

# Discovering Design with Earth Science

## Table of Contents

### Chapter 1: Basic Concepts Required to Study Earth Science..... 1



Introduction.....	1
The Earth's Shape.....	1
Experiment 1.1: Hull Down.....	2
Chemicals .....	4
Experiment 1.2: Very Similar but Very Different!.....	4
It's Just a Phase .....	6
Units.....	7
The Metric System.....	8
Math With Units .....	10
Volume .....	12
Converting Between Metric Units.....	13
Converting Between Unit Systems.....	16
The Importance of the Factor-Label Method.....	18
Identifying Measurement Based on Units .....	20
It's Not the Heat.....	21
Experiment 1.3: Movement You Do Not See.....	22
Measuring Temperature.....	24
Measuring Density.....	25
Measuring Concentration.....	27
Answers to the Comprehension Check Questions.....	29
Chapter Review .....	33

### Chapter 2: It's a Little Crusty..... 35



Introduction.....	35
Spheres Within Spheres.....	36
The Geosphere.....	37
But Wait A Minute .....	38
Crusty and Dirty .....	40
Experiment 2.1: It's More Than Just Dirt.....	41
Components of Topsoil.....	42
Experiment 2.1 Continued.....	42
Experiment 2.2: Water Sorting.....	44
Particle Sizes in Soil.....	46
Experiment 2.3: Percolation .....	46
But Where Does Soil Come From?.....	49
Experiment 2.4: Breaking Down Rocks .....	49
Experiment 2.5: Physical Weathering .....	51
More About Physical Weathering .....	51
Other Kinds of Physical Weathering.....	53
Chemical Weathering .....	54
More About Chemical Weathering.....	56
Erosion.....	57
Uniformitarianism and Catastrophism.....	60
Answers to the Comprehension Check Questions.....	62
Chapter Review .....	64

**Chapter 3: Minerals ..... 65**



Introduction.....	65
Minerals and Rocks .....	65
Experiment 3.1: Minerals and Rocks.....	65
Color: An Optical Property of Minerals .....	67
Other Optical Properties of Minerals.....	68
Experiment 3.2: Optical Properties of Minerals.....	68
Mechanical Properties of Minerals.....	71
Experiment 3.3: Mechanical Properties of Minerals .....	72
Other Properties of Minerals .....	74
Experiment 3.4: Effervescence and Magnetic Properties in Minerals ...	74
Chemical Properties of Minerals .....	77
How Do Minerals Form? .....	82
Polymorphism.....	85
How We Use Minerals.....	86
Precious and Semi-Precious Gems .....	89
Minerals in the Soil.....	91
Answers to the Comprehension Check Questions.....	92
Chapter Review .....	94

**Chapter 4: Rocks ..... 95**



Introduction.....	95
Minerals in Rocks .....	95
Experiment 4.1: Minerals in Granite .....	96
Three Basic Types of Rock.....	97
Igneous Rock .....	98
Experiment 4.2: Igneous Rock .....	98
Sedimentary Rock.....	101
Experiment 4.3: Sedimentary Rock.....	101
Metamorphic Rock .....	104
Experiment 4.4: Metamorphic Rock.....	104
The Rock Cycle .....	107
Different Scientific Perspectives of The Rock Cycle .....	108
Sedimentary Rock Formations .....	111
Stranger Sedimentary Rock Formations.....	114
More on Sedimentary Rock.....	116
The Relative Age of Rocks.....	117
Really Useful Rocks .....	118
Answers to the Comprehension Check Questions.....	121
Chapter Review .....	123

