DISCUSSION & STUDY GUIDE

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Introduction

Humanity's fascination with flight has stretched for millennia. As we looked up, beautiful creatures soared through the sky almost effortlessly, inspiring and awing us. What was their secret to flight? How did such creatures come to be? How do they actually fly?

Illustra Media's documentary *Flight: The Genius of Birds* provides a study of birds and their anatomical complexities providing such aerial freedom. Through expert interviews and engaging computer graphics of unique bird characteristics, viewers are treated to a stirring scientific exploration of our feathered friends.

This film highlights intelligent design (ID) concepts, and challenges some evolutionary claims about the origins of birds. In so doing, the film shows how the scientific evidence points to bird flight being the result of design rather than purely naturalistic, unguided processes.

This Discussion & Study Guide ("guide") is designed to help you and others learn about these concepts in more detail. It is broken into five segments and should be used in conjunction with viewing the Illustra Media film *Flight.* The guide has short-answer-style questions, fill-in-the-blanks, multiple-choice questions, and true/false statements as well as discussion 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. Because the discussion questions are sometimes more open ended, possible (though not exhaustive) answers are provided. 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 often open-ended and have been broken into two different categories: 1) those relating directly to a video topic, and 2) those that relate to a video topic, 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.

If you would like to start a club to discuss intelligent design and evolution at your school, university, or 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. Please see www.ideacenter.org for further information.

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

1. Chapters 1 & 2: Prelude & Flight

(0:00-14:38)

Basic Questions:

1.1. Provide the opening quote by the famous French philosopher Voltaire.

1.2. Currently known unique animal species number over (circle one) a thousand / million / billion.

1.3. Current estimates suggest about five times the previous answer for the number of animal species yet to be discovered and classified. True or false?

1.4. Wings are not the only unique features of birds. Hidden beneath bird's feathers and skin are complex coordinated systems consisting of ________, _________, and biochemical machines carrying out many required tasks for survival.

1.5. List at least two of the three abilities noted in the film providing evidence for design and purpose in the living world based on the identifiable characteristics of those systems, such as integrated networks of components empowering and regulating those abilities.

1.6. What principle does Paul Nelson recall his father, an aeronautical engineer, said about how something came to work properly, such as controlled flight?

1.7. Even though over 9000 bird species exist, most of which can fly, birds thrive in only a few different kinds of climates and geography. True or false?

1. Chapters 1 & 2: Prelude & Flight

1.8. Eggs range in weight from less than an _______ to more than three ________.

1.9. An egg can be described as a package of ______________.

1.10. How far back in time have scientists studied chicken eggs to gain a better understanding of bird development?

1.11. All birds develop in basically the same way in an egg. True or false?

1.12. Within about _______ days after the egg is laid, the general anatomical layout (e.g., front, back, top, bottom, left, and right) of the bird is defined.

Discussion Questions:

1.13. Briefly describe how a fertilized egg functions during a bird's development.

1.14. Explain why studying fertilized chicken eggs provides insight into the development of other birds and their flying abilities.

1. Chapters 1 & 2: Prelude & Flight

1.15. Ann Gauger notes that early in a bird's development inside its egg, there is something like an "elaborate dance" occurring with "thousands of members." Why does she say this?

1.16. Describe some of the ways adult birds get their nestlings out of the nest to fly.

1.17. Tim Standish notes a single cell can become billions of different kinds of cells after 21 days of development. What does he state is occurring (which is characteristic of designed objects)?

Discussion Questions Beyond the Video:

1.18. Describe some of the particular features provided by a bird's egg that strike a remarkable balance between providing protection and facilitating development. How does this compare with the development of other animals at similar early stages (i.e., embryological development)?

1.19. During a chick's early development within a fertilized egg, cell specification and differentiation defines the basic body plan and key features. Is this dictated purely by the genes? Explain your answer and indicate whether this poses problems for neo-Darwinian explanations for body plan development.

1. Chapters 1 & 2: Prelude & Flight

1.20. Ann Gauger notes genes are "switched on and off" during a bird's early development inside a fertilized egg. What are some genes that act like on/off switches? Do these genes provide a neo-Darwinian mechanism for generating novelty which, over the course of history, could have produced the diversity of life we see? Why or why not?

1.21. While Ann Gauger notes that early development of birds is similar to a ballet "with thousands of cast members," what other analogy to human design can you think of to describe this development process?

2. Chapters 3 & 4: Anatomy & Hummingbirds

(14:39-20:54 and 20:55-29:43)

Basic Questions:

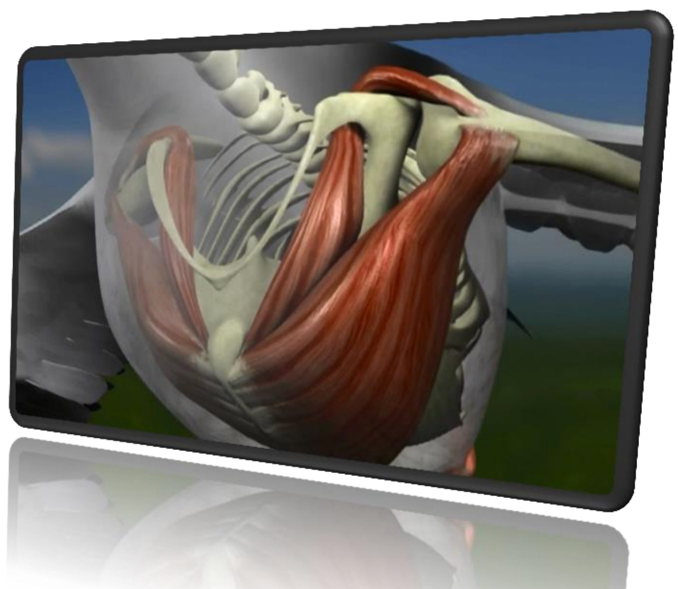
2.1. For flight to occur, a bird must be both strong and light. Its ________________ is one of several systems meeting both requirements.

2.2. Most bones in birds are completely hollow, without internal struts and similar structures. True or false?

2.3. Being light yet durable, the skeletal framework of birds is well-suited for what specific loading and stress aspects of flight?

2.4. Birds are covered by only one type of feather. True or false?

2.5. The configuration and anatomy of bones and muscles associated with flight act like a ______________ system to move the wings up and down.



2.6. There are (circle one) two / tens of / hundreds of muscles and ligaments used to move wings in various ways.

2.7. All specialized features and multiple systems making flight possible are well _________________ together.

2. Chapters 3 & 4: Anatomy & Hummingbirds

2.8. Two examples noted of many engineered features working together to make flight possible are reduced weight of components and compact grouping of anatomical features towards the center of mass. True or false?

2.9. The Nano Air Vehicle (NAV) is based upon ______________________ flight.

2.10. Does the NAV have flight abilities equivalent to its natural inspiration?

2.11. On which continents are hummingbirds found?

2.12. Hummingbirds are often referred to as nature's _________________ because they can hover in place.

2.13. Some hummingbirds can beat their wings more than (circle one) 10 / 100 / 1000 times per second.

2.14. A hummingbird's skeletal system does not play a significant role in its ability to fly in unique ways. True or false?

2.15. About (circle one) 30 / 40 / 50 percent of a hummingbird's body mass is made of muscle, thereby providing flight abilities most birds cannot achieve.

2.16. Due to their muscular demands during flight, some hummingbirds' heartbeat rate can reach __________ beats per minute.

2.17. What makes the hummingbird rapid heart rate possible?

2. Chapters 3 & 4: Anatomy & Hummingbirds

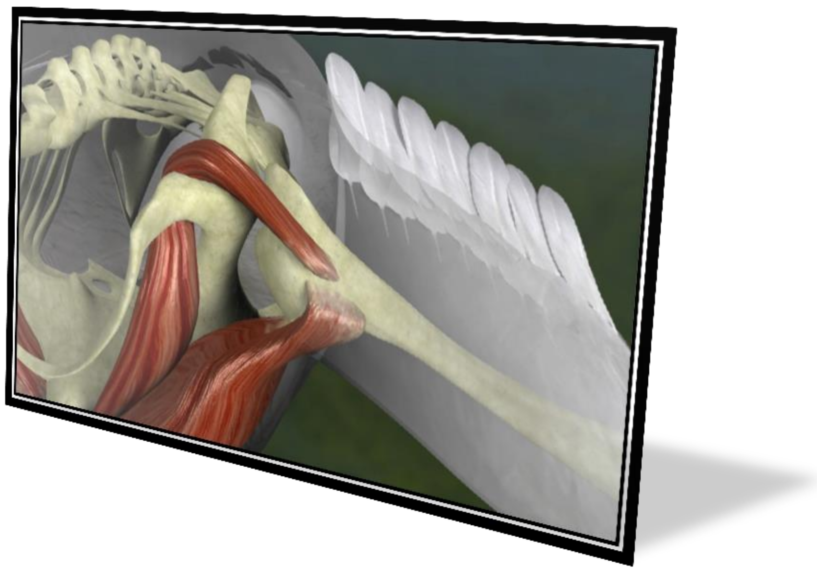
2.18. Relative to its body weight, how much does a hummingbird eat daily?

2.19. While awake, hummingbirds eat every ___________ minutes.

2.20. If an average adult human had the same metabolism as a hummingbird, the quantity of food consumption required would be about 20 pounds of food each day. True or false?

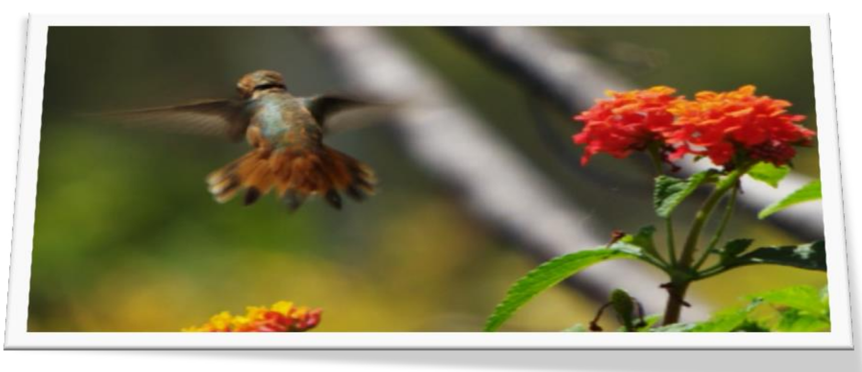
2.21. What benefit is given by a hummingbird's tongue being twice its beak length?

2.22. A hummingbird typically inserts and withdraws its tongue about once every second. True or false?



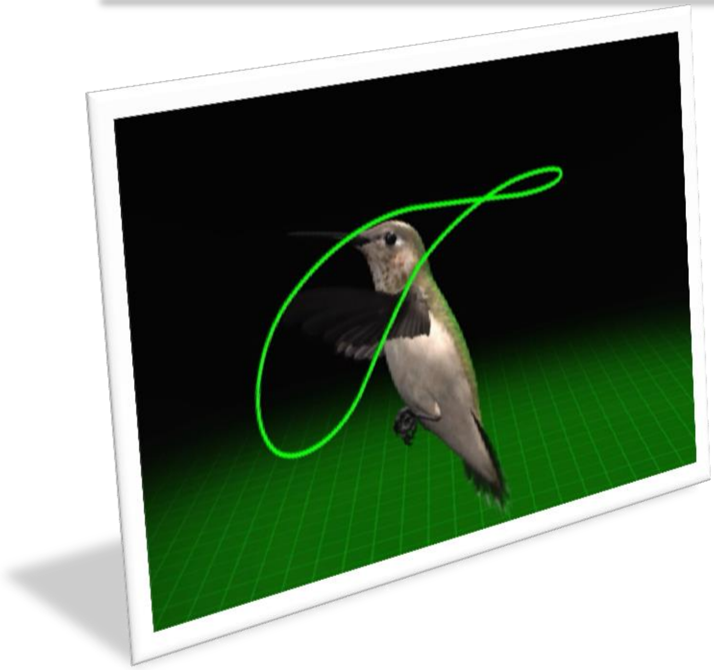
Discussion Questions:

2.23. What simple engineered system is seen in the anatomical layout of the primary muscles (i.e., supracoracoideus) and adjacent bones associated with lifting up a bird's wing? Explain some benefits this system provides.



2.24. Describe the role of a hummingbird's tail with respect to flight.

2. Chapters 3 & 4: Anatomy & Hummingbirds



2.25. Name two of the three different types of flight hummingbirds use. What wing motions are associated with those?

2.26. Describe some of the unique physiological features of hummingbirds required for them to hover. Explain how these work together to provide this remarkable ability.

2. Chapters 3 & 4: Anatomy & Hummingbirds

2.27. Describe how the hummingbird's tongue functions to obtain nectar.

Discussion Questions Beyond the Video:

2.28. A unique feature of birds is the avian lung. Describe some of the unique features the avian respiratory system exhibits compared to living reptiles and mammals, and their utility in facilitating flight.

