OLLI SG 492
Plate Tectonics

Session 1 - September 19, 2022

Today’s Meeting

- Introductions
- My Background and Approach
- Review of Operational Procedures
- Review of the Syllabus
- Recommended Readings and Resources
- What We Will and Wont Cover
- Problems Encountered in the Study of Geology; Geologic Time Scale
- Formation of the Earth

Introductions

- Knowledge of Geology or Related Sciences
  - Academic experience - High School, College?
  - Work experience - Geologists, Petroleum/Mining Engineers, etc.?
  - Lectures? Smithsonian Associates?
- Your Interest in Taking This Study Group

My Background

- BA, Philosophy, 1972, Temple University, Philadelphia
- Teaching Fellowship in Philosophy, Graduate School, Temple Univ. (4 years)
- Career in Information Technology (Mostly Federal Govt.)
- First OLLI Study Group - Fall 2015
- Led 17 Unique Study Groups - 9 Biology, 3 Geology, 5 Philosophy
- With Repeats, Led 23 Study Groups

My Approach

- Not a Teacher, Not a Lecturer, Just a Study Group Leader
- Encourage Optimum Participation
- Mix of Presentation, Discussion, Comments, Q&A
- Maintain a Casual Atmosphere - but focused on the subject.

Operational Procedures

- I will email a PDF of the slides used in each meeting right after the meeting.
- I will also post all material used in this study group on OLLI's website.
- Caveat: If the email file exceeds a certain size, I will only make it available on OLLI's website. My email provider rejects very large emails.

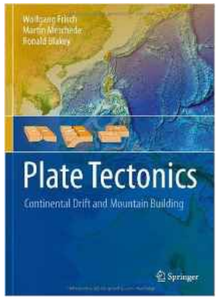
Syllabus

OLLI 492 Syllabus Fall 2022

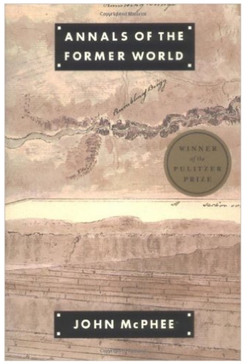
Session 1, Sep. 19:	Introduction and Overview; Formation of the Earth
Session 2, Sep. 26:	Earth's Structure and the Formation of the Moon
Session 3, Oct.3:	Introduction to Plate Tectonics: Theory and Evidence
Session 4, Oct.10:	Plate Boundaries, Rock Cycle, and Formation of the Oceans
Session 5, Oct. 17:	Formation of the Continents; Supercontinent Cycle
Session 6, Oct. 24:	Hot Spots, Basalt Flows, Yellowstone, and Hawaii
Session 7, Oct. 31:	Convergent Boundaries - Southern Europe and the Mediterranean - Turkey and the Middle East
Session 8, Nov. 7:	Convergent Boundaries - The Pacific Rim - India and the Himalayas
Session 9, Nov. 14:	Divergent Boundaries - East African Rift Valley and the Red Sea - Basin and Range and Grand Tetons
Session 10, Nov. 21:	Divergent and Transform Boundaries - Failed Rifting - San Andreas Fault and New Zealand Summary and Conclusion: What Will the Future Look Like

Recommended Reading and Resources

- Earth: An Introduction to Physical Geology - Edward J. Tarbuck and Frederick K. Lutgens, Illustrated by Dennis Tasa, 13th ed., Pearson, 2020.

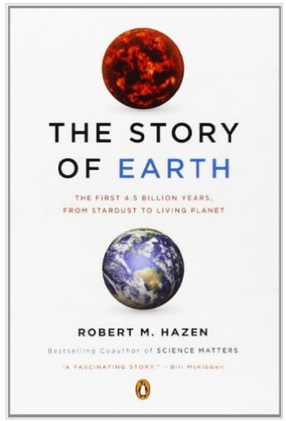


- Plate Tectonics: Continental Drift and Mountain Building - Wolfgang Frisch, Martin Meschede, and Ronald Blakey, Springer, 2011

