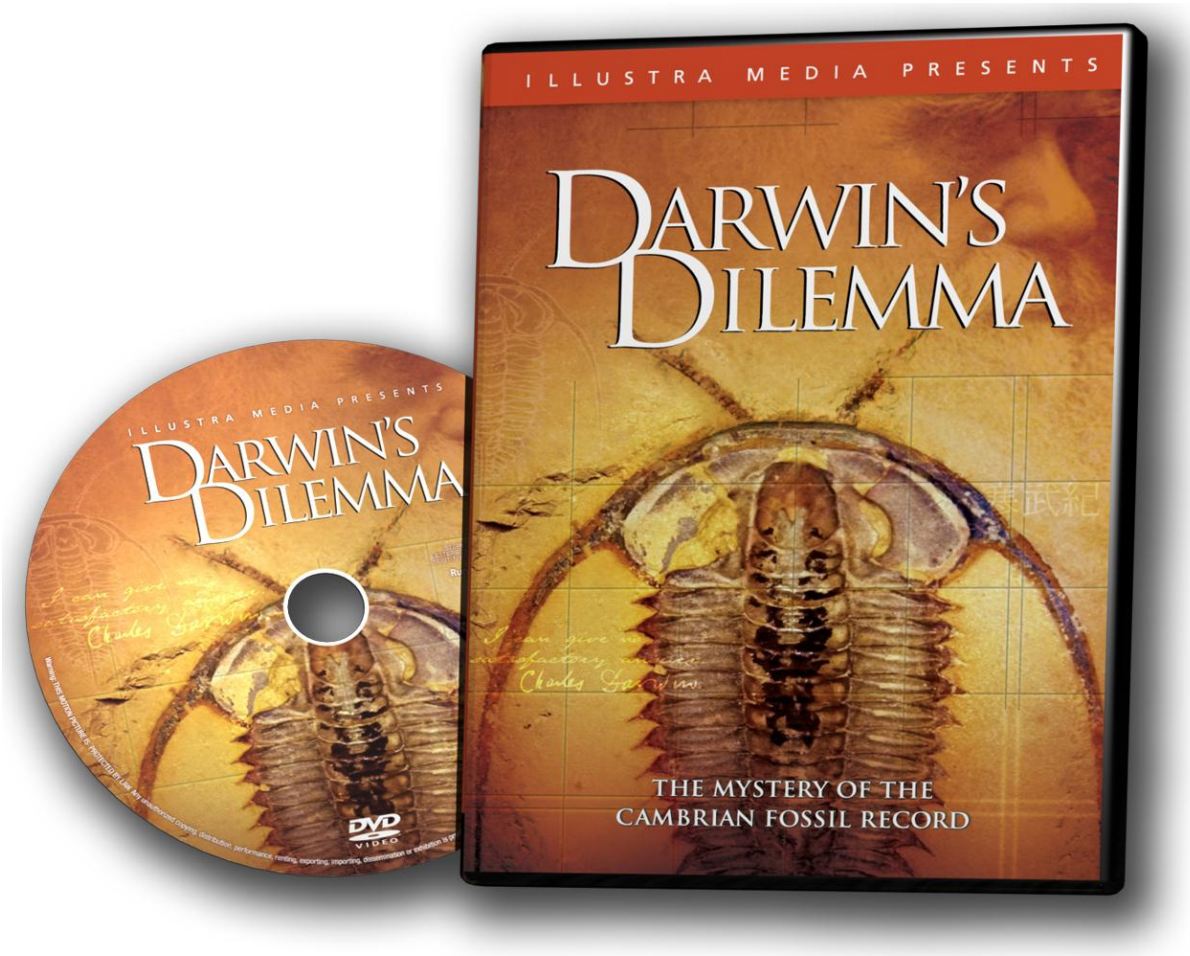

DISCUSSION & STUDY GUIDE

By Ryan Huxley

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Introduction

Many evolutionists think that anyone who questions evolution must be anti-science or ignorant of the evidence. The fossil record is often cited as evidence for evolution. But does it show the pattern of gradual change which Darwin predicted we should find if his theory was correct?

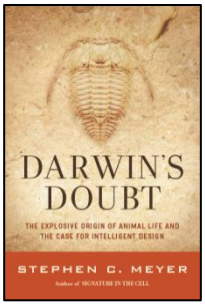
When Darwin wrote *Origin of Species*, he acknowledged that the fossil record posed problems for his theory. Today, over 150 years later, the fossil record is still a problem for neo-Darwinian theory. Can the theory of intelligent design (ID) better explain the fossil evidence?

Illustra Media's documentary *Darwin's Dilemma* looks at the fossil record and explores these questions. However, many people have misunderstandings about intelligent design.

This Discussion & Study Guide ("guide") is designed to help you and others learn about these concepts and scientific evidence associated with the Cambrian explosion in more detail. The guide is broken up into five segments and should be used in conjunction with viewing *Darwin's Dilemma.* The guide has short-answer-style questions, fill-in-the-blank, multiple-choice and true/false statements as well as discussion-oriented questions. It can be used for individual or group study, though the discussion questions are best for group learning situations. Answers to questions are provided at the back of the guide. Additional resources are referenced in the 'Answers' portion for those interested in gaining a more detailed understanding of a particular topic.

The short-answer questions are taken directly from the video. Tougher questions are usually at the end. Discussion questions are open-ended and broken into two different categories: 1) those relating directly to a video topic, and 2) those that are related, but are not explicitly covered in the video. Answering questions that extend the material covered in the video may require "a little digging" to arrive at an answer using additional resources.

Before getting into the study guide, it is worth noting a wonderful book was published in 2013 which makes the most comprehensive arguments for intelligent design from the Cambrian explosion to date. It is Stephen C. Meyer's book, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOne, 2013), available at www.darwinsdoubt.com.



Finally, if you would like to start a club to discuss intelligent design and evolution at your school, university, or in your community, consider starting an Intelligent Design and Evolution Awareness (IDEA) Club. The IDEA Center helps students start IDEA Clubs on college and high school campuses, as well as in communities, around the U.S. and the world. The IDEA Center can provide resources to help you start an IDEA Club - and you do not have to be an ID expert to start one - see www.ideacenter.org for further information.

Please direct any feedback or input about the guide to ryan@ideacenter.org.

Chapter 1: The Cambrian Explosion

Basic Questions:

1.1. Based on the quote at the beginning of the video by Stephen Jay Gould, one of the most influential paleontologists and evolutionary biologists of the 20th century, what did he think about the Cambrian explosion?

1.2. Most paleontologists think complex life first originated on Earth about _____ years ago.

1.3. This seminal event was well understood early in the 19th century. True or false?

1.4. At that time, the fossils in Northern Wales posed a serious problem for Darwin's theory (which had not yet been conceived), and still do today. True or false?

1.5. Why are the Cambrian fossils in Northern Wales described as an "explosion?"

1.6. Railroad workers referred to the fossils on Mount Stephen as _____ _____.

1.7. Name the fossil icon for this fossil event.

1.8. _____ is a common Cambrian fossil of a soft bodied crab that, legend claims, was discovered just off a horse trail.

1.9. Why was this crab fossil find so incredible?

1.10. What year did major study efforts begin for the Cambrian fossils in Canada?

Chapter 1: The Cambrian Explosion

1.11. The large Cambrian fossil deposit in Canada discussed at length in the video is the _____ _____.

1.12. What ocean is thought to be associated with the Canadian fossils?

1.13. What does atheist Richard Dawkins admit about the various body plans found in the Cambrian explosion?

1.14. Are these body plan findings consistent with a gradual development of life on Earth?

Discussion Questions:

1.15. What feature is most surprising about many of the Cambrian fossils? Why is this surprising?

1.16. What key points about the historical documentation of life's development seen in Cambrian fossils are made by paleobiologist Simon Conway Morris (University of Cambridge, England)?

1.17. Other than its rapidity, why is the diversity of life found in the Cambrian fossil event remarkable? Discuss some of the implications of your answer.

Chapter 1: The Cambrian Explosion

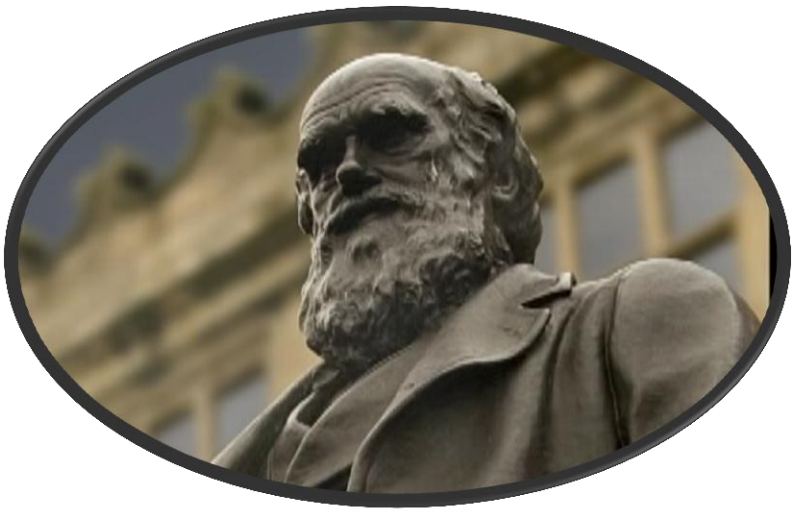
1.18. Explain why the types of fossils preserved in the Cambrian period are remarkable compared to fossils from later periods.

Discussion Questions Beyond the Video:

1.19. While both Adam Sedgwick and Charles Darwin studied fossils, did they reach the same conclusion regarding the origination of those life forms? Explain your answer.

1.20. Describe what you understood previously about the Cambrian explosion prior to viewing this video. Did you gain new information by viewing the video? If so, what was it? Has this new information impacted your view of the claim that the fossil record supports neo-Darwinian evolutionary theory? Why or why not?

Chapter 2: Darwin's Dilemma



Basic Questions:

2.1. According to Stephen Jay Gould, how did Darwin feel about the Cambrian explosion?

2.2. What is the short name of Darwin's landmark book?

2.3. The two revolutionary aspects of Darwin's book noted in the video are: _____ _____ and _____ _____.

2.4. What visual image used by Darwin illustrates his proposed historical biological relationship among various species?

2.5. According to Darwin, life on Earth diversified or branched out after a long period of time. True or false?

2.6. Both Charles Darwin and Charles Doolittle Walcott explained the puzzle caused by the Cambrian explosion by claiming the fossil record was _____.

2.7. What types of future studies did Charles Doolittle Walcott suggest would address problems posed to Darwin's theory by the Cambrian explosion?

