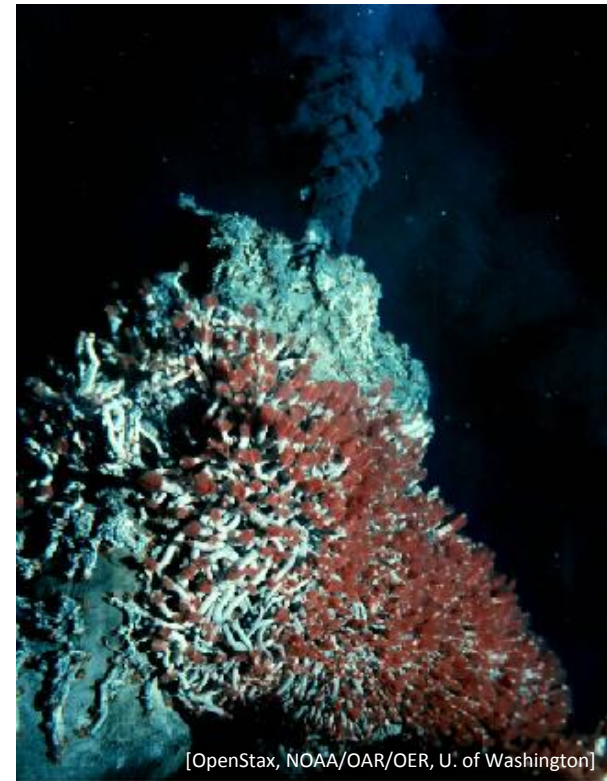
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Hot spring (Yellowstone Nat. Park): multi-colored photosynthesizing bacteria (solar energy). Central pool (92°C) bacteria use chemical energy.



Hydrothermal vent: chemical energy (metal sulfides).

Examples of Hardy Life



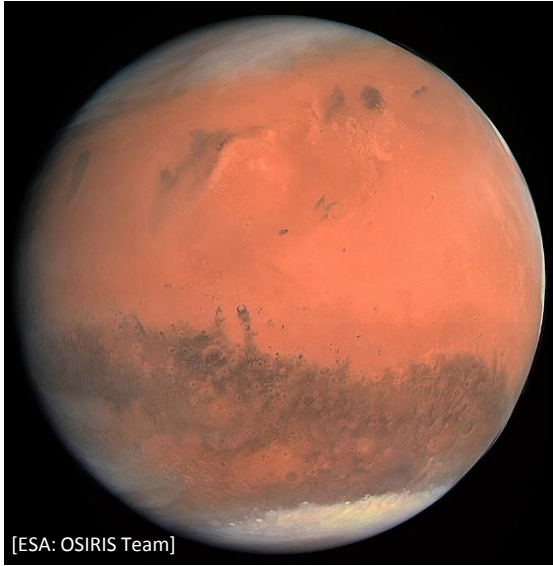
The Tardigrade (length: ~0.5 mm) can survive

- -270° C to 150° C for a few minutes.
- Vacuum to 1000 bars.
- Years of dehydration.
- 1000x lethal radiation dose of animals.



Cyanobacteria are photosynthesizing bacteria that have existed on Earth for 2.1 billion years ago (maybe longer)

Where to look for life In the Solar System ?

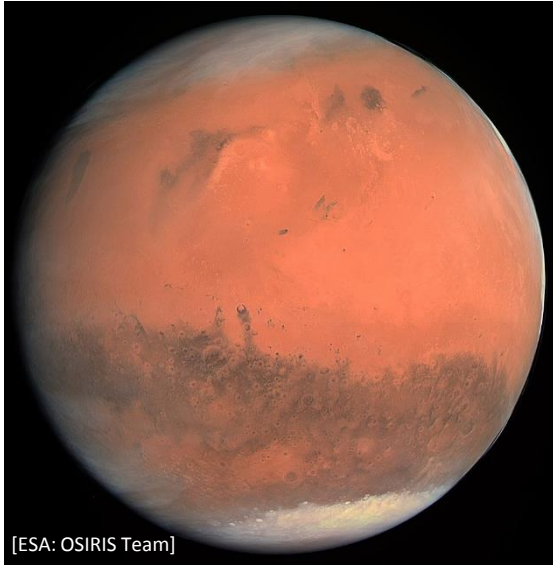


[ESA: OSIRIS Team]

