Reading Guide: A Short History of Nearly Everything
IB Physics 1 and 2 NOT REGULAR PHYSICS
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Over the summer I want you to focus on the following 5 broad questions. Have a one paragraph response for each of the 5 questions ready to turn in on day one. Throughout the year we will focus on a chapter at a time. The questions for those chapters are included in this document, but you don't have to answer them over the summer (I would rather you wait to do them for when we are about to discuss it in class so that it is fresh in your mind).

As you read this book, there are many general questions to ask yourself about the nature of scientific knowledge, the nature of the scientific endeavor and the human side of science. These include:

1. How does a scientific discovery/theory relate to the discoveries/theories that preceded it? Does the new discovery/theory build on the old one? Does it completely replace the old one?

2. Many science textbooks start with a chapter describing THE scientific method. Based on the dozens of stories in this book, is there one scientific method? Did every scientist work the same way? Are there many similarities between the methods each scientist used? Some? None?

3. Humans are competitive. How has this competitive nature helped the progression of science? How has it hindered the progression of science? You should be able to find examples of both in this book.

4. What is the role of a scientist in promoting her own or his own cause? Should they be aggressive advocates, pushing their work no matter what? Or, should they let the scientific community decide on the importance of their work? Should the government or the general populace decide which scientific ideas or theories are to be supported?

5. The author is a master at numerical analogies. For example, on page 135 he notes that one atom is to the width of a millimeter line as the thickness of a piece of paper is to the height of the Empire State Building. How do these analogies help you learn the content they are trying to explain? Can you think of any others? Writing one of your own is great practice for proportional reasoning.

I hope you enjoy the book, I know I did. If I don't already know you I look forward to meeting you and having an awesome year together. Have a great summer!

-Mr. Simpson

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Chapter 1: How to Build a Universe

This chapter describes the evidence for how the universe was formed. Be on the lookout for some very large (10^{89}) and very small (10^{-43}) numbers about the universe.

Discussion Questions

1. What does the author mean when he writes "from nothing, our universe begins"?

2. Describe the discovery of the cosmic background radiation. How does this radiation support the Big Bang Theory?

3. Some people claim the universe is "fine tuned" for our existence. What information from this chapter might someone use to provide evidence to support this claim?

4. J. B. S. Haldane once noted: "The universe is not only weirder than we suppose; it is weirder than we can suppose." What do you think Haldane meant by this? List two possible examples.

5. What are the main components of an atom? Is an atom a solid thing? Explain.

6. What are the scientific challenges to understanding the universe *before* the big bang? What was Dr. Linde's comment about this?

7. How is the concept of an "edge" or "center" of the universe not meaningful?

8. Who coined the term "big bang"? How did that person regard the theory?

9. What evidence of the big bang was inadvertently discovered by Penzias and Wilson in 1965? Had this evidence been predicted? Who got the Nobel prize for this, the discoverers or the predictor? How is the 2006 Nobel prize in Physics related to this discovery?

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Chapter 2: Welcome to the Solar System

Discussion Questions

1. Describe Percival Lowell's contributions to astronomy. Classify each as important or unimportant to furthering the study of astronomy. Defend each classification.

2. What are some characteristics of Pluto that may have led to its reclassification as a dwarf planet?

3. If the earth were reduced to the diameter of a pea, how large and how far away would Jupiter be? How large and how far away would Pluto be? The Exploratorium website is helpful for these questions.

4. What are some problems that must be solved before people can travel to Mars?

5. Why is it unlikely that aliens have visited Earth?

6. What are some arguments for or against Pluto's status as a planet?

7. What is the current thinking about objects beyond Neptune that belong to the solar system? (How are they classified? What characteristics do they share?)

8. How long did it take for the Voyager craft to reach Neptune's orbit?

9. How much farther from the sun is Pluto compared with earth? (What unit of distance easily expresses this comparison?)

10. What is the Oort Cloud? If we can't see it, even with the best telescopes, what makes us think it is there?

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11. Given current estimates of the number of stars in a typical galaxy and the number of galaxies in the universe, how many total stars are there in the universe? Express your answer in scientific notation.

Chapter 3: The Reverend Evan's Universe

Discussion Questions

1. Why is this chapter named after Reverend Evans? (Try to think beyond the obvious answer.)

2. What is a supernova? What is the closest supernova? Are we in danger of being harmed by a supernova? Why or why not?

3. Describe the skills and discoveries of Fritz Zwicky. List some personal characteristics that led to his success. How were Zwicky's skills similar to Evans' skills?