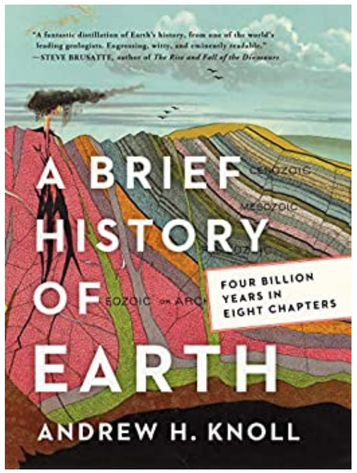


- Annals of the Former World - John McPhee, Farrar, Straus and Giroux, 1998

Recommended Reading and Resources

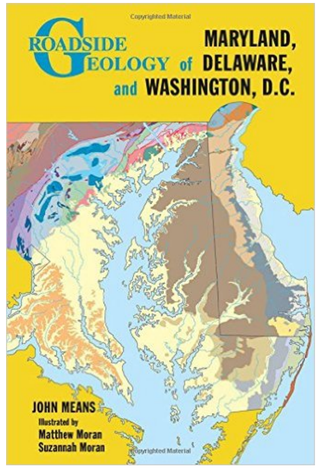


- The Story of Earth: The First 4.5 Billion Years, From Stardust to Living Planet - Robert M. Hazen, Penguin Books, 2013

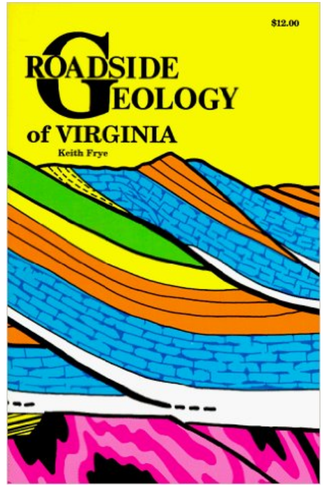


- A Brief History of Earth: Four Billion Years in Eight Chapters - Andrew H. Knoll, Custom House, 2021

Recommended Reading and Resources



- Roadside Geology of Maryland, Delaware, and Washington D.C. - John Means, 2010, Mountain Press Publishing



- Roadside Geology of Virginia - Keith Frye, 1986, Mountain Press Publishing

Recommended Reading and Resources

- Websites:
  - Callan Bentley’s Blog - Mountain Beltway
  - NASA - Earth Observatory
- Courses and Lectures:
  - Great Courses
    - The Origin and Evolution of Earth: From the Big Bang to the Future of Human Existence - Robert M. Hazen
    - Wonders of the National Parks: A Geology of North America - Ford Cochran
  - Smithsonian Associates
  - Carnegie Institution for Science - Earth and Planets Laboratory

What We Will Cover

- An Overview of Plate Tectonics
  - What is it?
  - What drives it, what effects does it have?
  - How do we know it’s true?
  - How did the plates/continents change over time?
- Other major geologic processes that shape our world.
- The effects of both on geologically significant and active areas of the world.