Mars may have suitable conditions for life just below its surface:

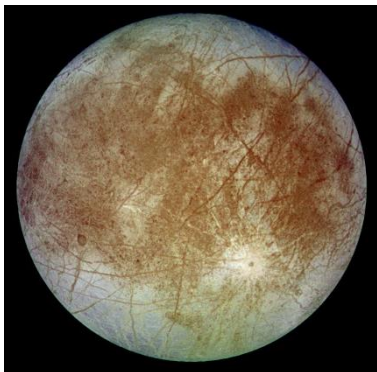
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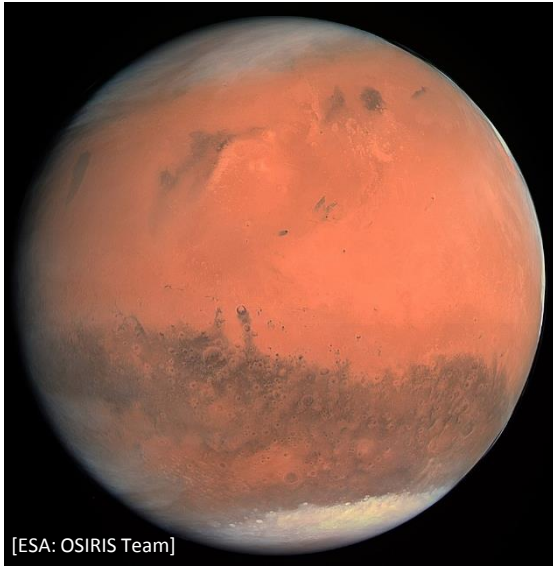
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Europa (Jupiter moon)

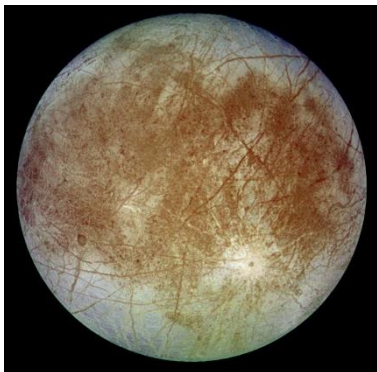
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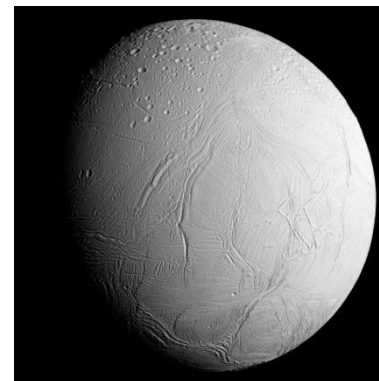
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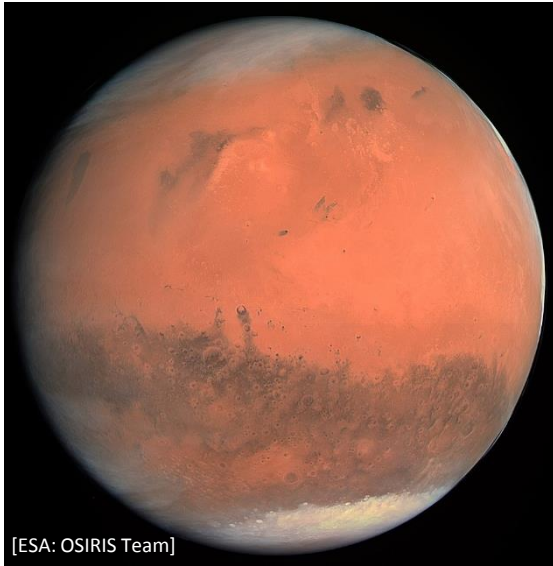
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Enceladus (Saturn moon)