4. Briefly describe the formation of our solar system.

5. What are the advantages of looking for supernovae using a CCD camera? Using the naked eye like Reverend Evans does?

6. What is a neutron star? Why is it so dense?

7. Approximately how many stars are visible to the naked eye from earth? (Another way to phrase this question would be "How many stars are class 6 or brighter?")

8. How often can we expect supernovae to occur in our galaxy?

9. What sort of information do we gain by (searching for, but) not observing any supernovae?

10. Bryson reports conflicting opinions about how close a supernova would have to be in order to be lethal. Even if the larger number is correct, are we in danger? Explain.

11. What evidence is there to suggest that we are the byproducts of a supernova?

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12. Who coined the term "big bang"? Was this person a leading proponent of the theory?

Chapter 4: The Measure of Things

Discussion Questions

1. Summarize the accomplishments of Edmond Halley. Why do you think his scientific contributions were so diverse compared to today's scientists?

2. What are Newton's three laws of motion? What is the formula representation of his law of universal gravitation?

3. Of what significance is it to navigators if the Earth is not a perfect sphere?

4. What was Richard Norwood's main contribution to science? Why can we say, with a great deal of confidence, that Norwood was a very careful worker?

5. Describe one way to determine the mass of the earth.

6. What was history's first cooperative scientific venture?

7. How did the discovery of contour lines relate to determining the mass of the Earth?

8. Who was "the most gifted English scientist of his age"? Provide evidence of why this person was awarded that "title".

9. Describe the chain of events leading from a wager to the foundation of modern physics: Newton's *Principia*.

10. What does an "inverse square law" mean? How does it apply to the motion of planets?

11. Describe two efforts to measure the size of the earth.

12. What complicating factor (or invalid assumption) made precise navigation difficult?

13. Describe the strategy proposed by Edmund Halley to measure the distance between the earth and sun.

14. What is the link between the effort to carry out Halley's proposed measurement and the informal name for the southern U.S. states?

Chapter 5: The Stone-Breakers

1. What particular weakness did James Hutton have and how did this slow the dissemination of his groundbreaking geological ideas?

2. What particular geological phenomenon intrigued scientists of the day?

3. Explain the difference between plutonists and neptunists.

4. What explanation did James Hutton propose for the phenomenon above (question 3)?

5. What role did James Playfair play in disseminating Hutton's ideas?

6. What prerequisite was evidently required to join the Geological Society in the early 1800s?

7. Charles Lyell is often credited for developing and popularizing the ideas of Hutton. When was Lyell born? When did James Hutton die?

8. Explain the difference between catastrophism and uniformitarianism.

9. Catastrophism is often (mistakenly) associated with idea of Noah's Flood. How was the catastrophism of the early 19th century different from the biblical view that the rock record was due to a single world-wide flood?

10. Charles Darwin once said that he didn't understand science until he studied geology. How was Lyell's way of thinking about *slow* geological change similar to ideas about evolutionary change developed by Charles Darwin twenty years later?

11. Where did the Cambrian, Silurian, and Ordovician periods get their names from?

12. What sources did Bishop James Ussher consult to determine the age of the Earth in 1650?

13. Among geologists of the 19th century what was the dominant view on the age of the Earth?

14. Edmond Halley sought to calculate the age of the Earth by estimating the amount of salt in the oceans. Does this man's name sound familiar? Find out what famous celestial object bears his name.

15. What experimental approach did the Comte de Buffon take to estimate the age of the Earth? Based on what we know about the source of the Earth's internal heat today, why was his approach doomed to failure?

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16. Lord Kelvin (aka William Thomson) generally believed the Earth to be millions of years old. What role did the sun play in his argument for a "relatively youthful" solar system?

Chapter 6: Science Red in Tooth and Claw

1. Why was late 18th century America so interested in documenting its large animals?

2. Why did the idea of animal extinctions raise religious questions in the mind of 19th century naturalists?

3. George Cuvier argued that animals had actually gone extinct. What did the opposition argue was the case with these allegedly extinct animals?

4. William Smith discovered that fossils occur in an ordered fashion in the rock layers of the Earth. This insight made him the father of biostratigraphy and laid the foundations for the construction of the geological time scale. William Smith did not know why fossils occurred in this ordered succession throughout the rocks. Indeed, most of the geological time scale was constructed (it was rocks in Europe that were first ordered based on their fossil content) before anyone could explain this phenomenon. Why DO different species appear at different times (different aged rocks) in the rock record?

5. Who was Mary Anning? What three extinct groups of ancient reptiles did she discover along the cliffs of the English Channel?