What We Will Cover

- Plate and Continent Movement from 540 MA to Today

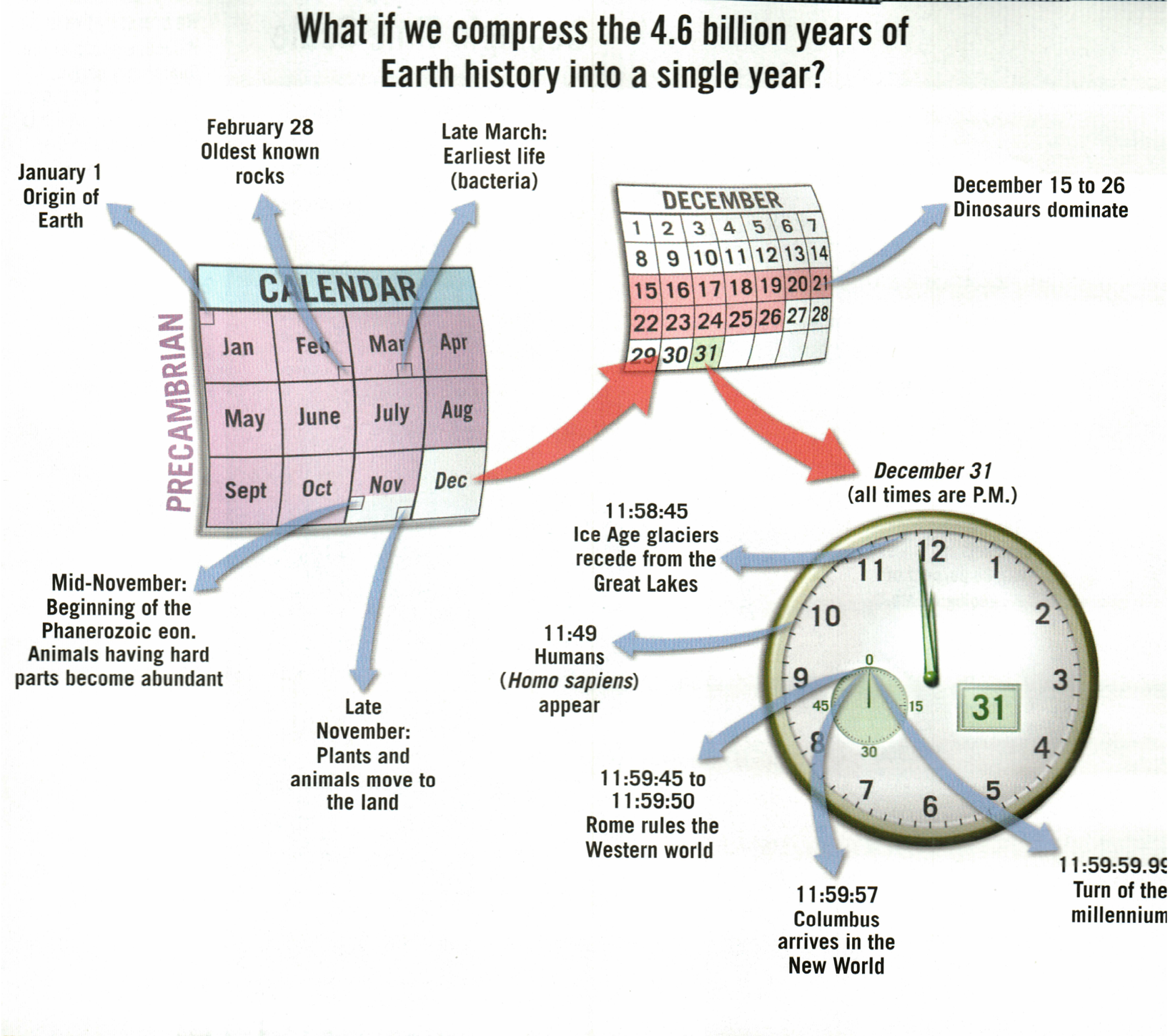
What We Wont Cover

- Details about the chemistry and physics of plate tectonics.
- Details about rocks, minerals, natural resources, etc.
- Details about the effect of plate tectonics on climate or climate change.
- Details about the effect of plate tectonics on life.

Problems Encountered in the Study of Geology

- Immensity of the time scale - geologic time - 4.5 billion years!
- Immensity of the scope of study - from continents, mountains, and oceans to foraminifera and zircon crystals.
- Constant change - evidence of the past lost through destruction caused by weathering, erosion, deformation, compression, subduction, etc.
- Terminology
- (Often) difficult and (often) hazardous working conditions.