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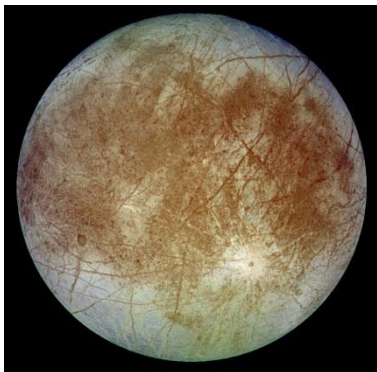
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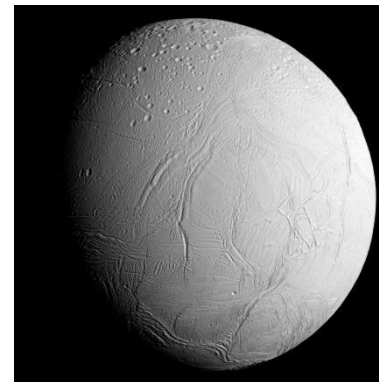
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[NASA/JPL/DLR: Galileo mission, 1996]

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[NASA: Cassini mission, 2015]

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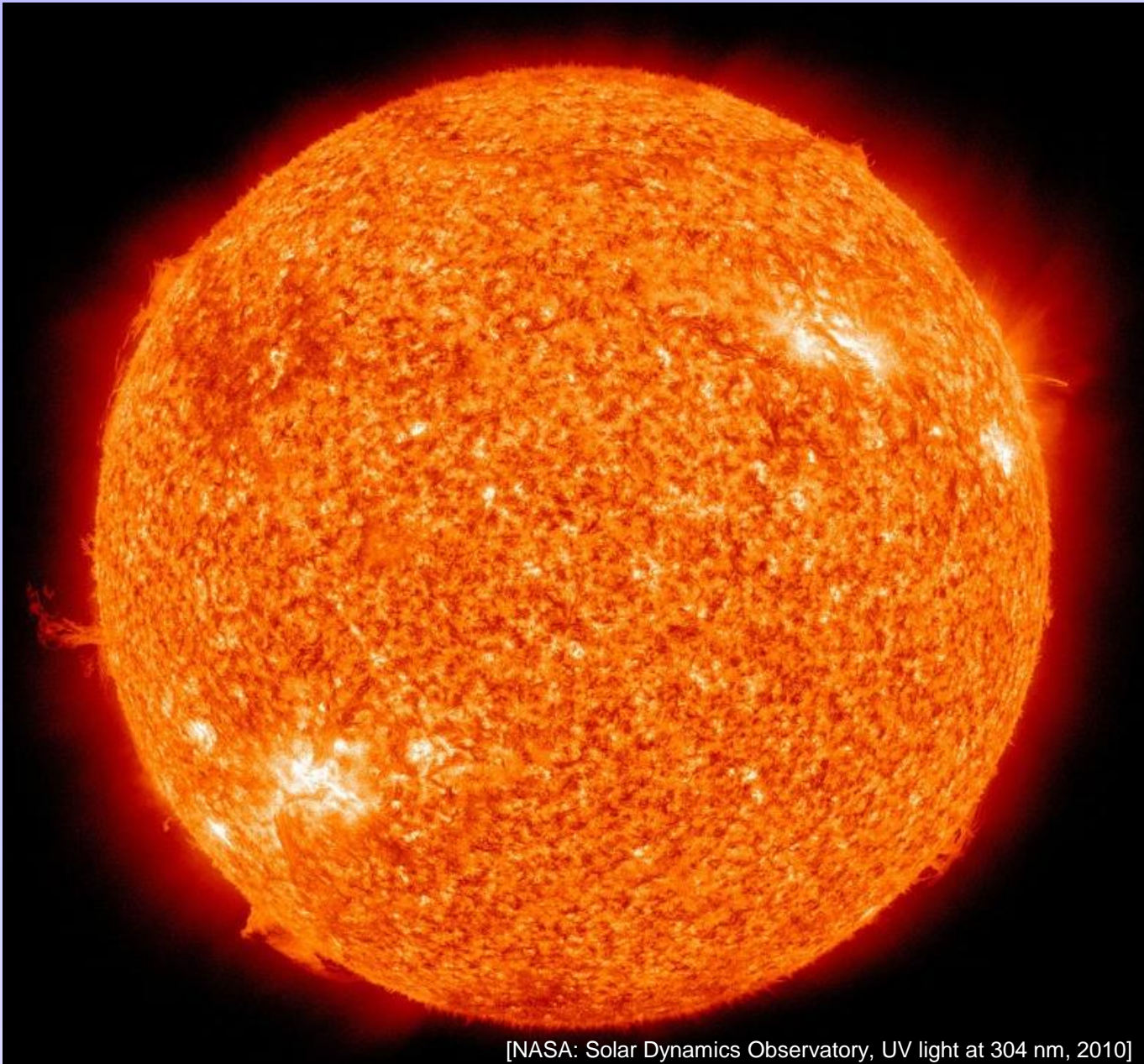
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More speculative: Ganymede sub-surface water, upper atmosphere of Venus.