2.29. Proponents of Darwinian evolution often claim dinosaur bones, including hollow bones which likely included air sacs forming part of the respiratory system, provide an intermediate link between birds and dinosaurs. How might you respond to such claims?

2.30. To support common ancestry claims, evolutionists point to other similar skeletal features shared by theropod dinosaurs and birds. What specific examples of skeletal features provide counter evidence to such claims?

2. Chapters 3 & 4: Anatomy & Hummingbirds

2.31. An evolution proponent may claim, as argued in past publications by the National Academy of Sciences (e.g., their 1999 booklet on *Science and Creationism: A View from the National Academy of Sciences*), that dramatic evolutionary changes leading to speciation, are seen and well documented in beaks of finches on the Galápagos Islands. They may indicate that finch beaks increased in size during droughts which, over time, led to new finch species. How would you respond to such a claim?

2.32. The skeletal system of birds is similar in total weight to other similarly sized land-mammals. Additionally, bone material in birds is frequently denser than other mammalian bones. However, the film notes a bird's skeletal system is relatively small compared to total body weight and provides a "light but durable framework …" How can this apparent conflict of skeletal weight properties be resolved? (Hint: think of the structural benefits provided by the types of bones in birds.)

2.33. From a structural engineering perspective, what benefits are provided by struts and ties internally crisscrossing the hollow bones of birds?

2.34. With the aid of high speed photography, what recent scientific finding related to hummingbird wing control during flight indicates even faster nerve synapse firing than suggested in the film?

2.35. What other significant anatomical differences are there between modern reptiles and birds that challenge common ancestry claims?

2. Chapters 3 & 4: Anatomy & Hummingbirds

2.36. What kinds of questions must be answered, and processes described, from an evolutionary perspective in order for common ancestry claims about birds and reptiles to be plausible?

3. Chapter 5: Starlings
(29:44-38:32)

Basic Questions:

3.1. Some suggest starlings follow particular flight paths to avoid being blinded by sunlight while flying. True or false?

3.2. Huge flocks of starlings are called ________________________, which likely resulted from the sound made by vast numbers of beating wings.

3.3. Starling airborne predators are thought to be scared off by the massive nature and movements of starling flocks. True or false?

3.4. Does current research of starling murmurations indicate each bird somehow monitors the entire flock?

3.5. Starlings use a property called ______________ _______________ to gauge where they are with respect to other birds in the flock.

3.6. Starlings seem to respond to their neighbors' movements at about the same speed as the "blink of an eye." True or false?

3.7. No further research is needed on starlings since their flock movement and regions of habitat are well understood. True or false?

3. Chapter 5: Starlings

Discussion Questions:

3.8. Describe what makes possible the relative unity of movement for starling flocks. How is this similar and/or dissimilar to modern human flight?

Discussion Questions Beyond the Video:

3.9. ID critics may claim that the evolutionary development of murmurations can be explained by the potential survival advantage of scaring off predators. How would you respond to such claims?

3.10. Evolutionists may claim that while there are some interesting features yet to be explained about starling murmurations, the evolutionary origin of birds and bird flight is well understood and documented by fossil evidence at the time of the dinosaurs. How would you respond to such a claim?

4. Chapter 6: Arctic Terns

(38:33-49:51)

Basic Questions:

4.1. What other name is given to Arctic terns, in light of the fact that they spend substantial time in perpetual daylight?

4.2. From May to early August, Arctic terns live in the _____________ region. But from about November until April, they are in the _______________ region.

4.3. Arctic tern flights represent the longest known animal migration. True or false?

4.4. Arctic terns spend most of their lives (circle one) in air / on ground / eating food.

4.5. Based on his research, Carsten Egevang of the Greenland Institute of Natural Resources is credited for accurately determining what about Arctic terns?

4.6. Based on the mid-migration and end stops made by Arctic terns, what is one of their main food sources?

4. Chapter 6: Arctic Terns

4.7. When Arctic terns feel the cold coming on, the entire population leaves the Antarctic in early April within a matter of (circle one) hours / days / weeks.

4.8. During their journey back to the Arctic, the birds travel nearly _______ miles a day.

4.9. Name two of the three challenges facing Arctic terns during their migrations.

4.10. Due to the grueling migration, hardly any Arctic terns make the incredible journey more than four times during their life. True or false?

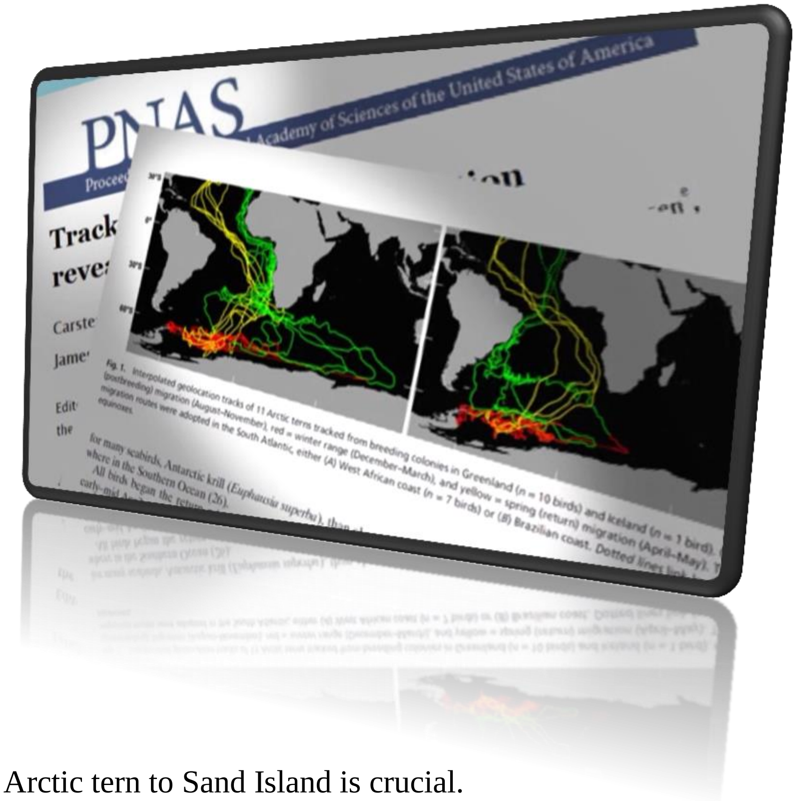
4.11. Based on distances traveled over the birds' lives, Egevang equates those distances to trips to the moon and back (circle one) three / four / five times.

Discussion Questions:

4.12. Describe basic features of Carsten Egevang's scientific research conducted on the Arctic terns.

4. Chapter 6: Arctic Terns

4.13. Describe three key features discovered through Egevang's Arctic tern research regarding their trip south from the Arctic to the Antarctic.



4.14. Describe the migration path from the Antarctic to the Arctic taken by the Arctic tern and suggested reason for that path.

4.15. Explain why the return timing of the Arctic tern to Sand Island is crucial.

<u>Discussion Questions Beyond the Video:</u>

4.16. What have scientists suggested allow birds to properly navigate? Describe the basic features of recent experiments on reed warblers in Russia which provides strong evidence that birds' beaks somehow contribute to navigation.

4.17. Based on recent discoveries, what other systems may be associated with navigation?

5. Chapter 7: Design

(49:52-1:01:33)

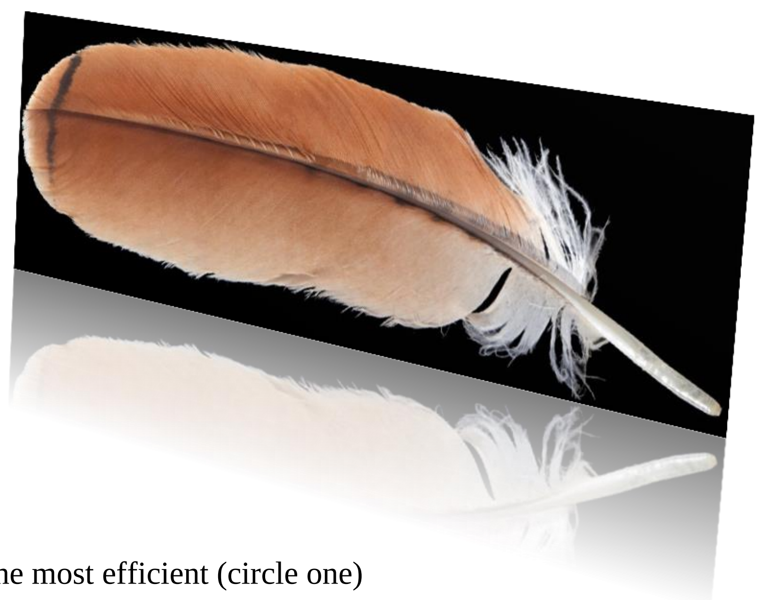
Basic Questions:

5.1. Paul Nelson refers to "vera causa," a philosophy of science term popularized in the early 19th century, when asking what is the __________ __________ for the origin of flight.

5.2. A summary of scientific materialism is the belief that matter and energy are all that exist in the universe. True or false?

5.3. What quote does Paul Nelson note from Nobel Laureate Francis Crick regarding what biologists must constantly keep in mind while studying life?

5.4. There are no currently known ways to test the validity of design in nature. True or false?



5.5. Are the various parts of a feather and their proper interaction required for bird flight?

5.6. The feather is part of a combination of several different ____________ providing the ability to fly.

5.7. A feather can be used to test the design hypothesis. True or false?

5.8. Compared to other animals, birds have the most efficient (circle one) digestive / circulatory / respiratory system.

5. Chapter 7: Design

5.9. Due to their acute vision, some birds can spot food from a ________ _______ above the earth.

5.10. Hallmarks of foresight, purpose, and planning associated with human engineered flight include the ___________ and __________ of complex operational systems.

5.11. This film uses only negative arguments against natural processes when describing features of human engineered flight. True or false?

5.12. Ann Gauger identifies a key feature of natural selection limiting its causal power. What is this feature?

5.13. Ann Gauger notes that biological organisms, such as birds, are nearly as complicated as 747 airplanes. True or false?

5.14. Ann Gauger notes that biological organisms, like birds, are integrated wholes; they are not simply the ________ of their __________.

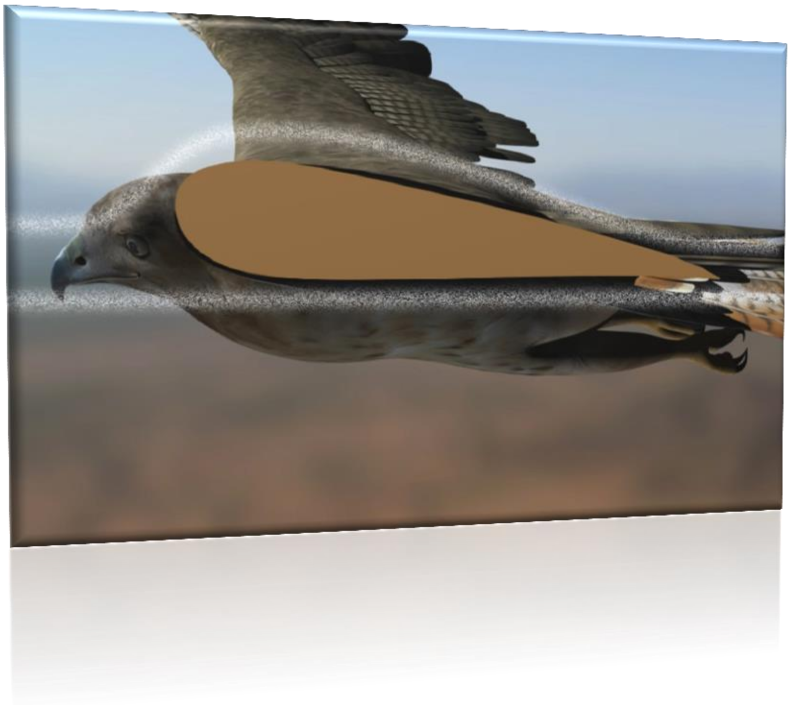
5.15. Tim Standish identifies the systems and subsystems of birds as "engineering marvels" and "works of art." He reasons that because we know where engineered, integrated, and interlocking systems—or works of art—come from, why would we think that a bird comes from anything else other than ________?

<u>Discussion Questions:</u>

5.16. Describe two of the three hypothesized Darwinian explanations for the origin of flight.

5. Chapter 7: Design

5.17. What kind of language or terms does Ann Gauger note are difficult to avoid using when making biological descriptions of life?



5.18. Recalling the brief discussion given by Tim Standish, describe how the airfoil shape of a bird's wing contributes to flight. What human engineered things can you think of which also operate in this fashion?

5.19. Identify two of the four components noted within a system required for powered bird flight. Describe the purpose of these interactions.

