SCIENCE

7th-9th grade
1 year
1 credit

REVISED & UPDATED

APPLIED ENGINEERING: STUDIES OF GOD'S DESIGN IN NATURE

P.L.P. Parent Lesson Planner

- Weekly Lesson Schedule
- Student Worksheets
- Quizzes & Tests
- Answer Key

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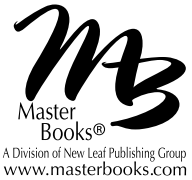

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Psalm 11:3

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But sanctify the Lord God in your hearts, and always be ready
to give a defense to everyone who asks you a reason for the hope
that is in you, with meekness and fear.
1 Peter 3:15

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Publisher's Note: This course was originally named *Applied Science*, and now includes updated worksheets, quizzes, and tests based on the primary student readings in *Discovery of Design*, with bonus questions developed from further study students can complete for additional credit.

Lessons for a 36-week course!

Overview: This *Applied Engineering: Studies of God's Design in Nature PLP* contains materials for use with *Made in Heaven, Champions of Invention,* and *Discovery of Design*. Materials are organized in the following sections:

- Study Guide Worksheets
- Quizzes and Tests
- Answer Key

Features: Each suggested weekly schedule has four easy-to-manage lessons which combine reading, experiments, research paper, invention challenge, and worksheets. Worksheets and quizzes are perforated and three-hole punched — materials are easy to tear out, hand out, grade, and store. As always, you are encouraged to adjust the schedule and materials as you need to in order to best work within your educational program.

Workflow: Students will read the pages in their book and then complete each section of the course materials. Tests are given at regular intervals with space to record each grade. Younger students may be given the option of taking open-book quizzes.

Lesson Scheduling: Space is given for assignment dates. There is flexibility in scheduling. For example, the parent may opt for a M-W schedule rather than a M, W, F schedule. Each week listed has five days but due to vacations the school work week may not be M-F. Please adapt the days to your school schedule. As the student completes each assignment, he/she should put an "X" in the box.

	Approximately 30 to 45 minutes per lesson, four days a week
	Includes answer keys for worksheets, quizzes, and tests
	Worksheets for each chapter
	Quizzes are included to help reinforce learning and provide assessment opportunities
	Designed for grades 7 to 9 in a one-year course to earn 1 science credit
	Suggested labs (if applicable)

Jeff Seto has worked as an aerospace engineer in experimental research and development for over 20 years, holds a B. Eng in aerospace and an electrical engineering diploma in avionics. **Ray Comfort** is a best-selling author of more than 70 books, the president of Living Waters ministry, and co-host of an award-winning television program with actor Kirk Cameron called *Way of the Master*. **John Hudson Tiner** received five National Science Foundation teaching fellowships during his 12 years as a teacher of mathematics and science that allowed him to study graduate chemistry, astronomy, and mathematics. **Don DeYoung** is Chairman of the Science and Mathematics Department, Grace College, Winona Lake, Indiana. He is a graduate of Michigan Tech University (B.S., M.S., Physics), Iowa State University (Ph.D., Physics), and Grace Seminary (M.Div.). **Derrik Hobbs** has an active interest in creation studies, including business models based on principles and processes found in nature.

Contents

Course Description

Discovery of Design

From the frontiers of scientific discovery, researchers are now taking design elements from the natural world and creating extraordinary breakthroughs that benefit our health, our quality of life, and our ability to communicate, and even help us work more efficiently. An exciting look at cutting-edge scientific advances, *Discovery of Design* highlights incredible examples that include:

How things like batteries, human organ repair, microlenses, automotive engineering, paint, and even credit card security all have links to natural designs; innovations like solar panels in space unfurled using technology gleaned from beech tree leaves, and optic research rooted in the photonic properties of opal gemstones.

Take a fantastic journey into the intersection of science and God's blueprints for life — discovering answers to some of the most intricate challenges we face in a multi-purpose educational supplement.

Made in Heaven

Science shamelessly steals from God's creation, yet refuses to give God the glory!

Discover how the glow of a cat's eyes innovates road reflectors; the naturally sticky inspirations for Velcro and barbed wire, as well as a fly's ear, the lizard's foot, the moth's eye, and other natural examples are inspiring improvements and new technologies in our lives.