Geologic Time Scale



Geologic Time Scale and Periods

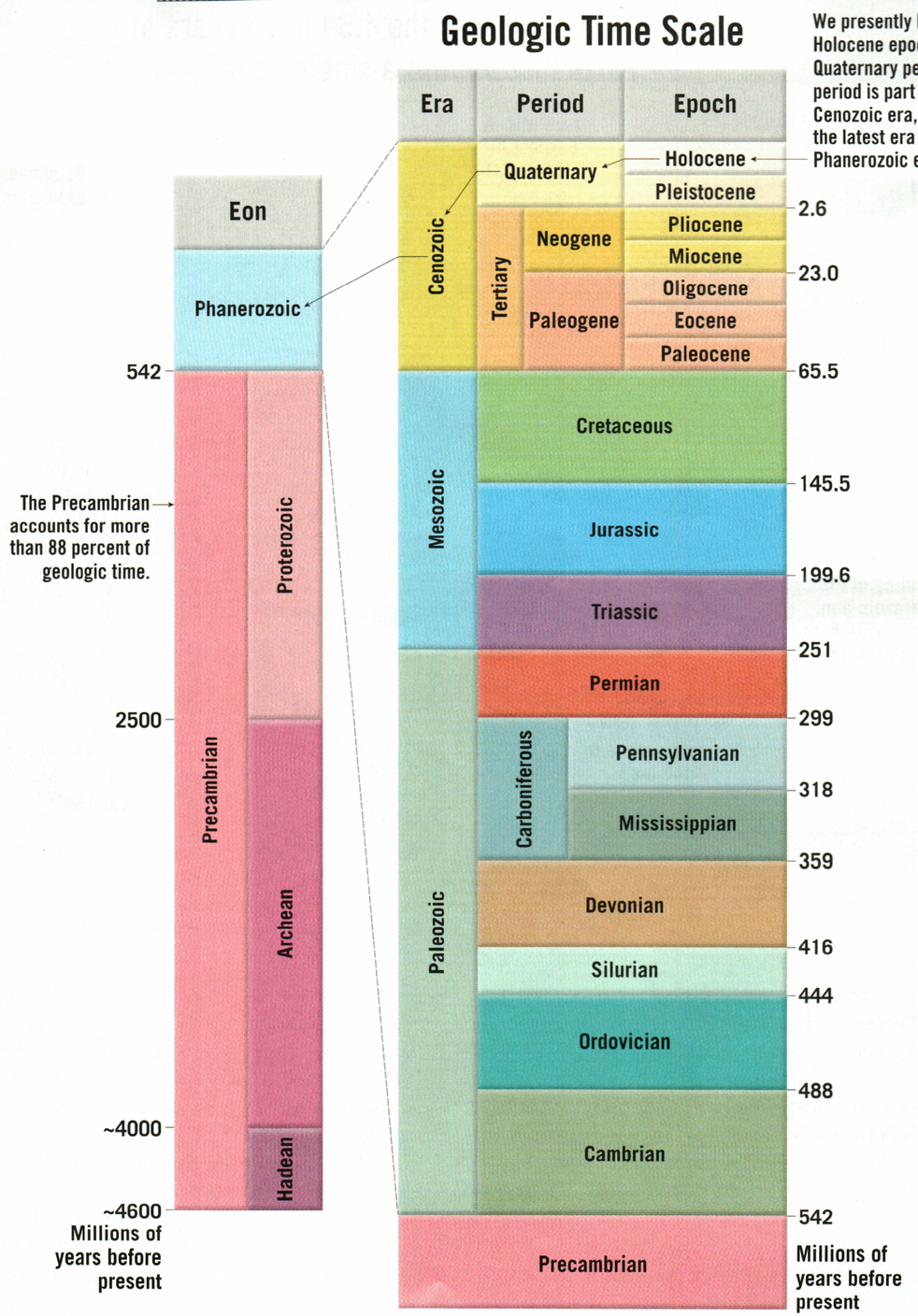
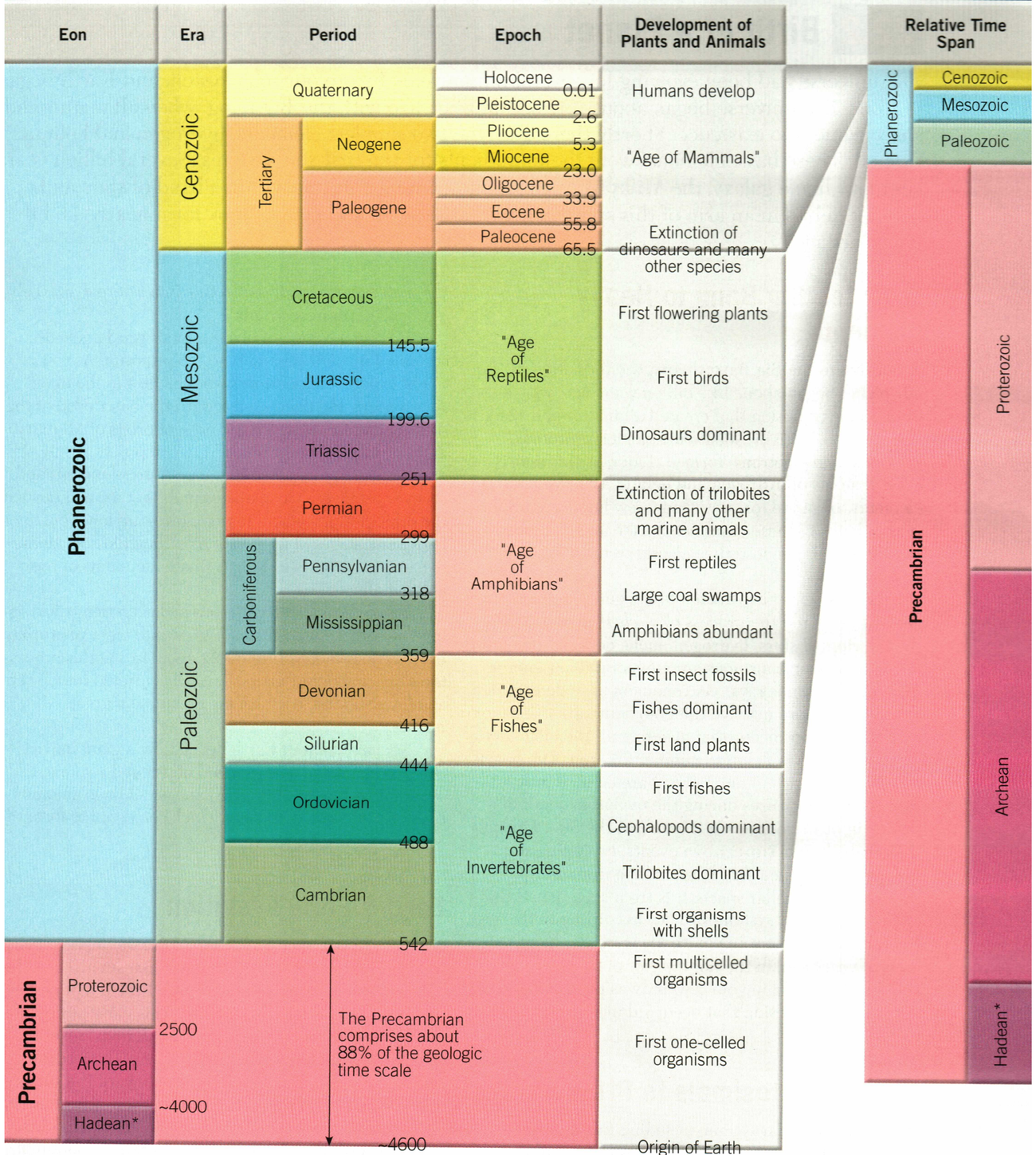