2.8. What percentage of the proposed period of life on Earth does the Precambrian take up?

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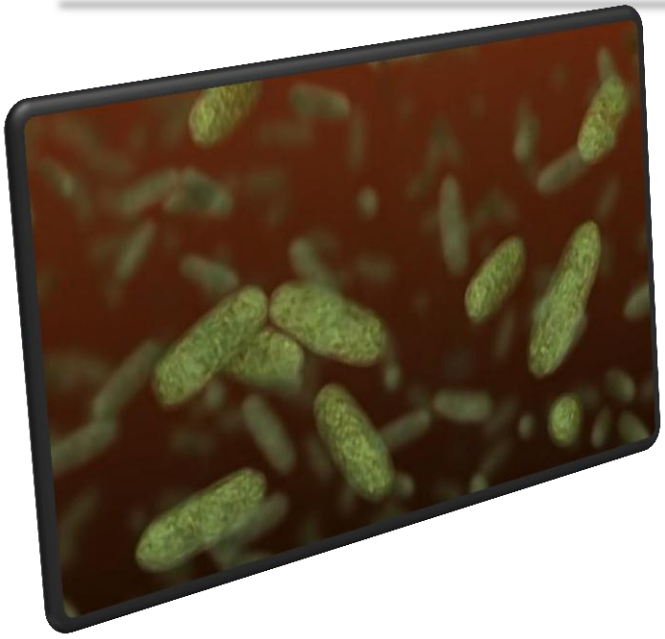
Chapter 2: Darwin's Dilemma



2.9. Single celled organisms dominated existing life prior to the Precambrian. True or false?

2.10. What big difference exists between most life in the Precambrian and Cambrian periods?

2.11. The _____ _____ is the name given for the Precambrian life just before the Cambrian.

2.12. Approximately how long ago do the first signs of life appear?

2.13. Using a 24 hour period for the history of life, at approximately what hour does complex animal life show up?

2.14. In that same 24 hour period, it takes about _____ _____ (period of time) for most of the major groups of complex animal life to "show up."

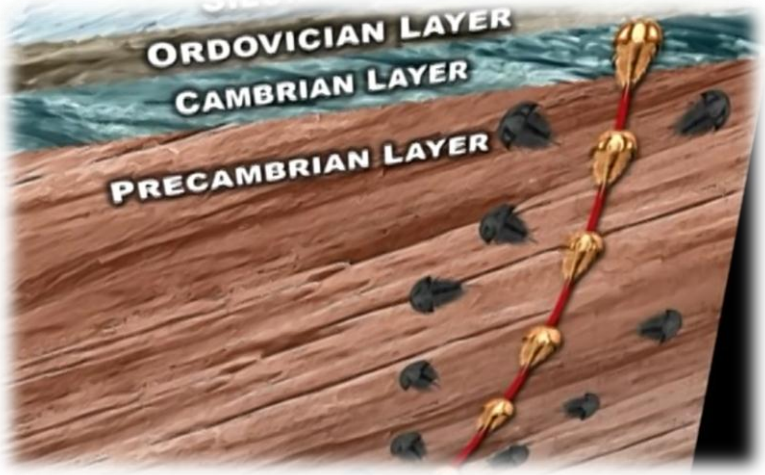
2.15. On how many different continents can we find fossils from the Cambrian explosion?

Chapter 2: Darwin's Dilemma

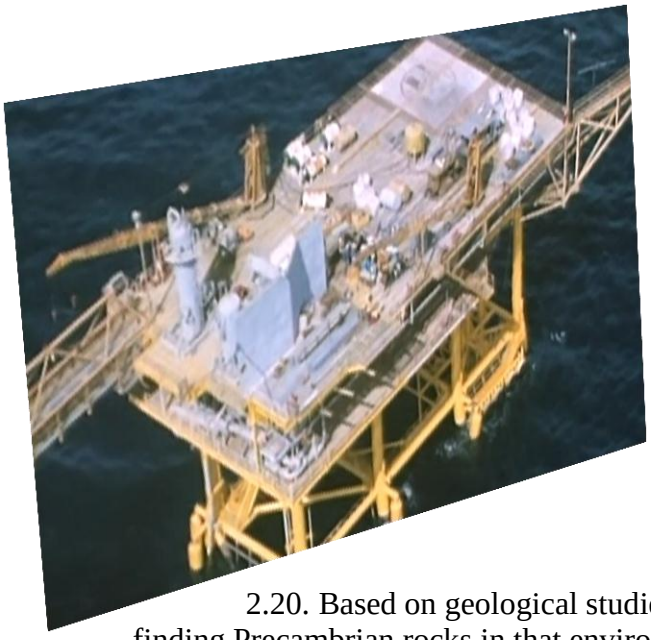
Discussion Questions:

2.16. Explain why Darwin's theory is appealing to biologists.

2.17. What did Darwin think should exist prior to the Cambrian explosion? Why did he think this?



2.18. Why did the Cambrian explosion cause problems for Darwin's theory?



2.19. Charles Doolittle Walcott suggested future ocean floor studies would address problems posed to Darwin's theory by the Cambrian explosion. What modern exploration efforts tested Walcott's proposals? Explain how this modern exploration affected the validity of Walcott's proposal.

2.20. Based on geological studies of the rocks on the ocean floor, is there a chance of finding Precambrian rocks in that environment? Why or why not?

Chapter 2: Darwin's Dilemma

2.21. What aspect of this video segment did you find most interesting or surprising? Why?

Discussion Questions Beyond the Video:

2.22. Following Darwin, many modern evolutionary scientists have suggested the incompleteness of the fossil record as a way to explain away the lack of transitional forms. Assuming their proposal is valid, what effect does this have on the claimed certainty of neo-Darwinian evolution?

2.23. Is it possible to test claims that the fossil record is incomplete? If so, how? Do any studies show the fossil record is incomplete?

2.24. Frequently, new fossil discoveries are hailed as filling in so-called "missing links." What remark about the new "missing link" is often made in the context of prior knowledge? What does this imply regarding previous claims about the fossil record evidence supporting neo-Darwinian theory?

Chapter 3: Chinese Fossils

Basic Questions:

3.1. The Chinese Cambrian explosion discovery is located in _____.

3.2. This discovery was made in the year _____.

3.3. Name one of the three features noted about this fossil location making it such a useful discovery.

3.4. Some say the condition of the fossils in the wet stone make them almost alive. True or false?

3.5. University of San Francisco marine biology professor, Paul Chien, learned of the discovery from _____ _____.

3.6. What comment in the Chinese newspaper articles caught Chien's attention?

3.7. The cover story and name given to the Chinese fossil findings in the 1995 December issue of Time magazine was _____ _____ _____.

3.8. Chien suggests that researchers can be sorted into two groups whenever the Cambrian explosion is brought up: those who _____ it and those who attempt to _____ it.

3.9. What problem does Chien identify that the Cambrian explosion causes for the Darwinian view?

3.10. Paleontologists determined the fossils in China are younger (i.e., more recent) than those at Burgess Shale. True or false?

Chapter 3: Chinese Fossils

3.11. The Cambrian fossils in China show (circle one) more details / fewer details than those at the Burgess Shale.

3.12. What approximate time duration is given for the Cambrian explosion based on the Chinese fossils?

3.13. Chien refers to the fossilized sudden 'jump' in animal diversity as a _____ _____ by geologic time standards covering billions of years.

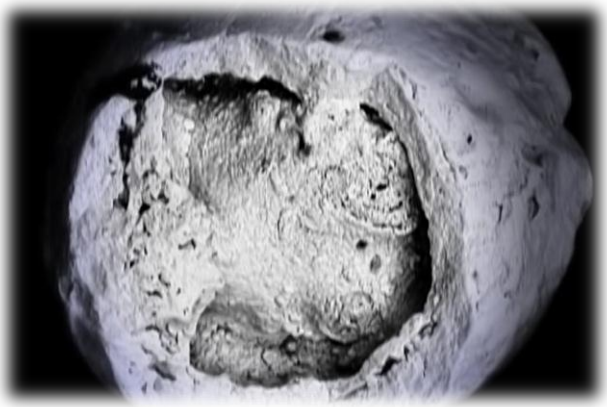
3.14. The fossils in China are considered to be the most inclusive and representative of the Cambrian explosion. True or false?

3.15. The Chengjiang site also includes _____ _____, which is another interesting feature with respect to the time periods represented by it.

3.16. Some of these fossils predate the Cambrian by _____ million years.

3.17. What size range is given by Chien regarding the fossils he's been studying since 1999?

3.18. What are some surprising fossils found in layers of rock immediately preceding the Cambrian rocks?



3.19. What features of the fossils found in rocks preceding the Cambrian challenges a common claim of Darwinian evolution regarding such life and its ability to fossilize?

3.20. Chien has been able to see subcellular features in the fossils with an electron microscope. True or false?

Chapter 3: Chinese Fossils

3.21. Conway Morris states that the Cambrian fossil record is very _____.

3.22. What do some Chinese paleontologists say regarding the claimed missing transitional forms in the Cambrian and Precambrian fossils?

Discussion Questions:

3.23. If the Chinese fossils date earlier than those in the Burgess Shale, what does this suggest about the time period originally proposed for the Cambrian explosion? Based on your answer, does this cause more or fewer problems for the neo-Darwinian perspective? Why?

3.24. What key point is made by molecular and cell biologist Jonathan Wells regarding how short the Cambrian explosion may have been based on the 'resolution' of the fossil record?

3.25. What is interesting about the rocks associated with the Cambrian fossils according to evolutionary paleobiologist James Valentine? What does Valentine suggest must have occurred since then to explain this feature? Does that explanation describe how new body plans came to be from a neo-Darwinian perspective? Why or why not?

3.26. If small soft bodied fossils exist in the Precambrian region of the fossil record, what other kinds of fossils are expected there? Why? How does this impact the claim that the fossil record is not complete enough to show the history of life during this ancient time?

Chapter 3: Chinese Fossils

3.27. While new fossilized animal species may be found in the future, does philosopher of biology and evolutionary theory Paul Nelson think they will likely fall into an already recognized taxonomical category? Why or why not?

Discussion Questions Beyond the Video:

3.28. Some evolutionary proponents claim the Precambrian life forms solve "Darwin's dilemma." Is this correct? Why or why not?

3.29. Say an evolutionist claims something like the following: "The Cambrian explosion is not an 'explosion' since it took place over many millions of years, which would be more than enough time for evolutionary mechanisms to generate the change – just look at other periods of rapid evolutionary change, frequently following mass extinctions." How would you respond to such a claim?

