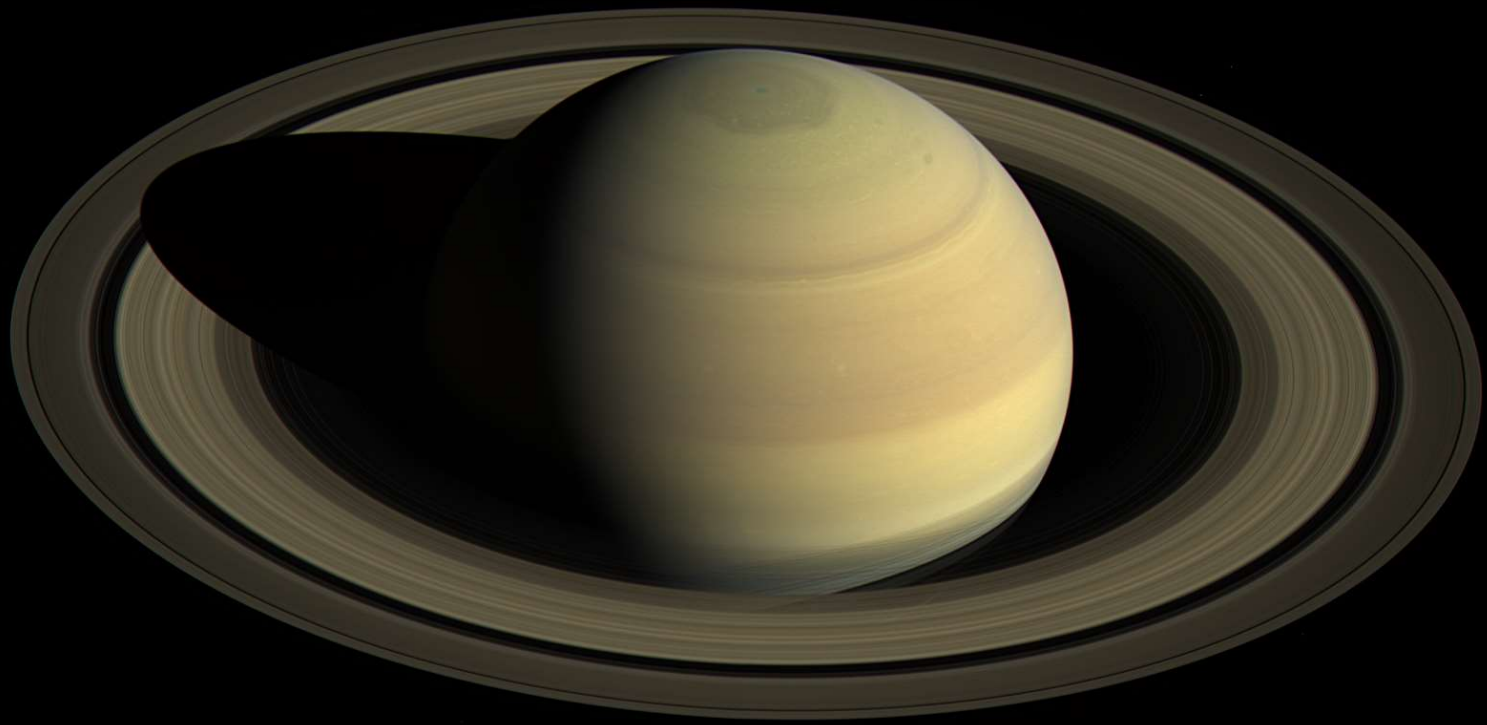
AST 2002
Introduction to Astronomy



A Few Quick Things…

E-mailing me: Must have AST2002 in the subject

Mary Hinkle, Graduate Teaching Assistant:

Office hours: Mon 1:30-3:00pm. PSB 316

~~My office~~ hours: Mon 3:00-4:00pm. PSB 316

(Amy in PSB316) Tue 3-4 pm. PSB 316

I will be in DC next week afterwards… Mon-Thur

Amy will be covering my office hours next week. I will try to be available Mon morning.

I will be going through the iClicker results Next Friday – Tuesday on an individual basis.

Curved Mid-term results are out on webcourses...

Homework is also out (next slide)

Final: Friday 27th April. 7am-9:50 am. (on all chapters; ~ 100 questions. 25:25:25:25)

LAST Knights Under the Stars Event – WAS Thursday 19th April

Opportunity to make up the 1% extra credit that was offered (if you haven't been yet, worth 2%) ***– Last chance for extra credit..***

Homework (Revised) & Evaluations

There are 3 homework sets on Webcourses:

- HW # 2 is on Chapters 1-5, 15 questions, due April 27th at midnight
- HW # 3 is on Chapters 6-9, 12 questions, due April 27th at midnight
- HW # 4 is on Chapters 10-13, 12 questions, due April 27th at midnight
- The Syllabus quiz has been re-opened and will be available until April 27th at midnight
- HW #1 has been re-opened and will be available until April 27th at midnight

Each quiz is worth 2%. The syllabus will be worth 1% and there will be a bonus 1% for putting up with the 'lack' of homework throughout this course…

Evaluations of the Course & Instructor are available on Webcourses – Please fill out this week!

The Exam… what to expect

Exam will be in Class in THIS ROOM on Friday 27th April 2018

- When you come in, please make sure you have plenty of space when you chose a seat

Do Bring:

- Scantron

https://ucfsga.com/services/free-scantrons-and-blue-books/

- Pencil (2B or #2 recommended)
- Make sure you know your PID
- Scientific Calculator
- An ID – you will need your ID to hand in the exam.

Don't Bring:

- Books, notes, or phones

The Exam… what to expect

- **The Exam will consist of 100 multiple choice questions.**
- **There will be 4 sections corresponding to ~ the same structure as the exams**
  - **Part I will be chapters 1-5 (25 questions)**
  - **Part II will be on chapters 6-9 (25 questions)**
  - **Part III will be on chapters 10-13 (25 questions)**
  - **Part IV will be on chapters 14-19 (25 questions)**
- **There will be matching questions and true or false questions in each section**
- **There will be minimal math questions…**
  - ***BUT – be prepared for doing some math, particularly in section I (chapters 1-5)***
- ***Some of the questions you will have encountered before!***

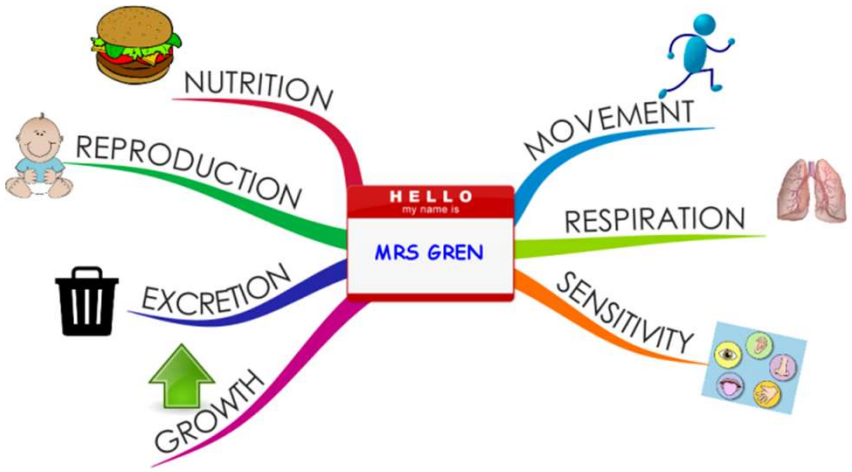
It will be based mostly on the lecture content BUT the general knowledge questions may rely on content within the books

THIS GUIDE MAY NOT COVER ALL THE MATERIAL THAT MAY BE ON THE EXAM, FOR THAT YOU SHOULD COVER ALL LECTURE MATERIAL AS WELL AS THAT FROM EITHER TEXT BOOK!!

Some material only covered in class could be on the exam…

Thought Question

… What is Life?