Engineers and inventors have long examined God's creation to understand and copy complex, proven mechanics of design in the science known as biomimicry. Much of this inspiration is increasingly drawn from amazing aspects of nature, including insects to plants to man, in search of wisdom and insight. We are surrounded daily by scientific advancements that have become everyday items, simply because man is copying from God's incredible creation, without acknowledging the Creator.

Champions of Invention

The great minds of the past are still with us today, in many ways. Individuals who explored the natural world hundreds and thousands of years ago have given us a treasure of knowledge in all the sciences.

In this exciting series from educator/author John Hudson Tiner, short biographies of the world's most gifted thinkers will inspire the leaders of tomorrow.

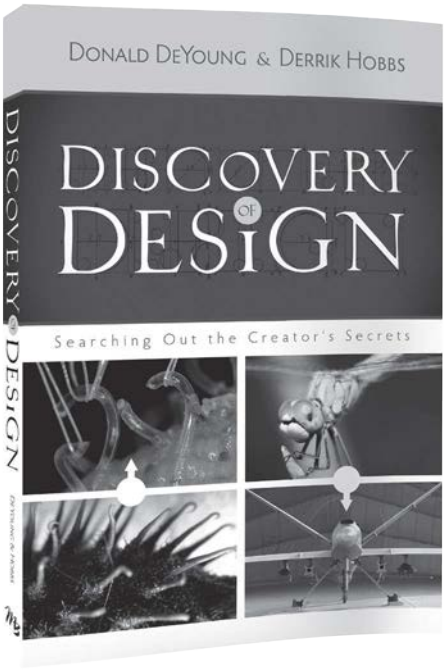
Study the life of the "forgotten" inventor, Joseph Henry, whose exploration of electricity set the standard for later innovators. Find out how a personal tragedy paved the way for Samuel F.B. Morse to put aside his painting and develop the telegraph.

These valuable learning guides will give students accurate accounts of lives from the halls of science, and explain what those scientists believed about the world around them.

First Semester Suggested Daily Schedule

Date	Day	Assignment	Due Date	✓	Grade
First Semester–First Quarter					
Week 1	Day 1	Introduction & Ch 1: Microorganisms: Bacteria-Micro-motor Read Pages 8–13 • *Discovery of Design* • (DoD) **Discovery of Design: Intro & Worksheet 1** • Pages 16–17 Lesson Planner • (LP)			
	Day 2	Ch 1: Bacteria-Battery • Read Pages 14–15 • (DoD) **Discovery of Design: Worksheet 2** • Page 18 • (LP)			
	Day 3	Ch 1: Biofilm-Bacteria Control • Read Pages 16–17 • (DoD) **Discovery of Design: Worksheet 3** • Page 19 • (LP)			
	Day 4	Ch 1: Diatom-Nanotechnology • Read Pages 18–19 • (DoD) **Discovery of Design: Worksheet 4** • Page 20 • (LP)			
	Day 5				
Week 2	Day 6	Ch 1: Protien-Solar Cells • Read Pages 20–21 • (DoD) **Discovery of Design: Worksheet 5** • Page 21 • (LP)			
	Day 7	Ch 2: The Insect World: Ants-Airlines • Read Pages 23–25 • (DoD) **Discovery of Design: Intro & Worksheet 1** • Pages 24–23 • (LP)			
	Day 8	Ch 2: Asian Beetle-Paper Whitener • Read Pages 26–27 • (DoD) **Discovery of Design: Worksheet 2** • Page 24 • (LP)			
	Day 9				
	Day 10				
Week 3	Day 11	Ch 2: Bombardier Beetle-Gas Turbine Engine Read Pages 28–29 • (DoD) **Discovery of Design: Worksheet 3** • Page 25 • (LP)			
	Day 12	Ch 2: Butterfly-Cosmetics • Read Pages 30–31 • (DoD) **Discovery of Design: Worksheet 4** • Page 26 • (LP)			
	Day 13	Ch 2: Dragonfly-Surveillance • Read Pages 32–33 • (DoD) **Discovery of Design: Worksheet 5** • Page 27 • (LP)			
	Day 14	Ch 2: Firefly-Light Stick • Read Pages 34–35 • (DoD) **Discovery of Design: Worksheet 6** • Page 28 • (LP)			
	Day 15				
Week 4	Day 16	Ch 2: Fly-Hearing Aid • Read Pages 36–37 • (DoD) **Discovery of Design: Worksheet 7** • Page 29 • (LP)			
	Day 17	Ch 2: Honey Bee-Surveillance • Read Pages 38–39 • (DoD) **Discovery of Design: Worksheet 8** • Page 30 • (LP)			
	Day 18	Ch 2: Insect Hearing-Atomic Force Microscope Read Pages 40–41 • (DoD) **Discovery of Design: Worksheet 9** • Page 31 • (LP)			
	Day 19	Ch 2: Insects-Robotics • Read Pages 42–43 • (DoD) **Discovery of Design: Worksheet 10** • Page 32 • (LP)			
	Day 20				