6. What does the name *Iguanadon* mean?

7. How are the teeth of dinosaurs different than those of modern lizards?
8. How was *Iguanadon* reoconstructed in Crysal Palace Gardens? How is this reconstruction incorrect?

9. What does the label "dinosaur" mean? What is unfortunate and potentially misleading about this descriptor?

10. Bryson leaves no holds barred when describing the character of Richard Owens. After receiving the Royal Medal for his work on belemnites (an extinct animal similar to a squid), Owen's reputation received a final major blow. This was due to a "crime of dishonesty", a crime that continues to be viewed as an "unforgivable sin" within the scientific community. What do we call this "crime" today? (hint: you can be expelled from colleges for committing it!)

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11. Despite Owen's questionable character, which of his major lasting achievements graces the streets of Kensington, London today?

12. What peculiar obsession did Cope develop in his later years?

Chapter 7: Elemental Matters

Discussion Questions

1. What is alchemy? How does it differ from chemistry? How is it the same as chemistry?

2. Summarize the discoveries of Karl Scheele. How did the nature of Scheele's work lead to his death?

3. Who is Antione-Laurent Lavoisier? How did his wealth influence his contributions to science?

4. Why did chemistry lose its bearings in the first decades of the nineteenth century? Give an example of twenty first century science potentially losing its bearings in a similar way?

5. In what ways is the periodic table of the elements periodic? What did Robert E. Krebs call the periodic table?

6. How do we know that early twentieth century scientists did not understand the dangers of radioactivity? What is a modern day example of this cavalier attitude toward something that was eventually considered dangerous?

Chapter 8: Einstein's Universe

Discussion Questions

1. What is the luminiferous ether? How does it relate to experiments about determining the speed of light?

2. Some writers classify Max Planck as the first quantum physicist. Provide evidence to support this classification.

3. Describe the meaning of $E=mc^2$.

4. Einstein reported that he seldom had a good idea. Do you agree with this? What do you think is Einstein's classification of a "good idea"? What is your classification of a good scientific idea?

5. In what ways are Einstein's relativity theories nonintuitive?

6. How does a train traveling at 60 percent of the speed of light illustrate Einstein's theory of special relativity?

7. How is spacetime like a sheet of stretched rubber?

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8. Describe the contributions of Henrietta Swan Leavitt and Annie Jump Cannon to our understanding of the universe.

Chapter 9: The Mighty Atom

Discussion Questions

1. If you had to reduce scientific history to one important statement, what would it be? Why?

2. Make an argument to support the statement that each one of us is billions of years old.

3. How can Dalton be considered the father of atomic theory even though the idea of the atom was invented by ancient Greeks?

4. Describe the experiment that Ernest Rutherford and Hans Geiger did with ionized helium atoms. What did it teach them about the structure of the atom?

5. In what way is it correct to say that objects never really tough each other?

6. Electrons are negatively charged and protons are positively charged. Negative and positive charges attract. According to Niels Bohr, why don't electrons fall into the nucleus owing to this attraction?

7. What is uncertain in the Heisenberg Uncertainty Principle?

8. Einstein did not believe that God "played dice". What did he mean by that statement?

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Chapter 10: Getting the Lead Out

Discussion Questions

1. List some health problems associated with lead poisoning.

2. Why are CFCs so harmful to the Earth?

3. Which of Thomas Midgley's two inventions do you think is the most dangerous? How does your answer differ if you are considering long term effects rather than short term effects?

4. What is carbon-14 dating? What are some problems with this method?

5. Why did Patterson use meteorites to determine the age of the Earth?

6. How can the ice in Greenland help us determine how the concentration of atmospheric lead has changed?

7. Now that leaded gasoline and CFCs are banned in the United States, are the threats from these items over? Why or why not?

"A Short History of Nearly Everything"
Debate Assignment about Chapter 10: Getting the Lead Out.

In this assignment, you and your classmates will discuss an important case study on the relationship between science, economics, ethics and public policy. I will divide the class into three groups: Thomas Midgley (the inventor of leaded gas), Claire Patterson (the lone early voice against leaded gas) and the president of Ethyl Corporation (who benefits financially from leaded gas). After each group has summarized, all students, staying in character, will get into groups of three and have a discussion about their points of view. After about 10 minutes, you will summarize the main points of the debate.

1. Meet with classmates who play the same role as you (either Midgley, Patterson or the president of Ethyl). Develop a list of points supporting your point of view as either the inventor of leaded gas, the crusader against leaded gas or the businessperson who depends on leaded gas to make money. Formulate 3 or 4 main points that support what you must do or have done in your role. These points should support why your actions are right or the other people's actions are wrong. (Take about 10 minutes for this.)