Well, there are >100 definitions…

Each have some flaw…

Definition from Wikipedia:

"From a physics perspective, living beings are thermodynamic systems with an organized molecular structure that can reproduce itself and evolve as survival dictates.[25][26] Thermodynamically, life has been described as an open system which makes use of gradients in its surroundings to create imperfect copies of itself.[27] ***Hence, life is a self-sustained chemical system capable of undergoing Darwinian evolution****.[28][29] A major strength of this definition is that it distinguishes life by the evolutionary process rather than its chemical composition."*

We Need a *Plausible* Pathway to the Origin of Life…

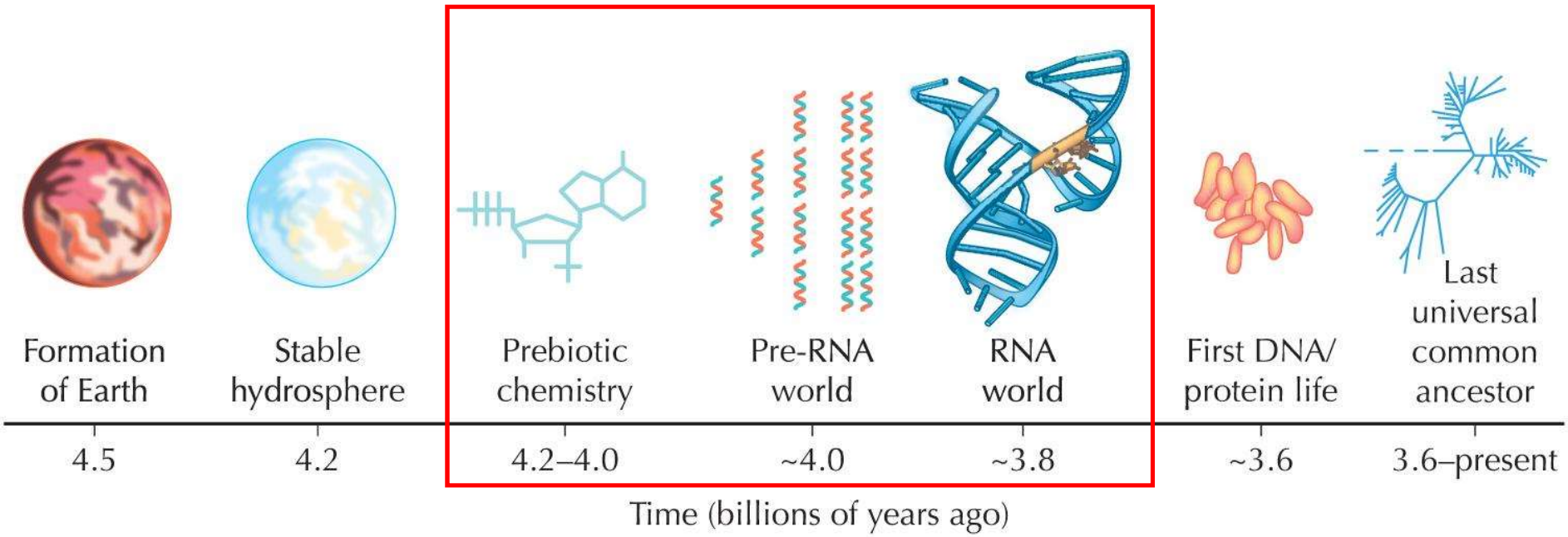


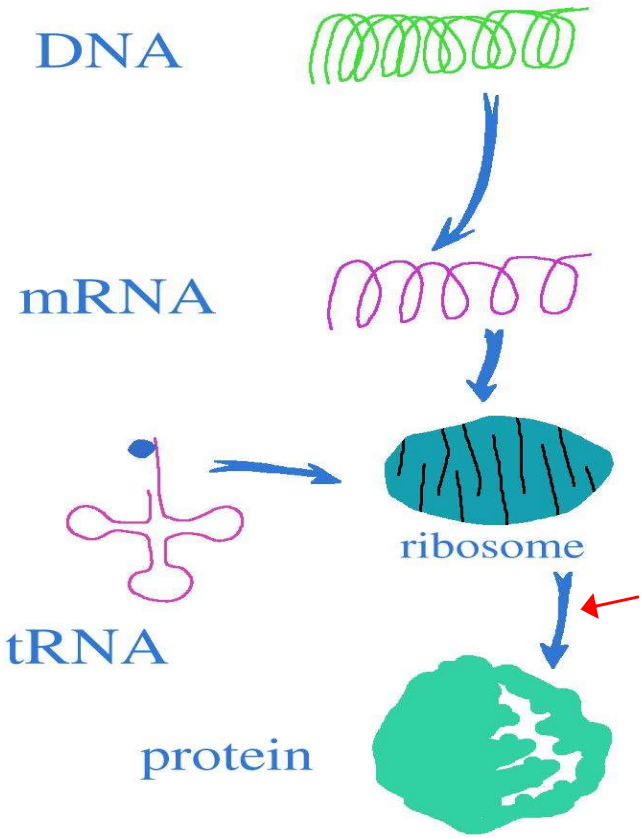
FIGURE 4.4. Steps in the origin of life.

4.4, modified from Joyce G.F., *Nature* **418:** 214–221, © 2002 Macmillan, www.nature.com

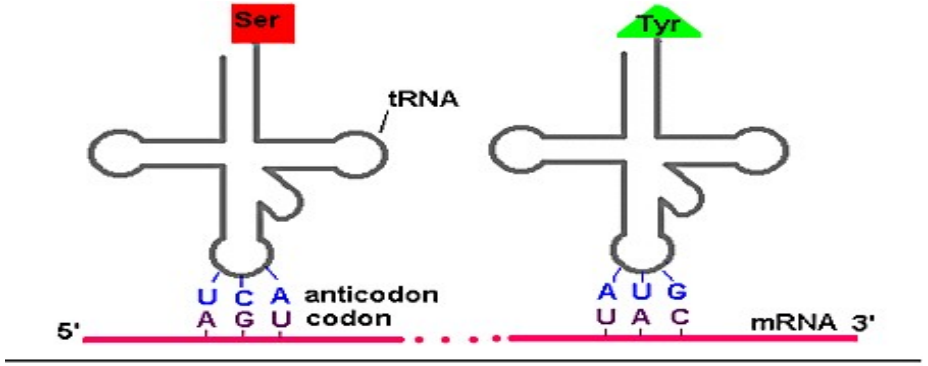
REVISED

The Molecular Basis of Present Day Life: The Universal Dogma

- Each three-letter DNA 'codon' translates to a specific amino acid. The code is then used to generate proteins, responsible for all biochemical processes…



TODAY, THIS STEP IS DONE BY RIBOZYMES (ENZYMES MADE of RNA)