FIGURE 1.6 Geologic time scale: a basic reference
The geologic time scale divides the vast 4.6-billion-year history of Earth into eons, eras, periods, and epochs. Numbers on the time scale represent time in millions of years before the present.

Geological Time Scale and Major Events



Formation of the Earth

- All of the elements that make-up Earth came from stellar nucleosynthesis and supernovae.
- Dust clouds that resulted from these processes formed nebulae and began to gravitationally collapse. They contained all the elements up to Uranium, several minerals, and water, ammonia, methane, carbon dioxide, etc.
- The nebula that formed our solar system contracted into a rotating disk.
- Gravity continued to contract the hydrogen and helium in the disk toward the center, ultimately resulting in the formation of the sun.
- As the rotating disk cooled, particles began to collide and coalesce; the accretion continued and planetesimals formed.
- Runaway accretion produced a winner in each orbit - a single planetesimal that sweept up all the other planetesimals. Earth won in the third orbit.

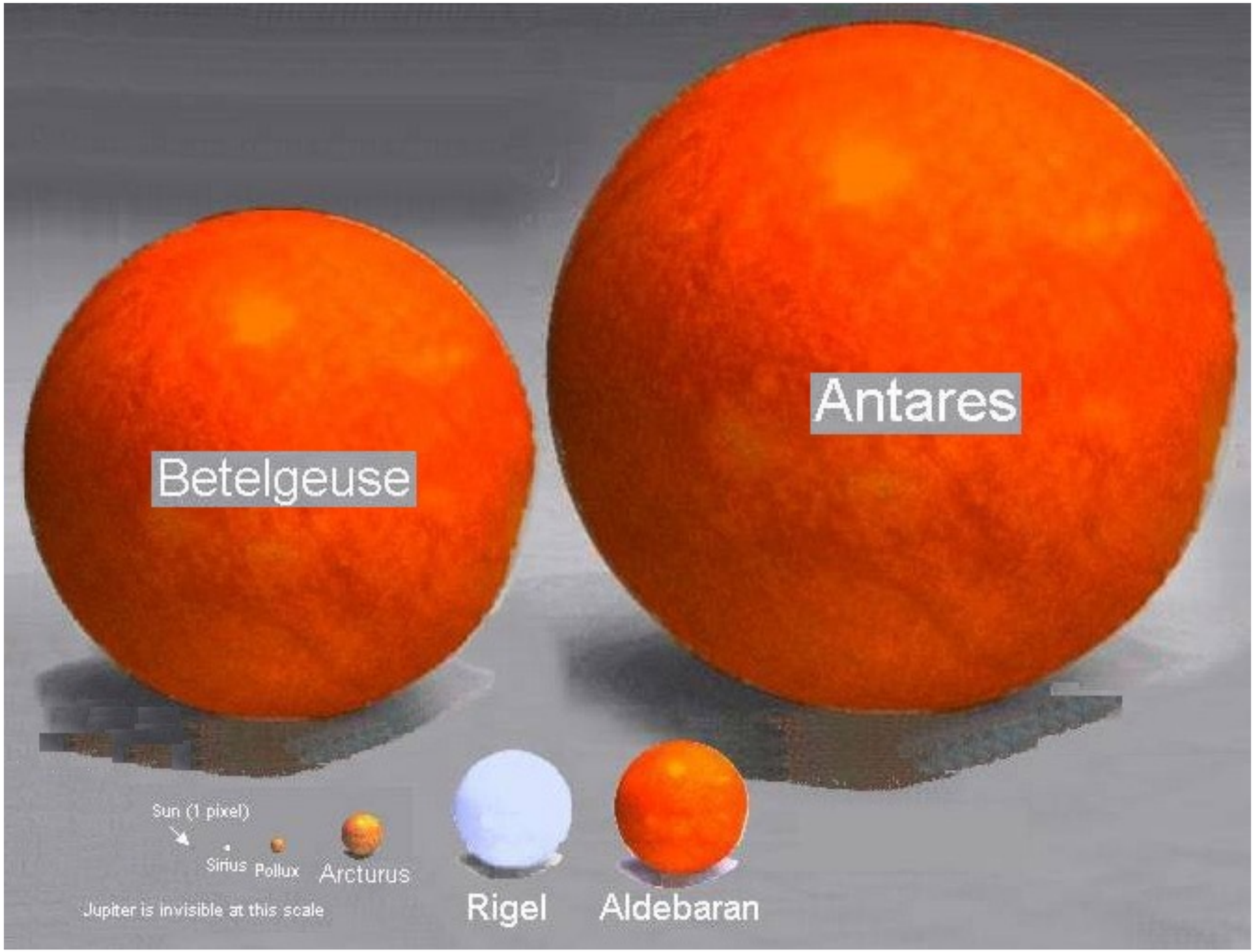
Stellar Nucleosynthesis

From a Talk By Lawrence Krauss, Arizona State University - Talk: (https://vimeo.com/31056022)