Date	Day	Assignment	Due Date	✓	Grade
Week 5	Day 21	Ch 2: Namib Beetle-Water Collector • Read Pages 44–45 • (DoD) **Discovery of Design: Worksheet 11** • Page 33 • (LP)			
	Day 22	Ch 2: Spider Silk-Fiber Optics • Read Pages 46–47 • (DoD) **Discovery of Design: Worksheet 12** • Page 34 • (LP)			
	Day 23	Ch 2: Termite Mound-Ventilation • Read Pages 48–49 • (DoD) **Discovery of Design: Worksheet 13** • Page 35 • (LP)			
	Day 24	Ch 2: Timber Beetle Larva • Read Pages 50–51 • (DoD) **Discovery of Design: Worksheet 14** • Page 36 • (LP)			
	Day 25				
Week 6	Day 26	Ch 2: Wasp-Paper • Read Pages 52–53 • (DoD) **Discovery of Design: Worksheet 15** • Page 37 • (LP)			
	Day 27	Ch 2: Water Strider-Water Repellent • Read Pages 54–55 • (DoD) **Discovery of Design: Worksheet 16** • Page 38 • (LP)			
	Day 28	**Discovery of Design: Ch.1–2 Quiz 1** • Pages 191–192 • (LP)			
	Day 29	Ch 3: Flight: Bat-Sonar Systems • Read Pages 57–59 • (DoD) **Discovery of Design: Worksheet 1** • Page 39 • (LP)			
	Day 30				
Week 7	Day 31	Ch 3: Bird Flight-Aircraft • Read Pages 60–61 • (DoD) **Discovery of Design: Worksheet 2** • Page 40 • (LP)			
	Day 32	Ch 3: Flying Reptile-Delta Wing Aircraft Read Pages 62–63 • (DoD) **Discovery of Design: Worksheet 3** • Page 41 • (LP)			
	Day 33	Ch 3: Kingfisher- Bullet Train • Read Pages 64–65 • (DoD) **Discovery of Design: Worksheet 4** • Page 42 • (LP)			
	Day 34	Ch 3: Owl Wing-Noise Reduction • Read Pages 66–67 • (DoD) **Discovery of Design: Worksheet 5** • Page 43 • (LP)			
	Day 35				
Week 8	Day 36	Ch 3: Swift-Aircraft Wings • Read Pages 68–69 • (DoD) **Discovery of Design: Worksheet 6** • Page 44 • (LP)			
	Day 37	Ch 3: Toucan Beak-Shock Absorber • Read Pages 70–71 • (DoD) **Discovery of Design: Worksheet 7** • Page 45 • (LP)			
	Day 38	Ch 4: Underwater Life: Boxfish-Automobile Design Read Pages 73–75 • (DoD) **Discovery of Design: Worksheet 1** • Page 47 • (LP)			
	Day 39	Ch 4: Brittlestar-Microlens • Read Pages 76–77 • (DoD) **Discovery of Design: Worksheet 2** • Page 48 • (LP)			
	Day 40				
Week 9	Day 41	Ch 4: Cuttlefish-Camouflage • Read Pages 78–79 • (DoD) **Discovery of Design: Worksheet 3** • Page 49 • (LP)			
	Day 42	Ch 4: Elephant Nose Fish-Electric Sensor Read Pages 80–81 • (DoD) **Discovery of Design: Worksheet 4** • Page 50 • (LP)			
	Day 43	Ch 4: Fish Motion-Ship Propulsion • Read Pages 82–83 • (DoD) **Discovery of Design: Worksheet 5** • Page 51 • (LP)			
	Day 44	Ch 4: Lobster Eye-Telescope Lens • Read Pages 84–85 • (DoD) **Discovery of Design: Worksheet 6** • Page 52 • (LP)			
	Day 45				



