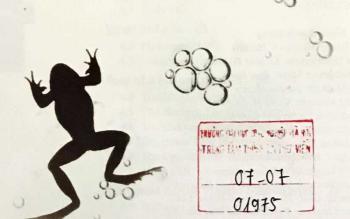
# Essentials of The Living World

0

George Johnson

# Essentials of The Living World



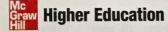
George B. Johnson

Washington University



GIFT OF THE ASIA FOUNDATION NOT FOR RE-SALE

QUÀ TẶNG CỦA QUỸ CHÂU Á KHÔNG ĐƯỢC BÁN LẠI



Boston Burr Ridge, IL Dubuque, IA New York San Francisco St. Louis
Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City
Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto



# ESSENTIALS OF THE LIVING WORLD, THIRD EDITION

Published by McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020. Copyright © 2010 by The McGraw-Hill Companies, Inc. All rights reserved. Printed in China. Previous editions © 2008 and 2006. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of The McGraw-Hill Companies, Inc., including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning.

Some ancillaries, including electronic and print components, may not be available to customers outside the United States.

This book is printed on acid-free paper.

Printed in China

567890 CTP/CTP 15432

ISBN 978-0-07-337793-3 MHID 0-07-337793-7

Publisher: Janice Roerig-Blong
Executive Editor: Michael S. Hackett
Director of Development: Kristine Tibbetts
Senior Development Editor: Rose Koos
Marketing Manager: Tamara Maury
Lead Project Manager: Sheila M. Frank
Senior Production Supervisor: Kara Kudronowicz
Senior Media Project Manager: Tammy Juran

Designer: Laurie B. Janssen Cover Designer: Elise Lansdon

(USE) Cover Image: ©PIER/Gettyimages

Senior Photo Research Coordinator: Lori Hancock Photo Research: Emily Tietz/Editorial Image, LLC Compositor: Electronic Publishing Services Inc., NYC

Typeface: 10.5/12 Times LT Std

Printer: China Translation & Printing Services Ltd

All credits appearing on page or at the end of the book are considered to be an extension of the copyright page.

# Library of Congress Cataloging-in-Publication Data

Johnson, George B. (George Brooks), 1942-

Essentials of the living world / George B. Johnson; illustration authors, William C. Ober and Claire W. Garrison. -- 3rd ed.

p. cm.

Includes index.

ISBN 978-0-07-337793-3 -- ISBN 0-07-337793-7 (hard copy : alk. paper) 1. Biology--

Textbooks. I. Title, OH308.2.J6199 2010

570--dc22

2009013753

# Contents

# Preface x

# Studying Biology 1

Learning 2

0.1 How to Study 2

0.2 Using Your Textbook 6

# Putting What You Learn to Work

0.3 Science Is a Way of Thinking 8

0.4 How to Read a Graph 10

# Part 1

# The Study of Life

# The Science of Biology 13 Biology and the Living World 14

- 1.1 The Diversity of Life 14
- 1.2 Properties of Life 15
- 1.3 The Organization of Life 16
- 1.4 Biological Themes 18