2. Get into your group of three. For one minute each, Midgley, Patterson or the president of Ethyl will present their main points to the other two people. After each person has presented their main points (uninterrupted), debate the relative strengths and weaknesses of each argument for about five minutes.

3. When you are done debating, your group should decide the best way to resolve the issues about leaded gas. For example, how can the problem be resolved without Ethyl going out of business? How can Patterson get people to listen to him? What responsibilities does Midgely have as the inventor of leaded gas? Write a one to two paragraph response to these and related issues as a small group.

By the end of class, you will turn in your individual list of 3 or 4 main points and your small group paragraph.

Homework assignment: Nuclear energy has similar ethical issues. Scientists, environmentalists, and business leaders continue to debate the plusses and minuses of nuclear energy. By next Thursday, write a one page paper about the following. What are the benefits of nuclear energy? What are the detriments of nuclear energy? What are the ethical issues involved with nuclear energy for the inventors? For the power companies? For the users? How does the argument for using nuclear energy differ from the argument for using leaded gasoline?

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Chapter 11: Muster Mark's Quarks

Discussion Questions

1. How do scientists trap neutrinos? Why are they so difficult to trap?

2. What do you think Leon Lederman meant when he said, "There is a deep feeling that the picture is not beautiful"?

3. More questions to be added…

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Chapter 12: The Earth Moves

1. Which "genius scientist" wrote a critical review of plate tectonics in 1955?

2. How did the "baked apple theory" of Eduard Suess explain the formation of mountains on Earth? What weaknesses did this model have in explaining this phenomenon?

3. How did biologists explain the occurrence of identical fossil species on separate continents before plate tectonics?

4. According to Alfred Wegener, how fast was Greenland moving away from Europe?

5. What role did convection currents play in Arthur Holmes model of continental drift?

6. If the oceans had existed in their current place and state since the beginning of Earth history what would one predict about sediments on the ocean floors? What did geoscientists actually discover about the ocean floor?

7. Where is the highest and longest mountain range on Earth located?

8. During what kind of impressive engineering feat of the 19th century did people first realize that the ocean floor was not just a smooth surface?

9. What was discovered about the age of the ocean floor by drilling operations in the 1960s? How was this a key piece of evidence in support of seafloor spreading?

10. How does subduction solve the mystery of the "missing sediments"?

11. What strange phenomenon was discovered by Bernard Brunhes in 1906 by studying the alignment of magnetic minerals in continental rocks?

12. How did an understanding of the behavior of the Earth's magnetic field lead to another key piece of evidence in support of plate tectonics?
13. Why was the label "continental drift" later abandoned in favor of "plate tectonics"?

14. What is the relationship between the outline of tectonic plates and continents?

15. Compared to the rest of the solar system, what is special about plate tectonics on Earth?

16. Did Alfred Wegener ultimately celebrate the vindication of his ideas?

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Chapter 13: Bang!

1. Upon discovery of the Manson Crater geologists attributed it to volcanic action. Was this an irrational conclusion at the time? Why or why not?

2. Why is the Manson Crater "invisible" at the surface of Iowa today?

3. Why did Daniel M. Barringer's mining operation in Meteor Crater, AZ fail?

4. Popular depictions of the asteroid belt between Mars and Jupiter show a dense accumulation of craggy rocks that are reminiscent of scenes from *Star Wars* movies (remember those TIE-Fighter chases?). In reality, what is the average distance between asteroids in the belt?

5. What is the current hypothesis that explains the existence of the asteroid belt?

6. How many asteroids large enough to "imperil civilization" regularly cross the orbit of our Earth?

7. What is the closest recorded distance that an asteroid has come to the Earth? What is unnerving about the timing of its discovery?

8. What is the K-T boundary? Why is it not called the C-T boundary?

9. How much space dust falls to Earth annually? Bryson isn't clear how this space dust gets here – what do you think?

10. Iridium is a very heavy element that is scarce in the Earth's crust. It is probably an important constituent of the Earth's core and perhaps also the lower mantle. Some geologists have argued that the iridium layer at the K-T boundary is volcanic in origin. How could volcanism create such an iridium-rich layer?

11. Who first proposed that the dinosaurs were dealt a death blow from space? When did the Alvarez father/son team propose the same idea? Despite not being the first, the Alvarez team is widely credited as being the source of this idea – why do you think this is so?