3.30. Say an evolutionist claims something like the following: "The Cambrian explosion does not call into question one of the unifying concepts of neo-Darwinian evolution – that being common ancestry – since there are transitional fossil forms between extant animals and their common ancestor." How would you respond to such a claim?

3.31. One of the key features for many animals in the Cambrian is their symmetry between right and left sides (called bilateral symmetry). Because this is common for many existing animals, why is it interesting during the Cambrian? Is this a problem for neo-Darwinian evolutionary theory? Why or why not?

Chapter 3: Chinese Fossils

3.32. What other major explosions have occurred throughout the history of life? Would these cause problems for the evolutionary understanding? Why or why not?

3.33. Why do you think many biology textbooks fail to discuss the questions raised by the Cambrian explosion?

Chapter 4: The Phyla

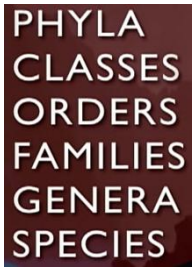
Basic Questions:

4.1. Based on the quote from biologist Rudolf Raff (Indiana University, Indiana), what problem does the Cambrian explosion cause for a Darwinian view of life?

4.2. Darwin traveled to the _____ _____ in 1835, a trip that had a major influence on his evolutionary views.

4.3. What evolutionary icon took shape in Darwin's mind during his trip and studies of the animal life on the islands?

4.4. Biological taxonomy provides the classification scheme for living things, a portion of which is shown. The phyla level discussed in the video at length deals with _____ _____.



4.5. Biologists currently believe it is not possible for an animal in one phylum to mutate into another or new phylum. True or false?

4.6. What does philosopher of science Stephen Meyer note that Darwin said about nature having the ability to provide sudden appearances of life forms?

4.7. Most of the major body plans that ever existed are present in the Cambrian explosion and this is where they first appear. True or false?

4.8. According to Darwinian evolution, a phylogenetic history of life should show (circle one) smooth curves / abrupt shifts..

4.9. What modern illustrative example used in the video communicates the basic idea of body plans?

Chapter 4: The Phyla

4.10. Name two of the three features noted in the video about the arthropod body plan.

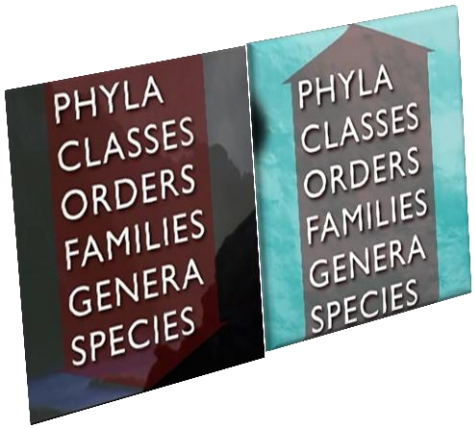
4.11. According to Jonathan Wells, evidence from the fossil record suggests a "lawn of life" rather than a "tree of life" because the phyla appear all at once and maintain themselves with minimal diversification rather than dramatic branching out. True or false?

4.12. What did Darwin say about the Cambrian explosion's effect on his theory from an evidential standpoint?

4.13. Since Darwin's day, problems posed to evolutionary theory by the Cambrian explosion have become (circle one) worse / better.

Discussion Questions:

4.14. What central idea about the Darwinian "tree of life" is noted near the beginning of this video segment? What is a corollary claim resulting from this idea?



4.15. Explain the difficulty caused by the Cambrian explosion for the Darwinian view of "bottom-up" development of complexity and differences between body plans of organisms. What is the key difference between the "top-down" and "bottom-up" views of the fossil record and which is better supported evidentially?

Chapter 4: The Phyla

4.16. If neo-Darwinian theory were correct, what should be observed in the fossil record during the Precambrian and Cambrian periods?

Discussion Questions Beyond the Video:

4.17. Wells notes some problems with the "tree of life" based on the fossil record. With the advent of molecular biology, evolutionary biologists have attempted to construct molecular phylogenies (i.e., "family trees" based upon the amino acid sequence of proteins, or the sequences of nucleotides in DNA). Have such "molecular trees" supported or countered a comprehensive "tree of life"? Why?

4.18. What are some of the responses you have heard to the problems posed by the Cambrian explosion? What criticisms do you or others have of those responses?

4.19. Why do you think biologists resist allowing for the obvious implications of the anomaly to Darwin's theory that the Cambrian explosion presents?

Chapter 5: Biological Information

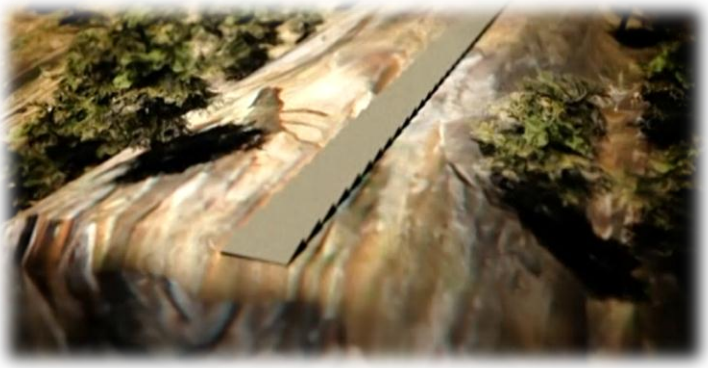
Basic Questions:

5.1. What quote on miracles by evolutionary biologist Richard Dawkins is noted at the beginning of this video segment?

5.2. Multicellular life is absent from the fossil record prior to the Cambrian. True or false?

5.3. The approximate change in complexity based on different cell types between Precambrian life (such as a sponge, with 4-5 different cell types) and Cambrian life (such as a trilobite) is at least _____ times.

5.4. What key question about this cell complexity increase is seen in the Cambrian animal fossils?



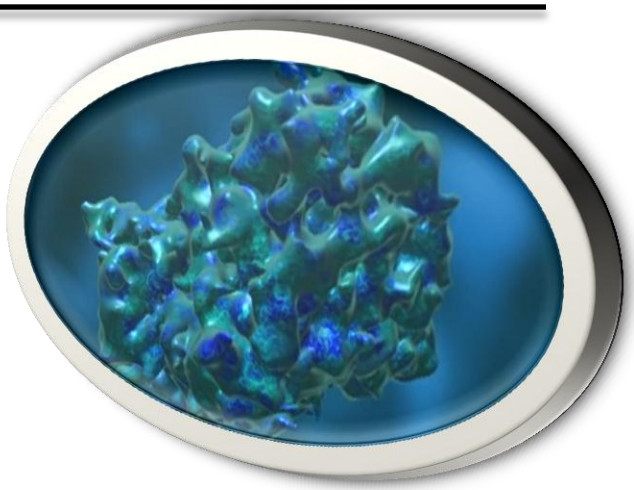
5.5. _____ _____ _____ is the illustration briefly discussed that Richard Dawkins uses to describe how the neo-Darwinian mechanisms work: one side is a sheer cliff (representing chance alone), while the other is gradual with steps (representing small changes caused by the mutation-selection mechanism).

5.6. Protein scientist Douglas Axe notes the relevant transitional changes can be observed or measured at the single _____ level.

5.7. What feature constitutes a transitional change at this level?

Chapter 5: Biological Information

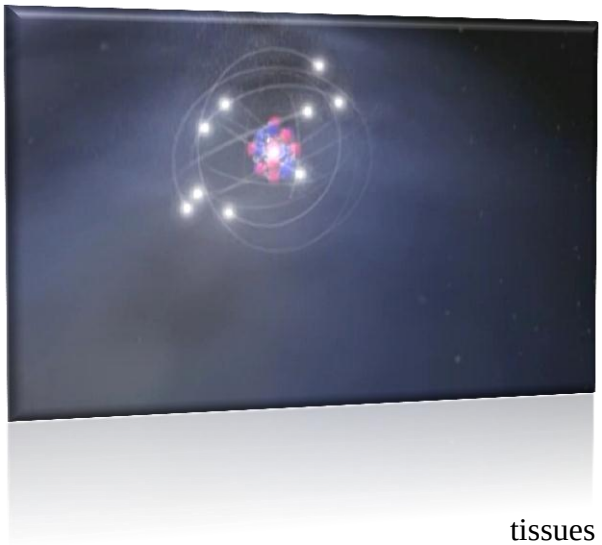
5.8. There are (circle one) tens / hundreds / thousands of different proteins in biological organisms.



5.9. Describe what makes up proteins.

5.10. Based on Axe's research, the number of required changes in the amino acid sequence for functional proteins is feasible by Darwinian mechanisms. True or false?

5.11. According to Axe's peer-reviewed research, the probability of getting a stable, functional protein fold is _____.

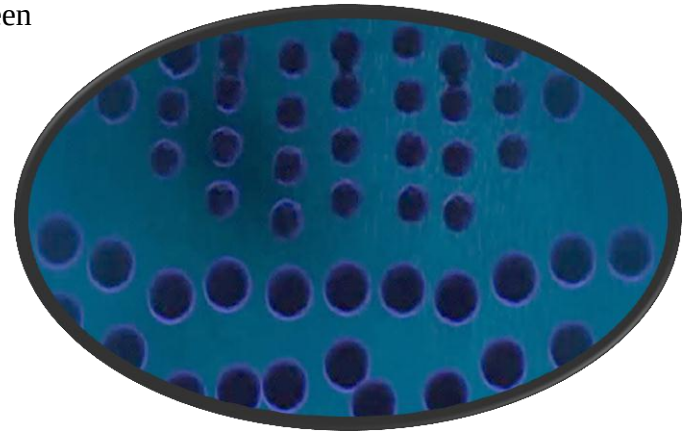


5.12. What illustration is used by Stephen Meyer to explain the incredibly small number noted in Axe's paper?

5.13. The technical terms describing how cells in the embryo gravitate towards their intended "jobs" or roles and functions in the fully developed organism are cell _____ and _____.

5.14. DNA alone contains all the needed directions to organize proteins into cell types and cell types into tissues and organs. True or false?