Applied Engineering Worksheets

for Use with

Discovery of Design

Introduction

1. What is the name of the science where designs are developed from designs in nature?

2. What are the two distinct explanations for the many successful ideas derived from studying nature?

3. What is the major flaw in crediting evolution for the successful design features found in nature?

4. What is the historic definition of science?

5. What are two reasons the Creator deliberately included all the useful design features in our world?

Bacteria > Micro-motor

1. What was the year of Leeuwenhoek's discovery of "small living creatures in rain water"?

2. How do many microscopic life forms propel themselves through liquids?

3. How many of these motors would fit along a one-inch length?

4. What are the three main parts of these "motors"?

5. Describe how myxobacteria move.

Digging Deeper

6. What is the precise meaning of the words *micro* and *nano*?

7. How does the speed of an electric fan compare with the 100,000-rpm rate of the molecular motor?

8. What are the chemical properties of silly string?

Bacteria > Battery

1. Why is *Rhodoferax ferrireducens* of special interest to scientists?

2. What is the efficiency rate for production of electric energy by *Rhodoferax ferrireducens*?

3. What are bacterial batteries?

4. What is the technological challenge toward making bacterial batteries a realistic option for energy-starved areas?

5. How much sugar would it take to power a 60-watt lightbulb for a number of hours using bacterial batteries?

Digging Deeper

6. What actually is a battery?

7. Why are most energy-conversion processes inefficient?

8. How many electrons pass through a standard 60-watt light bulb in one second?

Biofilm > Bacteria Control

1. What are biofilms?

2. How do members of biofilms communicate with one another?

3. What is the ability of biofilms to affect their surroundings by hundreds of chemical compounds called?

4. What is an example of biofilms helping to block invading foreign bacteria?

5. Studies are being done to determine if biofilms can control corrosion in what fuel-related equipment?

Digging Deeper

6. Estimate the number of bacteria on your hands.

7. Where might one find freshwater biofilms?

8. What are some unusual locations of biofilms?

Diatom > Nanotechnology

1. What are diatoms?

2. Where are diatoms found?

3. Why are scientists, who are interested in nanotechnology, looking at diatoms?

4. What two chemical substances are used to harden diatom components for use as microscopic mechanical gears?

5. What does the author mean by "designer diatoms"?

Digging Deeper

6. Are diatoms plants or animals?

7. What is the mineral name for glass?

8. Diatomaceous earth is a powdered form of diatom fossils. What are some of its uses?

Protein > Solar Cells

1. How do plants capture energy from the sun?

2. Which is more efficient at capturing energy from the sun – plants or silicon solar cells?

3. What part of plants have scientists succeeded in using to create small solar cells?

4. What happens when light shines on the plant-based proteins on an electricity-conducting glass surface?

5. What is one advantage for protein solar energy cells mentioned in the book?

Digging Deeper

6. How is electric current measured?

7. How is it possible that wind power, water power, and fossil fuels are all forms of solar energy?

8. Can you name three non-solar forms of energy?

Applied Engineering Worksheets

for Use with

Made in Heaven

Become a Champion of Invention!

You have completed enough coursework to have learned how many of today's most cutting-edge innovations are inspired by God's designs in nature. As you begin the remainder of this course, you will enjoy doing simple experiments and learn information on the science behind many of these innovations.

Now here is your challenge! Take steps to become an inventor:

1. Start an invention notebook, where you will detail your thoughts, and brainstorm ideas and do rough sketches.

2. Choose something related to nature that you find interesting.

3. Develop an idea for an improvement, innovation, or invention related to this natural design or feature of nature.

4. At the beginning, try to record as many of your thoughts as possible – even if they seem impractical. Try to list at least 8 to 10 ideas.

5. Next, look at your ideas, and see which ones are really needed and can be a practical help. This is where you narrow it down from the improbable to the practical. Try to list at least three of the most practical ideas. If needed, you can do simple drawings where you try to determine whether an idea is doable or not.

6. From these three ideas, choose the one you feel is most viable or able to be done. This is your proposed invention!

7. Now imagine what it would take for your idea to become a workable invention.

8. Create a plan for how you could possibly test out your idea in terms of making it an invention.

9. List three to five reasons for why your invention is needed.

10. Then present either a project notebook with a two-page presentation of your idea and your thoughts, or you can create a simple display on a poster.

Concepts and Definitions

The following information will lay a critical foundation for related Applied Learning activities. It is important that you read and understand this information so the Applied Learning opportunities can demonstrate and clarify important scientific concepts in action.