12. How was the impact of Shoemaker Levy 9 with Jupiter important to the K-T impact theory?

13. Where was Gene Shoemaker buried?

14. Why is the Chicxulub crater so difficult to study?

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Chapter 14: The Fire Below Us

1. How deep are the world's deepest mines?

2. What did Andrija Mohorovičić discover using seismic analysis?

3. Bryson states that "the Richter Scale has always been widely misunderstood by nonscientists". What two aspects have been misunderstood?

4. What factors other than energy (force-released) influence the amount of damage a quake causes?

5. What destroyed the town of Hilo, Hawaii in 1960? What was the geographic source of the calamity that befell the town?

6. On average, how many earthquakes of magnitude 2.0M or greater occur globally per year?

7. How many people perished in the 1923 Great Kanto earthquake in Tokyo, Japan? In comparison, go online and find out how many people died in the 2004 Indian Ocean tsunami.

8. Tokyo has not experienced a major earthquake since 1923. Why does this worry geoscientists?

9. What was the largest intraplate earthquake ever to hit the United States (hint: the quake caused church bells to ring in Boston but that city is over 1000 miles from the epicenter!)

10. How deep did the deepest drill hole in the Kola Peninsula, Russia penetrate into the Earth? Did they reach the mantle?

11. Some (much of?) of the mantle probably consists of a material called peridotite, a rock that is rich in a dark green mineral called olivine. Does the term peridotite sound familiar to you? What popular gemstone (a variety of olivine) bears a similar name?

12. What is peculiar about the Earth's magnetic field?

13. How does the magnetic field aid life on this planet?

14. What caused most of the deaths in the 1980 eruption of Mount St. Helens?

15. What was the estimated monetary damage done by Mount St. Helens?

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Chapter 15: Dangerous Beauty

1. What expected feature was conspicuously absent in Yellowstone Park?

2. What is a hot spot? List at least three volcanic centers on the Earth that are caused by such features.

3. What is peculiar about the hot spot below Yellowstone?

4. Why would another super eruption at Yellowstone spell economic disaster for the United States (and likely parts of Canada as well)?

5. What evidence is there that the magma chamber below Yellowstone is still active and "restless"?

6. According to the United States Geological Survey, Yellowstone Park is the most seismically active piece of real-estate in the world. On average how many earthquakes occur in the park per year?

7. *Old Faithful* is Yellowstone's most famour geyser – its name reflecting its regular eruptions. Based on what Bryson says about geyser eruptions in Yellowstone, is *Old Faithful* really such a good name? Are the eruptions of *Old Faithful* really that faithful? What is the average interval between eruptions? Find out at by taking the virtual tour of the *Old Faithful Geyser Basin* at http://www.nps.gov/archive/yell/oldfaithfulcam.htm.

8. Which five US states have an official *Volcanic Observatory*?

9. How are the eruption of Mount St. Helens in 1980 and the Hebgen Lake Earthquake of 1959 similar to one another?

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Chapter 16: Lonely Planet

Discussion Questions

1. Would the human body get crushed if left unprotected at the bottom of the ocean? Why or why not? What is the biggest danger to the human body at the bottom of the ocean?

2. What is "the bends"?

3. Provide three examples of dangerous experiments that J. B. S. Haldane performed on people.

4. What are the four principal characteristics of Earth that lead to it being a habitable place for humans?

5. Why is Venus inhospitable for life?

6. How does the molten interior of the Earth facilitate life on the surface of the Earth?

7. In what way is the carbon atom "shamelessly promiscuous"?

8. Make a 10-item shopping list of things you'd look for in a planet to determine if it would be habitable to humans.

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Chapter 17: Lonely Planet

1.Why is it a good thing that we have an atmosphere?

2.What is the danger of living at high altitudes?

3.What are the layers of the atmosphere?

4.Why does it get colder as you climb a mountain?

5.What influences air movement in the atmosphere?

6.How are clouds classified?

7.What was the "salinity crisis?"

8.How do the oceans influence climate and weather?

9.How does the Gulf Stream influence weather?

10.What is "thermohaline circulation?"

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11.Does life help keep the world hospitable? Are we humans disrupting this balance?

Chapter 18

1.What are the unique properties of water? Why are we looking for water on other planets?

2.Why shouldn't you drink seawater?

3.Where is most of the water of the world located?

4.Why should our world be called "Water" instead of "Earth?"

5.Why do we know so little about the Oceans?

6.What were some of the earliest deep ocean exploration vessels? The most recent?

7.Why is it so much harder to build a deep ocean exploration vessel than a space exploration vessel? What are some difficulties involved in each?

8.Are the depths and floor of the ocean "lifeless" flat and uninteresting?

9.Why do you think we seem to be more interested in space exploration than ocean exploration?

10.Why is ocean exploration so difficult?