5.20. Describe the various feather components the film notes and their contribution to flight.

5. Chapter 7: Design

5.21. Describe three of the several different systems which contribute to meeting demands of flying birds. Explain why these systems cause difficulty for a neo-Darwinian explanation for their origin.

5.22. Explain the problem Ann Gauger identifies for purely materialistic processes, like natural selection, to account for the development of bird flight.

5.23. Describe the features identified by Paul Nelson which provide a positive case for intelligence as an explanation for flight.

5.24. Explain why Tim Standish thinks ID is the best explanation for avian flight.

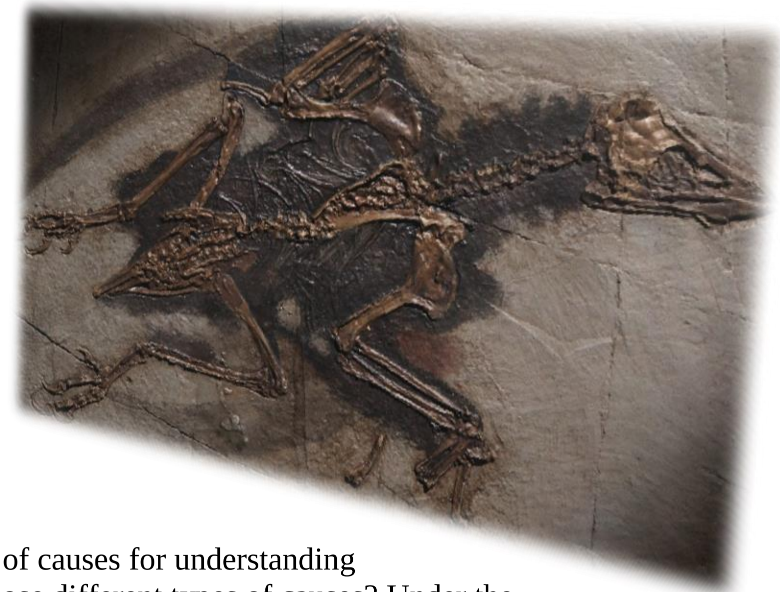
Discussion Questions Beyond the Video:

5.25. Some evolution proponents (e.g., Carl Zimmer, Francis Collins, and Karl Giberson) have claimed feathers evolved from scales on dinosaurs. How would you respond to such claims? What are some differences between scales and feathers?

5.26. Darwinian evolutionists may claim that there are clear examples of fossilized early forms of feathers or protofeathers. How would you respond to such claims? What problems are there with this claim?

5. Chapter 7: Design

5.27. Some have argued that *Archaeopteryx* (meaning “ancient wing”), which was first discovered around the time of Darwin’s initial publication of *The Origin of Species*, is a great example of a transitional form between reptiles and birds, thereby confirming Darwin’s theory. What would you say in response?



5.28. Philosophers identify different types of causes for understanding the origin of events or objects. What are those different types of causes? Under the theory of intelligent design, what type of cause is intelligence?

5.29. From a structural engineering perspective, what feature of the feather central shaft is noteworthy when considering a feather’s ability to resist wind loads during flight?

5.30. What well-known intelligent design terminology and concept can describe multiple required parts within a system? Who coined this term and why does it challenge neo-Darwinism?

5.31. Is a design claim for some observed feature, such as a feather, based strictly upon a lack of an evolutionary explanation? Why or why not?

5. Chapter 7: Design

5.32. As a feather grows from its follicle, what turns the colors on and off at the right time to produce the colorful result?

5.33. Is sexual selection an adequate explanation for the origin of feather patterning? Why or why not? (Provide evidence supporting your answer.)

5.34. Briefly explain how iridescence is made possible in feathers.

5.35. Based on recent experimental evidence, do genetics entirely control feather colors and patterning? Why or why not?

5.36. Describe other interesting features of feather production and patterning.

5.37. What kinds of arguments or claimed evidence have you heard put forward in favor of birds descending from dinosaurs? What evidence from the film, study guide, or other sources has challenged those arguments or claimed evidence?

5. Chapter 7: Design

Answers

Please note: Many of these answers contain links to other websites. These were accessed between July 2013 and March 2014. Simply because a link is provided does not necessarily imply endorsement of that site or the views it expresses. 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.

1. Chapters 1 & 2: Prelude & Flight (0:00-14:38)

Basic Questions:

1.1. "… all nature cries aloud … that there is a supreme intelligence ..." Voltaire (François-Marie Arouet)
1.2. million.
1.3. True.
1.4. muscle, bone.
1.5. movement, navigation, growth. Some of these characteristics are shared by nearly all living things as well as birds.
1.6. " … if something works it's not happening by accident."
1.7. False. They thrive in every environment. Though bird species share many common features, each species has specific features allowing them to survive particular challenges of the climate and geography in which they live.
1.8. ounce, pounds.
1.9. life.
1.10. Answers may vary, but may include one of the following: Since the time of philosopher Aristotle; thousands of years; for millenia.
1.11. True.
1.12. two.

Discussion Questions:

1.13. A fertilized egg functions as a package of life providing a safe haven for the developing bird. It serves as a factory in which numerous mechanisms needed for proper development and survival are fabricated and assembled in specific sequences over several weeks.
1.14. The development of birds is nearly the same across different species. Because of this, studying fertilized chicken eggs provides insight into the mechanisms necessary for flight for all flying birds.
1.15. Gauger notes there are many details of a bird's anatomy being worked out during development within the egg through genes being turned on and off. A great deal of interaction and cell communication is occurring during these stages. She analogizes this development process to a "ballet taking place on stage with thousands of cast members" in order to help illustrate the complexity associated with the proper sequence and timing required to achieve proper cellular, tissue, organ, and systems development.

Answers

1.16. Adult birds will no longer feed nestlings in their nest; rather, they will be a short distance from the nest, forcing the nestlings to come out for food. The nestlings often start to open up their wings while venturing out from the nest. For birds on remote islands, as the nestlings build their wing muscles through flapping while grounded, eventually parents begin to nudge their young closer to the cliff edge. Then the young bird jumps off and spreads its wings to begin flying.

1.17. Standish notes that a mechanism is involved throughout the development process—information is being translated into physical products. As Standish notes, there are "[m]achines doing jobs." Information storage, information processing, and the resulting products of that processing are common characteristics of designed objects.

Discussion Questions Beyond the Video:

1.18. Answers may vary depending on an individual's familiarity various animals' early development. Bird and other land dwelling animal eggs (e.g., reptilian and monotreme) must be essentially self-contained units ("a package of life" as noted in the film), for the developing animal. Some of those required features are noted below, along with a short comparison with other animals (note: features listed are common to most of the animals mentioned). Answers may include any of the following:

- A hard shell provides protection from drying and other weather elements as well as attack from some insects. Even though it is hard, it is gas permeable allowing oxygen and carbon dioxide exchange. Fish and most amphibian eggs are in water, have a soft covering, and will dry when not in water. (It is also worth noting that the bird egg is more complex than fish or amphibian eggs—there are many more different parts in a bird egg compared to fish or amphibian eggs.)
- An internal supply of water and nutrients are provided rather than being supplied substantially by the surrounding environment. Except for those that lay eggs (e.g., monotremes such as the platypus or echidna), newborn mammals receive most of their nutrients from the mother. Fish and most amphibian eggs obtain water from their surrounding watery environment.
- An internal waste disposal system. Placental mammals have their waste removed early in their development by the mother through the complex of blood vessels within the placenta.

The important role of the egg is best captured by this quote (though, with the underlying neo-Darwinian view present): "The land egg is one of nature's greatest innovations. It made possible the conquest of the land, first by reptiles and then by birds and mammals**. If the land egg had not developed, the land would have remained largely empty**." (emphasis added) Dal Stivens, *The Incredible Egg: A Billion Year Journey* (Weybright and Talley, 1974), p. 168.

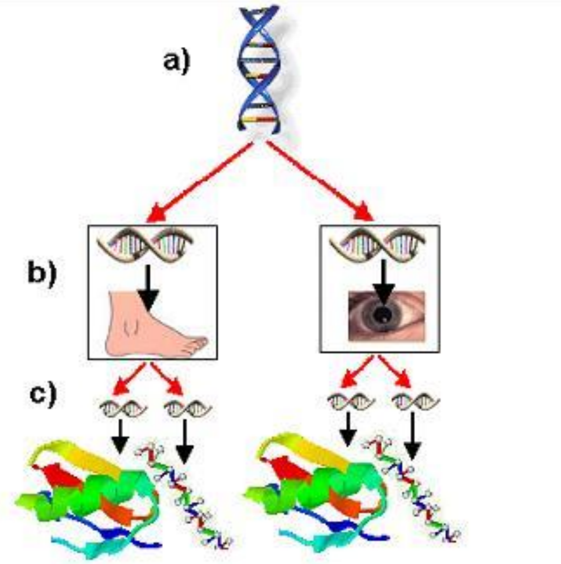
1.19. No, genes do not carry all the information for cell specification and differentiation during animal development. Scientists at this point cannot completely explain the source of the information; however, it seems to be at least a combination of genes, three-dimensional cellular structure, and biochemical signaling. This poses problems for the neo-Darwinian explanations since genes do not entirely dictate development of an organism. For additional information, refer to the following:

Answers

- "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.
- Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (Harper One, 2013), Chapter 14, "The Epigenetic Revolution."
- *Darwin's Dilemma* website at http://www.darwinsdilemma.org and corresponding discussion and study guide http://www.ideacenter.org/contentmgr/showdetails.php/id/1523, especially Chapter 5.

Answers

1.20. Homeobox genes, often referred to as *Hox* genes, serve as master control genes, like on/off switches, directing other "body part" genes responsible for protein creation for those "body parts." Refer to the image at right illustrating this concept, taken from Casey Luskin, "Evolution and the Problem of Non-Functional Intermediates" at http://www.ideacenter.org/contentmgr/showdetails.php/id/841. These genes have been suggested as possible sources for dramatic and rapid evolutionary changes contributing to the vast diversity in life we see today. For example, consider an often referenced quote in a TalkOrigins article, http://www.talkorigins.org/indexcc/CC/CC300.html: "*Hox* genes, which control much of an animal's basic body plan, were likely first evolving around that time. Development of these genes might have just then allowed the raw materials for body plans to diversify." While this is an interesting idea, there are several evidential problems with it (the following has been adapted from **Point 5: There are plausible explanations for the Cambrian radiation.** in 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):



This diagram shows the hierarchical, interconnected system of control in biology. Like an army, master control "Hox" genes send biochemical commands to lower-ranking genes. Hox genes **(a)** control genes at lower levels which manage creation of individual organs **(b)** by controlling the "body part" genes which create the structural proteins **(c)**. Mutations in high level genes are likely to be disastrous unless accompanied by necessary and highly unlikely mutations in lower-level genes. Mutations of low-level genes tend to destroy key biological functions.

- Developmental regulatory genes, like *Hox* genes, are part of a network of well integrated genes. Changing one can have significant changes in others, which are usually harmful or lethal.
- *Hox* genes do not dictate amino acid sequences; rather, they direct already existing "body part" genes, which do code for amino acid sequences. *Hox* gene mutations do not provide "raw material" for novel genetic information. If the "body part" gene was not already present, *Hox* genes would not direct anything.
- *Hox* genes are not active until after body plans have been established during embryological development nor do they have any role in directing epigenetic information (refer to Stephen Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design*, pp. 319-320 (HarperOne, 2013) at http://www.darwinsdoubt.com).

For additional information regarding problems with *Hox* genes providing evolutionary change, refer to the following:

Answers

- Steve Meyer, Scott Minnich, Jonathan Moneymaker, Paul Nelson, and Ralph Seelke, *Explore Evolution* (Hill House Publishers, Second Edition, 2013), pp. 108-111 at http://www.exploreevolution.com/.
- Gary Kemper, Hallie Kemper, and Casey Luskin, *Discovering Intelligent Design* (Discovery Institute Press, 2013) the section "Evo-Devo to the Rescue?," pp. 168-169, at http://discoveringid.org/.
- William A. Dembski, Jonathan Wells, *The Design of Life* (The Foundation for Thought and Ethics, 2008), pp. 48-49 at http://www.thedesignoflife.net/default.asp.

1.21. Answers may vary for each individual, but may include the following key points: proper sequence, timing and construction of multiple parts. Many engineered systems frequently follow these basic elements, including buildings and bridges. Proper sequence, timing, and construction of multiple parts are often associated with such engineered structures. Another example may include the composition of music, which requires proper sequence, timing, etc., to achieve a particular set of desirable sounds.