5.15. Cells' roles can be reversed once they have been initiated in the development process. True or false?

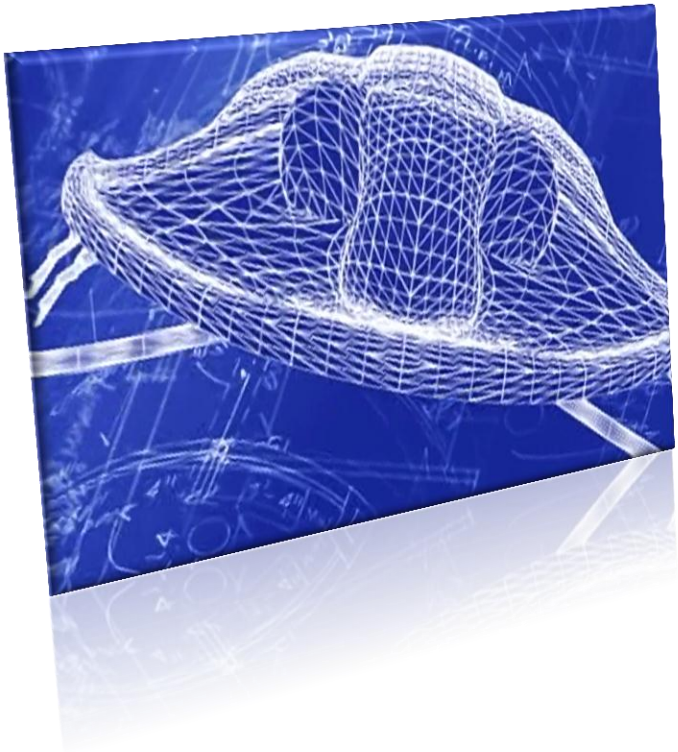


5.16. What cause is capable of explaining the emergence of new body plans?

Chapter 5: Biological Information

5.17. Stephen Meyer's 2004 paper, "The origin of biological information and the higher taxonomic categories," published in the Proceedings of the Biological Society of Washington, caused a maelstrom of criticism from evolutionary scientists. True or false?

5.18. Meyer thought the main reason for the response to his paper was due to his conclusion, in which he proposed _____ _____ as an explanation for the origin of biological information.



5.19. Do we know of a currently operating cause through our common experience that can bring about new information? If so, what is it?

5.20. Determining the cause of biological information uses a process which is outside of the realm of scientific descriptions of causal relationships. True or false?

5.21. Name two of the three different areas of scientific evidence which provide insight into the cause for the complex life found in the Cambrian explosion: _____, _____.

5.22. When we observe the same patterns with minor variations persisting in the fossil record, Meyer suggests this is continuity of an _____ by an _____.

5.23. According to evolutionary biologist Richard Sternberg, other than matter and energy in the universe, an often neglected puzzle piece needing consideration when exploring causes for what we observe in studies of life is _____.

5.24. If intelligent design theory is a correct causal explanation for some aspects of life, what does that imply?

Chapter 5: Biological Information

5.25. What did Darwin say about sudden appearances of many life forms and their impact to his theory?

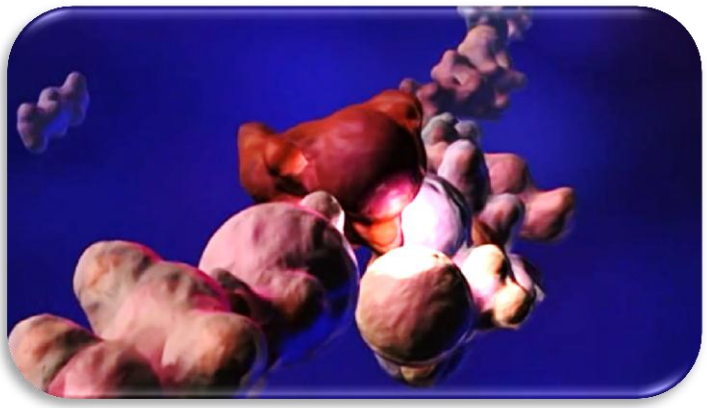
5.26. What is the Darwin quote given at the end of the video indicates his thoughts on the Cambrian explosion?

Discussion Questions:

5.27. What are some key questions noted regarding neo-Darwinian evolution and the fossil evidence from the Precambrian and Cambrian periods?

5.28. The key questions from the previous discussion question also apply down to what small level of life? Why?

5.29. Describe the two features of the most commonly cited mechanism by which neo-Darwinian evolution drives biological change.



5.30. What did Axe do in his research of proteins and why? Explain the implications of his research to the neo-Darwinian mechanisms.

Chapter 5: Biological Information

5.31. If one could describe all the necessary genetic mutations required to produce new functional proteins, would that answer the key question regarding the origins of new body plans? Why or why not?

5.32. What was Charles Lyell's dictum noted by Meyer with respect to understanding the past? Based on the concept associated with that dictum, what key question did Meyer ask himself with respect to his research since leaving Cambridge University as a graduate student?

5.33. What other features of the Cambrian explosion are consistent with this cause? In what way does this cause typically operate when dealing with problems and goals?

Discussion Questions Beyond the Video:

5.34. Describe the basic problem that the presence of information in the genome poses to naturalistic processes or explanations.

5.35. Explain the role DNA plays in natural selection today.

Chapter 5: Biological Information

5.36. Evolutionists sometimes grant that mutations have detrimental effects, but then cite the immense amount of non-protein coding or "junk" DNA as evidence that life evolved through unguided processes. How would you respond to such claims?

5.37. Have you heard of the phrase "ontogeny recapitulates phylogeny"? What does that phrase mean? Based on the information in the video, is the claim in the phrase correct? Why or why not?

5.38. Many evolutionary biologists and textbooks have claimed similarities in the earliest stages of vertebrate embryos show they share a common ancestor. Is this claim correct? Why or why not?

Answers

Please note: Many of these answers contain links to other websites. These were accessed between December 2012 and April 2013. Simply because a link is provided does not necessarily imply endorsement of that site or the views expressed on that site. In the discussion questions, while answers are frequently provided, individual responses are likely to vary; the answers provided for the discussion questions give some of the basic points that could be included in a response.

Chapter 1: The Cambrian Explosion

Basic Questions:

1.1. The Cambrian explosion was the most remarkable and puzzling event in the history of life.
1.2. 530 million.
1.3. False.
1.4. True.
1.5. By geological time standards, it occurred almost instantly.
1.6. stone bugs.
1.7. Trilobite.
1.8. *Marrella.*
1.9. Because it was of a soft bodied animal, it should not be there.
1.10. 1910.
1.11. Burgess Shale.
1.12. Pacific - it was considered to be a reef in the Pacific.
1.13. It is as though they were just planted there, without any evolutionary history.
1.14. No.

Discussion Questions:

1.15. They are soft bodied. Most scientists thought soft-bodied animals were unlikely to leave fossils and used this as one reason to explain why the fossil record lacks innumerable transitional forms.
1.16. Conway Morris notes Cambrian fossils are abrupt in their appearance – there are not many precursors to these fossils. He also indicates everything changes forever after these fossils. Other points also may be noted.
1.17. Answers may vary, but could include the following: the incredible diversity of fossils displaying nearly all of the existing animal phyla. One of the implications for this observed diversity is that animals belonging to such phyla cannot be explained through the gradual changes predicted by traditional evolutionary theory. The geologically short time span coupled with the lack of precursors over such a wide spectrum of life is counter evidence to Darwin's hypothesis of gradual change.
1.18. Answers may vary, but could include one or more of the following:
- Many 'soft' aspects of various animals are seen in the fossils.
- Some of the inner organs are visible, even gut contents.
- Remarkable detail for some features, such as hairs used by worms to facilitate burrowing.

Answers

Discussion Questions Beyond the Video:

1.19. No, Sedgwick and Darwin did not agree (though this was not clear at the time Sedgwick was mentoring Darwin in geology). Darwin wrote his book, *The Origin of Species*, many years after studying geology under Sedgwick, but they remained friends and corresponded until Sedgwick's death in 1873. Upon reading Darwin's book (*The Origin of Species*), Sedgwick criticized it on several levels. One of the more noteworthy criticisms Sedgwick stated was that Darwin's sweeping conclusions used assumptions that "can neither be proved nor disproved." Additionally, Sedgwick criticized Darwin's use of geological evidence, indicating that Darwin did "*over* state the evidence of geology; [and] that you [Darwin] *under* state it while you are talking of the broken links of your natural pedigree" (emphasis in original). In other words, sometimes Darwin overstated geological evidence to prove his point, but understated it when dealing with the problems posed by gaps in the fossil record. See http://www.darwinproject.ac.uk/entry-2548 for additional information.

1.20. Answers will vary based on the individuals. It is likely that, unless the individual is either a paleontologist or biologist, they may have only had a fleeting introduction to this fossil find in a high school or college biology class. Biology textbooks frequently provide limited information on the Cambrian explosion, and often don't even mention it at all. For further information regarding how well some biology textbooks cover the Cambrian explosion, refer to "Not Making the Grade: An Evaluation of 22 Recent Biology Textbooks And Their Use of Selected Icons of Evolution" at http://www.evolutionnews.org/DiscoveryInstitute_2011TextbookReview.pdf and do a search for "Cambrian explosion" or "Darwin's Tree of Life."

Further Reading:

1. Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design*, (HarperOne, 2013) at http://www.darwinsdoubt.com.
2. *Darwin's Dilemma* website at http://www.darwinsdilemma.org.
3. "The Scientific Controversy over the Cambrian Explosion" at http://www.discovery.org/f/119.
4. "Questions about the Cambrian Explosion, Evolution, and Intelligent Design" at http://www.darwinsdilemma.org/pdf/faq.pdf.
5. "Primer: Fossil Evidence in a Nutshell" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1139.
6. "FAQ: Does intelligent design make predictions? Is it testable?" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1156.
7. "Punctuated Equilibrium and Patterns from the Fossil Record" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1232.
8. Casey Luskin, "BioEssays Article Admits 'Materialistic Basis of the Cambrian Explosion' is 'Elusive'," *Evolution News and Views* (June 24, 2009) at http://www.evolutionnews.org/2009/06/bioessays_article_admits_mater.html.
9. Casey Luskin, "Trails of Microorganisms Discovered on Ocean-Bottom Knock Down Favorite Darwinist Argument Against Cambrian Explosion," *Evolution News and Views* (December 14, 2008) at http://www.evolutionnews.org/2008/12/trails_of_microorganisms_disco.html.