11.Where is there a world independent of the sun?

12.What do we know about life beneath the seas?

13.How do scientists study life beneath the surface?

14.Where does most life in the sea occur? Why?

15.Why is knowledge of the ocean life important to fishermen?

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16.Discussion question: “We know very little about Earth’s biggest system.” What do you think about this statement?

Chapter 19

1.Describes Miller’s experiment. What does it have to do with the origin of life?

2.What is a protein? Why is it hard to make them? What is so strange about protein synthesis?

3.Discuss the statement: “It is little wonder we call it the ‘miracle of life.’”

4.What makes something “life?”

5.Discuss the statement: “Living things are collections of molecules, like everything else.”

6.What makes life “miraculous?”

7.When did life begin on Earth?

8.What is the theory of “panspermia?” What are some issues with it?

9.Why does Ridley state: “All life is one.”

10.What is a stromatolite?

11.What was early life like? Is there any evidence of it still existing today?

12.How do scientists study early life?

13.What was the world like 3.5 billion years ago?

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14.How long ago did life begin?

15.How long ago did complex life begin?

16.What are mitochondria? Where do they come from? What is strange about them?

Chapter 20: Small World

1. Bacteria are everywhere and in great numbers. They cover our body and are found in massive numbers in our gut. Bryson discusses their numbers in such terms as quadrillion and tons. Given their ubiquitousness and great numbers, why does the general public not think much about these organisms?

2. What organisms are classified as fungi? What role do they play in an ecosystem? How have humans come to use fungi such as yeast?

3. What are some of the unusual characteristics of slime molds? Are they best classified as bacteria, fungi, plants, or animals?

4. In 1969, all living organisms were classified into five kingdoms. What are they?

5. What did Carl Woese discover that quickly suggested that the five-kingdom system was not the most appropriate way to classify living organisms? What groupings did he suggest?

6. What is a virus? Why is it debatable as to whether viruses should be considered living organisms?

7. The final section of this chapter examines microbes as the cause of many human diseases. Bryson mentions several historical epidemics caused by microbes – English sweating sickness, encephalitis lethargica, and the Great Swine Flu. What are some microbial caused diseases we are currently dealing with? Why is the current avian (bird) flu outbreak in Asia of such great concern?

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8. What are antibiotics? Why does you doctor not prescribe antibiotics for viral infections (e.g. colds and most flus)? Why are antibiotics becoming less effective? What can be done?

Chapter 21: Life Goes On

1. Bryson discusses three requirements needed to make a fossil. List them.

2. Why are terrestrial animals ("land animals") so rare in the fossil record?

3. What percentage of the fossil record consists of animals that lived under water?

4. How long did the "reign of trilobites" last? In comparison, how long have humans been around?

5. What "fact" of the fossil record seemed difficult or impossible to explain with Darwin's evolutionary ideas in the 19th century?

6. What does Bryson call the "holy grail of paleontology"?

7. How were the creatures in the Burgess Shale preserved?

8. According to Stephen J. Gould could the animals of the Burgess Shale be readily assigned to known animal phyla?

9. The term "Cambrian Explosion" implies a sudden appearance of diverse organisms in a very short period of time (10-15 million years) as if out of nowhere. Is this view still supportable by the fossil evidence?

10. What was peculiar about the "soft-bodied oddities" also known as the Ediacaran Fauna?

11. How are most Burgess Shale animals classified today? (hint: are they still viewed as "unclassifiable"?)

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12. What hypothesis has been put forth for why the fossil record of ancestors for most of the Burgess Shale animals is so poor?

Chapter 22: Good-bye to All That

1. How are lichens actually a partnership between two different kingdoms of life?

2. How long does it take some lichens to reach the size of a shirt-button?

3. What major challenges does dry land pose to water-dwelling creatures?

4. What was one "incentive" or better, "evolutionary pressure" that might have played a role in favoring and driving the invasion of land?

5. What were the first land-dwelling organisms?

6. What were the first land-dwelling animals? (be specific)

7. What likely allowed animals to remarkably large during the Devonian and Carboniferous periods?

8. What group of animals first evolved flight? Can you name three other groups of animals that evolved flight independently? (hint: one of these groups is unfortunately extinct today)

9. How did Erik Jarvik stall our investigations of early terrestrial vertebrates? What do you think were Jarvik's motivations?

10. What are Bryson's four *megadynasties*?

11. What is the average life-span of a species in the fossil record?

12. How many major mass extinctions have there been throughout Earth's history?

13. Which extinction was the biggest one? What percentage of known animals species went extinct?

14. Why is the survival of amphibians following the KT-Impact event difficult to explain?

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15. Why might it have been advantageous to be "small, warm-blooded, nocturnal, flexible in diet, and cautious by nature" following the KT-Impact event?