Further Reading:

1. *Flight: The Genius of Birds* documentary website at http://www.flightthegeniusofbirds.com/.
2. Noble S. Proctor and Patrick J. Lynch, *Manual of Ornithology: Avian Structure and Function* (Yale University Press, 1998) at http://yalepress.yale.edu/yupbooks/book.asp?isbn=9780300076196.
3. Roberta Olson, *Audubon's Aviary: The Original Watercolors for The Birds of America*, (New York Historical Society / Skira Rizzoli, 2012) at http://www.amazon.com/Audubons-Aviary-Original-Watercolors-America/dp/0847834832.
4. The Cornell Lab of Ornithology at http://www.birds.cornell.edu/.
   - All About Birds at http://www.allaboutbirds.org/Page.aspx?pid=1189.

2. Chapters 3 & 4: Anatomy (14:39-20:54) & Hummingbirds (20:55-29:43)

Basic Questions:

2.1. skeleton

2.2. False. Most bird bones are hollow but do have internal struts to reinforce the outer bone shell.

2.3. Wing flapping, take-offs, and landings.

2.4. False. They are covered by several different types of feathers.

2.5. pulley.

2.6. Hundreds of.

2.7. integrated.

2.8. True.

2.9. hummingbird. (For additional information, see http://www.avinc.com/resources/press_release/aerovironment_develops_worlds_first_fully_operational_life-size_hummingbird and the several YouTube videos at http://www.avinc.com/nano.)

2.10. No. (But research continues in hopes of matching what hummingbirds can do.)

2.11. North and South America.

2.12. helicopters.

Answers

2.13. 100.
2.14. False—a hummingbird's shoulder joint allows movement during flight that is not possible in other birds.
2.15. 40.
2.16. 1250.
2.17. Rapid firing nerve synapses. (These play a crucial role in the heart muscle repeatedly constricting at this rapid rate.)
2.18. About twice its body weight.
2.19. 10-15
2.20. False. It would be about 150 pounds per day.
2.21. It provides the ability to reach deeply into a flower.
2.22. False. It takes less than about 1/20th of a second to complete a full cycle of insertion and withdrawal.

Discussion Questions:

2.23. Due to the layout of the supracoracoideus muscles and adjacent bones, a pulley system is achieved. This pulley system reduces the effort and, thus, energy usage or demand required to lift the wing. It also reduces the required size of the muscle to do the work required to lift the wing.
2.24. A hummingbird's tail provides both balance and maneuverability. As ornithologist Thomas Emmel notes, the tail provides the ability to fly in different directions and allows the hummingbird to stall.
2.25. Hummingbirds can fly forward, backward, and hover. Forward flight is provided by the common up and down motion. Backward flight is achieved through circular wing motion about the bird's head. Hovering occurs when the wings move in a figure-8 pattern.
2.26. A hummingbird's muscle mass, skeletal system, and wing motion work together to hover. Muscles provide the necessary power to maintain such flight. The shoulder joint allows hummingbirds to rotate their wings 140-degrees by twisting, thereby generating lift on both the forward and backward stroke and even during the twisting motion.
2.27. The hummingbird's tongue acts like a nectar trap. When the tongue comes into contact with liquid, the tip splits into two halves. Each fork consists of flaps that unfurl systematically and, when the tongue is withdrawn, close up tightly to capture the nectar for transporting back to the mouth for consumption. For additional information, see Alejandro Rico-Guevara and Margaret A. Rubega, "The hummingbird tongue is a fluid trap, not a capillary tube," *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, 108, no. 23 (April 8, 2011) at http://www.pnas.org/content/early/2011/04/27/1016944108.full.pdf+html.

Discussion Questions Beyond the Video:

2.28. Compared to extant reptiles and mammals, some of the unique features of the avian respiratory system, which also facilitate flight, are:
- Primarily unidirectional air flow within avian lungs rather than bi-directional in living reptiles and mammals.

Answers

- A complex system of air sacs (which do not participate in gas exchange), some of which extend into hollow bone areas (i.e., a pneumatized bone structure), all acting like bellows; air sacs are not present in extant reptilian or mammalian respiratory systems.
- Specialized air passageways connecting the lungs to the system of air sacs ensure a constant "fresh" air supply to the lungs. Extant reptilian and mammalian lungs often have "mixed" air (i.e., fresh mixed with "old" air) due to bi-directional air flow.
- Microscopic air tubules providing both the thinnest known barrier to oxygen as well as largest relative surface area for such an exchange.

All of these form a respiratory system enabling bodily oxygen intake to occur with "fresh" air during both inhalation and exhalation. This efficiency of oxygenated air use in birds helps meet the high energy demands of flight. For additional information and helpful diagrams showing air flow in avian lungs, refer to the following:

- Mechanics of Respiration in Birds at http://www.vetmed.vt.edu/education/curriculum/vm8054/Labs/Lab26/NOTES/BIRDRESP.HTM.
- Differences between avian and mammalian respiration at http://www.peteducation.com/article.cfm?c=15+1829&aid=2721.
- Avian Respiration at http://people.eku.edu/ritchisong/birdrespiration.html—about half-way down the page are illustrative animations of airflow through the lungs and airsacs. While this website claims evidence that birds descended from dinosaurs, there is evidence challenging this claim—see the next question below.
- Respiration at http://www.fernbank.edu/Birding/respiration.htm.

Answers

2.29. Responses may vary depending on familiarity with such claims and avian anatomy. Answers may include the following: With very rare exceptions, the fossil record is generally unable to provide detailed historical accounts of internal organ systems, including supposed reptile-to-bird intermediates. Due to this fact, the fossil record does not reliably document many organ system and other internal differences between birds and reptiles. Even so, a commonly referenced paper which proposes air sacs as part of the respiratory system in dinosaurs and provides a fairly detailed study of hollow bone features between dinosaurs and birds is by O'Connor and Claessens, "Basic avian pulmonary design and flow-through ventilation in non-avian theropod dinosaurs," *Nature*, 436 (July 14, 2005), pp. 253-256 at http://college.holycross.edu/faculty/lclaesse/O'Connor_Claessens2005.pdf. Arguments that birds evolved from theropods have many weaknesses, however. First, while identification of shared common features, such as hollow bones, is consistent with common ancestry, there are other areas of evidence that contradict the birds-from-dinosaurs hypothesis (that is, that birds evolved from maniraptoran theropods, also known as the "BMT" hypothesis). Common features alone cannot justify a Darwinian claim that birds came from dinosaurs; a naturalistic mechanism can only be plausible if there are sufficient probabilistic resources available for the changes to occur. Second, the avian pulmonary system must be functional throughout all supposed transitional stages of its evolution. In other words, going from a standard reptilian hepatic-piston style diaphragm-venting system to the air-bellows style venting system of birds must be fully explained both from a genetic and functional perspective. All intermediate stages must be functional and provide some advantage or at least be neutral (i.e., not be detrimental or a hindrance) to the organism. Specific problems with the view that hollow bones and air sacs evolved from standard reptilian forms are listed below:

- Other required skeletal features (e.g., a fixed thigh bone preventing abdominal air sac collapse; specialized sternum and costal ribs—a bird-like rib cage; sufficient abdominal volume to accommodate abdominal air sacs; etc.) for a proper functioning avian-lung in birds are not found in dinosaurs. For additional information, see Devon E. Quick and John A. Ruben, "Cardio-Pulmonary Anatomy in Theropod Dinosaurs: Implications for Extant Archosaurs," *Journal of Morphology*, 270, no. 10 (2009), pp. 1232-1246 at http://onlinelibrary.wiley.com/doi/10.1002/jmor.10752/pdf. (For a popularized version of key points in this paper referenced in the *Journal or Morphology*, see "Discovery Raises New Doubts About Dinosaur-Bird Links," *Science Daily* (June 9, 2009) at http://www.sciencedaily.com/releases/2009/06/090609092055.htm.)
- Hollow or pneumatized bones are found in many other non-avian dinosaurs (e.g., pterosaurs, sauropods, and other theropods not considered ancestral to birds, etc.).
- Cladistic and statistical studies are consistent with many different types of dinosaurs (e.g., early-archosaurs; crocodylimorphs) being equally (or more) viable ancestral candidates rather than the commonly held solely BMT view. (This could also be evidence of common design rather than common descent.) Additionally, there is cladistic and statistical evidence that contradicts the BMT. For additional information, see Frances C. James and John A. Pourtless IV, "Cladistics and the Origins of Birds: A Review and Two New Analyses," *Ornithological Monographs*, No. 66 (2009), pp. 1-78 at http://www.bio.fsu.edu/James/Ornithological%20Monographs%202009.pdf.

Answers

- Bird fossils are found predating the claimed BMT ancestors. See statements by zoologist John Ruben in "Discovery Raises New Doubts About Dinosaur-Bird Links," *Science Daily* (June 9, 2009) at http://www.sciencedaily.com/releases/2009/06/090609092055.htm.

Hollow bones and air sacs are only part of an integrated system of components providing the necessary features associated with avian lung function. Specifically, the fixed thigh bone provides a lateral support for abdominal air sacs and, thus, plays a crucial role in ensuring that abdominal air sacs do not collapse during inhalation. Because the claimed ancestral dinosaurs had moving thigh bones, abdominal air sacs could not exist because they would have collapsed (see John Ruben in "Discovery Raises New Doubts About Dinosaur-Bird Links," *Science Daily* (June 9, 2009) at http://www.sciencedaily.com/releases/2009/06/090609092055.htm). For additional information, including other responses to claimed ancestral relationships between dinosaurs and birds, refer to the following:

- The Vertebrate Animal Heart: Unevolvable, whether Primitive or Complex at http://www.ideacenter.org/contentmgr/showdetails.php/id/1113—refer to the "Getting a bird heart" section near the bottom of the page.
- Jonathan M., "Jerry Coyne's Chapter on the Fossil Record Fails to Show 'Why Evolution Is True'," *Evolution News and Views* (December 4, 2012) at http://www.evolutionnews.org/2012/12/jerry_coynes_c067021.html—refer to the "Into Thin Air: The Origin of Birds" section about half way down the page.
- Casey Luskin:
  - "'Old Theories Die Hard': Birds-Evolved-From-Dinosaurs Hypothesis Takes Big Hits With Two Recent Papers," *Evolution News and Views* (July 22, 2009) at http://www.evolutionnews.org/2009/06/old_theories_die_hard_birdsevo021861.html.
  - Refer to the section *Feathered Dinosaurs or Feathered Birds?* in "Of Whale and Feather Evolution: Nature's Two Macroevolutionary Lumps of Coal," at http://www.evolutionnews.org/2010/08/of_whale_and_feather_evolution037221.html.
  - "Inconsistent Reasoning Governs Evolutionary Interpretations of Feathered Dinosaurs," *Evolution News and Views* (September 10, 2010) at http://www.evolutionnews.org/2010/09/inconsistent_reasoning_governs038061.html.
  - "The 'Ancestor of All Dinosaurs' Might Have Had Feathers Dinofuzz," *Evolution News and Views* (July 13, 2012) at http://www.evolutionnews.org/2012/07/the_ancestor_of061991.html.
- Devon E. Quick, "New Insights into the Biology of Theropod Dinosaurs", Doctoral Dissertation (2008) at http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/10042/Quick_dissertation.pdf?sequence=1.

Answers

- Willem J. Hillenius and John A. Ruben, "The Evolution of Endothermy in Terrestrial Vertebrates: Who? When? Why?" *Physiological and Biochemical Zoology*, 77, no. 6 (November-December, 2004), pp. 1019-1042 at http://www.ncbi.nlm.nih.gov/pubmed/15674773 which notes in the abstract "**There is no positive evidence to support the reconstruction of a derived, avian-like parabronchial lung/air sac system in dinosaurs or nonornithurine birds**. Dinosaur lungs were likely heterogenous, multicameral septate lungs with conventional, tidal ventilation, although evidence from some theropods suggests that at least this group may have had a hepatic piston mechanism of supplementary lung ventilation." (emphasis added)

2.30. Fully developed digits 2-3-4 (for reference, 1 would be your thumb, and 5 your pinky) of extant birds conflict with the generally accepted digits 1-2-3 in theropod dinosaurs. It would be a dramatic shift to go from digits 1-2-3 to 2-3-4 from a developmental perspective. For additional information, see the following:

- Casey Luskin, "Questioning Orthodoxy: Dr. Alan Feduccia Speaks on the Origin of Birds" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1275.
- Alan Feduccia, Theagarten Lingham-Soliar, and J. Richard Hinchliffe, "Do Feathered Dinosaurs Exist? Testing the Hypothesis on Neontological and Paleontological Evidence," *Journal of Morphology*, 266 (November, 2005), pp. 125-166 at http://biology.kenyon.edu/courses/biol241/bird%20flight%202005%20Feduccia_Alan.pdf.
- Robert Dyes, "B.A.R.B.: Birds Are Really ..... Birds!" *Science Literature: A Discussion of ID-related Reading* (June 25, 2009) at http://www.arn.org/blogs/index.php/literature/2009/06/25/b_a_r_b_lugbl_ugirds_are_really_birds.