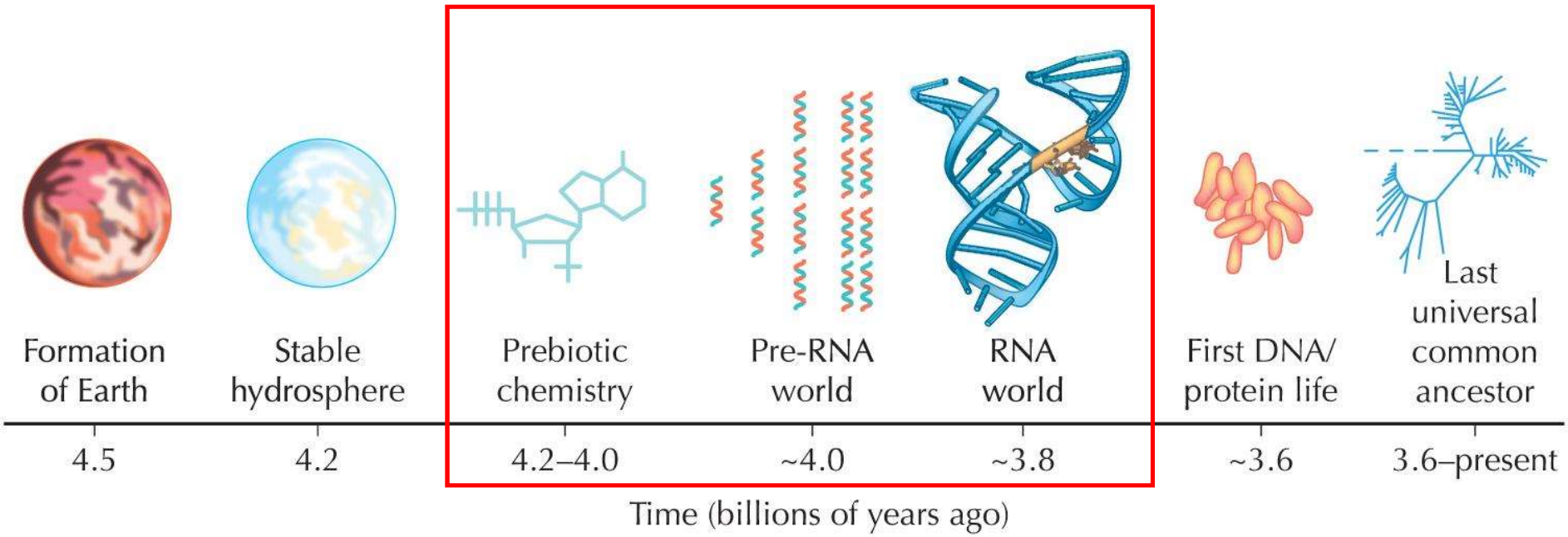
2nd base in codon

1st base in codon	U	C	A	G	3rd base in codon
U	Phe Phe Leu Leu	Ser Ser Ser Ser	Tyr Tyr STOP STOP	Cys Cys STOP Trp	U C A G
C	Leu Leu Leu Leu	Pro Pro Pro Pro	His His Gln Gln	Arg Arg Arg Arg	U C A G
A	Ile Ile Ile Met	Thr Thr Thr Thr	Asn Asn Lys Lys	Ser Ser Arg Arg	U C A G
G	Val Val Val Val	Ala Ala Ala Ala	Asp Asp Glu Glu	Gly Gly Gly Gly	U C A G

The Genetic Code

REVISED

We Need a *Plausible* Pathway to the Origin of Life…



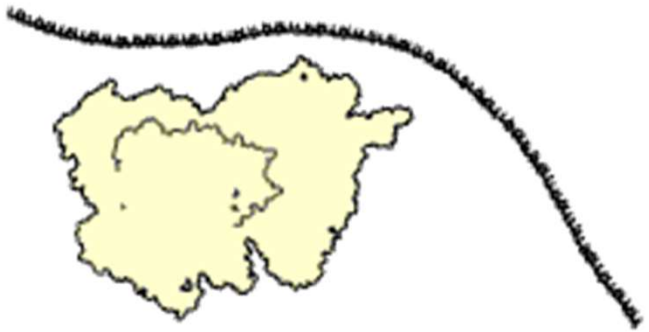
Since RNA can both store information as well as perform metabolic processes, ***most*** scientists think that the RNA world is a necessary intermediate step towards the protein/RNA/DNA world we observe today

Is RNA Prebiotically Implausible?
(is Prebiotic Peptide Formation any Easier?)

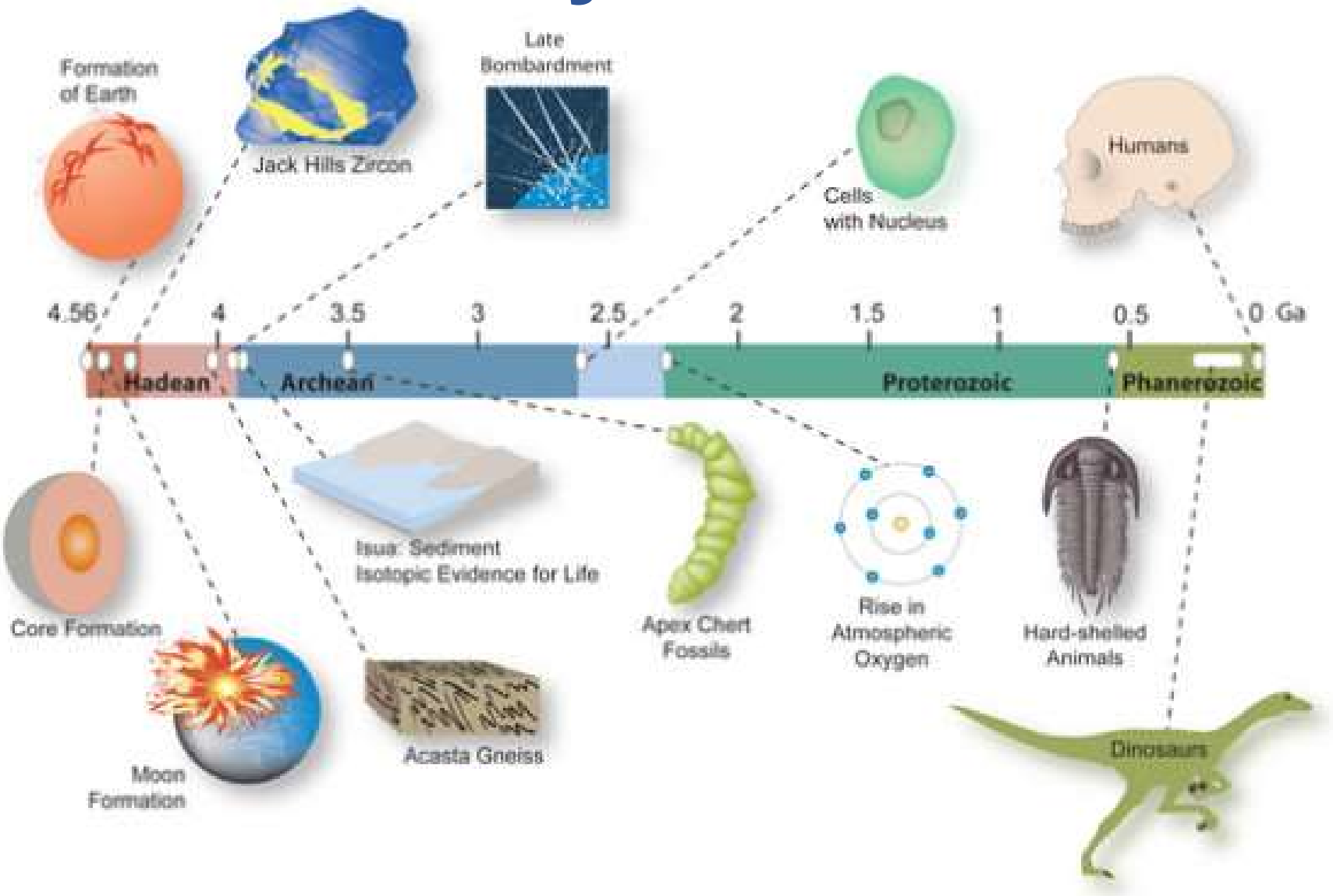
Present-day **Peptides** are made by **Ribosomal RNA**

Prokaryotes: 30S subunit = **16S** (1540 nuc.) + 21 proteins
50S subunit: = 5S (120 nuc.) + 23S (2900 nuc.)
+ 34 proteins

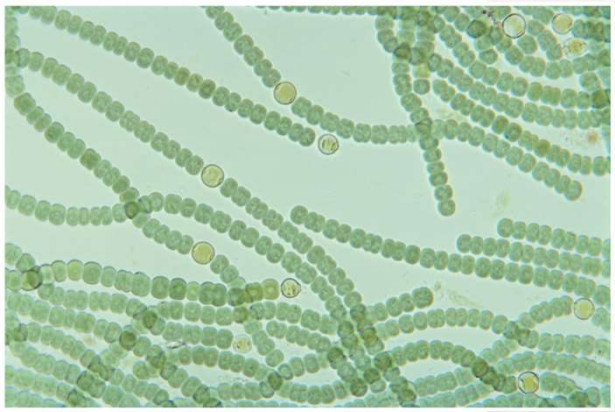
Eukaryotes: 40S subunit = 18S (1900 nuc.) + 33 proteins
60S subunit = 5S (120 nuc.) + 28S (4700n)
+ 5.8S (160 nuc.) + 49 proteins