Answers

10. Stephen Meyer, "The origin of biological information and the higher taxonomic categories," *Proceedings of the Biological Society of Washington*, 117: 213-239 (2004) at http://www.discovery.org/a/2177. For detailed information on the controversy that followed the publication of this peer-reviewed technical paper, visit the Smithsonian Controversy web page at http://www.richardsternberg.net/smithsonian.php.
11. Stephen Meyer, Marcus Ross, Paul Nelson & Paul Chien, "The Cambrian Explosion: Biology's Big Bang" at http://www.discovery.org/f/639, which is in *Darwinism, Design, and Public Education* (Michigan State University Press, 2003) (see http://www.discovery.org/a/1772).
12. Video: On the Origin of Phyla: An Interview with James Valentine at http://www.veritas-ucsb.org/video/PALEONTOLOGY/VALENTINE/Valentine.html.
13. Simon Conway Morris, "Darwin's dilemma: the realities of the Cambrian 'explosion'," *Philosophical Transactions of the Royal Society B*, 361: 1069-1083 (2006) at http://rstb.royalsocietypublishing.org/content/361/1470/1069.full.pdf+html.
14. Virtual Fossil Museum: The Cambrian Explosion at http://www.fossilmuseum.net/Paleobiology/CambrianExplosion.htm.
15. "Evolution's Big Bang" at http://www.time.com/time/covers/0,16641,19951204,00.html, *Time* magazine cover story on the Cambrian explosion (December 4, 1995).
16. Resources on the Fossils of the Burgess Shale:
    - "The Burgess Shale: Evolution's Big Bang" online exhibit at http://www.burkemuseum.org/static/bshale/.
    - "The Burgess Shale" (Smithsonian Institution National Museum of Natural History) at http://paleobiology.si.edu/burgess/.
    - "Charles Walcott and the Burgess Shale" at http://burgess-shale.rom.on.ca/en/history/discoveries/02-walcott.php.
    - "The Panoramic Photographs of Charles D. Walcott" at http://siarchives.si.edu/collections/search?query=%22Photography%22&facets=SEC_4&page=1&perpage=10&sort=relevancy&view=list.

Chapter 2: Darwin's Dilemma

Basic Questions:

2.1. Nothing distressed Darwin more than the Cambrian explosion.
2.2. The Origin of Species. (The full title was: On the Origin of Species by Means of Natural Selection, on the Preservation of Favored Races in the Struggle for Life.)
2.3. natural selection; common ancestry. Note: Darwin was unaware of genetic mutations at the time he wrote his book. Gregor Mendel discovered the genetic basis of heredity in Darwin's time, but Darwin was not aware of Mendel's work. Not until the late 1800s did some scientists realize Mendel had uncovered the previously unknown mechanism of heredity. This is why neo-Darwinism is often called the "synthetic theory of evolution" because it synthesized both Darwin's natural selection with Mendelian heredity/genetics.
2.4. A branching tree of life, starting with the 'protists' as the trunk.
2.5. True.
2.6. imperfect, or incomplete.
2.7. Later studies of the ocean floor. He thought such studies would show the apparently missing fossils.
2.8. 90%.

Answers

2.9. True.
2.10. Size and complexity - microscopic single celled life versus multi-cellular organisms.
2.11. Ediacaran fauna
2.12. About 3.8 billion years ago.
2.13. 21st hour.
2.14. 2 minutes.
2.15. All of them. For a list of the various places on each continent with fossil finds from different geological periods, see http://www.fossilmuseum.net/FossilSites.htm.

Discussion Questions:

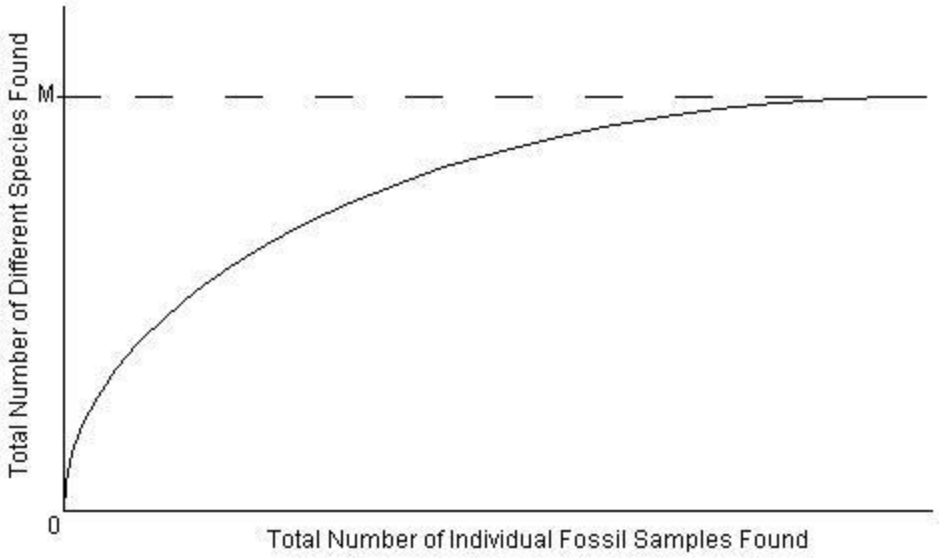
2.16. Darwin's theory attempts to provide a unifying concept of life through common ancestry. If all life forms are related somehow in the past, this is thought to help explain similarities and differences between different animal groups. If this is the case, then understanding how a biological system in one organism works can facilitate comprehension of similar systems in other related organisms. For a brief overview of evolutionary theory (and some of its problems), see "Primer: Evolutionary Theory" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1096. However, from an intelligent design perspective, the similarities and differences between different organisms can also be understood. Intelligent design considers common design based upon similar blueprints and functional needs useful to explain why many similarities exist between organisms. Unlike Darwinian theory, intelligent design is not limited to one particular "tree" of evolutionary relationships, and thus is not refuted by evidence which cannot fit into a treelike pattern.
2.17. There should be evidence of lots of transitional forms and biological dead ends or experiments resulting from the process of natural selection. Darwin thought this should be the case based on the unguided nature of natural selection and gradualistic tinkering he thought it would perform over time on life forms.
2.18. The major animal groups or phyla appeared essentially without evolutionary precursors in the fossil record. Additionally, discoveries of life forms not previously known to exist also had hardly any precursors. These two key points of evidence (i.e., new unknown forms and the majority of known phyla, both predominantly without precursors) countered the notion of innumerable transitional forms that should be present if Darwin's gradualistic theory of evolution is correct. Darwin openly recognized it could be used as counter-evidence to his claims.
2.19. Offshore oil drilling provides the ability to test Walcott's proposal. Of the drill cores taken, the fossils found were not Cambrian explosion precursors. Walcott's proposal has been falsified and rejected based on this information.
2.20. No, because the earliest ocean floor rocks date to the Jurassic period, which is millions of years after (or younger) than the Cambrian.
2.21. Answers will vary for each individual.

Answers

Discussion Questions Beyond the Video:

2.22. Admissions of this type reduce the certainty level for claims made about the fossil record supporting Darwinism. If the fossil record is unreliable, then how can it be said to support neo-Darwinism, or any theory for that matter? This implies that fossils should not be cited to claim that traditional evolutionary theory is "fact," and beyond scientific dispute. If the fossil record is incomplete, then claims about common ancestry should be made tentatively, in keeping with the paucity of evidence from the fossil record. Nonetheless, as seen in the answer to the next question, the fossil record is not entirely incomplete.

2.23. By reviewing statistical studies of fossils found the fossil record's completeness can be tested. One statistical method used to determine the "completeness" of the fossil record is the collector's curve, seen in the chart below:



A collector's curve measures the total number of fossil specimens found vs. the total number of different species found. As seen in the chart, when fossil collection began, each new find tends to also represent a new species that was not known before. But as time goes on, and more discoveries are made, new types of fossils will eventually be much less common. Put another way, once you have surveyed much of what is out there, there is not much new that is left to find.

Using these kinds of methods, some studies have found that the fossil record is relatively complete. One paper in *Nature* found that among the higher taxonomic categories (family and above), "the past 540 million years of the fossil record provide uniformly good documentation of the life of the past." (See M. J. Benton, M. A. Wills, and R. Hitchin, "Quality of the fossil record through time," *Nature*, 403: 534-536 (February 3, 2000) – abstract available at http://www.ncbi.nlm.nih.gov/pubmed/10676959.) Or, as another paper observes, "in many respects our view of the history of biological diversity is mature." (See Mike Foote, "Sampling, Taxonomic Description, and Our Evolving Knowledge of Morphological Diversity," *Paleobiology*, 23: 181-206 (Spring, 1997).)

Answers

2.24. Answers may vary, but could include the following: Admissions are often made about previous knowledge of phylogenetic (i.e., 'family tree') relationships not being well understood or well documented. It seems some evolutionists are comfortable admitting their prior ignorance only after so-called "missing links" are found. For some specific examples of this, see the following:

- "Retroactive Confessions of Ignorance and Overblown Claims of Evolution: Observing Evolutionist and Media Behavior after Discovering 'Missing Links'" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1408.
- Casey Luskin, "Ida's Bust Maroons Retroactive Confessions of Ignorance about Primate Evolution," *Evolution News and Views* (April 10, 2010) at http://www.evolutionnews.org/2010/04/idas_bust_maroons_retroactive033671.html.

In other instances, admissions are made about the new find causing significant problems for prior understandings of phylogenetic relationships. This frequently is due to a new fossil being found much earlier than was previously thought possible for that type of fossil. For a specific example of such a find, see Casey Luskin, "*Tiktaalik* Blown 'Out of the Water' by Earlier Tetrapod Fossil Footprints," *Evolution News and Views* (January 7, 2010) at http://www.evolutionnews.org/2010/01/tiktaalik_blown_out_of_the_wat030621.html. The kinds of acknowledgements made when "missing links" are found suggest prior claims of certainty of the supportive evidence provided in the fossil record were, in fact, not "certain."

Further Reading:

1. Refer to Chapter 1 Further Reading items.
2. Casey Luskin, "More Problems with TalkOrigins' Response on the Cambrian Explosion," *Evolution News and Views* (May 22, 2012) at http://www.evolutionnews.org/2012/05/more_problems_w059921.html.
3. Jonathan M., "In Explaining the Cambrian Explosion, Has the TalkOrigins Archive Resolved Darwin's Dilemma?," *Evolution News and Views* (May 2, 2012) at http://www.evolutionnews.org/2012/05/has_the_talk-or059171.html.
4. Casey Luskin, "Fossil Finds Show Cambrian Explosion Getting More Explosive," *Evolution News and Views* (May 28, 2010) at http://www.evolutionnews.org/2010/05/fossil_finds_show_cambrian_exp035191.html.

Chapter 3: Chinese Fossils

Basic Questions:

3.1. China (Chengjiang, Yunnan Province).
3.2. 1984.
3.3. Three features of the fossils: 1) older, 2) better preserved, and 3) more diverse than at other locations in the world.
3.4. True.
3.5. Chinese newspapers.
3.6. These findings challenged Darwin's theory. Note: Some have joked that in China you can challenge Darwinism but not the government, while in America, you can challenge the government but not Darwin.
3.7. "Evolution's Big Bang."
3.8. love; avoid.
3.9. Rather than displaying gradualism, most animals appear without precursors.