Answers

2.31. Answers may vary depending on an individual's familiarity with finch beak variation. Some may reply that finch beaks did indeed become slightly larger (about 5%) during the periods of drought during the multi-year study in the 1970s by Peter R. Grant and B. Rosemary Grant. But once the drought ended, finch beaks returned to their pre-drought size. Cyclic variation driven by climatic conditions was what occurred and was observed rather than long-term change. As Peter Grant wrote: "Effects of the droughts of 1977 and 1982 were approximately offset by selection in the opposite direction—toward smaller body size—in 1984-85. A relative scarcity of large seeds, together with an ample supply of small ones, favored small finches. Because the food supply on this island changes in composition and size from year to year, the optimal beak form for a finch is shifting in position, and the population, subjected to natural selection, is oscillating back and forth with every shift. Whether or not there is a net directional arrow through the oscillations, is unclear and could be determined by a much longer study." (Peter R. Grant, "Natural Selection and Darwin's Finches," *Scientific American*, 265, no. 4 (October, 1991), pp. 86-87.) Moreover, no new species have evolved within the Galápagos finches. Aside from small differences in beak shape, size, and feeding habits, the finches are highly similar. They are so similar that it can be quite difficult to tell the finch species apart. In his Pulitzer Prize winning book *The Beak of the Finch* (http://www.amazon.com/The-Beak-Finch-Story-Evolution/dp/067973337X), Jonathan Weiner compares the largest and smallest species of Galápagos ground finches and remarks that they are "almost indistinguishable." (Jonathan Weiner, *The Beak of the Finch* (Vintage Books, 1994), p.43.) Likewise, a paper in *BioScience* noted that after a full 14 million years of evolution, the finches remain highly similar and even "retain the ability to interbreed and produce viable, fertile hybrids." (Jeffrey Podos and Stephen Nowicki, "Beaks, Adaptation, and Vocal Evolution in Darwin's Finches," *BioScience*, 54, no 6 (June, 2004), pp. 501-510 at http://biology.duke.edu/nowicki/papers/PN04bs.pdf.) The small-scale differences between the finch species do not demonstrate that all living organisms are related through descent with modification. Rather, the finches show that after millions of years of evolution, very little has changed within a group of highly similar finches. They demonstrate microevolution, but cannot necessarily be extrapolated to demonstrate macroevolution. Additionally, chromosome comparisons of all the finches showed no differences between them; molecular phylogenies created based on genetics were not based on those genes associated with beak shape. For additional information, refer to the following:

- Jonathan Wells, *Icons of Evolution: Science or Myth? Why much of what we teach about evolution it wrong* (Regnery, 2000) Chapter 8, available at http://www.iconsofevolution.com/.
- Steve Meyer et al., *Explore Evolution* (Hill House Publishers, Second Edition, 2013), pp. 88-89 at http://www.exploreevolution.com/.
- William A. Dembski, Jonathan Wells, *The Design of Life* (The Foundation for Thought and Ethics, 2008), pp. 104-105 at http://www.thedesignoflife.net/default.asp.

Answers

- For an interesting discussion noting that, despite the "Darwin's finches" name, Darwin actually did *not* derive much of his speciation views from studying finches on the Galápagos Islands, see Casey Luskin, "Back to School to Learn about the 'Darwin's Finches' Icon of Evolution," *Evolution News and Views* (September 22, 2012) at http://www.evolutionnews.org/2012/09/back_to_school_064601.html and "*Nature's* Microevolutionary Gems Part 2: Bird-Sized Evolutionary Change," *Evolution News and Views* (July 30, 2010) at http://www.evolutionnews.org/2010/07/natures_microevolutionary_gems_1037051.html.
- Responses to the National Academy of Sciences' booklets:
  - 1999 version: Casey Luskin, "A Critical Analysis of *Science and Creationism: A View from the National Academy of Sciences* (2nd. ed)," at http://www.ideacenter.org/contentmgr/showdetails.php/id/1131.
  - 2008 version: Casey Luskin, "The Facts about Intelligent Design: A Response to the National Academy of Sciences' *Science, Evolution, and Creationism*," at http://www.ideacenter.org/contentmgr/showdetails.php/id/1452. The 2008 NAS booklet is available at http://www.nap.edu/catalog.php?record_id=11876.

2.32. This apparent conflict is resolved by recalling that many bird bones are mostly hollow. Yet, if they are the same weight (with the leg bones being an exception, which are heavier since they provide support for the entire bird when standing) as those in comparable land-dwelling mammals, this implies that bird bones must be larger in diameter. From a structural engineering perspective, a hollow cross section is stiffer than a solid section with the same amount of material. Because bird bones are denser where the material occurs, it provides a key feature to maximize the stiffness while minimizing the required bone mass; by concentrating the bone matter in as large as a cross section as possible, the material is efficiently used to achieve maximum stiffness. For further information, refer to Elizabeth R. Dumont, "Bone density and the lightweight skeletons of birds," *Proceedings of the Royal Society B*, 277, no. 1691 (March 17, 2010), pp. 2193-2198 at http://rspb.royalsocietypublishing.org/content/277/1691/2193.full. (A more popular level summary of this article can be found at the *Science Daily* article "Bird Bones May Be Hollow, but They Are Also Heavy" (March 23, 2010) at http://www.sciencedaily.com/releases/2010/03/100322112103.htm). A helpful figure (Fig. 2) from Dumont's paper illustrates the basic concept (see next page):

Answers

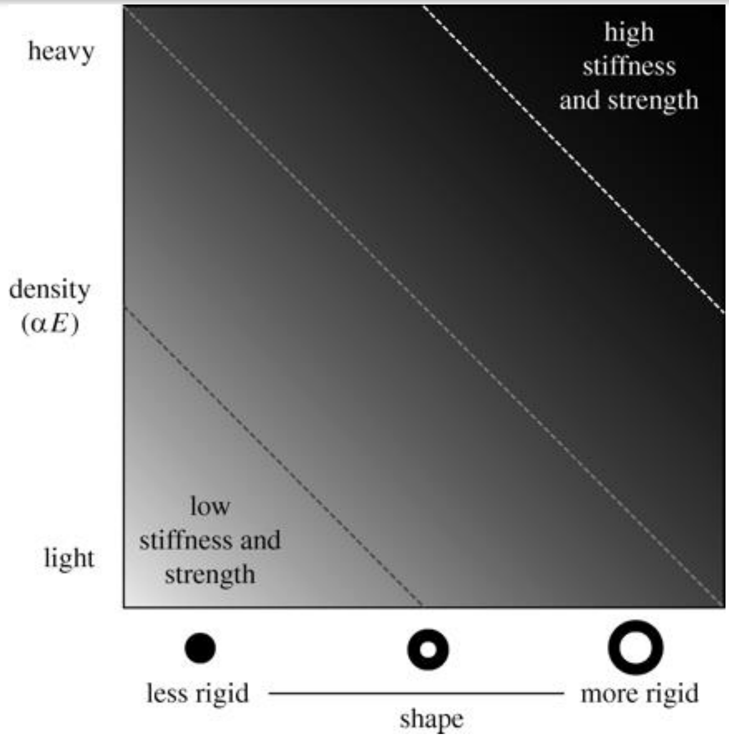


Figure 2 from Elizabeth R. Dumont, "Bone density and the lightweight skeletons of birds," *Proceedings of the Royal Society B*, 2010, 277, 2193-2198, by permission of the Royal Society.

2.33. As noted in the previous answer, the hollow shape is stiff or rigid by concentrating material to the perimeter of the hollow shape; the more material that can be placed away from the center, the stiffer the shape becomes. However, as the outer walls become thinner, there is another structural phenomenon that can weaken such a shape: local buckling caused by compressive loading. This kind of buckling is recognized as a problem to avoid and there are limitations on ratios of diameter to wall thickness for structural members (for example, refer to the information for round hollow structural sections given in the national design reference standard for steel structures, the American Institute of Steel Construction's ANSI/AISC 360-05 Table B4.1, Case 15 or ANSI/AISC 360-10 Table B4.1a Case 9 and B4.1b Case 20, of which the latter reference standard is at http://www.aisc.org/WorkArea/showcontent.aspx?id=26516). If these ratios are exceeded, a reduced effective area must be used in analysis and design that accounts for local buckling or, in some cases, they are not permitted for use in some lateral force resisting systems, such as braced frames (for example, refer to the national design reference standard for seismic design of steel structures, the American Institute of Steel Construction's ANSI/AISC 341-05, Part I, Table I-8-1 or ANSI/AISC 341-10, Table D1.1, of which the latter reference standard is available at http://www.aisc.org/WorkArea/showcontent.aspx?id=29248). The internal struts and ties help stabilize the outer shell to minimize the chance for localized buckling of the outer wall, thereby allowing thinner, larger diameter and, thus, stiffer bone structures.

Answers

2.34. Researchers discovered that hummingbirds have an incredible ability to control wing shape by adjusting feather orientation. Each wing position is provided with a slightly different wing shape to optimize lift. This requires dazzling nerve speed between the wings and brain in order for a hummingbird's brain to receive the signal from the wings, recognize the position of the wing, and then send signals back to the wing to trigger changes in the feather positions based on that position—it seems virtually instantaneous. For a short video clip showing this, see Victoria Gill, "Hummingbirds' wings 'shape-shift'," BBC News (July 4, 2013) at http://www.bbc.co.uk/news/science-environment-23143678, as noted by the article "To Hover, Hummingbirds Use Precision Feather Control," *Evolution News and Views* (July 10, 2013) at http://www.evolutionnews.org/2013/07/to_hover_hummin074281.html.

2.35. Answers may vary depending on an individual's familiarity with reptilian and avian anatomy. Answers may include the following: feathers on birds versus no feathers on reptiles; generally unidirectional avian air-sac respiratory system versus bidirectional reptilian diaphragm actuated respiratory system; four chambered avian heart and pulmonary system versus three chambered heart and pulmonary system present in most reptiles. For additional information, refer to the following:
- Figure 16-3 on p. 176 in Gary Kemper, Hallie Kemper, and Casey Luskin, *Discovering Intelligent Design* (Discovery Institute Press, 2013) at http://discoveringid.org/.
- Pp. 128-139 in Steve Meyer, Scott Minnich, Jonathan Moneymaker, Paul Nelson, and Ralph Seelke, *Explore Evolution* (Hill House Publishers, Second Edition, 2013) at http://www.exploreevolution.com/.

2.36. Some of the questions which must be asked if the processes are to be explained from an evolutionary perspective include:
- Do genes alone describe development of the particular feature or characteristic being investigated? Researchers frequently find epigenetic (i.e., outside of the genome) factors affect development of various characteristics of animals. There are often complex interactions between the genes and these other factors driving production of a given feature.
- If genetics are involved, what specific genetic regions are associated with the feature of interest? Are the same sections of DNA responsible for the divergent feature between the ancestors and descendent?
- What specific genetic mutations are required to go from ancestral feature to descendent feature? Is there a stepwise evolutionary pathway that can be followed to produce the new feature? What advantages are provided at each step? Are multiple mutations required to gain an advantage, meaning that "multimutation" features are required?
- Based on the number of changes and types of changes required and considering the probabilistic resources available in terms of population size and generation times, are these changes feasible within the timeframe allowed by the fossil record? Asking this question provides a realistic look at the probabilistic resources available and relevant time scale to arrive at the new feature.

Answers

- What changes to the paleoenvironment can be identified and linked to the supposed changes, or what other selection pressures caused the new features to evolve? If this question cannot be answered, then even identifying the genetic differences cannot provide any causal mechanism to explain why the innovation arose, and thus the "explanation" lacks sufficient explanatory power of describing how the change occurred by commonly accepted scientific standards.

For additional information on these kinds of important questions in relation to evolutionary explanations for the origin or development of some aspect of life, refer to Casey Luskin, "Asking the Right Questions about the Evolutionary Origin of New Biological Information," *Evolution News and Views* (February 24, 2010) at http://www.evolutionnews.org/2010/02/asking_the_right_questions_abo032211.html.

Further Reading:

1. Crawford H Greenewalt, *Hummingbirds* (Dover Publications, 1991) at http://www.amazon.com/Hummingbirds-Crawford-H-Greenewalt/dp/0486264319.
2. Thomas C. Emmel faculty page at University of Florida at http://www.biology.ufl.edu/people/faculty/tcemmel.aspx.

3. Chapter 5: Starlings (29:44-38:32)

Basic Questions:

3.1. False. They follow particular flight paths to avoid turbulence that would slow them down during their journey.
3.2. murmurations.
3.3. True. (For responses to evolution-proponents claiming this provides a reason for development of such behavior, see question 3.10.)
3.4. No. Current research suggests that each bird only keeps track of those directly in front, each side, above, and below it.
3.5. topological distance.
3.6. False. They respond in less than 100 milliseconds, which is about 1/3 of the time to blink an eye.
3.7. False. For example, the initial cause for heading back to the reeds for the night is not understood. There does not seem to be a specific leader that could direct their downward landing path.