Our Sun



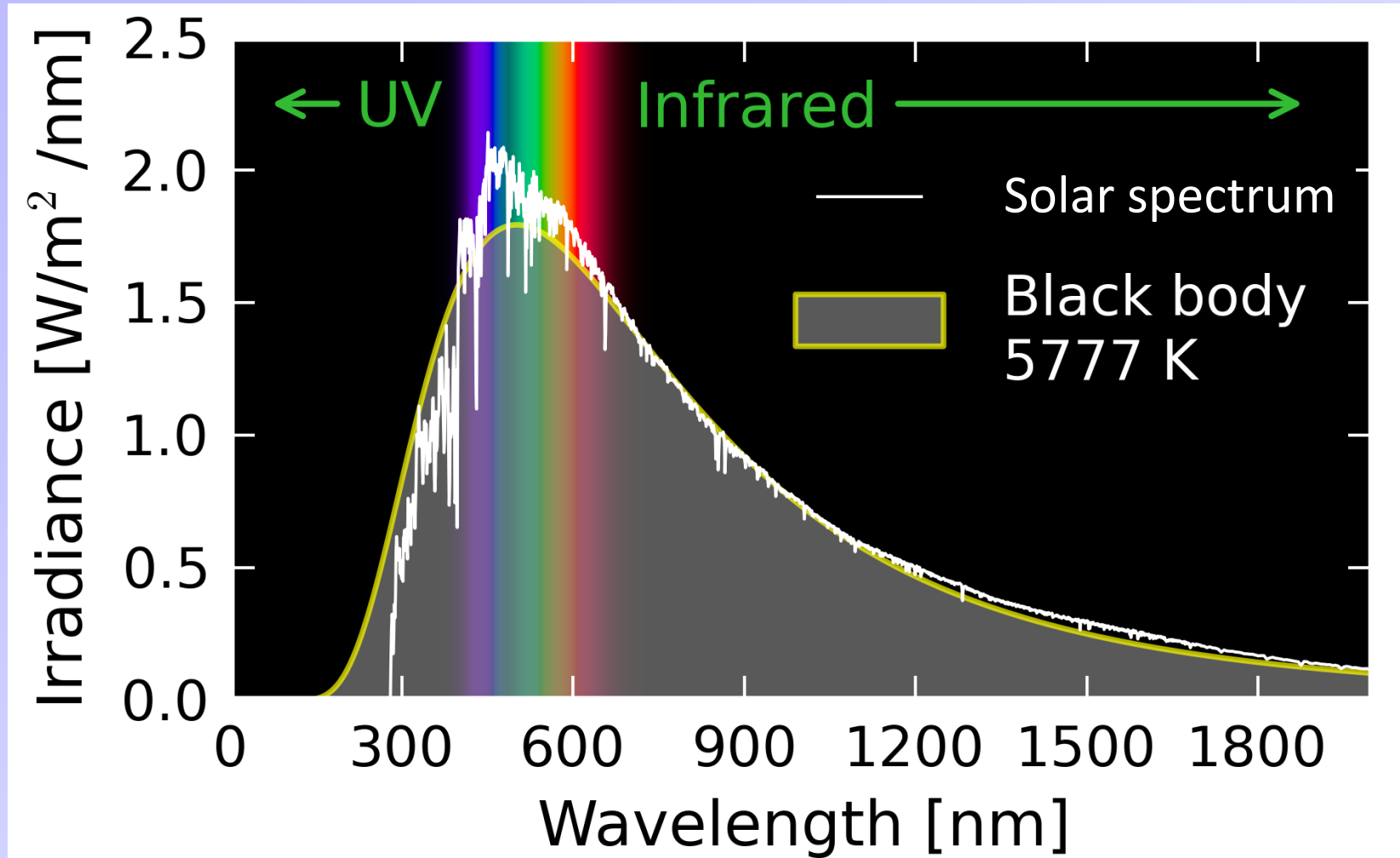
Our Sun



[NASA: Solar Dynamics Observatory, UV light at 304 nm, 2010]