16. What kind of carnivore was dominant in North America for millions of years following the KT-event?

Chapter 23: The Richness of Being

1. It is not unusual for taxonomists (biologists who classify and name organisms) to change the scientific name of an organism. Why do you suppose such changes are considered necessary? Why do you think such name changes often seem upsetting to both biologists and non-biologists?

2. Joseph Banks' expedition that began in 1769 was extraordinary in the number of biological specimens collected, but it was not unusual in that many other such expeditions were mounted in the late 1700's and into the 1800's. What did western scientists and others learn from these explorations? Do you think such expeditions can still be valuable? If so, where might present-day biologists go? How would such expeditions be similar? Different?

3. Who was Linnaeus and what was his major contribution to biology?

4. Humans long before Linnaeus, as well as in modern cultures not exposed to our current scientific classification of living organisms, seem compelled to name and categorize types of living organisms in the world around them. Why do you think we "need" to do this?

5. Why is it so difficult to get a handle on exactly how many species exist on earth today? Why is it important?

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6. In addition to finding and describing species, another difficulty for biologists is defining what exactly a species is. Distinguishing species in some groups of organisms is pretty straight forward (e.g. birds), but how would you go about designating species of bacteria?

Chapter 24: Cells

1. Bryson emphasizes the smallness of cells and the amazingly large numbers required to make up individual organisms. Why do you think cells are so small, or put another way, why are there no really big cells?

2. One large cell you are familiar with is the yolk of a chicken egg. That cell is large because of the tremendous amount of nutrients stored in it for use by a developing chick. Why do you think the human egg cell is so much larger than the human sperm cell (p. 373)?

3. Who first described and named a cell? Why did he use the term "cell"?

4. The Cell Theory is simply the idea that all living organisms are made up of cells. Although this seems so obvious today, it was not widely accepted by biologists until the mid 1800's, relatively recently in term of human history. Why did it take us so long to figure out this simple fact?

5. On page 376, Bryson refers to a cell as "a complex chemical refinery". Not a bad analogy, but another way to look at a cell is as a center for energy conversion. Organisms take in energy stored in certain forms such as carbohydrates or lipids and convert these forms to chemical energy that can be used by the cell. What is the form of this chemical energy (p. 378)? What do cells use this energy for?

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6. Cells are capable of reproducing themselves by cell division. For single celled organisms, cell division is essentially reproduction. For multicelled organisms, division is necessary for growth and renewal. Even though cell division is natural and necessary, what happens when the rate of cell division becomes too rapid and out of control? How can we get rid of such rapidly dividing cells in the human body?

Chapter 25: Darwin's Singular Notion

1. Darwin, like many of the scientists in this book, was from a well-to-do family. Why do you think most of these historical figures of science before the 20th century were from wealthy backgrounds?

2. Biological evolution was not an idea newly formed by Darwin. In fact, a number of naturalists during and before Darwin's day were intrigued with the idea of organismal change over generations. Darwin's formulation of natural selection gave science a mechanism that could explain such change, a mechanism others had failed to fully realize. What is natural selection? How does it cause evolutionary change?

3. Evolution by natural selection occurs at the level of populations of organisms. Why don't individuals evolve?

4. The change from non-evolutionary to evolutionary thought can be seen as a paradigm shift. What is a paradigm shift?

5. In terms of our scientific knowledge, the ideas and views of William Paley and Samuel Wilberforce seem simplistic and out-of-date. Nevertheless, however scientifically naïve these views may be, they are far from forgotten. Compare Paley's idea of the pocket watch with the current concept of "intelligent design". Why do you suppose biological evolution remains so misunderstood and controversial in America today?

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6. After the publication of *The Origin of Species*, Darwin was revered by most within the scientific community and despised by many outside of science. He was both famous and infamous. On the other hand, Gregor Mendel's work was never recognized by his colleagues or the general public. Why was Mendel's work not known and appreciated?

Chapter 26: The Stuff of Life

1. What do the letters DNA stand for?

2. Because of Mendel, scientists knew that some sort of "packets" of hereditary information was passed from one generation to the next. What do we call these packets today? Where are they located in your body? What are they made of?

3. Why has the fruit fly (*Drosophila melanogaster*) proved to be so important for much or our understanding of genetics?