Answers

3.10. False – paleontologists found they are older.
3.11. more details.
3.12. 5-10 million years.
3.13. quantum jump.
3.14. True.
3.15. Precambrian fossils.
3.16. 60.
3.17. 500-800 micrometers or 0.5-0.8 millimeters, which is about 0.02-0.03 inches or 2-3 hundredths of an inch.
3.18. Sponge eggs and embryos.
3.19. They are small and soft bodied. Note: This refutes the Darwinian claim that transitional forms prior to the Cambrian explosion were missing because they were small and soft bodied.
3.20. True.
3.21. complete.
3.22. They are not there – we've looked long and hard enough.

Discussion Questions:

3.23. The initially proposed 20-40 million years was too long. This causes further problems for the neo-Darwinian view because of less time for mutations to occur and bring about the diversity found in the fossils. For further information regarding the "complexity problem" caused by the Cambrian fossils, see Casey Luskin, "From the Cambrian Explosion: Complex Brains and Other 'Headaches' for Darwinian Evolutionists," *Evolution News and Views* (October 11, 2012) at http://www.evolutionnews.org/2012/10/from_the_cambri_1065181.html.
3.24. It occurred in less time than the resolution provided by the fossil record - it could have happened overnight. We do not know how long it actually was - all we know is it was very fast by geologic standards.
3.25. The rocks are phosphatic. The chemistry of the sea must have changed during the Cambrian because the method of fossilization proposed no longer exists. This explanation, while helpful for providing a possible mechanism for excellent fossil preservation, does not elucidate the origination of the new body plans; it does not address the cause for new information required for new body plans. For additional information, see Casey Luskin, "Does Lots of Sediment in the Ocean Solve the 'Mystery' of the Cambrian Explosion?," *Evolution News and Views* (April 27, 2012) at http://www.evolutionnews.org/2012/04/lots_of_sedimen059021.html.

Answers

3.26. Answers may vary, but could include the following: Large soft bodied fossils should also be found if sponge eggs and embryos are, including those creatures purported to be the precursors of the Cambrian. Even more so should the speculated hard shelled precursors to the hard shelled trilobites be present if small soft bodied fossils are present. But they are not. Furthermore, explaining the origin of arthropods, brachiopods, most echinoderms, etc. (animals with hard outer shells and soft tissue inside) becomes similar to a "chicken and egg" problem since these kinds of animals cannot live without their hard outer shell/skeletal structure. The fact that they are not present in the Precambrian suggests they never existed. For additional information, see Jonathan Witt, "Derbyshire III: Soft Bodies a Femme Fatale for Darwinism," *Evolution News and Views* (February 15, 2005) at http://www.evolutionnews.org/2005/02/title_9000829.html.

3.27. Nelson thinks new species will likely fall into existing categories based on past findings. Fairly extensive work occurred over the last couple of decades on Cambrian fossils. Because of this extensive work, few paleontologists anticipate that many fundamentally new types of animals will be found. (Refer to the answer for question 12.23 on page 29 which supports this reasoning with the collector's curve.)

Discussion Questions Beyond the Video:

3.28. Precambrian life forms provide a partial answer to Darwin's Dilemma for those animals that can be identified as precursors to Cambrian life forms. However, the majority of Cambrian life forms show no ancestral forms; most of the Precambrian animals (if they are indeed animals, a matter of dispute given the unique features of the Precambrian fossils) are not precursors to the Cambrian animals. Additionally, the origination of Precambrian life forms must be explained; if they abruptly appear themselves, all that has occurred is the initial problem has been pushed back in time – it remains unresolved. For additional information, refer to the following:

- Gregory J. Retallack, "Ediacaran life of land," *Nature* 493: 89-92 (2012) at http://www.nature.com/nature/journal/vaop/ncurrent/full/nature11777.html.
- For a popular summary of the above reference, along with other past similar articles, see Casey Luskin, "*Nature* Paper Removes Enigmatic Ediacaran Fossils from the Ancestry of Cambrian Explosion Animals," *Evolution News and Views* (December 18, 2012) at http://www.evolutionnews.org/2012/12/nature_paper_re_1067571.html.
- Casey Luskin, "Alas, Precambrian Microfossils Are Not the Solution to Darwin's Dilemma," *Evolution News and Views* (December 29, 2011) at http://www.evolutionnews.org/2011/12/precambrian_mic054611.html.
- Jonathan Wells, "Deepening Darwin's Dilemma" at http://www.discovery.org/a/12471.
- Question 2, "Has the Precambrian fossil record solved 'Darwin's dilemma'?" in "Questions about the Cambrian Explosion, Evolution, and Intelligent Design" at http://www.darwinsdilemma.org/pdf/faq.pdf.

Answers

3.29. Answers may vary, and might include the following. There are two separate claims which must be considered separately: 1) millions of years is a sufficient time period for evolutionary mechanisms to generate new animal body plans, and 2) there are other examples of similar rapid evolutionary change in the fossil record. Regarding the first claim, the most recent estimates of the timing of the Cambrian explosion indicate it took much less than 20 million years, with the bulk of the explosion taking place in a mere 5 to 10 million years. See Douglas H. Erwin, Marc Laflamme, Sarah M. Tweedt, Erik A. Sperling, Davide Pisani, and Kevin J. Peterson, "The Cambrian Conundrum: Early Divergence and Later Ecological Success in the Early History of Animals," *Science*, 334: 1091-1097 (2011) at http://hdl.handle.net/10088/17621. Moreover, it must be asked whether 5, 10, 20, or even 100 million years is enough to generate the complex features found in animal body plans. According to Stephen Meyer's 2013 book *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design*, even many millions of years are far from sufficient to generate the new proteins needed for new animal body plans. For an evolutionist to claim the Cambrian explosion is not a problem, he or she must show that the relevant mutation rates and population sizes are sufficient to produce complex biological features—but such arguments are almost never made by evolutionists.

For the second claim, it commits a logical fallacy of begging the question or circular reasoning as it asserts the very thing that is being questioned – a need for an evolutionary mechanism to explain the rather abrupt appearance of life forms in the fossil record. Citing other periods in the fossil record also showing rapid change does not demonstrate that Darwinian mechanisms are sufficient to produce the rapid change which emerged in those explosions. (Aside: When evolutionary proponents put forth assertions, ask them to substantiate their claims with evidence consistent with established evolutionary mechanisms.)

3.30. Answers may vary, but may include something like: This completely sweeps under the rug the central problem with the Cambrian explosion: the majority of life forms found during that period have no precursors – there is no common ancestor that is identifiable in the fossil record. Attempting to use other claimed transitional fossil forms in later periods does not address the problem posed specifically by the Cambrian explosion. Additionally, simply referring to claimed fossilized transitional forms between living animals and their primitive ancestors is not providing the necessary evidence associated with the mutation-selection evolutionary mechanism. Simply because one life form is similar to another does not prove unguided processes brought about the changes; the specific mutations needed to go from one form to another in light of the environment surrounding those organisms must be proposed. Neo-Darwinism is not a theory of similarity, but is instead of unguided processes providing all the generative power to sufficiently explain all of life's diversity. Furthermore, the similarity seen could be the result of common design rather than common descent. For additional information, see Ann Gauger, "Confusing Similarity with Evolutionary History," *Biologic Institute* (December 16, 2012) at http://www.biologicinstitute.org/post/38126556097/confusing-similarity-with-evolutionary-history.

Answers

3.31. This is interesting because there are quite a few Cambrian fossils exhibiting bilateral symmetry. For Darwinism to be correct, there must be precursors to this symmetry in the Precambrian. Similar to many other aspects for the Cambrian animals, the origination of this feature must be explained through unguided natural processes. Some evolutionary scientists have claimed to have found this ancient bilaterian animal, *Vernanimalcula*, in Precambrian rocks. However, recent studies have suggested that this supposed ancestor is nothing of the sort – it may not even be an animal. See Casey Luskin, "Paper Lays to Rest '*Vernanimalcula*,' Supposed Precambrian Ancestor of Bilaterian Animals," *Evolution News and Views* (December 10, 2012) at http://www.evolutionnews.org/2012/12/paper_lays_to067271.html. There is also a podcast discussing this at *ID The Future* (January 11, 2013) "Paper Lays to Rest '*Vernanimalcula*,' Supposed Precambrian Ancestor of Bilaterian Animals" at http://www.idthefuture.com/2013/01/paper_lays_to_rest_vernanimalc.html.

3.32. Other explosions in the history of life include:

- A Silurian-Devonian fish explosion
- An explosion of marine Mesozoic reptiles.
- An explosion of angiosperms in the Cretaceous.
- A bird explosion in the late Cretaceous
- A mammal explosion in the early Tertiary
- The appearance of our own genus *Homo* has also been called an explosion.

These cause problems for an evolutionary explanation because the necessary genetic changes for new life forms must be explained within a geologically short time span. Unguided natural processes, such as the mutation-selection mechanism, cannot explain the appearance of such great biodiversity in such a short amount of time. For a discussion, see Casey Luskin, "Three (or Four) Reasons Everyone Should Read Darwin's Doubt," *Evolution News & Views* (April 9, 2013) at http://www.evolutionnews.org/2013/04/three_or_four_r071001.html.

3.33. Answers may vary, but may note the following: Textbooks may avoid extensive discussions on the Cambrian explosion due to the significant problems it poses for Darwin's theory of gradual evolution. This suggests his extrapolation from the microevolution (i.e., small scale changes) that occur within species to the macroevolution (i.e., large scale change) of new species may be unwarranted For a recent (2011) review of 22 textbooks' treatment of the Cambrian explosion, see "Not Making the Grade: An Evaluation of 22 Recent Biology Textbooks And Their Use of Selected Icons of Evolution" at http://www.evolutionnews.org/DiscoveryInstitute_2011TextbookReview.pdf.

Further Reading:

1. Casey Luskin, "Three (or Four) Reasons Everyone Should Read *Darwin's Doubt*," *Evolution News & Views* (April 9, 2013) at http://www.evolutionnews.org/2013/04/three_or_four_r071001.html.
2. Chengjiang China Fossils—"A Window to the Cambrian Explosion," Virtual Fossil Museum at http://www.fossilmuseum.net/Fossil_Sites/Chengjiang.htm.
3. Fred Heeren, "Challenging Fossil of a Little Fish," *The Boston Globe* (May 30, 2000) at http://www.fredheeren.com/boston.htm.
4. Fred Heeren, "Paleontologic Agitprop?," *Insight on the News* (July 24, 2000) at http://www.fredheeren.com/washtimes.htm.