**Chapter 5: The Lithosphere ..... 125**



Introduction..... 125

One Big Difference Between Oceanic and Continental Crust..... 126

Experiment 5.1: Density of Rocks..... 126

A Surprising Thing About the Continents ..... 128

Experiment 5.2: Magnetic Alignment ..... 129

The Earth’s Magnetic Field ..... 131

What Causes the Earth’s Magnetic Field?..... 132

Experiment 5.3: An Electromagnet ..... 132

How Does This Relate to the Motion of the Continents? ..... 134

It Is Not Constant..... 135

Learning From the Ocean ..... 136

Why Does the Oceanic Crust Slip Under Continental Crust? ..... 139

Experiment 5.4: When Crusts Collide ..... 139

Plate Tectonics..... 140

Plate Movements ..... 141

Hot Spots and Volcanic Islands ..... 145

What’s Actually Moving the Plates? ..... 146

Experiment 5.5: Convection ..... 146

Sample Data and Calculations for Experiment 5.1 ..... 149

Sample Data and Calculations for Experiment 5.4..... 149

Answers to the Comprehension Check Questions..... 150

Chapter Review ..... 152

**Chapter 6: More About Motion in the Lithosphere ..... 153**



Introduction..... 153

Different Types of Faults..... 153

Experiment 6.1: Friction in Faults ..... 154

Earthquakes..... 156

Don’t Lose Your Focus ..... 160

Focusing in on Waves..... 161

Experiment 6.2: Waves..... 161

More About Seismic Waves ..... 164

Reflection and Refraction ..... 168

Experiment 6.3: Refraction of Light Waves..... 169

Tsunamis..... 171

Earth Has Its Ups and Downs ..... 172

More About Volcanoes..... 175

Answers to the Comprehension Check Questions..... 180

Chapter Review ..... 182



**Chapter 7: Fossils in Rocks**..... **183**



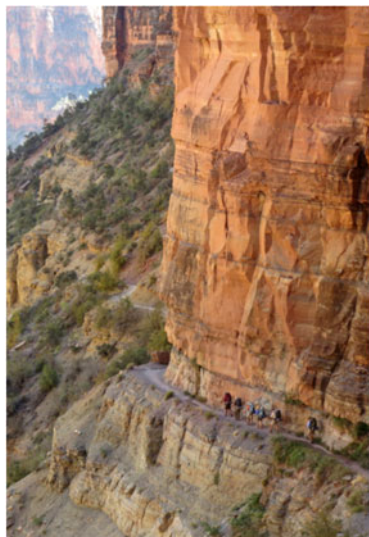
Introduction..... 183  
 Different Fossils..... 184  
 Experiment 7.1: Examining Fossils..... 184  
 The Key to Fossilization..... 185  
 Experiment 7.2: Partially Preventing a Reaction..... 186  
 Fossil Molds and Casts ..... 189  
 It Looks Like a Mold, But... ..... 190  
 Fossil Footprints ..... 192  
 Petrification..... 194  
 Experiment 7.3: A Quick Petrification ..... 194  
 What Can We Learn from Petrified Fossils?..... 197  
 Experiment 7.4: Detailed Examination of Petrified Fossils ..... 197  
 Surprising Fossils..... 200  
 Reading too Much into Fossils ..... 202  
 Extinct or Not?..... 204  
 There Is a Pattern ..... 206  
 Answers to the Comprehension Check Questions..... 210  
 Chapter Review ..... 212

**Chapter 8: Interpreting the Geological Record**..... **213**



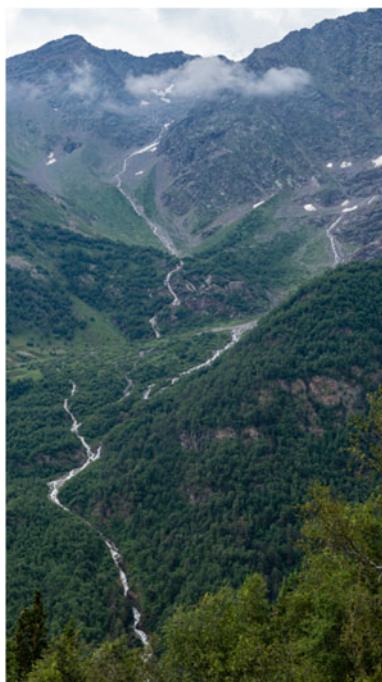
Introduction..... 213  
 Making Interpretations Based on Limited Data..... 213  
 Experiment 8.1: Did it Change? ..... 213  
 Uniformitarianism’s Approach to the Geological Record..... 216  
 Atoms and Radioactivity ..... 216  
 The Speed at Which Radioactive Decay Occurs ..... 221  
 Experiment 8.2: Half Life..... 221  
 Using Radioactive Decay to Determine the Age of Rocks..... 223  
 Experiment 8.3: Gases in Liquids..... 224  
 Radiometric Dating and the Geological Column..... 226  
 The Earth’s History According to Uniformitarians ..... 228  
 Catastrophism and the Worldwide Flood ..... 231  
 The Young-Earth Creationist View of the Geological Column ..... 233  
 The Earth’s History According to Young-Earth Creationists..... 237  
 Answers to the Comprehension Check Questions..... 242  
 Chapter Review ..... 244