4. The quest to discover and define the molecule responsible for inheritance is filled with much of what scientific progress is really like – building on previous discoveries, experimental evidence, theoretical hypotheses, as well as competition, desire for recognition and fame, conflicting egos and personalities. Science as a "pure" process is carried out by people, and people are emotional beings. This combination of a logical process practiced by emotional beings both helps and hinders the progression of knowledge. Identify the various logical and emotional events leading to the discovery of DNA (pp. 403-407).

5. One characteristic of DNA is its ability to replicate itself. Why is this important? Sometimes, mistakes are made during DNA replication. Why are such mistakes potentially harmful? Why are such mistakes necessary for evolution?

6. Why is potentially 97% of human DNA referred to as "junk DNA"? What does this imply about how much DNA actually instructs the formation of organisms? What might it imply about our knowledge of DNA?

7. On average, Bryson reports that individual human genomes are 99.9% similar. When comparing human and chimp DNA, scientists estimate that anywhere from 95-98.8% similarity. Even humans and fruit flies share approximately 60% DNA similarity. What does this imply about DNA? About evolutionary relatedness?

8. What was the Human Genome Project? How many genes do humans have? How does this compare to other organisms?

Chapter 27: Ice Time

1. What caused the "year without a summer" in 1816?

2. What was the average global temperature drop following this event?

3. What creative explanation did de Luc propose to explain the presence of large erratic granite boulders atop high limestone mountains?

4. Who was Karl Schimper and what did he fail to receive credit for?

5. Who is generally known as the father of glaciology today?

6. Why was Agassiz's glacial theory met with skepticism in England?

7. What discovery in 1852 lent great support to Agassiz's view that large continent-sized ice sheets had once covered much of Europe and North America?

8. Who first proposed that orbital changes could produce ice ages? What was peculiar about this fellow? (hint: why does this remind you of the movie *Good Will Hunting*?)

9. Milutin Milankovitch suggested that obliquity, precession, and eccentricity affect the Earth's climate. Go online to figure out what each of these actually means in terms of the Earth's motion. Explain.

10. How was Wladimir Köppen's idea of what causes ice ages different from all previous views?

11. How many glacial episodes have there been in the last 2.5 million years?

12. How are the formation of the Isthmus of Panama and the lofty heights of the Himalayas responsible for lowering global temperatures?

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13. What do geologists mean by *Snowball Earth*?

14. How does the biological (fossil) evidence create a problem for the *Snowball Earth* idea?

15. How fast (per year) did the Wisconsian ice sheet move?

16. What was the *Younger Dryas*?

17. How might global warming cause increased snowfall in some areas?

18. If all the ice sheets (mountain and continental) were to melt, by how much would sea level rise?

Chapter 28

1. Where did "humans" come from? What do we know about human ancestry?

2. Why does Bryson say, "Did you have a good ice age?"

3. How did the ice age influence human development?

4. Where and how were the first human fossils found?

5. Bryson states, "In their eagerness to reject the idea of earlier humans, authorities were willing to embrace the most singular possibilities." What are some examples?

6. Who were "Java man" and "Neanderthal man" and "Peking Man"?

7. Who was Dart and what was the "Taung child"?

8. Why was there such confusion of human fossils and identification in the 1950s?

9. What are the classifications of human fossils?

10. What are some of the problems with identifying human fossils?

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11.How was (and is) human fossil identification another example of "Fitting the evidence to our preconceptions."

12.Who was "Lucy?" Is she a human ancestor?

13.What were some of the "risks" in human development?

14.Why does Bryson say bipedalism and large brains are "risky?"

15.What is the current knowledge of human history?

Chapter 29

1.What were the first human made tools? What's strange about them?

2.How did humans get to Australia 60,000 years ago?

3.What do we know about human migration? How did we get around the world?

4.How did the earlier humans of "the first wave" (i.e. Neanderthal, etc.) die out? Did *homo sapiens* interbreed with them?

5.Who were the first *homo sapiens*? When and where did they live?

6.How is biochemical evidence being used to study human evolution? What does it say about who we are and where we come from?

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7.What are the problems with using DNA evidence to study human history?

8.Bryson mentions a factory that existed for a million years. Where was this "factory" located? What did it make and why? What is strange about it?

Chapter 30

1.What is the connection between humans and extinctions?

2.How did the dodos and passenger pigeons become extinct?

Bryson summarizes this section, and indeed the whole book, with these two statements:
"It's an unnerving thought that we may be the living universe's supreme achievement and it's worst nightmare simultaneously."
"We enjoy not only the privilege of existence but also the singular ability to appreciate it and even to make it better."

1.What do you think about these statements?

2.Does this chapter (or book) influence how you feel about being human? Our responsibility to the world? Our ability to influence the world?

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