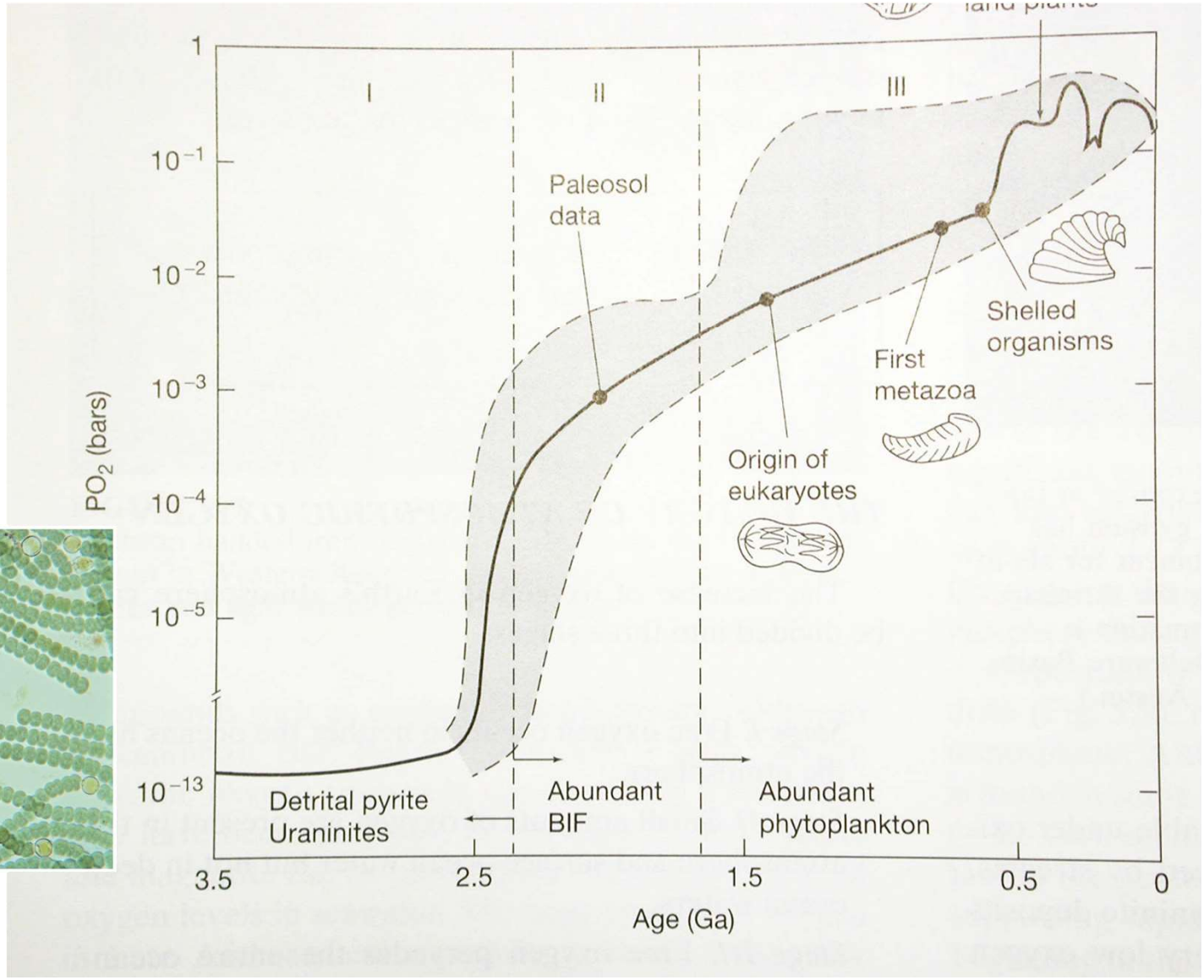


Brief History of Life on Earth

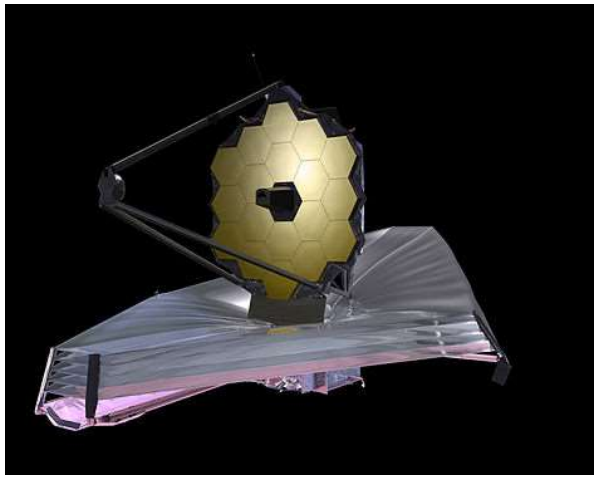


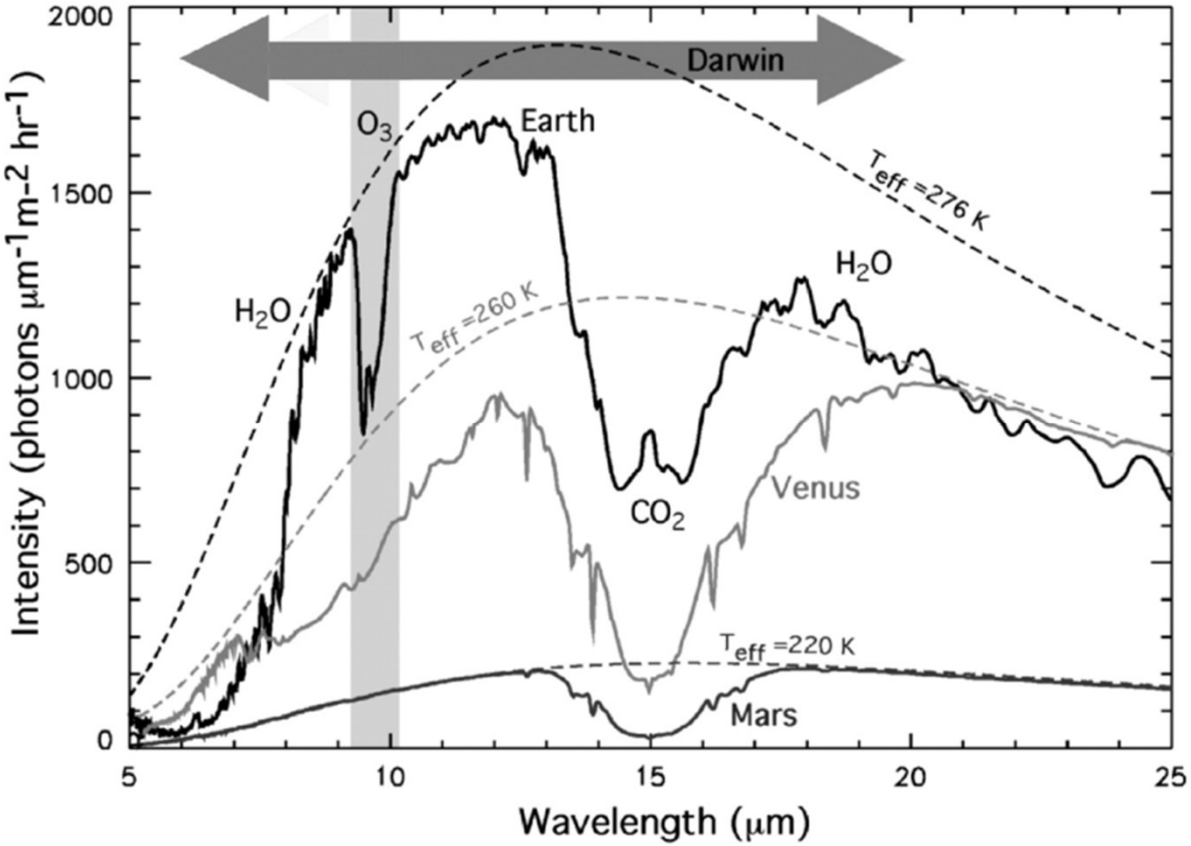
By 2.5 Billion years ago plankton were altering the oxygen content of the atmosphere