**Chapter 9: Uniformitarianism Versus Catastrophism ..... 245**



Introduction..... 245  
 Using Present-Day Observations to Interpret the Past ..... 245  
 Experiment 9.1: How Long Has It Been Sitting There?..... 245  
 Potassium-Argon Dating ..... 248  
 Carbon-14 Dating ..... 250  
 Evidence for the Uniformitarian Interpretation ..... 253  
 Evidence for the YEC Interpretation ..... 258  
 Evolution and the Geological Column ..... 263  
 Do Similarities Imply Macroevolution? ..... 266  
 Data That Are Hard To Reconcile With Macroevolution ..... 268  
 Data That Are Hard To Reconcile With Young-Earth Creationism..... 270  
 It’s Time to Talk About Time..... 273  
 Science Cannot Say Which Is Better ..... 277  
 Answers to the Comprehension Check Questions..... 278  
 Chapter Review ..... 280

**Chapter 10: Water and the Hydrosphere..... 281**



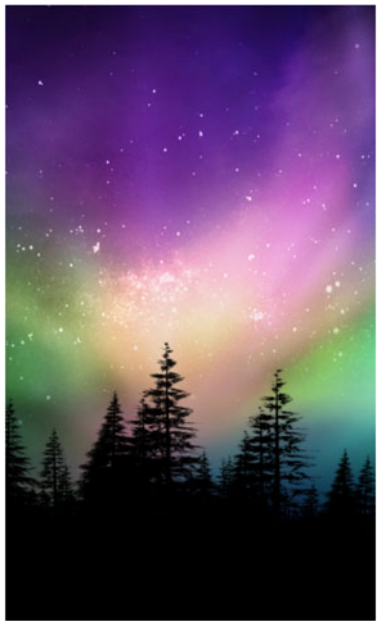
A Very Important Chemical ..... 281  
 A Molecule with Charge..... 281  
 Experiment 10.1: Floating Paper Clips..... 282  
 An Exceptional Molecule ..... 284  
 Experiment 10.2: Density Change..... 284  
 A High-Capacity Molecule..... 286  
 Experiment 10.3: Heating Things Up..... 286  
 The Opposite of Fresh is... Salt? ..... 289  
 Experiment 10.4: Freshwater versus Saltwater ..... 289  
 Evening Things Out..... 292  
 It's a Salty World After All..... 296  
 Why Do Both Exist on Earth? ..... 297  
 Experiment 10.5: Purifying Water..... 297  
 The Hydrologic Cycle..... 300  
 How Long Have You Been a Resident? ..... 303  
 Sample Data and Calculations for Experiment 10.2..... 305  
 Sample Data and Calculations for Experiment 10.4..... 305  
 Answers to the Comprehension Check Questions..... 306  
 Chapter Review ..... 307

**Chapter 11: More on the Hydrosphere ..... 309**



Introduction..... 309  
Motion in the Ocean, Part 1: Surface Waves..... 309  
Experiment 11.1: Making Waves ..... 309  
Motion in the Ocean, Part 2: Tides..... 312  
Motion in the Ocean, Part 3: Surface Currents..... 317  
Experiment 11.2: Bending the Path ..... 318  
More on Surface Currents..... 320  
Surface Currents Causing Vertical Currents..... 323  
Thermohaline Currents ..... 324  
Experiment 11.3: Temperature and Density ..... 325  
Freshwater in the Hydrosphere, Part 1: Glaciers ..... 327  
Freshwater in the Hydrosphere, Part 2: Groundwater ..... 330  
Freshwater in the Hydrosphere, Part 3: Water in the Atmosphere ..... 332  
Experiment 11.4: Making a Cloud..... 332  
Answers to the Comprehension Check Questions..... 335  
Chapter Review ..... 337

**Chapter 12: The Atmosphere ..... 339**



Introduction..... 339  
Air Has Weight and Takes Up Space ..... 339  
Experiment 12.1: Air Has Weight and Takes Up Space ..... 339  
Air Pressure ..... 341  
Experiment 12.2: Air Pressure..... 342  
The Composition of Air..... 344  
Divisions of the Atmosphere ..... 346  
Why Does the Temperature Vary Like That?..... 349  
Experiment 12.3: Blowing Away the Temperature ..... 349  
What About the 1%?..... 352  
More About Carbon Dioxide ..... 355  
Carbon Dioxide, Acids, and Bases ..... 356  
Experiment 12.4: Carbon Dioxide and pH ..... 357  
The Effect of Increasing Carbon Dioxide on Global Temperature ..... 359  
The Effect of Increasing Carbon Dioxide on Ocean pH..... 362  
Answers to the Comprehension Check Questions..... 365  
Chapter Review ..... 367