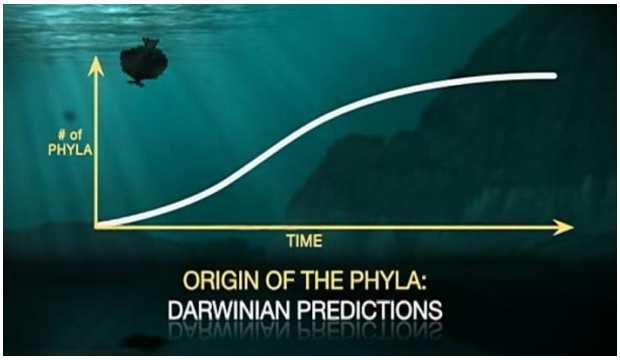
Answers

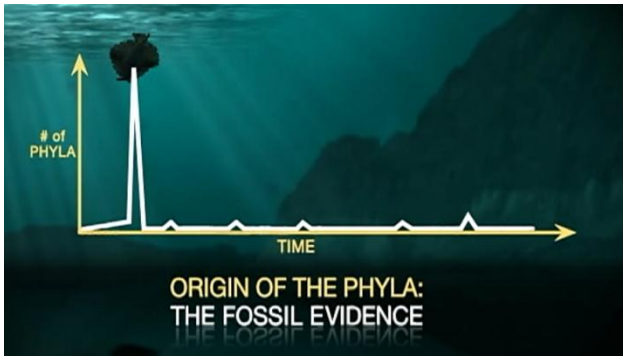
5. Video:
   - "Investigating Evolution: The Cambrian Explosion, pt. 1" at http://www.youtube.com/watch?v=4DkbmuRhXRY.
   - "Investigating Evolution: The Cambrian Explosion, pt. 2" at http://www.youtube.com/watch?v=iZFM48XIXnk.
6. Paul Chien's QUIZ & ANSWERS for: Intelligent Design and the Origin of Animal Phyla from the 2002 University of San Francisco IDEA Conference at http://www.ideacenter.org/contentmgr/showdetails.php/id/814.

Chapter 4: The Phyla

Basic Questions:

4.1. All of the known animal body plans seem to have appeared in the Cambrian radiation.
4.2. Galápagos Islands.
4.3. His "tree of life."
4.4. body plans. For example the vertebrate body plan has a hard skeleton on the inside surrounded by soft tissue. The arthropod body plan has a hard exoskeleton on the outside, and soft tissue on the inside.
4.5. True.
4.6. Sudden appearance of organisms should not occur. If they do occur, they could be positive evidence for an intelligent design-based view of life.
4.7. True.
4.8. smooth curves. See images below for a comparison of Darwin's predication versus actual fossil evidence:



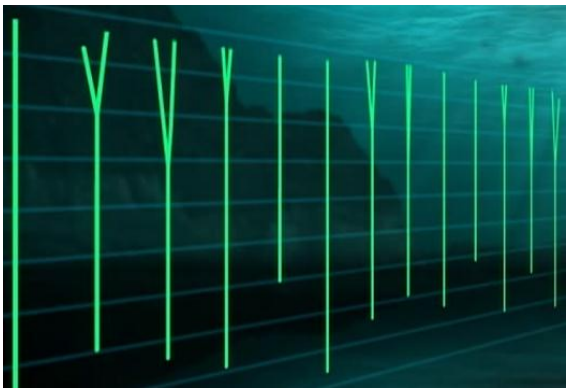


4.9. Automobiles – basic structure of a frame, 4 wheels, engine, transmission and drive shaft are common to all automobiles as the basic body plan. Differentiation into different types of cars over time appears (sedans, trucks, sports cars, etc.).
4.10. Segmented torso, segmented legs, exoskeleton.

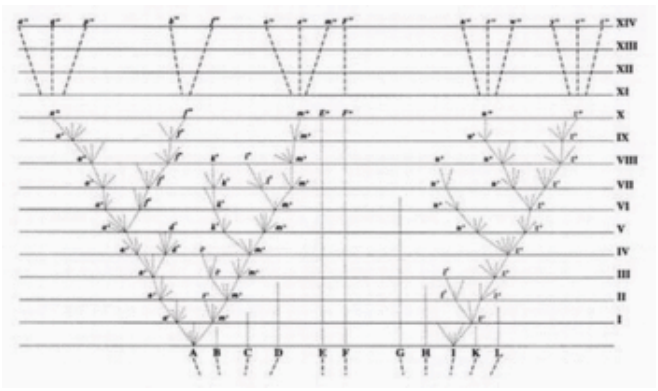
Answers

4.11. True. For additional information, see "A Primer on the Tree of Life" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1481.

Wells



Darwin



4.12. It could be used as evidence against it.
4.13. worse.

Discussion Questions:

4.14. As species change over time, their differences become more pronounced and, eventually, lead to major differences between animals or differences on the phyla level. This leads to the corollary claim that all of life is related through common ancestry. The tree seemed a natural way to illustrate this idea.
4.15. The abundance of different phyla appearing in the fossil record almost simultaneously during the Cambrian explosion does not provide supporting evidence for the "bottom-up" view; the majority of current body plans show up during the Cambrian period without precursors. The fossil record supports the "top-down" view which says the body plan differences were already present from the beginning rather than developing over time.
4.16. The fossil record should document the appearance of an increasing number of phyla from the Precambrian to the Cambrian with readily identifiable ancestral relationships. However, this is not the case – many different phyla appear rapidly (by geological time spans) with hardly any likely precursors in the Precambrian.

Discussion Questions Beyond the Video:

4.17. As molecular biology has dramatically increased our understanding of the workings of the cell, it also provided the ability to attempt to construct phylogenies based upon biomolecules. However, molecular phylogenies often conflict one-another, or with conventional phylogenies based upon based on the morphology or organismal form and structure of organisms. In fact, conflicts between molecular and morphology based phylogenies are very common – see Trisha Gura, "Bones, Molecules or Both?," *Nature*, 406: 230-233 (July 20, 2000) at http://www.nature.com/nature/journal/v406/n6793/full/406230a0.html. Rather than resolve previously missing portions of phylogenies, molecular evidence accentuated the problems. For additional information, see the following:
    - "Summary of Breakdowns in Attempts to Reconstruct the Tree of Life" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1512.

Answers

- "Primer: Genetic Evidence in a Nutshell" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1140.
- "A Primer on the Tree of Life" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1481.

4.18. Punctuated equilibrium (PE). The basic idea for this theory is that species will experience long periods of stasis (i.e., no changes) with short (i.e., punctuated) periods of rapid changes. These rapid changes are thought to occur in relatively small portion of individuals of a given species through geographical isolation from others within that species. One of the main difficulties associated with PE is that it must "walk the tightrope" of having significant genetic changes occur over a short period of time while also having such a small population that no fossils are left. A reasonable question to ask is, even if this can occur, is it the likely mechanism which occurred throughout the much of life's development based on the apparent missing links? For additional information on PE, refer to the following:

- "Punctuated Equilibrium and Patterns from the Fossil Record" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1232.
- Casey Luskin, "What I did on My Summer Vacation: A Book Report and Summary of Steven Stanley's 'The New Evolutionary Timetable Timetable: Fossils, Genes, and the Origin of Species'" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1262.

4.19. Answers will vary depending on the individual. There are at least two notable websites that attempt to address the problems posed by the Cambrian explosion:

- "Does the Cambrian Explosion pose a challenge to evolution?," *BioLogos* at http://biologos.org/questions/cambrian-explosion.
- A *TalkOrigins* article addressing creationist claims, CC300, at http://www.talkorigins.org/indexcc/CC/CC300.html.
- Criticisms for the first (*BioLogos*) article are noted in the answer to question 13.29 on page 33. Criticisms of the second (*TalkOrigins*) reference can be found at the blog post by Jonathan M., "In Explaining the Cambrian Explosion, Has the TalkOrigins Archive Resolved Darwin's Dilemma?," *Evolution News and Views* (May 2, 2012) at http://www.evolutionnews.org/2012/05/has_the_talk-or059171.html and Casey Luskin, "More Problems with TalkOrigins' Response on the Cambrian Explosion," *Evolution News and Views* (May 22, 2012) at http://www.evolutionnews.org/2012/05/more_problems_w059921.html.

4.20. Because biologists are trained to believe that neo-Darwinian evolution is the only possible explanation of how life developed on earth. Replacing conventional, long-held beliefs is as slow in science as in other disciplines. The sluggishness of scientific revolutions is documented in Thomas Kuhn's book, *The Structure of Scientific Revolutions*. Max Planck, known as the "Father of quantum mechanics," when asked why the scientific community took so long to accept his ideas, stated that *"A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."* (See http://en.wikiquote.org/wiki/Max_Planck, citing *Wissenschaftliche Selbstbiographie. Mit einem Bildnis und der von Max von Laue gehaltenen Traueransprache*., Johann Ambrosius Barth Verlag, (Leipzig 1948), p. 22, as translated in *Scientific Autobiography and Other Papers*, trans. F. Gaynor (New York, 1949), pp.33-34, as cited in T.S. Kuhn, *The Structure of Scientific Revolutions*, p. 150).) This has been paraphrased as "Science advances one funeral at a time."

Answers

Further Reading:

1. Casey Luskin, "Darwin's Failed Predictions, Slide 13: 'The abrupt appearance of biological forms' (from JudgingPBS.com)," *Evolution News and Views* (January 10, 2008) at http://www.evolutionnews.org/2008/01/darwins_failed_predictions_sli_12004658.html. See also the website http://www.judgingpbs.com/.
2. Paul Nelson, "Molecular Phylogeny and Phylogenetic Trees," *Explore Evolution* at http://www.exploreevolution.com/exploreEvolutionFurtherDebate/2009/02/molecular_phylogeny_and_phylog.php.
3. Jonathan M., "Fact-Checking Wikipedia on Common Descent: The Evidence from Paleontology," *Evolution News and Views* (October 23, 2011) at http://www.evolutionnews.org/2011/10/fact-checking_wikipedia_on_com_1051951.htm
4. Stephen C. Meyer, Scott Minnich, Jonathan Moneymaker, Paul Nelson, Ralph Seelke, *Explore Evolution: The Arguments For and Against Neo-Darwinism* (HillHouse, 2007). See http://www.exploreevolution.com.
5. Chapter 13, "Tree Huggers," in Gary Kemper, Hallie Kemper, and Casey Luskin, *Discovering Intelligent Design* (Discovery Institute Press, 2013). See http://discoveringid.org/.

Chapter 5: Biological Information

Basic Questions:

5.1. "Without gradualness … we are back to a miracle."
5.2. False. Sponge embryo fossils have been found from the Precambrian era.
5.3. 10.
5.4. Where did the new genetic information come from that produced these new cell types?
5.5. Climbing mount improbable.
5.6. protein or amino-acid
5.7. A new protein fold.
5.8. thousands.
5.9. Amino acids. More specifically, chains of about 20 different kinds of amino acids in a particular sequence. The sequence is specified by the nucleotides of the DNA (the "rungs" across the "ladder" of the double helix).