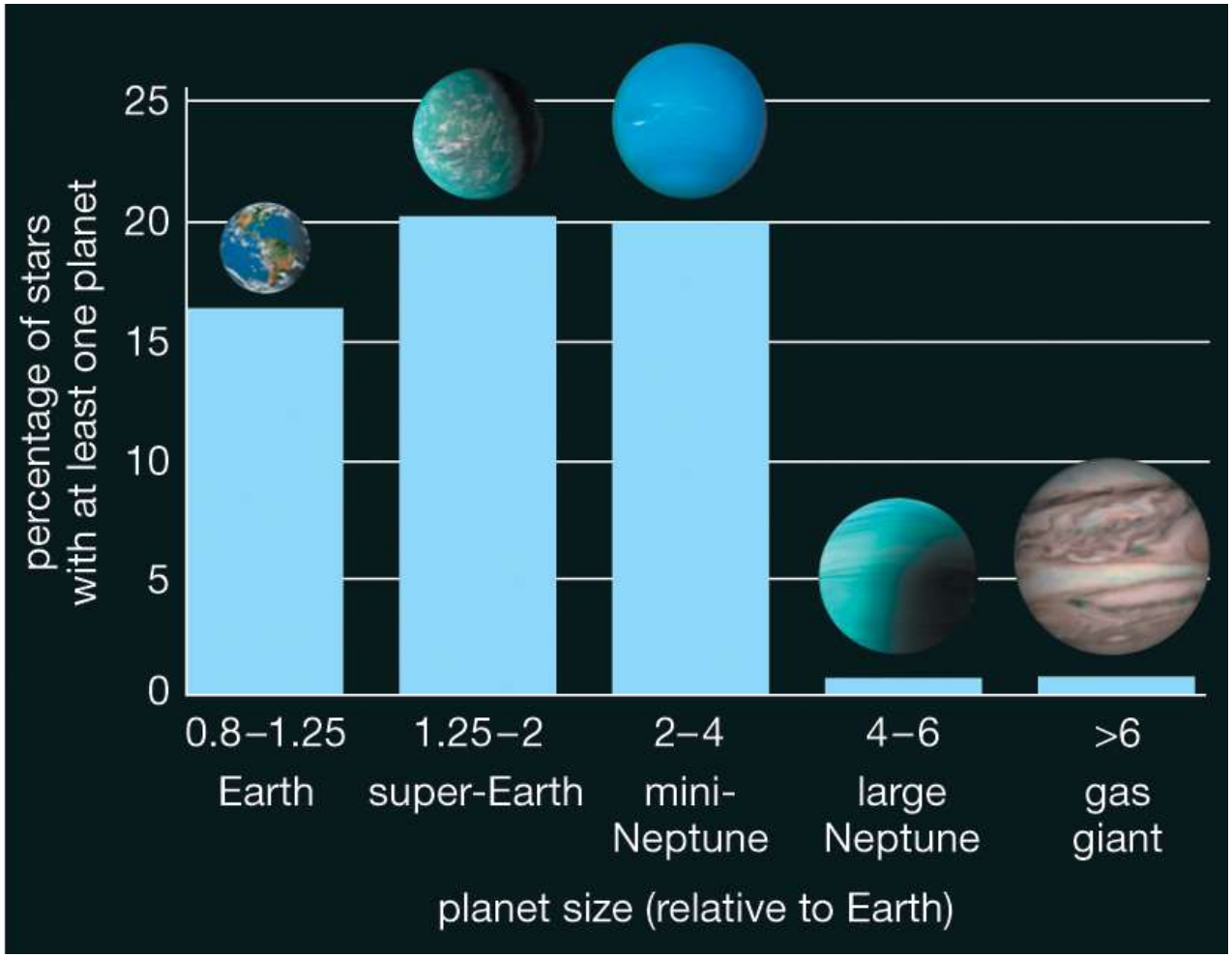
What are the Prospects for Finding Life Around Other Planets?





- The James Webb telescope (to be launched in 2019?) would be able to detect potential biosignatures within the atmospheres of Earth-like planets..

What kinds of extrasolar worlds might be habitable?



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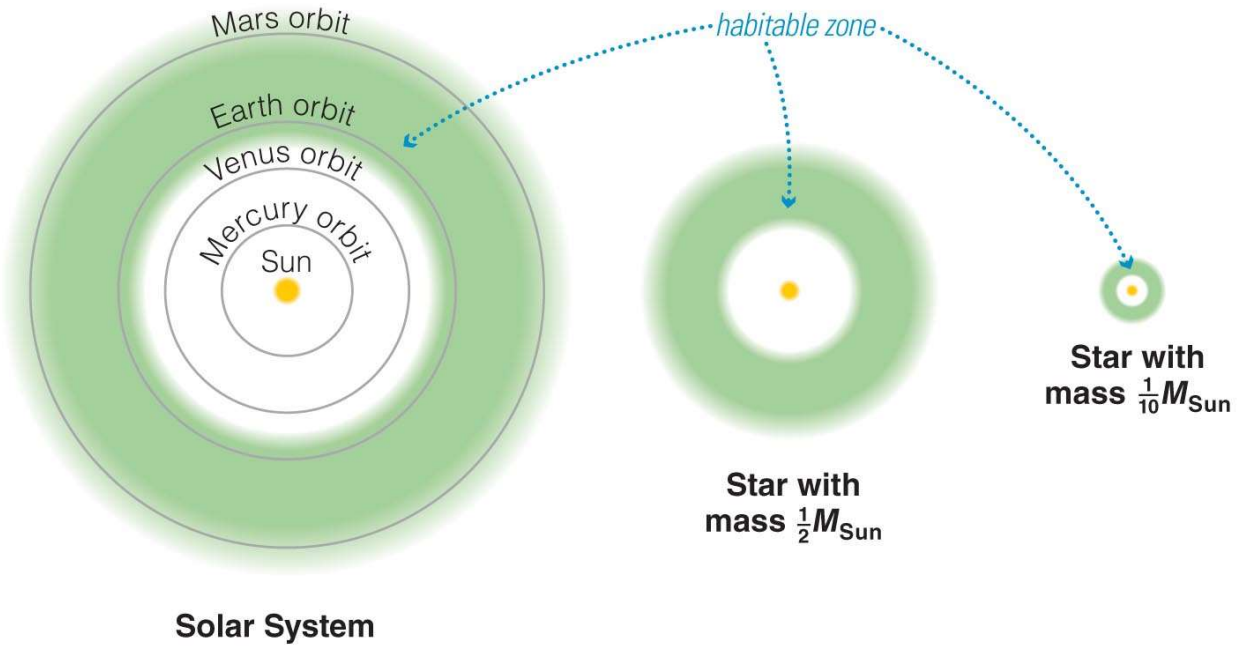
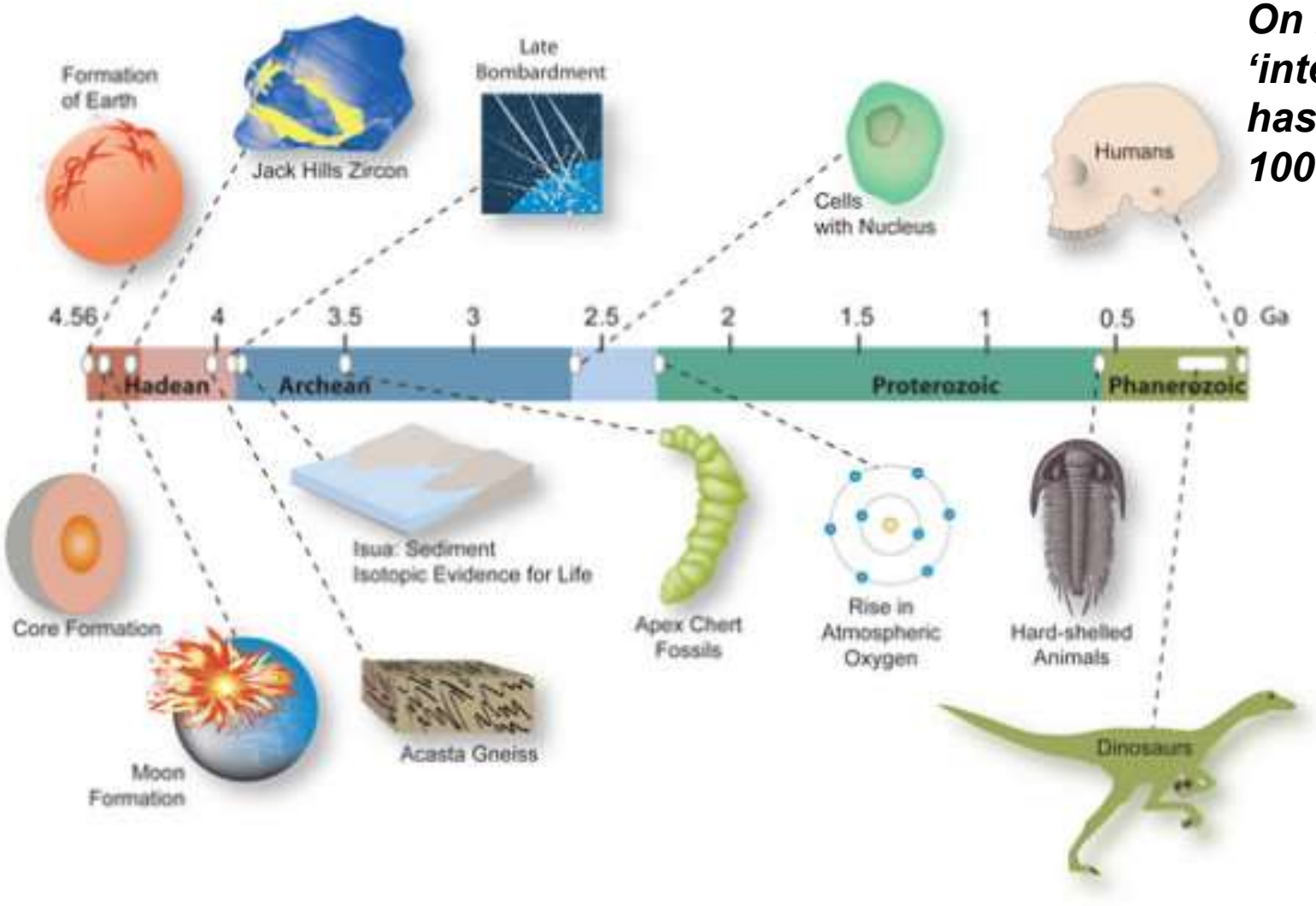