Discussion Questions:

3.8. Rather than monitor the entire flock, each bird just keeps track of those immediately around it. When an immediate neighbor moves, they match that move. This is similar to fighter jets in tight formations tracking with their neighbor. However, the birds respond much more quickly—in about 100 milliseconds, to any movement by their neighbor.

Answers

Discussion Questions Beyond the Video:

3.9. Answers may vary, but may include the following information. It is important to note that murmurations are a result of group activity rather than individual effort. It cannot be assumed that the birds somehow "realized" that if they were to group together, then they would not be attacked. Based on population genetic considerations, unless identical genetic mutations occurred simultaneously in a sufficiently large group bringing about these new behaviors coupled with the relevant abilities, achieving the required fixation of the mutations is extremely unlikely. In order to even be considered plausible, the relevant genetic factors bringing about this unique behavior and functions must first be identified. Then, through population genetic analysis using established mutation rates, the required suite of modifications must be shown to be feasible given the proposed time frame between initial "non-murmuration" state to the end state of murmurations.

3.10. Actually, there is an ongoing debate between those claiming that flight developed from the "ground-up" or from the "trees-down." Each side cites evidence for this claim. Even Wikipedia, not always known for accuracy when it comes to controversial topics (see "Responses to Wikipedia's Error-Filled Article on the IDEA Center," at http://www.ideacenter.org/contentmgr/showdetails.php/id/1445), acknowledges the controversy in this area in its entry for Birds (http://en.wikipedia.org/wiki/Bird—see the section "Alternative scientific theories and controversies"). Both the origination of birds and flight are still contested issues. A somewhat technical discussion of many disputed topics within bird evolution is provided by Alan Feduccia, "Bird Origins Anew," *The Auk*, 130, no. 1 (January, 2013), pp. 1-12 at http://www.bioone.org/doi/pdf/10.1525/auk.2013.130.1.1 with a more popular, shorter summary of some of this paper at "Is it a bird? Is it a dinosaur?," *New Scientist*, 2862 (April 28, 2012), pp. 28-19 at http://bio.unc.edu/files/2011/04/New-Scientist-2012.pdf. Another popular discussion of some of the above references, and other papers, and the debate about the origin of flight is given in an article by John Ruben, "Paleobiology and the origins of avian flight," *PNAS*, 107, no. 7 (February 9, 2010), pp. 2733-2734 at http://www.pnas.org/content/107/7/2733.full. It is interesting to note what Ruben states in this commentary: "When interpreting the paleobiology of long extinct taxa, new fossils, and reinterpretations of well-known fossils, sharply at odds with conventional wisdom never seem to cease popping up. Given the vagaries of the fossil record, **current notions of near resolution of many of the most basic questions about long-extinct forms should probably be regarded with caution**." (emphasis added)

Further Reading:

1. George F. Young et al.,"Starling Flock Networks Manage Uncertainty in Consensus at Low Cost," *Public Library of Science (PLoS) Computational Biology*, 9, no. 1 (2013), e1002894 at http://www.ploscompbiol.org/article/info%3Adoi/10.1371/journal.pcbi.1002894.
2. Toni Feder, "Statistical physics is for the birds," *Physics Today*, 60, no. 10 (October, 2007) at http://dx.doi.org/10.1063/1.2800090.
3. David Klinghoffer, "Why Starling Murmurations Suggest Intelligent Design," *Evolution News and Views* (February 6, 2014) at http://www.evolutionnews.org/2014/02/starling_murmur081951.html.

Answers

4. Chapter 6: Arctic Terns (38:33-49:51)

Basic Questions:

4.1. Birds of the sun.
4.2. Artic, Antarctic.
4.3. True.
4.4. in air.
4.5. An accurate map of their immense migration path.
4.6. Small fish.
4.7. days.
4.8. 300.
4.9. Distance, weather, and navigation.
4.10. False. Some arctic terns make up to 30 round trips in their lifetime.
4.11. three.

Discussion Questions:

4.12. In order to learn their migration path, he would capture birds, equip them with geolocators, and release them to freely travel their epic migration. Then he would try to find the same birds with geolocators when they returned. He could then take off the tracking device and download the data.
4.13. During their journey south to the Antarctic, they first stop in the middle of the North Atlantic to eat enough for the rest of the trip. Second, when they near the equator, the flock splits, with some traveling south along the African coast while others travel west toward Brazil. Third, they eventually rejoin in the Antarctic.
4.14. They take an S-shaped path from the Weddell Sea to Greenland. The suggested reason for this path is to follow prevailing global winds, thereby utilizing the most energy efficient route during their journey.
4.15. They have a limited window of time (about eight weeks) to accomplish key tasks to maintain their population before heading back down to the Antarctic: mate, lay their eggs, and raise the chicks.

Answers

Discussion Questions Beyond the Video:

4.16. Scientists think the sun, stars, and earth's magnetic field are used by birds to navigate during journeys. The recent study by Dmitry Kishkinev et al. "Migratory Reed Warblers Need Intact Trigeminal Nerves to Correct for a 1,000 km Eastward Displacement," *PLoS ONE*, 8 (June 26, 2013) at http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0065847 (for a more popular version of this research, see Katia Moskvitch "Beak-to-Brain Nerve May Help Birds Navigate," *Science News*, June 27, 2013, at http://news.sciencemag.org/plants-animals/2013/06/beak-brain-nerve-may-help-birds-navigate?rss=1) took a group of about 60 reed warblers in Kaliningrad and cut the trigeminal nerve (which has a path from brain-to-beak) in some of the birds but not others. Then they displaced the birds 1000 kilometers to the East. Those warblers with an intact nerve headed in the correct direction, northwest, to breeding grounds. Those with the cut nerve flew in the same direction, northeast, as if they had been back where they were originally captured (see the figure on the next page, taken from Figure 2 in the noted *PLoS ONE* paper). This nerve is part of a "map system," but not a "compass system" both of which are needed for proper navigation. This is similar to findings in another paper noted in the *Science News* article in research conducted by Henrik Mouritsen et al. "Visual but not trigeminal mediation of magnetic compass information in a migratory bird," *Nature*, 461 (October 29, 2009), pp. 1274-1277 with abstract available at http://www.nature.com/nature/journal/v461/n7268/full/nature08528.html. See "Where Does a Bird's Magnetic Sense Reside?," *Evolution News and Views* (June 30, 2013) at http://www.evolutionnews.org/2013/06/where_does_a_bi073911.html for a summary of these findings. It should be noted that future experiments are needed and other systems may contribute to navigation that were not specifically studied in that research (see the next answer below for an example).

Answers

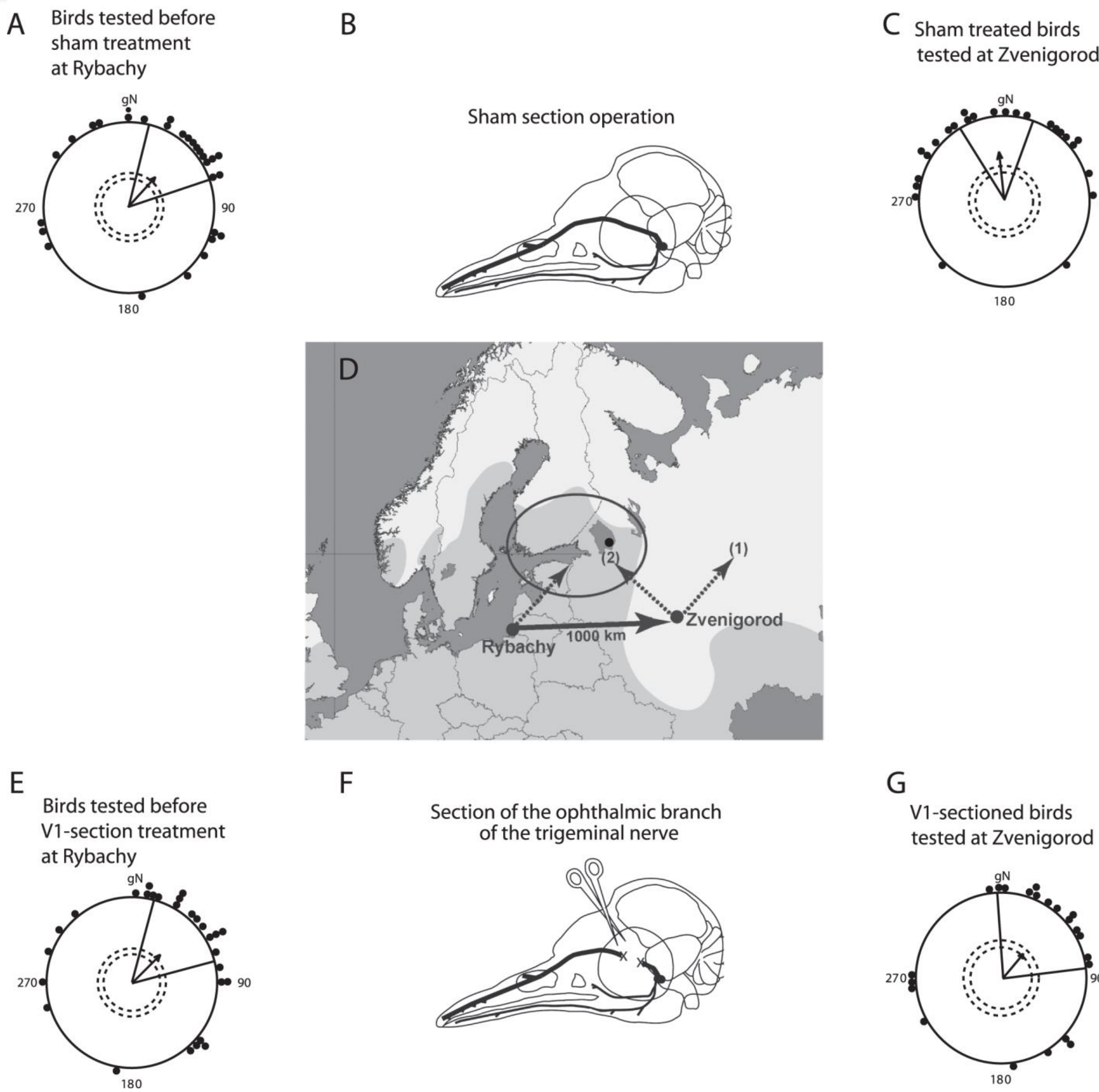


Image from Figure 2, Dmitry Kishkinev, Nikita Chernetsov, Dominik Heyers, and Henrik Mouritsen, "Migratory Reed Warblers Need Intact Trigeminal Nerves to Correct for a 1,000 km Eastward Displacement," *PLoS One* (June 26, 2013), DOI: 10.1371/journal.pone.0065847 at http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0065847#pone-0065847-g001 — Used by permission under Attribution 2.5 Generic (CC BY 2.5) Creative Commons License.

Answers

4.17. The discovery of an organelle in the inner ear of birds with high iron concentrations may be associated with navigation. Based on electrophysiological studies of pigeons (see Mattias Lauwers et al., "An Iron-Rich Organelle in the Cuticular Plate of Avian Hair Cells," *Current Biology*, 23, no. 10 (May 20, 2013), pp. 924-929 with abstract and figures at http://www.sciencedirect.com/science/article/pii/S0960982213004338), the vestibular system seems to be associated with magnetic sensation. The location of the iron rich organelle may facilitate in providing this ability, but it is uncertain until further research can conclusively demonstrate it. It is interesting to note what the article states regarding this organelle exhibiting "evolutionary conservation" based on how widespread it is seen in birds. This does not provide an evolutionary explanation for the origination of such a feature; rather, it suggests this is a vital component in birds because it is seen so frequently in them, though not in rodents or humans. In other words, the paper explains the maintenance of this organelle, but *not* how it came into being in the first place.

Further Reading:

1. Carsten Egevang, *Bird of the Sun* at http://issuu.com/egevang/docs/sun.
2. Carsten Egevang et al., "Tracking of Arctic terns *Sterna paradisaea* reveals longest animal migration," *PNAS* Early Edition (December, 2009) at http://www.pnas.org/content/early/2009/12/29/0909493107.full.pdf+html.
3. Carsten Egevang, *Migration and Breeding Biology of Arctic Terns in Greenland*. PhD thesis (2010) at http://www.bi.ku.dk/bibliotek/phd/Carsten%20Egevang.pdf.

5. Chapter 7: Design (49:52-1:01:33)

Basic Questions:

5.1. true cause.

5.2. True. This is also known as philosophical or metaphysical naturalism. It holds that all things can be explained as the result of materialistic or naturalistic process. The late Carl Sagan popularized this view in his show *Cosmos*, in which he noted "The Cosmos is all that is, or ever was, or ever will be." To learn more about naturalism in science, see "Primer: Naturalism in Science" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1169.