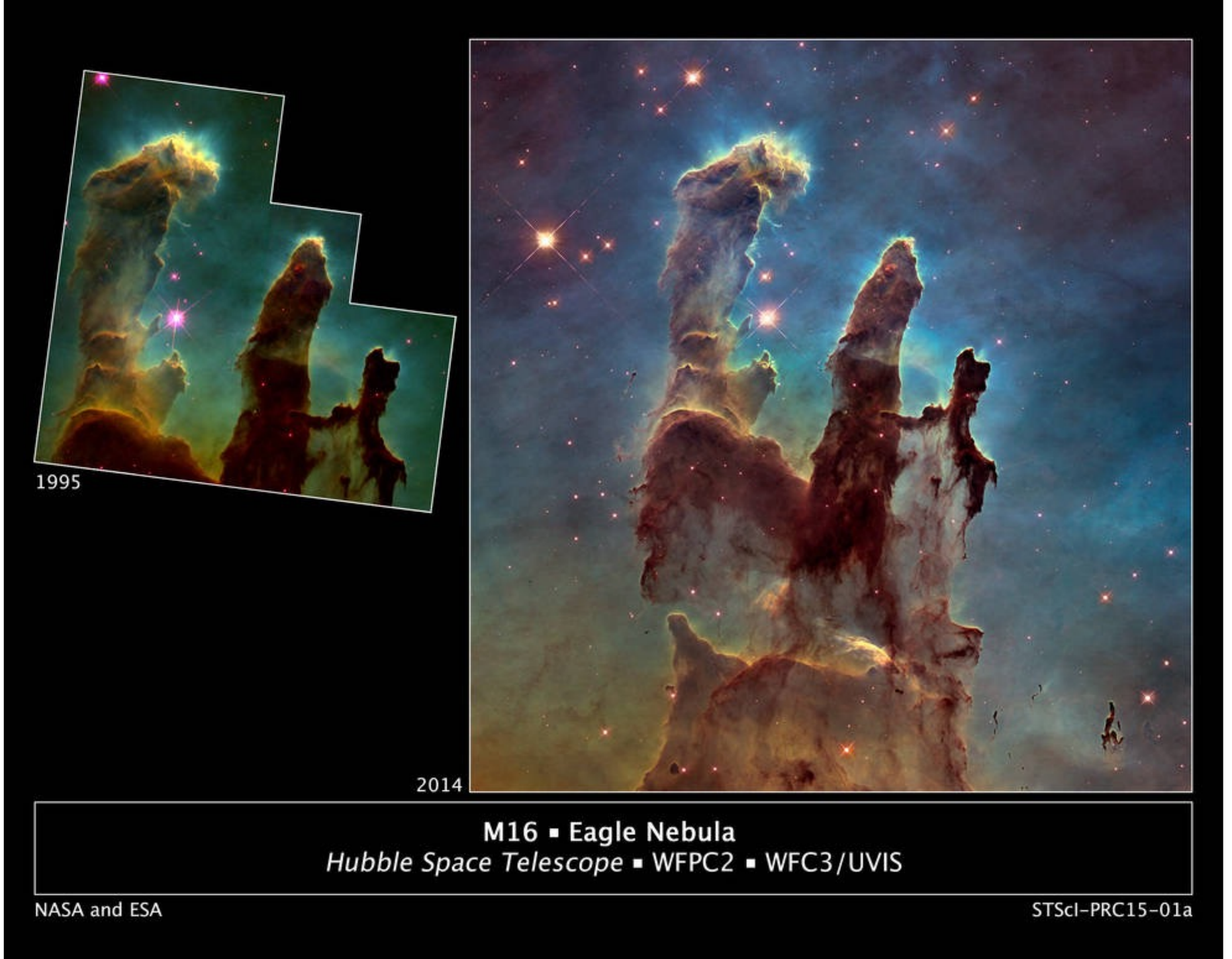
“Every atom in your body came from a star that exploded. And, the atoms in your left hand probably came from a different star than your right hand. It really is the most poetic thing I know about physics: You are all stardust. You couldn’t be here if stars hadn’t exploded, because the elements - the carbon, nitrogen, oxygen, iron, all the things that matter for evolution and for life - weren’t created at the beginning of time. They were created in the nuclear furnaces of stars, and the only way for them to get into your body is if those stars were kind enough to explode.... The stars died so that you could be here today.”

"All the hydrogen burns into helium in 10 million years.... All the helium burns to carbon in 1 million years.... Again, the star starts to collapse, because there's no more fuel. But then it heats up and the carbon starts to burn ... to form neon and nitrogen. And all of the carbon in the star burns in 100 thousand years.... And you get to oxygen. Oxygen ... burns to silicon in 10 thousand years. It's getting hotter and hotter and hotter. Less efficient. And then when all the oxygen burns to silicon, you're in the last day of the star because, remarkably, it is so hot at that point that all of the silicon in the center of the star, many thousands of times the mass of the Earth, burns to form iron in one day.... Iron can't burn to form anything. Iron is the most tightly-bound nucleus in nature. So once that's happened, there's no more fuel... When all the silicon has burned to iron, suddenly the star realizes there's no place left to go and that interior of the star, which has been held up by the pressure of nuclear burning, collapses. That whole collapse happens in one second.... There's a shock wave and that shock wave ... spews out all of the atoms that were created during the life history of a star. The carbon, the nitrogen, the helium, the iron. And that's vitally important, because every atom in your body was once inside a star that exploded.... The atoms in your left hand probably came from a different star than in your right hand, because 200 million stars have exploded to make up the atoms in your body."