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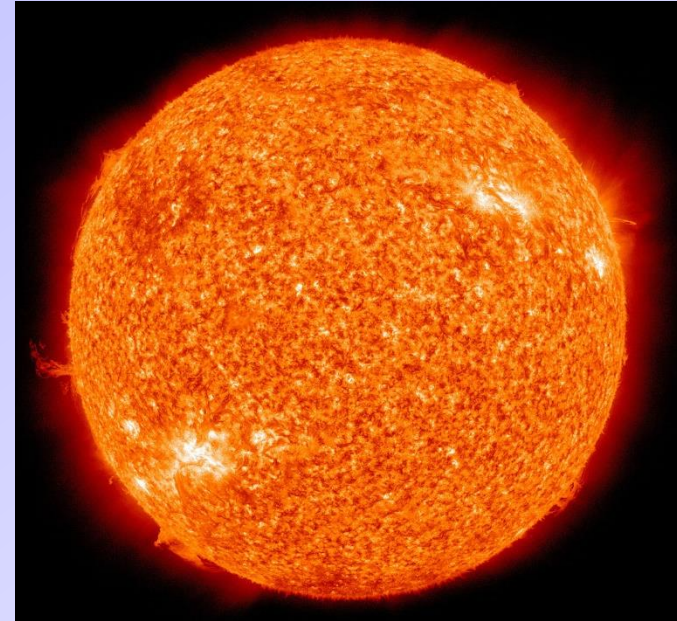
Blackbody Radiation Source



Our Sun: Surface (photosphere)

Properties

- Temperature = 5777 K (surface/photosphere)
- Substance: Plasma (electrons & nuclei are dissociated).
- Magnetosphere: ~ 1 Gauss at surface.
(*exception: sunspots at 3000 G*)
- Rotation period: $T_{\text{equator}} = 25$ days, $T_{\text{poles}} = 34$ days.
- Rotation axis tilt: 7.25° with respect to ecliptic.