Fluid dynamics may sound like a science that is limited to fluid or water. But did you know that any object that moves through air or in water experiences the same aerodynamic effects and follows identical principles? It's true. Fluid does not mean liquids; rather any medium such as oil, air, gas, and various liquids that are subject to motion are classified as a "fluid." The only difference is the speed in which an object will travel.

This is due to different fluid densities. Density is defined as the mass (weight) per unit volume. As an example, if you had a gallon of water and a gallon of air, the gallon of water would be heavier. The density of water (62.4 lbs/ft^3) is much greater than the density of air (.08 lbs/ft^3).

The science of fluid dynamics is comprehensive and we will not be able to cover all that it entails. Rather, we will focus on the articles from the book *Made in Heaven* that are subject to the laws of fluid dynamics and the following characteristics of fluid flow over an object, which are covered in the book.

Boundary Layer

This is the thin layer that is adjacent to the surface of an object that is unaffected by either laminar or turbulent flow.

Laminar Flow

All fluid flow that moves over an object that takes on the appearance of smooth flow, parallel to the objects surface. Laminar flow contributes to speed, or flow, of an object. This is the opposite effect of turbulent flow.

Turbulent Flow

Turbulent flow is all fluid flow that moves in a rough/erratic flow pattern. This is the opposite effect of laminar flow.

Transition Point

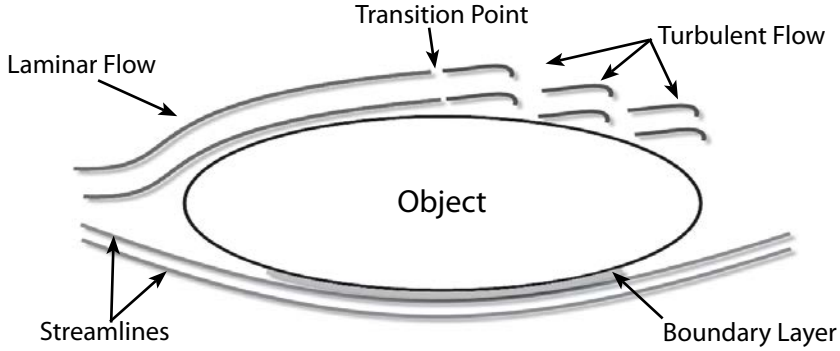
This is the location where the fluid flow transitions from laminar to turbulent flow.

Streamlines

This is a trace or an outline of the flow pattern around an object that defines the flow characteristics around the object.

Drag

Drag is exactly what it sounds like. Drag slows down and is a hindrance in the flow of fluid.



Q: Which flow type would you expect to exhibit drag?

A: If you said turbulent, then you are correct.

Rough flow = drag, and drag is caused by the shape of the object.

Applied Learning

The following activity or experiment illustrates important concepts for this portion of the coursework. Please make note of the scientific aspects of the activity as well as the specific areas of focus. These should reinforce important concepts and definitions that you have learned as you apply them.

Science

Fluid dynamics

Definition/Focus

Focusing on laminar and turbulent flow

Smooth flow is based on the shape of an object

Parts Lists

- Hand
- Large container of water, such as a pool or bathtub

Experiment

In the bathtub or a swimming pool, try to push the water with your hand in the following configurations:

1. An open palm with the fingers tightly pressed together
2. An open palm with your fingers spread apart (as far as you can)
3. Your hand balled up in a fist
4. With the edge of your hand (like a karate chop)

☑ Take Away

Note the difference in resistance felt by forming different shapes with your hand in the water. Different shapes exhibit different resistances. Fish are created with a shape that minimizes drag.




Questions:

1. Which shape moved the fastest in water?

2. Why do you think objects of that shape move faster?

3. Can you think of other types of shapes that move with speed?

4. What other examples in God's creation can you think of that might follow this principle?

Quizzes Section

Q	*Discovery of Design* Concepts & Comprehension	Quiz 1	Scope: Chapters 1–2	Total score: ____of 100	Name

Answer Questions: (5 Points Each Question)

1. What is the name of the science where designs are developed from designs in nature?

2. How do many microscopic life forms propel themselves through liquids?

3. What are bacterial batteries?

4. What is an example of biofilms helping to block invading foreign bacteria?

5. What does the author mean by "designer diatoms"?

6. What happens when light shines on the plant-based proteins on an electricity-conducting glass surface?

7. Which insect is named in the Bible verse Exodus 10:4?

8. When it comes to ants, what determines the overall group behavior?

9. Where are several species of brilliant white beetles found?

10. What chemical does the bombardier beetle's spray and rocket fuel have in common?

11. What is the process called that cosmetic companies are using to mimic the light wave properties of butterfly and to replace the use of pigments, dyes, waxes, and oils?