Answers

5.10. False. Axe's research discussed is in "Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Folds," *Journal of Molecular Biology*, 341: 1295–1315 (2004) (the abstract is available at http://www.ncbi.nlm.nih.gov/pubmed/15321723) and is summarized by the following at http://www.discovery.org/a/2640: This experimental study shows that functional protein folds are extremely rare, finding that "roughly one in 10^{64} signature-consistent sequences forms a working domain" and that the "overall prevalence of sequences performing a specific function by any domain-sized fold may be as low as 1 in 10^{77}." Axe concludes that "functional folds require highly extraordinary sequences." Since Darwinian evolution only preserves biological structures that confer a functional advantage, it would be very difficult for such a blind mechanism to produce functional protein folds. This research also shows that there are high levels of specified complexity in enzymes, a hallmark indicator of intelligent design. Axe himself has confirmed that this study adds to the evidence for intelligent design: "In the 2004 paper I reported experimental data used to put a number on the rarity of sequences expected to form working enzymes. The reported figure is less than one in a trillion trillion trillion trillion trillion trillion. Again, yes, this finding does seem to call into question the adequacy of chance, and that certainly adds to the case for intelligent design." See John G. West, "Scientist Says His Peer-Reviewed Research in the Journal of Molecular Biology 'Adds to the Case for Intelligent Design'," *Evolution News and Views* (January 10, 2007) at http://www.evolutionnews.org/2007/01/journal_of_molecular_biology_a.html.

5.11. $1/10^{74}$.

5.12. A blind-folded individual throws a dart and hits a single atom in our entire galaxy.

5.13. specification; differentiation.

5.14. False. DNA does not carry all the information for cell specification and differentiation. Scientists at this point cannot completely explain the source of the information; however, it seems to be a combination of genes, three-dimensional cellular structure, and biochemical signaling. For additional information, refer to the following:

- "Cell Positioning Uses 'Good Design'," *Evolution News and Views* (March 2, 2013) at http://www.evolutionnews.org/2013/03/cell_positionin069471.html.
- Jonathan M., "Beyond The Genome: A Non-Reductionist Perspective On Development," *Evolution News and Views* (June 2, 2011) at http://www.evolutionnews.org/2011/06/beyond_the_genome_a_non-reduct047021.html.
- Jonathan Wells, "Cellular Zip Codes: Where's the Postmaster?," *Evolution News and Views* (January 23, 2007) at http://www.evolutionnews.org/2007/01/cellular_zip_codes_wheres_the003087.html – note that some answers have now been provided to questions posed in this link – see links above and below for further information.
- Jonathan M., "'Junk DNA' and the Molecular Basis of Cell Identity," *Evolution News and Views* (March 24, 2011) at http://www.evolutionnews.org/2011/03/junk_dna_and_the_molecular_bas045091.html.
- Chapter 14, "The Epigenetic Revolution," in Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOn3, 2013).

5.15. False.

5.16. intelligence.

5.17. True.

5.18. intelligent design.

Answers

5.19. Yes. An intelligent cause can generate new information.
5.20. False. It should be noted that some may claim this does fall outside of the realm of science – but this is only true if one defines science in such a way that only material causes are permitted. However, doing so provides limitations on the explanatory "toolset" available to science. A more appropriate definition of science allows whatever explanations we can identify from everyday experience and the scientific method that the evidence supports, thereby releasing scientific understanding from certain philosophical restrictions that may be unnecessary.
5.21. Any two of the following: paleontology, genetics, embryology.
5.22. idea; intelligence.
5.23. information.
5.24. Life was designed or intended rather than the result of unguided processes.
5.25. Darwin wrote in Origin of Species: "If numerous species belonging to the same genera or families have really started into life all at once, the fact would be fatal to the theory of descent with slow modification through natural selection." A shortened paraphrase might be: If life forms do not have precursors, it will be a big problem for my theory.
5.26. The case, at present, must remain inexplicable … I can give no satisfactory answer.

Discussion Questions:

5.27. Answers may vary, but could be along the following lines: How do new body plans and new forms of life come into existence? What is the origin for all these life forms in the Cambrian with essentially no pre-cursors? How did all the new information associated with the new life forms arise given the dramatic increase in complexity between most Precambrian and Cambrian life forms?
5.28. These questions can be applied to the molecular level of life because the origin of new types of proteins and their coding genes must also be explained (recall the comparison used between Precambrian sponges and Cambrian trilobites). It is at this molecular level through genetic mutations that the creative force frequently cited in neo-Darwinism operates. Therefore, explanations in the molecular arena are necessary to substantiate the extensive credit given to naturalistic mechanisms for the diversity of life seen in the fossil record.
5.29. The two features of the most well-known neo-Darwinian mechanism are: genetic mutation and natural selection. If a genetic mutation provides a survival benefit to an organism, this change will likely persist in future generations. These mutations bring about changes in proteins, which can effect cells and lead to new types of organisms. For further discussions of evolutionary theory, see:
- "Primer: Evolutionary Theory in a Nutshell" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1138.
- "Primer: Evolutionary Theory" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1096 .
- "What is the modern theory of evolution?" at http://www.discovery.org/a/9491.
- "Primer: Mutations in a Nutshell" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1145.

Answers

5.30. Axe randomly knocked out and replaced various amino acids in a protein and then studied whether a new functional protein fold occurred. He did this to model the neo-Darwinian mechanism of random genetic mutations and their effect on proteins. (Some background information regarding protein generation is worth providing here. Amino acids are linked together in a linear chain following a unique sequence specified by segments of DNA. Once the chain is assembled, it folds into a unique 3-dimensional shape - with the assistance of other molecules, such as the HSP-60- that gives it the properties needed to function in the cell. Changes in the amino acid sequence - caused by genetic mutations or other mechanisms - will cause the protein to fold differently, thereby having a different function (or lack thereof). It is in this way that transitional changes can be objectively observed and measured.) More specifically, Axe wanted to determine the likelihood of beneficial mutations occurring to bring about a new functional protein. The implications of his research are that the chances of getting beneficial mutations leading to new functional proteins are prohibitively small for random genetic mutations.

5.31. No. The body plan is not defined by the genes. There are other epigenetic (i.e., outside of the genome) biochemical factors driving the body plan formation during initial developmental stages following conception. The body plan is defined in another layer of information located in the three dimensional structure and chemistry of the fertilized egg and embryo. Refer to the links provided in answer 5.14 on page 39 for additional information.

5.32. The present is the key to the past. We can apply causes we see operating today to explain past events. Meyer asked: What cause is operating today that brings about new information? His answer: intelligence.

5.33. Top-down pattern of appearance rather than simpler to more complex appearance. Hierarchical arrangement of parts. Absence of Transitional Fossils. This cause operates by starting off with the big picture or goal and working down to the details for how that end goal will be achieved.

Discussion Questions Beyond the Video:

5.34. Complex and specified information cannot be produced by unguided natural processes. Moreover, information does not require material objects for its origin. While it does rely on various material mediums for expression, it is separate from those mediums in meaning. An analogy would be that words written on a sheet of paper convey information that is completely independent of the chemistry of the ink and paper. Information and the medium through which it is expressed are independent entities.

5.35. Mutations in DNA are thought to bring about physical changes in organisms, upon which natural selection can act. Without DNA, there is no reliable inheritance mechanism to pass on altered traits.

Answers

5.36. Answers will vary depending on the individuals familiarity with these topics, but may include the following: Recent research has shown that non-coding DNA is not "junk" but has important functions. As a result of the ENCODE research which came out in late 2012, at least 80% of the human genome has some type of biochemical function. Whether the 'function' can be considered 'meaningful' is still being debated. But one thing is certain, the idea of "junk DNA" can no longer be used to justify an evolutionary history. For additional information, see Jonathan Wells, *The Myth of Junk DNA* (http://www.mythofjunkdna.com/, Discovery Institute Press, 2011) or Casey Luskin, "Junk No More: ENCODE Project Nature Paper Finds 'Biochemical Functions for 80% of the Genome'," *Evolution News and Views* (September 5, 2012) at http://www.evolutionnews.org/2012/09/junk_no_more_en_1064001.html.

5.37. Answers may vary depending on whether or not individuals have heard of the phrase noted. The phrase means that embryological development reflects some evolutionary history. Based on the information noted in the video, this is unlikely due to the lack of a genetic heritability mechanism to drive changes in body plans. In other words, because genes alone do not dictate body plan development, the phrase is unlikely to be correct with respect to the commonly cited mutation-selection mechanisms. For additional information, see "Primer: Developmental Evidence in a Nutshell" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1141.

5.38. No, vertebrate embryos are not similar in their earliest stages. A 2010 paper in *Nature* explained that "Counter to the expectations of early embryonic [similarities], many studies have shown that there is often remarkable divergence between related species both early and late in development." [Alex T. Kalinka et al., "Gene expression divergence recapitulates the developmental hourglass model," *Nature*, 468: 811–814 (December 9, 2010) (internal citations removed), an abstract is available at http://www.nature.com/nature/journal/v468/n7325/full/nature09634.html.] Or, as an article in *Trends in Ecology and Evolution* stated, "despite repeated assertions of the uniformity of early embryos … development … is very varied." [Brian K. Hall, "Phylotypic stage or phantom: is there a highly conserved embryonic stage in vertebrates?" *Trends in Ecology and Evolution*, 12: 461–463 (December, 1997).]

Further Reading:

1. Stephen C. Meyer, "Not by chance: From bacterial propulsion systems to human DNA, evidence of intelligent design is everywhere," *National Post of Canada* (December 1, 2005) at http://www.discovery.org/a/3059.
2. Stephen C. Meyer, "DNA and the Origin of Life: Information, Specification, and Explanation," in *Darwinism, Design, and Public Education* (Michigan State University Press, 2003) at http://www.discovery.org/scripts/viewDB/filesDB-download.php?command=download&id=1026.
3. Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (Harper One, 2009) at http://www.signatureinthecell.com/.
4. "IDEA Center FAQs and Primers" at http://www.ideacenter.org/resources/faq.php.

For a good list of additional reading references, see the Discovery Institute's essential reading list at http://www.discovery.org/csc/essentialReadings.php.

Answers

For several years' worth of the "Top Ten Darwin and Design News and Resources," refer to http://www.arn.org/top10/.

As was noted in the introduction to this study guide, if you would like to start a club to discuss intelligent design and evolution at your school, university, or in your community, consider starting an IDEA Club! The IDEA Center can provide resources to help you with doing just that, and you do not have to be an ID expert to start one - see www.ideacenter.org for further information.