### The Scientific Process 20

- 1.5 Stages of a Scientific Investigation 20
- 1.6 Theory and Certainty 22

# Core Ideas of Biology 24

1.7 Four Theories Unify Biology as a Science 24

# Part 2

# **The Living Cell**

# The Chemistry of Life 31

Some Simple Chemistry 32

- 2.1 Atoms 32
- 2.2 Ions and Isotopes 34
- 2.3 Molecules 35

### Water: Cradle of Life 38

- 2.4 Hydrogen Bonds Give Water Unique Properties 38
- 2.5 Water Ionizes 40

# 3 Molecules of Life 45

# Forming Macromolecules 46

3.1 Polymers Are Built of Monomers 46

# Types of Macromolecules 48

- 3.2 Proteins 48
- 3.3 Nucleic Acids 52
- 3.4 Carbohydrates 54
- 3.5 Lipids 56

# 4 Cells 61

# The World of Cells 62

4.1 Cells 62

### Kinds of Cells 65

- 4.2 Prokaryotic Cells 65
- 4.3 Eukaryotic Cells 66

### Tour of a Eukaryotic Cell 68

- 4.4 The Plasma Membrane 68
- 4.5 The Nucleus: The Cell's Control Center 70
- 4.6 The Endomembrane System 72
- 4.7 Organelles That Harvest Energy 74
- 4.8 The Cytoskeleton: Interior Framework of the Cell 76

### Transport Across Plasma Membranes 78

- 4.9 Diffusion and Osmosis 78
- 4.10 Bulk Passage into and out of Cells 80
- 4.11 Selective Permeability 81

# 5 Energy and Life 87

### Cells and Energy 88

- 5.1 The Flow of Energy in Living Things 88
- 5.2 The Laws of Thermodynamics 89

### Cell Chemistry 90

5.3 Chemical Reactions 90

# Enzymes 91

- 5.4 How Enzymes Work 91
- 5.5 How Cells Regulate Enzymes 93

### How Cells Use Energy 94

5.6 ATP: The Energy Currency of the Cell 94

6	Photosynthesi	Energy	
	from the Sun	99	

# Photosynthesis 100

- 6.1 An Overview of Photosynthesis 100
- 6.2 How Plants Capture Energy from Sunlight 104
- 6.3 How Photosystems Convert Light to Chemical Energy 106
- 6.4 Building New Molecules 108

# Photorespiration 109

6.5 Photorespiration: Putting the Brakes on Photosynthesis 109

# 7 How Cells Harvest Energy from Food 113

# An Overview of Cellular Respiration 114

7.1 Where Is the Energy in Food? 114

# Cellular Respiration 116

- 7.2 Respiration Without Oxygen: Glycolysis 116
- 7.3 Respiration With Oxygen: The Krebs Cycle 117
- 7.4 Using the Electrons to Make ATP 120

# Harvesting Electrons Without Oxygen:

### Fermentation 123

7.5 Cells Can Metabolize Food Without Oxygen 123

# Other Sources of Energy 124

7.6 Glucose Is Not the Only Food Molecule 124

# Part 3

# The Continuity of Life

# 8 Mitosis 129

Cell Division 130

- 8.1 Prokaryotes Have a Simple Cell Cycle 130
- 8.2 Eukaryotes Have a Complex Cell Cycle 131
- 8.3 Chromosomes 132
- 8.4 Cell Division 134

### Cancer and the Cell Cycle 137

8.5 What Is Cancer? 137

# 9 Meiosis 143

### Meiosis 144

- 9.1 Discovery of Meiosis 144
- 9.2 The Sexual Life Cycle 145
- 9.3 The Stages of Meiosis 146

### Comparing Meiosis and Mitosis 150

9.4 How Meiosis Differs from Mitosis 150

# 10 Foundations of Genetics 155

### Mendel 156

- 10.1 Mendel and the Garden Pea 156
- 10.2 What Mendel Observed 158

# 10.3 Mendel Proposes a Theory 160

10.4 Mendel's Laws 163

# From Genotype to Phenotype 164

- 10.5 How Genes Influence Traits 164
- 10.6 Why Some Traits Don't Show Mendelian Inheritance 166

# Chromosomes and Heredity 170

- **10.7** Chromosomes Are the Vehicles of Mendelian Inheritance 170
- 10.8 Human Chromosomes 172

# Human Hereditary Disorders 174

- 10.9 The Role of Mutations in Human Heredity 174
- 10.10 Genetic Counseling and Therapy 178

# 11 DNA: The Genetic Material 183

# Genes Are Made of DNA 184

- 11.1 The Griffith Experiment 184
- 11.2 The Avery and Hershey-Chase Experiments 185
- 11.3 Discovering the Structure of DNA 186