12. What physical feature makes dragonflies unusual among insects?

13. What does a firefly create by mixing chemicals in its abdomen?

14. What is an additional potential benefit for hearing aids created by studying the fly?

15. How does light travel through the eye of a bee?

16. What do insects like grasshoppers or moths hear with their ultra-sensitive listening systems?

17. What is the major advantage of small, multi-leg robots over actual insects?

18. How does the beetle "drink" the water collected?

19. Why is synthetic spider silk one of the most sought after technologies in biomimicry?

20. Why are the termite mounds built by *Macrotermes michaelseni* of interest to architects?

21. What is another name for the chipper chain?

22. Why was paper so expensive centuries ago?

Bonus Questions: (10 Points Each Question)

1. How were big trees harvested before chainsaws were invented?

2. How do water striders move so rapidly on water?

Answer Keys

Introduction

1. Biomimicry
2. Millions of years of supposed evolutionary change developed these innovations; valuable, practical designs have been with since the beginning of time
3. Patterns and information are conserved with the passing of generations, but the DNA blueprint does not increase in complexity or gain new information.
4. The historic definition of science is the search for knowledge and truth about the physical world, wherever this may lead.
5. Design examples show us how to properly care for nature and maintain its health; the other purpose was for the benefit of living things, and also that ideas could be discovered and utilized for the welfare of mankind.

Chapter 1 – Worksheet 1

1. 1657
2. Using molecular motors
3. 10 million
4. flagellus, central shaft of protein, electrochemical reactions
5. This organism has hundreds of tiny nozzles covering its outer surface. It manufactures a slime that shoots from these nozzles, much like silly string. As a result, the bacterium recoils in the opposite direction using the principle of jet propulsion.
6. The prefixes micro and nano come from Greek roots meaning, respectively, "small" and "dwarf." Technically, micro stands for one millionth, or 10^{-6}. The, thickness of a sheet of paper is about 4000 micro-inches. A nano is defined as one billionth, or 10^{-9}. In one inch there are one million micro-inches, and one billion nano-inches.
7. Typical speed for a household electric fan is 1500 rpm. This is 60 times slower than the speed of the bacteria flagellum.
8. Silly string was first introduced as a child's toy in 1972. A liquid polymer in a pressurized aerosol container quickly turns solid when exposed to air. Polymers are compounds with long chains of chemically bonded molecules. One container can produce silly string hundreds of feet long.

Chapter 1 – Worksheet 2

1. This tiny microbe produces electrical current using simple sugars as its fuel source.
2. 80%
3. Energy-producing microorganisms
4. To combine the electric output from a large number of these bacteria to produce a practical level of current.
5. One cup
6. A battery is a chemical cell useful for storing electrical energy. Energy storage is a challenge for technology, and research continues on batteries with high efficiency and capacity.
7. When fuel is burned in a car to produce motion, much of the resulting heat energy is unused. This heat radiates outward from the engine and water coolant, and also leaves with the hot exhaust gases. The second law of thermodynamics describes such inevitable losses in every energy transfer process.
8. A light bulb, whether in a flashlight or reading lamp, has an electric current of about one ampere. This amounts to over six million-trillion electrons (actually 6.25×10^{18}) passing through the bulb filament each second. These electrons move through the filament at a snail's pace, somewhat similar to a large crowd passing through a narrow gate.

Chapter 1 – Worksheet 3

1. Large organized communities of bacteria
2. By releasing chemicals
3. Signal blocking
4. Protecting animals like dogs and cattle from cholera infection, or biofilms added to paint to prevent barnacles from attaching to the surface of boats