- The more massive the star, the larger the habitable zone—higher probability of a planet in this zone.
- However, our current techniques for detecting exoplanets are more likely to detect planets within the habitable zone around smaller stars where their orbital period is less.
- Also note that low-mass stars have longer lifetimes… why is that important?

Brief History of Life on Earth



On Earth, 'intelligent' life has existed for ~ 100 years

Andrée Valley, University of Wisconsin

So Where is Everyone? – The Fermi Paradox

That's 7 sextillion ($7x10^{22}$) stars in the known Universe:

- That's 70 000 000 000 000 000 000 000
- (also, many stars have multiple planets)

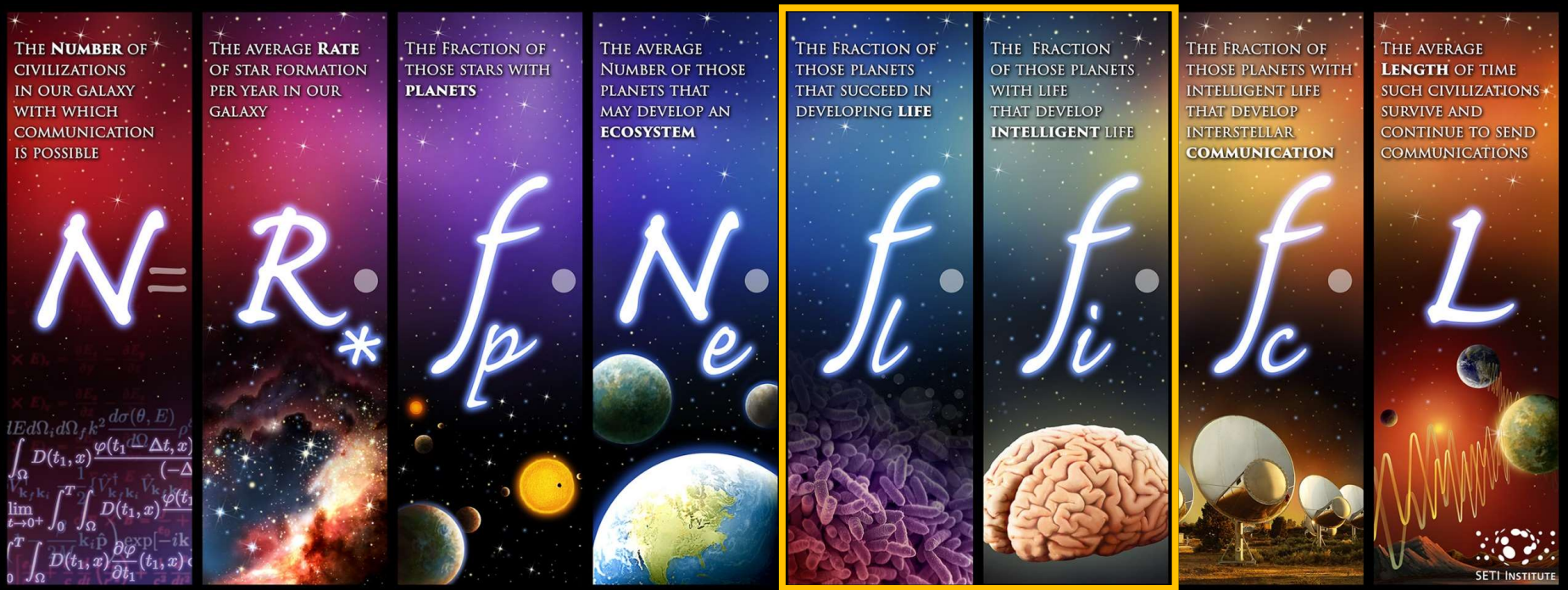
Enrico Fermi (1901 – 1954)

"(i) if such beings exist they would have visited Earth, and

(ii) if such civilizations existed then they would have given us some sign of their existence." - Fermi & Hart (1932)

Prof. Brian Cox (1968 –)
(Formerly of D:REAM)

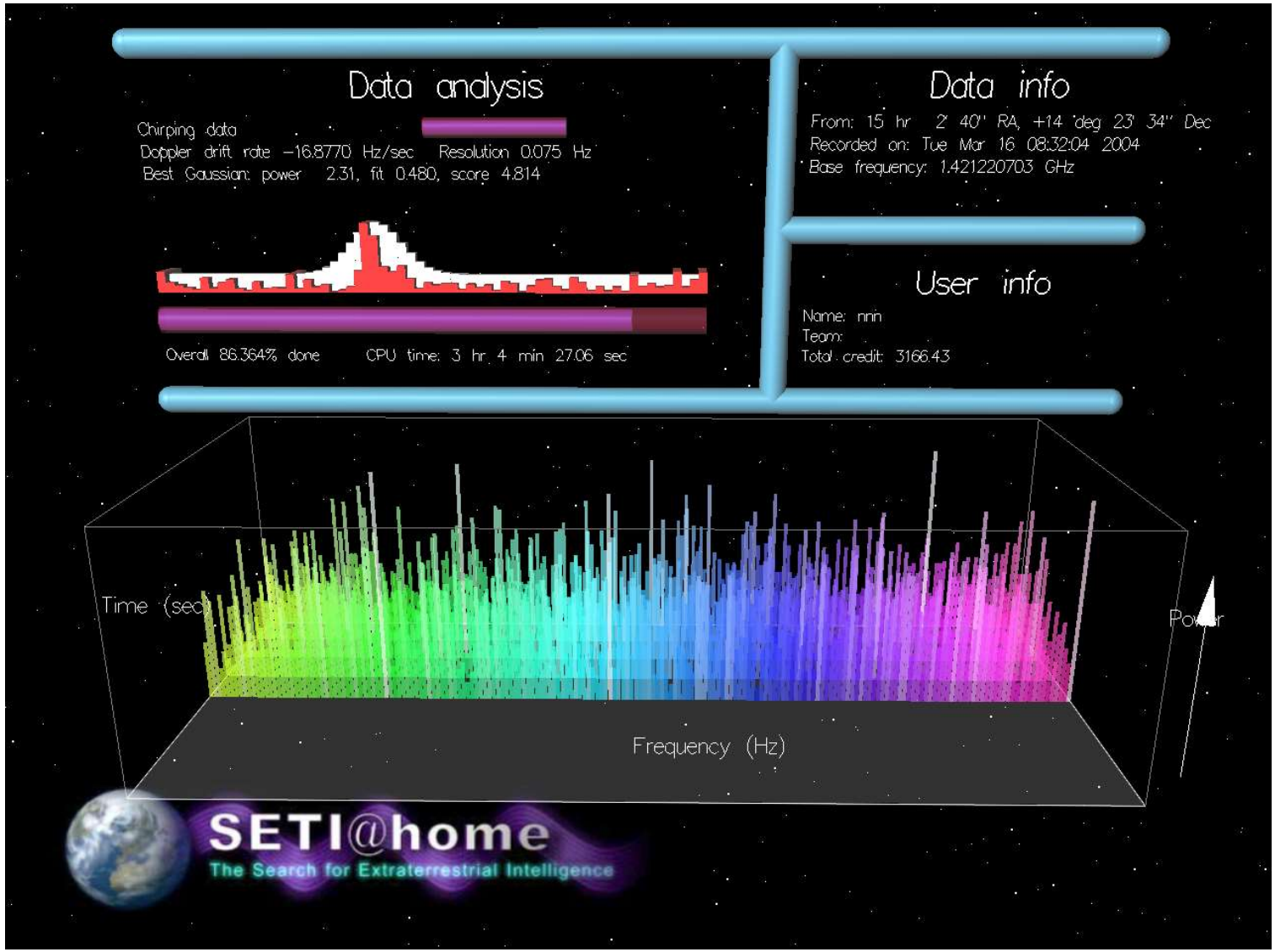
The Drake Equation (Frank Drake, 1961)