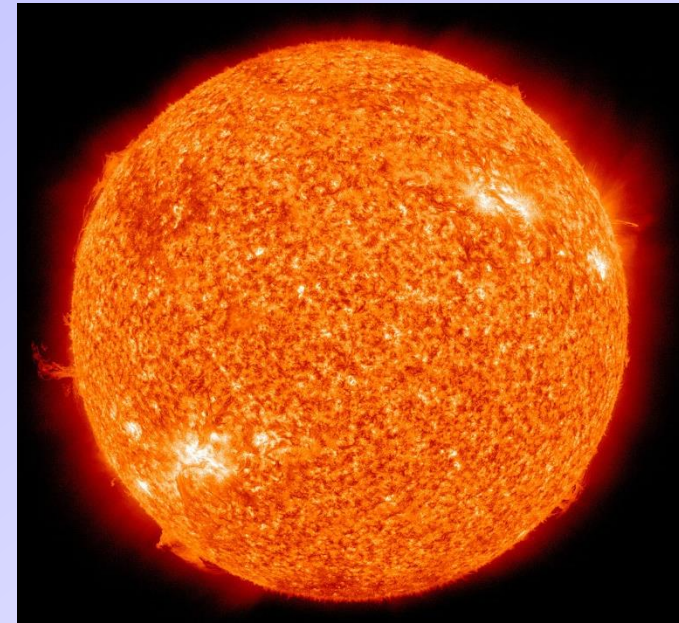


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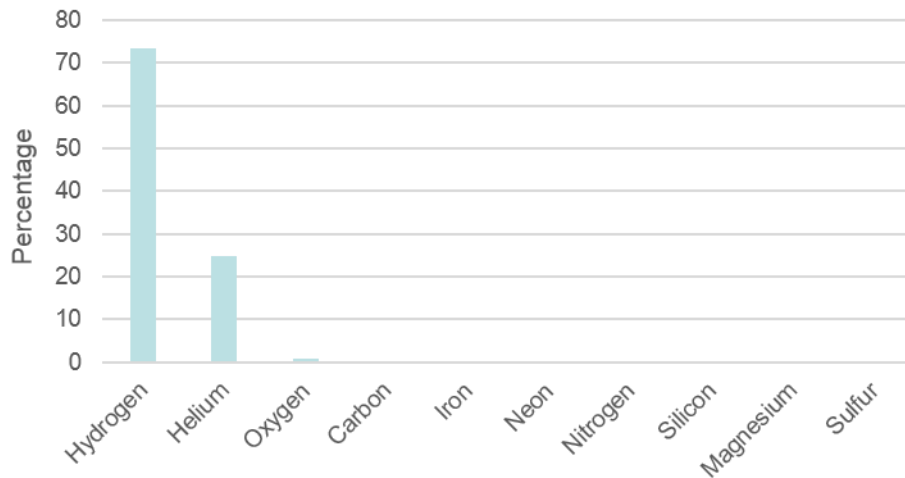
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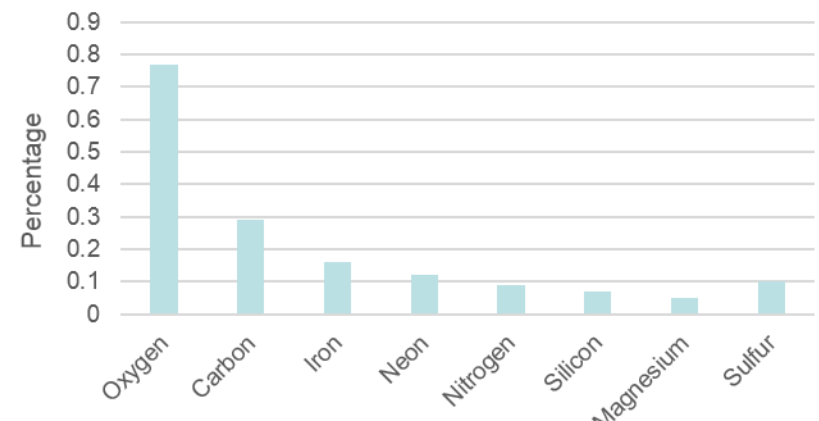
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Elemental Abundance in Photosphere