Discovery of Design Quiz Answer Keys

Quiz 1 – Chapters 1–2

1. Biomimicry
2. Using molecular motors
3. Energy-producing microorganisms
4. Protecting animals like dogs and cattle from cholera infection, or biofilms added to paint to prevent barnacles from attaching to the surface of boats
5. These are diatoms that researchers hope to encourage growth into new and useful shapes.
6. The lights causes a faint current of electricity to pass thru adjacent layers and by putting multiple layers in series, the plant-based protein generates a useful electrical current.
7. Locusts
8. Countless interactions between nearby ants
9. Southeast Asia
10. Hydrogen peroxide (H_2O_2)
11. The butterfly effect
12. Four distinct wings
13. Cold light
14. A smaller "fly-sized" hearing aid
15. Light first enters through a micro lens, which caps the outer end of the column. The light then moves through the hollow column until it meets photoreceptors at the internal end.
16. Faint vibrations
17. If the robot is overturned, the mechanical legs can be pivoted 180 degrees downward and the upside-down machine can continue walking forward.
18. Upon reaching a certain size, the water droplets overcome electrostatic attraction forces and roll down the beetle's tilted back to its mouth.
19. Because of possible improvements to everything from bulletproof vests to suspension cables for bridges
20. The self-cooling systems these termites build into their termite mounds.
21. Oregon chain
22. It was made from cotton and linen rags and of limited quantity

Bonus Questions

1. Along with the axe, crosscut saws date back to Roman times. These saws cut horizontally through the tree trunk, across the grain. Such saws improved over time with new metal alloys and tooth design. They are still much used around the world, often with a woodsman on each end of the saw.
2. The striders move by "digging" their feet into the water surface and generating vortices or tiny swirls. Pushing against the resulting "mini wall" of water, they recoil forward rapidly with speeds measured at five feet per second (1.5 meter/sec).

Quiz 2 – Chapters 3–4

1. Parallel navigation
2. Design small aircraft for the military and underwater submersibles
3. Instead of evolutionary progress, the fossil lizard indicates the loss of a particular flight design.
4. When a train exits a tunnel at high speeds, there is a rapid expansion of air that was compressed in front of the train. This results in a loud sonic boom that rattles windows and awakens people. Japan has strict laws on sound pollution.
5. Special curved wing feathers
6. The adjustment or "morphing" of their wing shape
7. The outer surface is made of keratin, the common protein material found in our own fingernails and hair. The keratin coating in the toucan beak consists of overlapping hexagonal layers that are somewhat flexible. This allows for bending and twisting motions of the beak. Meanwhile, the interior of the beak contains a foam-like, criss-crossed scaffold of tiny, flexible, lightweight bones. Some internal parts of the beak remain hollow, surrounded by the lattice of supporting bones.

Discovery of Design Test Answer Key

1. Energy-producing microorganisms
2. Protecting animals like dogs and cattle from cholera infection, or biofilms added to paint to prevent barnacles from attaching to the surface of boats
3. Hydrogen peroxide (H_2O_2)
4. If the robot is overturned, the mechanical legs can be pivoted 180 degrees downward and the upside-down machine can continue walking forward.
5. The self-cooling systems these termites build into their termite mounds.
6. Instead of evolutionary progress, the fossil lizard indicates the loss of a particular flight design.
7. When a train exits a tunnel at high speeds, there is a rapid expansion of air that was compressed in front of the train. This results in a loud sonic boom that rattles windows and awakens people. Japan has strict laws on sound pollution.
8. The design of the microlenses is advanced beyond any optical devices manufactured today.
9. Rapid color-changing gel that can be applied to military clothing and equipment
10. The fabrication of biological hard tissue and artificial bone
11. No
12. A series of circulation valves in the neck prevents major blood pressure changes in the giraffe's head. Also, the giraffe's legs have especially tight skin and strong muscles. These features prevent blood from pooling in the long legs of the giraffe.
13. Colored masks or screens that are more transparent and safer than the old-style dark masks that obstructed vision
14. Cleats and mucus
15. It is located off-center from the bone.
16. Fully 60 percent
17. Velcro®
18. A self-cleaning spray that repels water, dust, and grime.
19. A thermostat for heating and air conditioning
20. The intricate pattern of veins on the underside of the Victoria Amazonia lily

Bonus Questions

1. To avoid predators, the color of this beetle matches its frequent habitat, bright white fungi. How the fungi itself produces this color is yet another marvel that is not well understood. The beetle's reflective surface also provides cooling for its body.
2. The mechanism of blood clotting requires precise reactions of many interrelated chemicals. If any one of these biochemical steps is missing, the mechanism may fail. An entire graduate course could be built on our limited understanding of the blood-clotting process. Many scientists conclude that blood clotting is far too complex, and essential, to evolve by mere chance. Instead, it shows divine planning of the internal workings of living creatures.