# **DNA Replication** 188

11.4 How the DNA Molecule Copies Itself 188

# Altering the Genetic Message 192

11.5 Mutation 192

# 12 How Genes Work 199

### From Gene to Protein 200

- 12.1 Transcription 200
- 12.2 Translation 201
- 12.3 Gene Expression 204

## Regulating Gene Expression 206

- 12.4 Transcriptional Control in Prokaryotes 206
- 12.5 Transcriptional Control in Eukaryotes 208
- 12.6 RNA-Level Control 210

# 13 The New Biology 215

# Sequencing Entire Genomes 216

- 13.1 Genomics 216
- 13.2 The Human Genome 218

### Genetic Engineering 220

- 13.3 A Scientific Revolution 220
- 13.4 Genetic Engineering and Medicine 223
- 13.5 Genetic Engineering and Agriculture 227

### The Revolution in Cell Technology 230

- 13.6 Reproductive Cloning 230
- 13.7 Stem Cell Therapy 232
- 13.8 Therapeutic Cloning 234
- 13.9 Gene Therapy 236

# The Evolution and Diversity of Life

# 14 Evolution and Natural Selection 241

**Evolution 242** 

14.1 Darwin's Voyage on HMS Beagle 242

14.2 Darwin's Evidence 244

14.3 The Theory of Natural Selection 245

# Darwin's Finches: Evolution in Action 247

14.4 The Beaks of Darwin's Finches 247

14.5 How Natural Selection Produces Diversity 249

# The Theory of Evolution 250

14.6 The Evidence for Evolution 250

14.7 Evolution's Critics 254

### How Populations Evolve 258

14.8 Genetic Change in Populations: The Hardy-Weinberg Rule 258

14.9 Agents of Evolution 260

# Adaptation Within Populations 264

14.10 Sickle-Cell Disease 264

14.11 Peppered Moths and Industrial Melanism 266

14.12 Selection on Color in Guppies 268

# How Species Form 271

14.13 The Biological Species Concept 271

14.14 Isolating Mechanisms 272

# 15 Exploring Biological Diversity 277

The Classification of Organisms 278

15.1 The Invention of the Linnaean System 278

15.2 Species Names 279

15.3 Higher Categories 280

15.4 What Is a Species? 281

### Inferring Phylogeny 282

15.5 How to Build a Family Tree 282

### Kingdoms and Domains 286

15.6 The Kingdoms of Life 286

15.7 Domains: A Higher Level of Classification 288

# 16 Evolution of Microbial Life 293

Origin of Life 294

16.1 How Cells Arose 294

Prokaryotes 297

16.2 The Simplest Organisms 297

Viruses 299

16.3 Viruses Infect Organisms 299

### The Protists 302

16.4 General Biology of Protists 302

16.5 Kinds of Protists 304

### Fungi 306

16.6 A Fungus Is Not a Plant 306

16.7 Kinds of Fungi 308

# 17 Evolution of Plants 313

Plants 314

17.1 Adapting to Terrestrial Living 314

17.2 Plant Evolution 316

### Seedless Plants 318

17.3 Nonvascular Plants 318

17.4 The Evolution of Vascular Tissue 319

17.5 Seedless Vascular Plants 320

### The Advent of Seeds 322

17.6 Evolution of Seed Plants 322

17.7 Gymnosperms 324

### The Evolution of Flowers 326

17.8 Rise of the Angiosperms 326

# 18 Evolution of Animals 331

Introduction to the Animals 332

18.1 General Features of Animals 332

18.2 Five Transitions in Body Plan 334

18.3 The Animal Family Tree 336

# Evolution of the Animal Phyla 338

18.4 Sponges and Cnidarians: The Simplest Animals 338

18.5 The Advent of Bilateral Symmetry 340

18.6 Changes in the Body Cavity 342