5.3. "Biologists must constantly keep in mind that what they see was not designed, but rather evolved." Note: this quote from Francis Crick is tantamount to requiring that biologists must adhere to naturalism as the only possible explanation for what they see rather than one possible explanation.

5.4. False. As Ann Gauger notes, there are many opportunities to test such claims "woven throughout the network of biological systems" associated with flight, such as the feather.

5.5. Yes. Different parts of a feather must work together properly to have a correctly functioning feather.

5.6. systems.

5.7. True. There are several different parts making up a feather, which is crucial to flight. (For additional information on feathers and their role in facilitating flight, see question 5.20.)

5.8. respiratory.

5.9. half mile.

5.10. design, integration.

Answers

5.11. False.
5.12. It is unguided.
5.13. False. She indicates they are far more complicated.
5.14. sum, parts.
5.15. intelligence/mind.

Discussion Questions:

5.16. Many scientists suggest small dinosaurs gradually evolved feathers, wings, and the relevant physiology for powered flight being the result of:
- Running and jumping away from predators.
- Leaping between tree limbs in trees.
- Flapping feather-covered arms to catch flying insects.

5.17. It is difficult for materialist evolutionists to avoid language indicating purpose because everywhere they look, they see design.

5.18. Due to the airfoil shape, there is a difference in pressure—lower pressure occurs on the top of the wing compared to the bottom. The air above the wing moves much more quickly than below. This difference in air speed causes a difference in pressure, thereby contributing to lift (along with other effects). In a sense, the bird is "sucked up into the air" from this component of flight. Some additional components leading to flight are the angle of attack for the wing as well as flapping. Airplane wings are an obvious example of human engineered technology which operates using the same basic principles. The airfoil shape exploits the effect of the difference in air pressure which promotes lift. Angle of attack is another features making lift possible. It is worth noting that there are some incorrect explanations (often due to oversimplification) frequently given to explain how lift is achieved (see the several incorrect theories described at the NASA's Glenn Research Center at http://www.nasa.gov/centers/glenn/home/index.html#.UxGVyPmwLrU starting with the first of three at http://www.grc.nasa.gov/WWW/k-12/airplane/wrong1.html). Complete mathematical descriptions accurately accounting for all the factors affecting lift are extremely complicated (e.g., Navier-Stokes equations which are partial differential equations in fluid mechanics resulting from application of Newton's second law to fluids) and often involve approximations and/or simplifications because closed form solutions are usually not possible. For additional information regarding airfoils and lift from a more basic and general perspective, including some educational resources for different grade levels (noted below), refer to the following NASA sites:
- Grade level 4-5: http://www.nasa.gov/content/lesson-title-air-foils/#.UxGPYPldU34
- Grade level 7-9: http://www.nasa.gov/offices/education/programs/national/summer/education_resources/engineering_grades7-9/E_beginners-guide.html#.UxGQGfmwLrU

5.19. There is a network or system of muscles, ligaments, bones, and feathers. The muscles, ligaments, and bones work together to adjust feather positions. Various features of flight (e.g., powered flight, gliding, landing, etc.) are facilitated through providing this maneuverability of feathers.

Answers

5.20. Feathers contain several distinct parts: central shaft, barbs, and barbules (for additional information on feather structure, refer to the following page at The Cornell Lab of Ornithology: http://www.birds.cornell.edu/AllAboutBirds/studying/feathers/feathers). The lower portion of the central shaft, the calamus, is hollow, making it light weight. Extending diagonally from the central shaft are the strand-like barbs, which in turn have even smaller barbules extending diagonally from them. These barbules have hook-like and ridge-like microscopic structures, depending on which side of the barbule they are on, which interlock to block airflow. Blocking the airflow contributes to the pressure differential noted earlier in the film, thereby contributing to lift and flight. For a discussion, see Gary Kemper, Hallie Kemper, and Casey Luskin, *Discovering Intelligent Design* (Discovery Institute Press, 2013) the section "The Intelligently Designed Structure of Feathers," pp. 178-179.

5.21. Answers may vary, but may include the following
- Massive chest muscles to power flight.
- Efficient respiratory system.
- Digestive system facilitating high metabolisms.
- Navigational systems using the sun, constellations, and earth's magnetic field.
- Internal stabilization systems ensuring proper body position during rapid flight maneuvers.
- Acute vision for food identification from far away.
- Many instincts to prompt and direct migrations.

The more systems and components within those systems which are needed to meet demands associated with birds flying create more and more challenges in explaining their development from unguided natural processes.

5.22. Gauger indicates natural selection does not have any foresight or direction—it lacks teleology or purpose. Because of this lack of foresight, unguided materialistic processes are unlikely to be capable of generating integrated parts and systems, all of which play crucial roles in bird flight.

5.23. Nelson notes there are multiple independent points in a complex space which must be brought together in such a way that the distant functional endpoint of flight can emerge. He further notes that through our common understanding of causal processes, only intelligence is capable of visualizing an achievable goal and bringing together all that is necessary to reach that goal.

5.24. Tim Standish notes that engineered systems often result from anticipating a problem and figuring out a solution to that problem, and that this process typically requires multiple steps. Because these kinds of systems are used in modern human engineered flight and can be identified in birds, design appears the best explanation for the origination of bird flight.

Answers

Discussion Questions Beyond the Video:

5.25. Answers may include the following: First, to clarify where such claims are made by the noted evolution proponents, see Carl Zimmer "Evolution of Feathers," *National Geographic Magazine* (February, 2011) at http://ngm.nationalgeographic.com/print/2011/02/feathers/zimmer-text or Karl Giberson and Francis Collins, *The Language of Science and Faith: Straight Answers to Genuine Questions* (InterVarsity Press, 2011), pp. 35, 38. In response to these claims, citing the work of others, Xing Xu et al. ("The origin and early evolution of feathers: insights from recent paleontological and neontological data," *Vertebrata PalAsiatica*, 47, no. 4 (October, 2009), pp. 311-329 at http://www.ivpp.cas.cn/cbw/gjzdwxb/xbwzxz/200911/P020091104362654347399.pdf) indicates "[s]everal models of evolutionary origin of feathers based on developmental data suggest that the origin of feathers is a completely innovative event and **the first feathers have nothing to do with reptilian scales**." (emphasis added; it is important to note that Xu et al. disagree with the "completely innovative event" for feathers—rather, they suggest a combination of transformation and innovations, but not from scales). Based on embryological developmental studies, the feather filament and barb ridges (precursors to the rachis, barbs, and barbules) are formed prior to the follicle from which it will sprout (Xu et al., 2009, pp. 322-323). While the proteins are similar for scales and feathers (i.e., β-keratins or ϕ-keratins), these proteins are used in many other structures protruding from the skin (e.g., claws, beaks, and bristles); similarity in proteins is insufficient to account for the dramatically different developmental and structural features of scales and feathers. It has been acknowledged that feather development must involve a relatively complex developmental mechanism (Xu et al., 2009, p. 323). While birds do have scales on their toes (and sometimes further up their leg), it has been suggested these scales are actually derived from feathers no longer forming on the legs (see Danielle Dhouailly, "A new scenario for the evolutionary origin of hair, feather, and avian scales," *Journal of Anatomy*, 214, no. 4 (April, 2009), pp. 587-606 at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2736124/). Regarding differences between scales and feathers, a good starting place is the basic features of each. Scales are merely skin folds while feathers are separate structures arising from specialized follicles in the skin. Due to their anatomical features, feathers can be broken into distinct components: central shaft (which has different regions, the calamus at the base region and rachis taking up the remaining and majority of the length), barbs, and barbules (for additional information on feather structure, refer to the following page at The Cornell Lab of Ornithology: http://www.birds.cornell.edu/AllAboutBirds/studying/feathers/feathers). Because scales are skin folds, they lack these kinds of distinct components. These differences and others noted before (e.g., developmental differences) have cast significant doubt that feathers are derived from scales. Instead, some scientists have suggested that feathers evolved for some other purpose, such as for insulation, which then evolved into flight feathers. For additional information, see Casey Luskin, "A Scientific Analysis of Karl Giberson and Francis Collins' *The Language of Science and Faith*," Part II: Giberson and Collins Make Outdated Argument That Feathers Evolved From Scales at http://www.ideacenter.org/contentmgr/showdetails.php/id/1511.

Answers

5.26. There are several different ways to respond to such a claim. First, request they justify their claim with evidence. However, there are generally three main problems with claimed "feathered dinosaur fossils": (1) they aren't feathered, (2) they aren't dinosaurs, (3) they are not fossils. To summarize these further, (1) so-called "protofeathers" are actually "dinofuzz," a structure very different from feathers; (2) the claimed ancestral dinosaurs are actually secondarily flightless birds; (3) there are some cases of fraudulent fossils. See below for additional information on each of these items:

- For item (1), some alleged feathered dinosaurs are covered in what some claim is a down-like material, but, according to critics, they are not feathers. Critics identify this as "dinofuzz" that is more akin to hair-like structures that are not similar to feathers. Evolution proponents may reply that evidence for common ancestry is provided by the fact that both hair and feathers are made from keratins and having melanosomes. However, the structure of keratin is quite different between hairs and feathers (i.e., hair has α-keratin and feathers have β-keratin) and there are more specialized features to feathers (e.g., barbs and interlocking barbules) requiring significant genetic modifications from any hair-like structure. Other evolution proponents may cite more recent work (e.g., such as the previously referenced paper by Xu et al. in *Vertebrata PalAsiatica*) to argue for a gradualistic development of feathers from hair-like structures. However, there are problems with those claims: a) flattening during fossilization may lead to distortions of feathers causing incorrect interpretations of claimed feather morphotypes (see Christian Foth, "On the identification of feather structures in stem-line representatives of birds: evidence from fossils and actuopalaeontology," *Paläontologische Zeitschrift*, 86, no. 1 (March, 2012), pp. 91-102 with abstract available at http://link.springer.com/article/10.1007%2Fs12542-011-0111-3); b) it has been suggested that feathers developed independently from hairs (see Danielle Dhouailly, "A new scenario for the evolutionary origin of hair, feather, and avian scales," *Journal of Anatomy*, 214, no. 4 (April, 2009), pp. 587-606 at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2736124/); c) for any claims about transitions between hairs and feathers to be considered plausible, the following must be provided:
  - i) a detailed description of all the proposed genetic changes for each stage.
  - ii) the amount of genetic difference between each stage.
  - iii) a survival benefit provided for each stage, preferably linked to the paleoenvironment.
  - iv) a populations genetic study showing that the amount of genetic change between each stage is feasible within the proposed time frame between stages.

  For additional information on "dinofuzz," refer to the following:
  - Casey Luskin, "The "Ancestor of All Dinosaurs" Might Have Had ~~Feathers~~ Dinofuzz (Updated)," *Evolution News and Views* (July 13, 2012) at http://www.evolutionnews.org/2012/07/the_ancestor_of061991.html
  - Several blog posts indicating similar and other problems with claimed "protofeathers" by David Tyler, at *Science Literature: A discussion of ID-related Reading*:
    - "The Taphonomy of *Sinosauropteryx*," (August 7, 2012) at http://www.arn.org/blogs/index.php/literature/2012/08/07/the_taphonomy_of_sinosauropteryx

- "The claim that *Sinosauropteryx* had proto-feathers," (July 18, 2012) at http://www.arn.org/blogs/index.php/literature/2012/07/18/the_claim_that_sinosauropteryx_had_proto;
- "Feathered dinosaurs—speculation and controversy," (July 21, 2009) at http://www.arn.org/blogs/index.php/literature/2009/07/21/feathered_dinosaurs_speculation_and_cont
- "Dino skin shows no trace of protofeathers," (November 11, 2008) at http://www.arn.org/blogs/index.php/literature/2008/01/11/dino_skin_shows_no_trace_of_protofeather.