Made in Heaven Worksheet Answer Keys

Chapter One

1. Number 4, the edge of your hand
2. The hand in this orientation simulates a wedge shape, which slices through the water. The other shapes have a larger frontal area, which cause more drag.
3. All shapes with rounded ends
4. Dolphins, squid, birds

Chapter Two

1. The corrugations and the popsicle sticks ran parallel with each other and provided no rigidity in the other direction.
2. Gluing down the second set of popsicle sticks 90 degrees to the corrugations provided the increase in strength.
3. There would still be additional strength added, as long as the second set of popsicle sticks do not run parallel with the cardboard corrugations.

Chapter Three

1. Able to break thread and paper, unable to break the remaining materials
2. Thread should have been the easiest
3. Fishing line, you were probably unable to break.
4. metal, wood, plastic

Chapter Four

1. Yes, after drying, the paper's shape changed and became wrinkled, resulting in the paper contracting.
2. Yes, the sponge did also shrink in size, but did not significantly change its shape as compared to the paper.
3. No, they did not. The sponge took more time to dry because of the larger size and the fact that it absorbed more water than the piece of paper.

Chapter Five

1. It would make no difference.
2. No, the only way is to physically glue it down.

Chapter Six

1. The only way is to make the air intake end stiffer to prevent it from moving all around. One method is to add tape around it a number of times to increase the thickness.
2. Less air in the balloon means less pressure, which will result in the balloon moving more slowly.
3. The farther away you stand, the more difficult it will be to hit the target. The closer you are, the better chance you have of directing the balloon through your friend's arms.

Chapter Seven

1. Violet, indigo, blue, green, yellow, orange, red
2. The rainbow will shift and/or disappear.

Chapter Eight

1. 360 degrees
2. A peak and trough
3. Since the peak of one wave will occur at the trough of the other wave, the net result is that they would cancel each other out in their entirety and result in a flat line.

Chapter Nine

1. Will be dependent on your camera, but your eyes will have a larger field of view than your camera. Some cameras have what is called a panoramic view setting which will provide you with a field of view far wider.

Chapter Ten

1. 27
2. Will vary from individual to individual
3. 4 x 4 x 4 x 4 = 1024
4. Thousands every day, which are variants of existing viruses

2. You will notice that the tunnel without the cardboard will collapse first.

Chapter Thirty

1. You could use anything that is shiny and has facetted surfaces. Shiny facetted-surface objects would work best.
2. Yes, you would have the same results as long as there was a reflected surface (plastic report cover). It would still work, regardless of the length of the can.
3. Mirrors, foil wrap, shiny metal surfaces

Chapter Thirty-One

1. Without sunlight there would be no photosynthesis process. No oxygen bubbles were produced in the dark.
2. Yes, the results were the same.

Chapter Thirty-Two

1. You will never see that.
2. You will notice leaves grow out from the center in a circular direction.
3. Yes they do — that is the main structural support that the leaf branches off from.

Made in Heaven Quiz Answer Keys

Quiz 1 – Chapter 1–8

1. resistances
2. drag
3. orientation, toughness
4. tension
5. thickness
6. strength
7. elasticity
8. tensile
9. temperature
10. metals
11. polymers
12. ceramics
13. semiconductors
14. material
15. material
16. pinecones
17. coarse
18. nanobots
19. magnetic
20. frequency
21. light
22. frequency
23. seven
24. peak
25. 360 degrees

Quiz 2 – Chapter 9–16

1. optics
2. reflected ray
3. refracted ray
4. reflected and refracted
5. Snell's
6. index
7. camera
8. mathematics
9. cognitive
10. thousands every day, which are variants of existing viruses
11. brain
12. small
13. neurons
14. For a whole brain we would need 42 x 10 = 420 semi-trailers.
15. sine
16. color
17. visible
18. ultraviolet

Made in Heaven Test Answer Key

1. drag
2. elasticity
3. pinecones
4. nanobots
5. seven
6. optics
7. camera
8. brain
9. chemistry
10. Ten times the length of the beetle. Example: if the beetle is 2" long, then the range would be 10 x 2 = 20".
11. fingertips
12. proteins
13. reflective
14. electromagnetism
15. drag
16. They need fans.
17. windshield wipers
18. sound
19. thermodynamics
20. You will notice leaves grow out from the center in a circular direction.