	1.5 - 3	~1	20% (HZ)	13%?	100%?	10-20%	10^4 - 10^9 yrs?

- N_e – ecosystem meaning support life. i.e. habitable zone… statistically, this would put several potential candidates within 12-50 AU.
- Based on these numbers, N is 156 million (optimistic) or 780 (pessimistic) within the milky way

SETI experiments look for **deliberate** signals from extraterrestrials



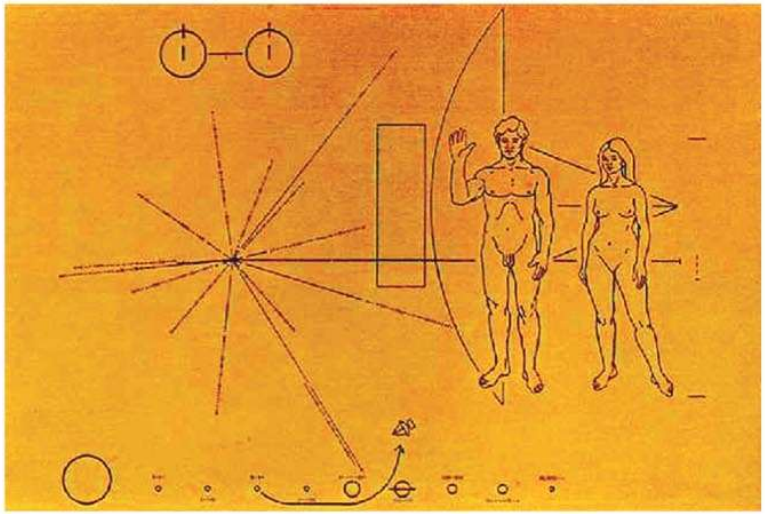
Your computer can help! SETI @ Home: a screensaver with a purpose

We've even sent a few signals ourselves…

- Earth to globular cluster M13: Hoping we'll hear back in about 42,000 years!
- Radio waves are thought to have the best chance for success…
- If they are no focused, die out in ~ 50-100 light years…

Messages on Current Spacecraft

- Current spacecraft travel at <1/10,000*c*; 100,000 years to the nearest stars



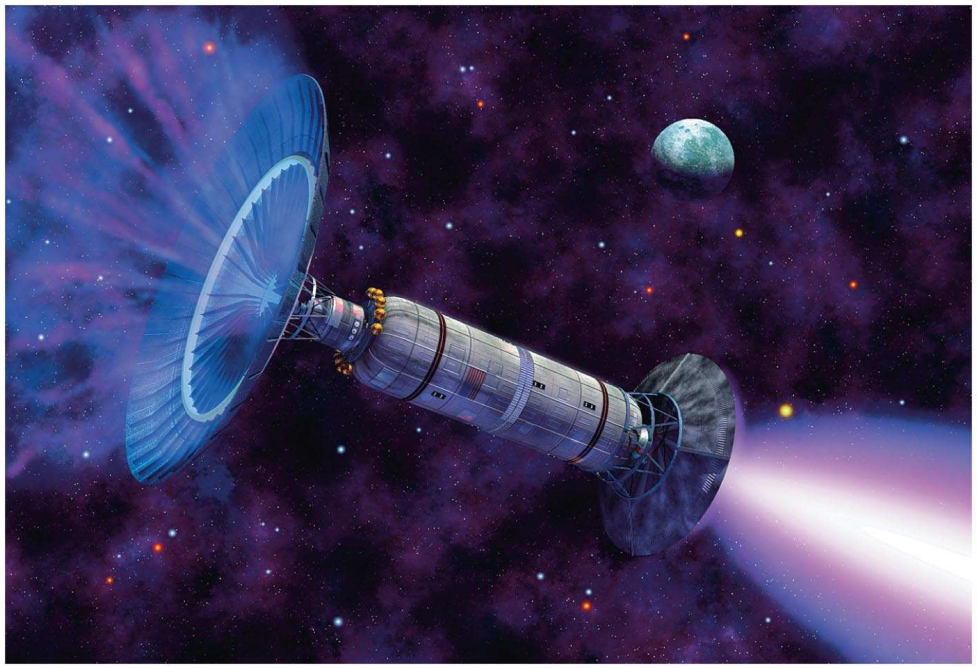
a The *Pioneer* plaque, about the size of an automobile license plate. The human figures are shown in front of a drawing of the spacecraft to give them a sense of scale. The "prickly" graph to their left shows the Sun's position relative to nearby pulsars, and Earth's location around the Sun is shown below. Binary code indicates the pulsar periods; because pulsars slow with time, the periods will allow someone reading the plaque to determine when the spacecraft was launched.

Pioneer plaque

b *Voyagers 1* and *2* carry a phonograph record—a 12-inch gold-plated copper disk containing music, greetings, and images from Earth.

Voyager record

Difficulties of Interstellar Travel & Communication



- Far more efficient engines are needed.
- Energy requirements are enormous.
- Ordinary interstellar particles become like cosmic rays.
- There are social complications of time dilation.

Possible solutions to Fermi's Paradox:

- Origin of Life occurs very rarely (requires special conditions, e.g. Moon-forming impact)
- Intelligent life rarely occurs, which is able to develop signatures
- Interstellar travel & may be impossible, communicating with light too slow…
- Civilizations exist, but have no interest in contacting us … yet!

Study Guide – Chapter 14

14.1. White Dwarfs

- What is a white dwarf?
  - What stars will form a white dwarf, and what Is it? [ch14 slides 4-8]
  - What stops a white dwarf from collapsing to an infinitely small point? [ch14 slides 7-8] – DEGENERACY PRESSURE. What kind? ELECTRON DEGENERACY
- What can happen to a white dwarf in a close binary system?
  - How does a Nova occur? [ch14_slides 9-10]
  - What happens if a white dwarf gets larger than 1.4 M_{sun}? [ch14_slides 11-15]
  - What causes a type Ia versus a type II supernova? [ch14_slide 13]
    - Why are Type Ia supernova useful? [ch16 slides 60-61]

14.2. Neutron Stars

- What is a neutron star?
  - What stars will form a neutron star? [ch14_slides 4-5]
  - What is a neutron star? [ch14 slides 16-19]
- How were neutron stars discovered? [ch14 slide 20]
  - Most neutron stars are pulsars (act like lighthouses!) [ch14 slides 20-24]

Study Guide – Chapter 14

- What can happen to a neutron star in a close binary system?