- For item 2), some scientists have suggested that these "feathered dinosaurs" are not dinosaurs at all, but rather are secondarily flightless birds. Experts who make these claims include: Alan Feduccia[1] Theagarten Lingham-Soliar[1] J. Richard Hinchliffe[1] Storrs L. Olson[2] Terry D. Jones[3] James O. Farlow[3] John A. Ruben[3] Donald M. Henderson[3] Willem J. Hillenius[3] Peter Wellnhofer[4] Teresa Marya?ska[5] Halszka Osmólska[5] H. M. Wolsan[5] Frances C. James[6] John A. Pourtless[6], from the following references:
  [1.] Alan Feduccia, Theagarten Lingham-Soliar, and J. Richard Hinchliffe, "Do Feathered Dinosaurs Exist? Testing the Hypothesis on Neontological and Paleontological Evidence," *Journal of Morphology*, 266 (2005), pp. 125-166 at http://bio.unc.edu/files/2011/04/Journal-of-Morphology-2005.pdf.
  [2.] http://dml.cmnh.org/1999Nov/msg00263.html
  [3.] Terry D. Jones, James O. Farlow, John A. Ruben, Donald M. Henderson, & Willem J. Hillenius, "Cursoriality in bipedal archosaurs," *Nature*, 406 (August 17, 2000), pp. 716-718 with abstract at http://www.nature.com/nature/journal/v406/n6797/full/406716a0.html.
  [4.] P. Wellnhofer P. "The plumage of *Archaeopteryx*: feathers of a dinosaur?," In: Currie PJ, Koppelhus EB, Martin AS, Wright JL, editors. *Feathered dragons: studies on the transition from dinosaurs to birds* (Bloomington: Indiana University Press, 2004), pp. 282-300.
  [5.] Maryanska T, Osmolska H, Wolsan HM, "Avialan status for Oviraptorosauria,"*Acta Palaeontol Pol*, 47 (2002), pp. 97-116 at http://www.app.pan.pl/archive/published/app47/app47-097.pdf.
  [6.] James FC, Pourtless JA. Review of: Feathered dragons: studies on the transition from dinosaurs to birds. *Auk* 122 (2005), pp. 714-716 with a partial viewing at http://www.jstor.org/discover/10.2307/4090463?uid=3739560&uid=2134&uid=2&uid=70&uid=4&uid=3739256&sid=21103509246061; Frances C. James and John A. Pourtless IV, "Cladistics and the Origin of Birds: A Review and Two New Analyses," *The Ornithological Monographs*, 66 (April 30, 2009), pp. 1-78 at http://www.bio.fsu.edu/James/Ornithological%20Monographs%202009.pdf.
  See also Casey Luskin, "Is the Latest "Feathered Dinosaur" Actually a Secondarily Flightless Bird?," *Evolution News and Views* (November 12, 2008) at http://www.evolutionnews.org/2008/11/is_the_latest_feathered_dinosa013131.html

Answers

- For item 3), there are known cases of fraud, such as the notorious case of *Archaeoraptor*. In its zeal to push feathered dinosaurs on to the public in 1999, *National Geographic* rushed a cover story about the fossil *Archaeoraptor*. Claiming it was a "missing link between terrestrial dinosaurs and birds," the magazine indicated it was "exactly what scientists would expect to find in dinosaurs experimenting with flight." However, a short time later, *Archaeoraptor* was shown to be a forgery—it was actually a cleverly combined dinosaur and bird fossil. The retraction was buried in a short letter-to-the-editor months later. For additional information, see below:
  - See Nancy Pearcey, "The Missing Link that Wasn't: *National Geographic*'s 'Bird Dinosaur' Flew Against the Facts" (March 10, 2000) at http://www.arn.org/docs/pearcey/np_hespotlight0300.htm
  - Jonathan Wells, *Icons of Evolution: Science or Myth? Why much of what we teach about evolution it wrong* (Regnery, 2000), pp. 124-126 (2002 paperback edition), available at http://www.iconsofevolution.com/.
  - Gary Kemper, Hallie Kemper, and Casey Luskin, *Discovering Intelligent Design* (Discovery Institute Press, 2013) the section "The Fossil Record," p. 177, at http://discoveringid.org/.

5.27. While *Archaeopteryx* certainly shows an interesting combination of reptilian and bird features, one cannot claim it is a "transitional" form unless one examines this fossil's context within and among the larger framework of evolutionary theory and currently available evidence. This would include both review of the claimed ancestor and descendants of *Archaeopteryx* as well as where they occur within the fossil record. However, the field of cladistics, in which animals are grouped based on similar "shared derived" characteristics, completely ignores where species appear (temporally or spatially) in the fossil record when determining relationships. This has led to the problem of claimed ancestors of *Archaeopteryx* actually showing up later, rather than earlier, in the fossil record. (See Robert A. Martin, *Missing Links: Evolutionary Concepts and Transitions Through Time* (Jones & Bartlett, 2004), p. 153.) Additionally, there are some extant birds with some similar features to *Archaeopteryx*. For example, the hoatzin, which is found near the Amazon River, has claws on its wings at birth (used for climbing), a long neck and tail, small head, shallow breast bone (which limits its flying ability), as well as other similar features. *Archaeopteryx* may simply be a mosaic form, similar to the duck-billed platypus, which no one considers "transitional" between mammals and birds. Add to this other problems previously noted regarding conflicts between the "trees-down" or "ground-up" views of flight and birds (refer to the answer for question 3.9 for additional information), or anatomical problems evolving the avian respiratory system (refer to the answer for question 2.29 for additional information), and this leads to a very simple question: what exactly are the animals that *Archaeopteryx* is transitional between? For additional information, see the following:

- Casey Luskin, "*Archaeopteryx* and Intelligent Design" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1508 (which is an excerpt from the book *Intelligent Design 101: Leading Experts Explain the Key Issues*, edited by H. Wayne House (Kregel Publications, 2008) at http://www.amazon.com/Intelligent-Design-101-Leading-Experts/dp/0825427819).
- Jonathan Wells, *Icons of Evolution: Science or Myth? Why much of what we teach about evolution it wrong* (Regnery, 2000), Chapter 6, at http://www.iconsofevolution.com/.

Answers

- Gary Kemper et al., *Discovering Intelligent Design* (Discovery Institute Press, 2013) Chapter 16, pp. 174-176 (the section on “Dino-Bird”) at http://discoveringid.org/.

5.28. Since the time of the ancient Greek philosopher, Aristotle, philosophers can describe several different causes: final, efficient, formal, and material. Below is a short description of the conceptual nature for each cause:

- Final: ultimate purpose for the existence of something.
- Efficient: mechanism or method by which something came to exist.
- Formal: the original or Platonic Form or pattern, essence, or physical structure of something.
- Material: the physical materials (e.g., wood, steel, stone, plastic, atoms, molecules, etc.) which make up something.

ID is an efficient cause, though questions about final causes often arise in discussions about origins. This is because the implications, rather than the premises, of ID lead to such matters, which may lead to other philosophical or theological topics or the “big questions” of life affecting one’s worldview. For additional information, see FAQ: Could something be designed if it were an “evil design?” at http://www.ideacenter.org/contentmgr/showdetails.php/id/1172 as well as question and answer 1.1 and 1.14 in the Discussion and Study Guide for Illustra Media’s *Where Does The Evidence Lead?* (http://www.wheredoestheevidencelead.com/) at http://www.ideacenter.org/contentmgr/showdetails.php/id/1517.

Answers

5.29. A noteworthy feature is the feather shaft being hollow for the portion nearest to its base, the calamus, where loading effects from flight are largest due to the cantilever nature of the feather protruding from muscles and skin. Not only does it contribute to the feather being light, but it contributes to the structural integrity of the primary structural member of the feather, the shaft, including torsional resistance—something that is necessary to account for small pressure variations between each side on the same face of the feather that would tend to twist the shaft. By being hollow, it makes efficient use of material through geometrical placement over a larger diameter (which is one of the ways its strength is derived—with a large cross section) than would occur if the same amount of material was solid through the cross section, similar to the hollow bone studies in answer to question 2.32 noted earlier in this guide. (The hollow feature common to structural steel tubes and pipes is a frequently exploited engineered feature for these kinds of structural members; they are often used to provide torsional stiffness and resistance efficiently with respect to material used compared to other common structural shape geometries.) In fact, based on biomechanical analysis of feather shafts for claimed early forms of birds, such as *Confuciusornis* and *Archaeopteryx*, researchers discovered the feathers may have been too weak to allow for powered, flapping flight (see Robert L. Nudds and Gareth J. Dyke, "Narrow Primary Feather Rachises in *Confuciusornis* and *Archaeopteryx* Suggest Poor Flight Ability," *Science*, 328 (May 14, 2010), pp. 887-889, with abstract available at http://www.sciencemag.org/content/328/5980/887). Researchers found the shaft was too narrow and must have been solid to allow gliding flight; as one researcher put it, they "were rubbish at flying" (see "Prehistoric Birds Were Poor Flyers, Research Shows," *Science Daily* (May 26, 2010) at http://www.sciencedaily.com/releases/2010/05/100526100612.htm). Furthermore, this same study found that the feathers in *Confuciusornis*, which is found more recently in the fossil record than *Archaeopteryx*, were worse for flying. This suggests these animals were on their way to becoming secondarily flightless birds rather than being precursors of powered flight common in modern birds.

5.30. Irreducible complexity is the term that describes a feature often seen in biological systems, where multiple, integrated parts are required or else proper function is not possible. This term was coined by biochemist Michael Behe in his 1996 book, *Darwin's Black Box*. Irreducible complexity challenges neo-Darwinism because natural selection can only build structures one small step at a time, but irreducibly complex structures require lots of parts to be present all at once before providing any advantage. As a result, they cannot be built in the stepwise manner required by Darwinian selection. Non-functioning intermediate systems end up being "invisible" to natural selection since they do not provide any benefit to an organism. For further information on irreducibly complex systems, see the following links:

- "Primer: Irreducible Complexity in a Nutshell" at http://www.ideacenter.org/contentmgr/showdetails.php/id/1142.
- "Irreducible Complexity: The Challenge to the Darwinian Evolutionary Explanations of many Biological Structures" at http://www.ideacenter.org/contentmgr/showdetails.php/id/840.
- Various authors responding to criticisms of IC: "About Irreducible Complexity: Responding to Darwinists Claiming to Have Explained Away the Challenge of Irreducible Complexity" at http://www.discovery.org/a/3408.

Answers

5.31. In order to claim that some feature is designed, particular hallmarks of designed objects, such as complex specified information, must be positively identified and natural processes shown as unlikely to produce that feature. Our uniform and repeated experience of how intelligent agents act and the informational characteristics of a given feature provide us the ability to recognize designed features. One characteristic hallmark of design is the presence of high levels of complex and specified information. For additional information, refer to Casey Luskin, "The Positive Case for Design" at http://www.discovery.org/986.

5.32. Scientists have identified over a dozen components, including specialized coloring cell types, melanocytes, and multiple signaling proteins regulating feather coloration. Melanocyte stem cells, located at the base of the follicle producing the feather, generate the dark-colored protein, melanin, containing melanocyte cells. The production of the melanocytes is also modulated by agouti proteins in the feather follicle. Through a single melanocyte cell type, along with various feedback and regulatory mechanisms, a beautiful panoply of colors and patterns are generated, simultaneously with feather geometry. For additional information, see S. J. Lin et al., "Topology of Feather Melanocyte Progenitor Niche Allows Complex Pigment Patterns to Emerge," *Science*, 340, no. 6139 (June 21, 2013), pp. 1442-1445 with abstract at http://www.sciencemag.org/content/340/6139/1442.abstract. For a popular level article describing these findings, see Lin Edwards, "Research sheds light on how patterns form in bird feathers," *PhysOrg* (April 26, 2013) at http://phys.org/news/2013-04-patterns-bird-feathers.html or, with a discussion of the intelligent design aspects of this discovery, see "Feather Patterning Shows Planning, Foresight," *Evolution News and Views* (July 6, 2013) at http://www.evolutionnews.org/2013/07/feather_pattern074161.html.

5.33. Citing sexual selection alone is insufficient to explain the origin of feather patterning. First, sexual selection does not provide any explanation for why something arises other than "it was sexually attractive." But why was it sexually attractive? That second order question is rarely addressed. Second, sexual selection cannot account for the origination of the different cell types, feedback, and regulatory mechanisms controlling patterning in feathers. The origin of these structures must be described in detail, which sexual selection cannot do. Such elucidation would need to include the required genetic changes providing the new cell types and controls, along with feasibility studies incorporating probabilistic resources and time periods with population genetics.

5.34. Precision mechanisms provide nano-scale geometrical patterns corresponding to wavelengths of light, leading to optical interference that intensifies some colors and cancels out others.

5.35. No—other mechanisms are at work since the pigment-producing quail follicle has been inserted into a white chicken causing colored feathers at those sights.

5.36. Answers may vary depending on the individual, but may include the following: Melanocytes stop their activity upon feather completion, but initiate again to replace a feather if it's removed. This removal could be from being plucked or during development from a young stage to a full grown adult or even during seasonal changes in some species.

5.37. Answers may vary depending on the individual.

Answers

Further Reading:

1. A.C. McIntosh, "Evidence Of Design In Bird Feathers And Avian Respiration," *International Journal of Design & Nature and Ecodynamics*, 4, no. 2 (2009), pp. 154-169 with abstract available at http://journals.witpress.com/pdfs/abstracts/D&NE040201a.pdf .
2. Michael Behe, *The Edge of Evolution* (Free Press, 2007) at http://www.amazon.com/The-Edge-Evolution-Search-Darwinism/dp/0743296222.
3. Geoffrey Simmons, *Billions of Missing Links: A Rational Look at the Mysteries Evolution Can't Explain* (Harvest House Publishers, 2007) at http://www.amazon.com/Billions-Missing-Links-Mysteries-Evolution/dp/0736917462.
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.

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.