Stellar Nucleosynthesis - Relative Star Sizes

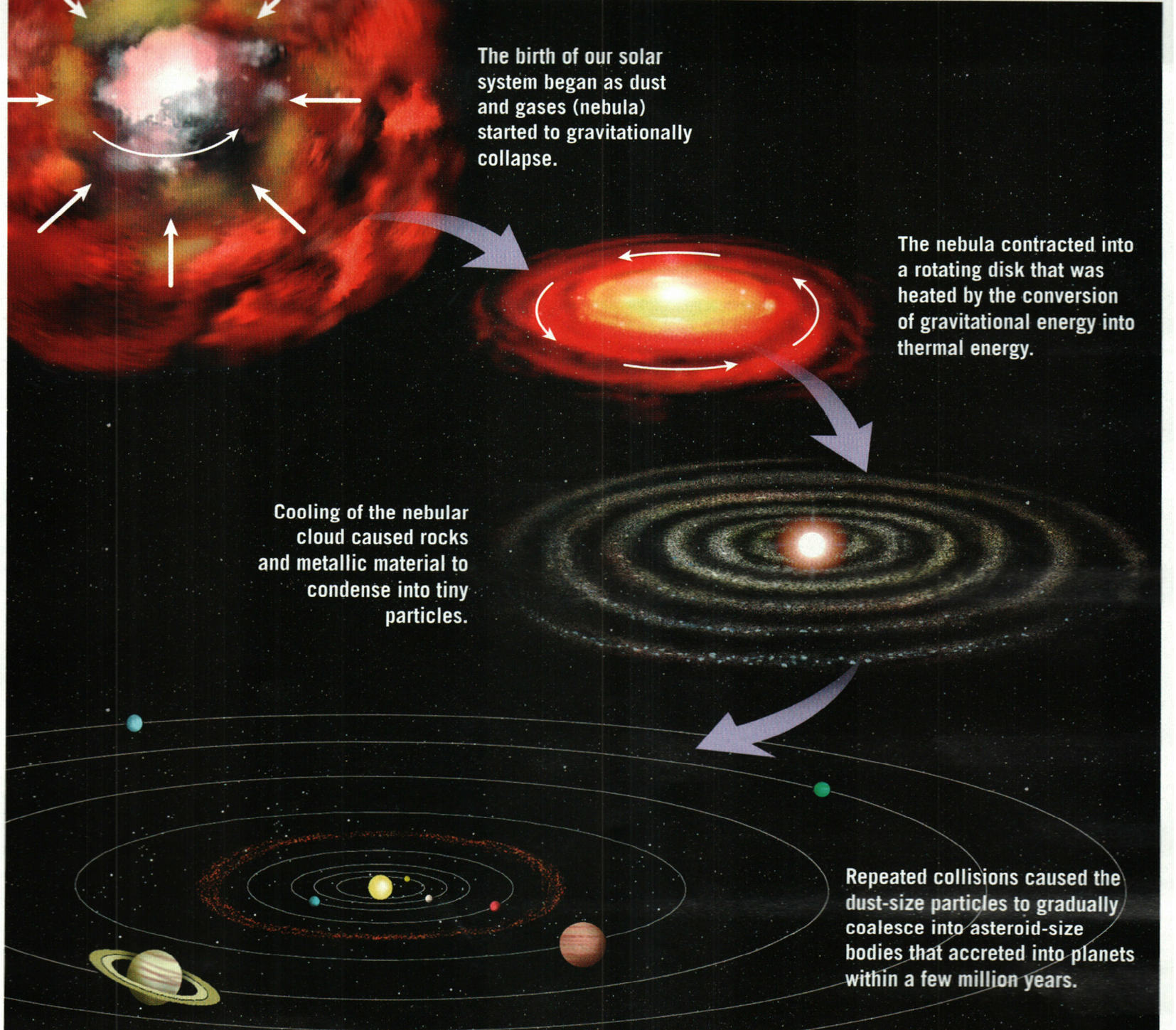


Pillars of Creation - Proto Stellar Nebulae



Cosmic Cliff - Proto Stellar Nebulae

Formation of the Solar System and Earth



Runaway Accretion

- Hazen on Runaway Accretion:
  - Video 1 - 3:45 to 6:06
  - Video 2 - 7:30 to 10:12

Next Up

- Chemical and physical differentiation of the Earth.
- Formation of Earth’s structure - crust mantle and core.
- Collision that formed the Moon.