14.3. Black Holes: Gravity's Ultimate Victory

- What is a black hole? [ch14, slides 34-38] [ch15, slide 21]
  - Special relativity ~~[ch14, slide 28]~~ [ch15, slide 12]
  - General relativity [ch14, slides 30-33] [ch15, slide 15]
- What would it be like to visit a black hole?
  - What is spaghettification? [ch14, slide 39], [ch15 slide 23]
- Do black holes really exist?
  - *We skipped this, BUT chapter 15 talks about it a little bit…*

14.4. Stars in Close Binaries

- What causes gamma-ray bursts? [ch15_slide 24]
- What happens when black holes merge?
  - Gravity wave detection: LIGO [ch14 slides 25-27]

Study Guide – Chapter 15

15.1. The Milky Way Revealed

- What does our galaxy look like? [ch15, slides 26-29]
  - Can you describe the size, shape and main features of the galaxy? [ch15 slide 28]
  - What kind of galaxy is the Milky Way thought to be? [ch15, slide 29]
  - What do different wavelengths tell us about? [ch15, slide 39]
    - *Which wavelengths tell us about dust?*
    - *Which wavelengths tell us about the presence of atoms? Molecules?*
- How do stars orbit in our galaxy?
  - Disk stars vs. halo stars vs. bulge stars [ch15, slides 30-33]

15.2. Galactic Recycling

- How is gas recycled in our galaxy? [ch15 slide 34]
  - Most stars give off substantial mass during their lifetime [ch14 slide 5]
  - Some stars lose their outer layers (white dwarfs)
  - Larger stars explode as supernovae
    - Very energetic – but falls back to the disk plane [ch15 slides 34-36]

Study Guide – Chapter 15

- Where do stars tend to form in our galaxy?
  - How does the spiral remain if stars are moving at different speeds? [ch15 slide 37]
  - Are older or younger stars found in the spiral arms? [ch15 slide 38]

15.3. The History of the Milky Way

- What do halo stars tell us about our galaxy's history?
  - Halo population is older with random directions [ch15 slides 33, 40]
- How did our galaxy form? [ch15 slide 40]

15.4. The Galactic Center

- What is the evidence for a black hole at our galaxy's center?
  - Many stars close to the center appear to orbiting something huge [ch15 slide 41]

Study Guide – Chapter 16

- **Chapter 16: A Universe of Galaxies (Abridged)**

16.1. Islands of Stars

- What patterns do we find among the properties of galaxy's?
  - Different types of galaxies [ch16 slides 43-52]
  - Which galaxies are older (redder), or more luminous? Why? [ch16 slide 53]

16.2. Distances of Galaxies

- How do we measure the distances to galaxies?
  - Parallax method (from previous chapters)
  - Standard candles [ch16 slides 55-61]
    - Cepheids [ch16 slide 58-59]
    - Type Ia supernova [ch16 slides 60-61]
  - Hubble's law
- What is Hubble's law?
  - What is relationship between red-shift and velocity? [ch16 slides 63-64]
  - What does Hubble's law tell us about the movement of galaxies? [ch16 slide 64]

Study Guide – Chapter 16

- How do distance measurements tell us the age of the universe?
  - We can use Hubble's law to tell us how old the Universe is [ch16 slide 66]
    - *BUT the universe is expanding AND had an inflation period early on…*
    - *These two cancel out in the derived Hubble constant…*
  - What do we mean by lookback time? [ch16 slide 67]
    - Examples – Betelgeuse, Andromeda

16.3. Galaxy Evolution

- How do we study galaxy evolution?
- Why do galaxies differ?
- How does gas cycle through galaxies?

16.4. The Role of Supermassive Black Holes

- What is the evidence for supermassive black holes at the center of galaxies? *Larger galaxies have larger black holes…*
- Do supermassive black holes regulate galaxy evolution?

Study Guide – Chapter 17

Chapter 17: The Birth of the Universe (Abridged)

17.1. The Big Bang Theory

- *The big bang was the creation of space itself* [ch17 slide 34]

- What were the conditions like in the Early Universe?
  - HOT! ... Laws of physics break down… [ch17 slides 29-30, 33, 37]
- How did the early universe change with time?
  - Planck Era → GUT Era → Electroweak Era → Particle era (10^{-10} s) [ch17 slides 35-39]
  - Particle Era – cool enough to form nuclei and excess of ordinary matter [ch17 slide 40]
  - Era of Nucleosynthesis – Fusion generates Deuterium, Helium, Lithium [ch17 slide 41, 42] – *Abundances confirm big bang predictions…*
  - Era of Nuclei – after a few minutes no longer hot enough to sustain fusion [ch17 slide 43]
  - Era of atoms ~ 3000 K, 380,000 years. Now cool enough for atoms to form [ch17 slide 44]
  - Era of Galaxies (NOW) – there was darkness until the first stars formed [ch17 slides 45-46]

Study Guide – Chapter 17

17.2. Evidence for the Big Bang

- How do observations of the cosmic microwave background support the big bang theory?
  - What is the cosmic microwave background? [ch17 slides 47-52]
  - Same in all directions indicates inflation
  - Scale of variations/patches consistent with 'flat' universe [ch17 slide 52]
- How do the abundances of the elements support the Big Bang theory?
  - Abundance of helium, deuterium and lithium all match [ch17 slide 42]

17.3. The Big Bang and Inflation

- What key features of the universe are explained with inflation?
- Did inflation really occur?

17.4. Observing the Big Bang for yourself

- Why is the darkness of the night sky evidence for the big bang?
  - COBE shows the same pattern in different directions – How?
  - What is Olber's paradox? [ch17 slide 28]

Study Guide – Chapter 18

- **Chapter 18: Dark Matter, Dark Energy, and the Fate of the Universe (Abridged)**

- 18.1. Unseen influences in the Cosmos
- What do we mean by dark matter and dark energy? [ch18 slide 18]
  - Can you describe what dark matter is?
  - Can you describe what dark energy is?
  - What % of each are needed to reach the critical density?
  - What % of each are needed to explain the observed density?

- 18.2. Evidence for Dark Matter
- What is the evidence for dark matter in galaxies? [ch18, slides 19-26]
- What is the evidence for dark matter in clusters of galaxies?
  - What is the Mass-to-light ratio? [Ch18 slide 27]
  - Evidence from gravitational lensing [Ch18, slides 28-29]
  - Evidence from X-rays of gases between clusters [ch18, slides 30-32]

Study Guide – Chapter 18

- Does dark matter really exist?
  - Ordinary matter alone cannot explain many features of the Universe… [ch18 slides 36, 41], as well as section 18.2
- What might dark matter be made of?
  - Probably not MACHOs [ch18 slide 32]
  - Probably WIMPS [ch18 slide 33]

18.3. Structure Formation

- What is the role of dark matter in galaxy formation? [ch18 slide 36]
- What are the largest structures in the universe? [ch18 slide 35]

- 18.4. Dark Energy and the Fate of the Universe [ch18 slides 37-41]
- What is the evidence for an accelerating expansion?
  - Observations of type Ia supernova & red-shifts [ch18 slide 39]
- Why is flat geometry evidence for dark energy? [ch18 slides 40-41]
  - Normal matter ~ 5%, Dark matter ~ 27 % … *'68% missing' but* $E=mc^2$
- What is the fate of the universe? [ch18 slides 37-41]

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Study Guide – Chapter 18

Chapter 19: Life in the Universe (Abridged)

19.1. Life on Earth

- When did life arise on Earth? [ch19 slides 19-38]
  - Can you explain the evidence and time of the following:
    - Earliest evidence for life? [ch19 slide 21]
    - Earliest fossils (and stromatolites)? [ch19 slide 22]
    - Cells with a nucleus
    - The rise in oxygen – what does this allow for? How? Ozone! [slide 37, 46]
    - The Cambrian explosion
    - The extinction of the dinosaurs (K-T boundary)

- How did life arise on Earth?
  - The path to RNA/DNA/protein world is unclear [ch19 slides 22-29]
  - LUCA and extremophiles [ch19 slides 28, 33]
  - Potential contributions from: [ch19 slides 30-32]
    - Atmosphere
    - Hydrothermal vents
    - Extraterrestrial delivery

Study Guide – Chapter 18

- What are the necessities of Life? [ch19 slide 34, 39, 48]
  - Liquid water! … also energy, and stable environment…

19.2. Life in the Solar System

- Could there be life on Mars? [ch19 slides 40-42]
- Could there be life elsewhere in the Solar System? [ch19 43-45]

19.3. Life Around Other Stars [ch19 slides 46-48]

- What are the requirements for surface life?
- What kinds of extrasolar worlds might be habitable?
- How could we detect life on extrasolar planets?

Study Guide – Chapter 18

19.4. The Search for Extraterrestrial Intelligence [ch19 slides 56-59]

- How many civilizations are out there? – How does SETI work?

19.5. Interstellar Travel and It's Implications for Civilization [ch19 slides 50-60]

- How difficult is interstellar travel? Where are the aliens?

Good Luck!