**Chapter 13: Weather, Part 1 ..... 369**




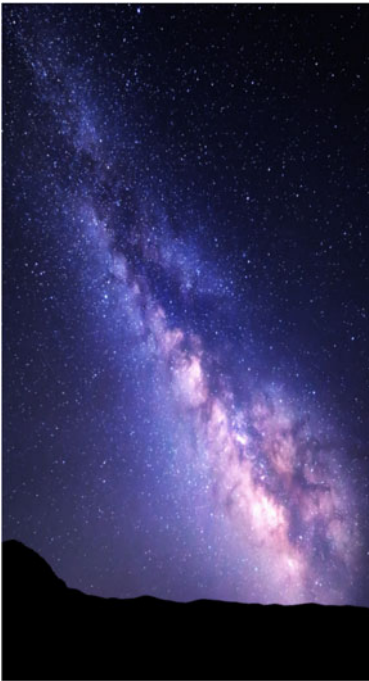
Introduction..... 369  
 You Are My Sunshine ..... 369  
 It's Like Night and Day..... 372  
 It's Not Even..... 373  
 Experiment 13.1: It's Not Really a Circle ..... 375  
 We Take This Trip Every Year ..... 376  
 Wind and Temperature ..... 382  
 Experiment 13.2: Making Wind ..... 382  
 Global Wind Patterns..... 384  
 Air Masses ..... 388  
 Why Is the Sky Blue? ..... 389  
 Experiment 13.3: Orange and Blue ..... 389  
 Clouds..... 392  
 Answers to the Comprehension Check Questions..... 397  
 Chapter Review ..... 399

**Chapter 14: Weather, Part 2 ..... 401**



Introduction..... 401  
 Weather Fronts..... 401  
 Weather Maps..... 403  
 Precipitation..... 406  
 Experiment 14.1: Skating Drops..... 406  
 More on Humidity ..... 408  
 Experiment 14.2: Cool and Warm Fingers ..... 409  
 More on Precipitation ..... 411  
 Thunderstorms ..... 416  
 Experiment 14.3: Knuckle Sparks ..... 417  
 Hail in Thunderstorms ..... 419  
 Tornadoes ..... 420  
 Hurricanes..... 424  
 Is Severe Weather Getting Worse?..... 427  
 Answers to the Comprehension Check Questions..... 429  
 Chapter Review ..... 431



<b>Chapter 15: Earth's Solar System</b> .....	<b>433</b>
	
Introduction.....	433
How Does Gravity Keep the Earth in Orbit Around the Sun? .....	433
Experiment 15.1: Twirling around .....	434
Our Solar System.....	436
But It Doesn't Look Like That to Us! .....	440
"Sampling" the Sun .....	445
Experiment 15.2: A CD Spectrometer.....	446
Focusing on the Sun.....	448
More Details About the Sun .....	453
Experiment 15.3: Hydrostatic Equilibrium.....	453
The Moon.....	456
Answers to the Comprehension Check Questions.....	461
Chapter Review .....	463
<b>Chapter 16: Earth's Solar System and the Universe</b> .....	<b>465</b>
	
Introduction.....	465
Measuring Distance with Parallax .....	465
Experiment 16.1: Parallax and Distance.....	465
Let's Get Some Perspective.....	468
Outside Our Solar System .....	470
Star Light, Star Bright.....	473
Experiment 16.2: Distance and Brightness.....	473
Distance Isn't the Only Factor.....	476
What Happens When Parallax Doesn't Work? .....	478
Classifying Stars .....	479
Differences Among the Stars.....	481
Stars Group Together.....	482
Our Sun Is a Special Star .....	483
It's a Dusty Universe .....	485
It's Getting Bigger .....	487
A Word About Distance and Time .....	488
Summing it All Up.....	490
Answers to the Comprehension Check Questions.....	491
Chapter Review .....	493
<b>Glossary</b> .....	<b>495</b>
<b>Photo and Illustration Credits</b> .....	<b>509</b>
<b>Appendix A</b> .....	<b>511</b>
<b>Appendix B</b> .....	<b>517</b>
<b>Index</b> .....	<b>525</b>