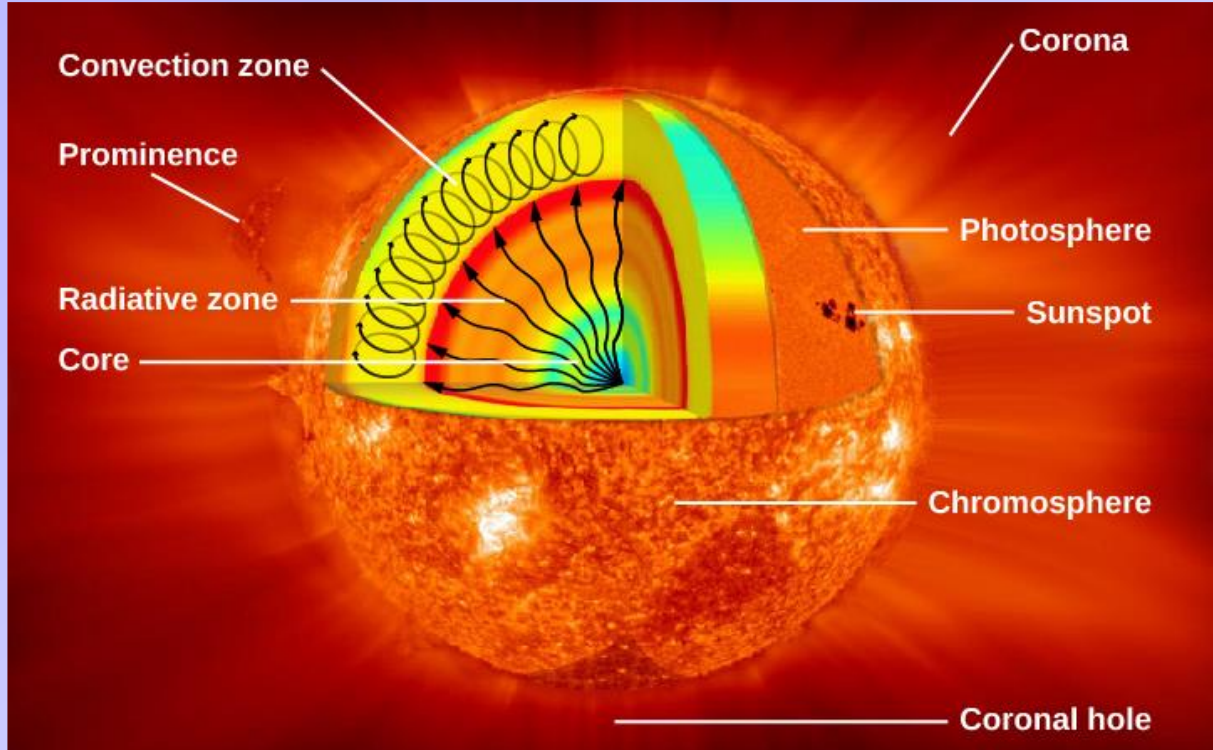
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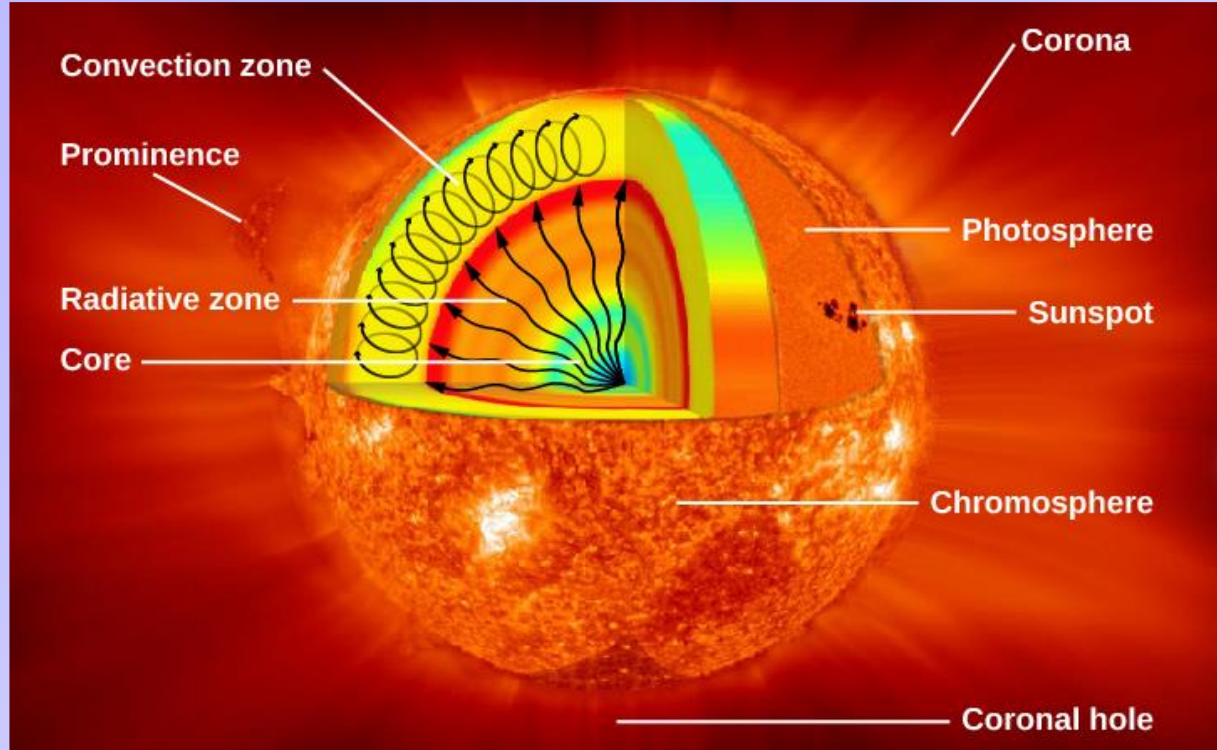
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Our Sun: Structure



[OpenStax: Astronomy]

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