18.7 Redesigning the Embryo 347

### The Parade of Vertebrates 350

18.8 Overview of Vertebrate Evolution 350

18.9 Fishes Dominate the Sea 352

18.10 Amphibians and Reptiles Invade the Land 354

18.11 Birds Master the Air 356

18.12 Mammals Adapt to Colder Times 357

# Part 5

# **The Living Environment**

# 19 Populations and Communities 361

Ecology 362

19.1 What is Ecology? 362

# Population Dynamics 364

19.2 Population Growth 364

19.3 The Influence of Population Density 366

19.4 Life History Adaptations 367

19.5 Population Demography 368

### How Competition Shapes Communities 369

19.6 Communities 369

19.7 The Niche and Competition 370



,	Species Interact in Many Ways 373		Saving Our Environment 440
	19.8 Coevolution and Symbiosis 373		22.6 Reducing Pollution 440
	19.9 Predation 375		22.7 Preserving Nonreplaceable Resources 441
	19.10 Plant and Animal Defenses 377		22.8 Curbing Population Growth 443
	19.11 Mimicry 378		Solving Environmental Problems 446
	Community Stability 381		22.9 Preserving Endangered Species 446
	19.12 Ecological Succession 381		22.10 Finding Cleaner Sources of Energy 449
	Serving Succession 581		22.11 Individuals Can Make the Difference 451
U	Ecosystems 385		ZZ-11 IIIGIVIAGUS CHI I-IAMA WA Z-1-I-I-I-I-I-I-I-I-I-I-I-I-I-I-I-I-I-I-
	The Energy in Ecosystems 386		The second secon
	20.1 Energy Flows Through Ecosystems 386	Par	t 6
	20.2 Ecological Pyramids 390	Anin	nal Life
	Materials Cycle Within Ecosystems 391		
	20.3 The Water Cycle 391	23	The Animal Body and How
	20.4 The Carbon Cycle 393		It Moves 455
	20.5 The Nitrogen and Phosphorus Cycles 394		
	How Weather Shapes Ecosystems 396		The Animal Body Plan 456
			<b>23.1</b> Organization of the Vertebrate Body 456
	20.6 The Sun and Atmospheric Circulation 396 20.7 Latitude and Elevation 397		Tissues of the Vertebrate Body 460
	20.8 Patterns of Circulation in the Ocean 398		23.2 Epithelium Is Protective Tissue 460
			23.3 Connective Tissue Carries Out Various Functions 462
	Major Kinds of Ecosystems 400		23.4 Muscle Tissue Lets the Body Move 465
	20.9 Ocean Ecosystems 400 20.10 Freshwater Ecosystems 402		23.5 Nerve Tissue Conducts Signals Rapidly 466
	20.11 Land Ecosystems 404		The Skeletal and Muscular Systems 467
	25 to Salamon and Control of the Salamon and the Salamon and Salam		23.6 Types of Skeletons 467
44	Behavior and the Environment 411		23.7 Muscles and How They Work 469
	Some Behavior Is Genetically Determined 412	24	Circulation 475
	21.1 Approaches to the Study of Behavior 412		Circulation 476
	21.2 Instinctive Behavioral Patterns 413		24.1 Open and Closed Circulatory Systems 476
	21.3 Genetic Effects on Behavior 414		24.2 Architecture of the Vertebrate Circulatory System 478
	Behavior Can Also Be Influenced by Learning 415		24.3 The Lymphatic System: Recovering Lost Fluid 481
	21.4 How Animals Learn 415		<b>24.4</b> Blood 482
	21.5 Instinct and Learning Interact to Determine		24.5 Human Circulatory System 484
	Behavior 416	25	Respiration 491
	21.6 Animal Cognition 417		Respiration 492
	Evolutionary Forces Shape Behavior 418		25.1 Types of Respiratory Systems 492
	21.7 Behavioral Ecology 418		25.2 Respiration in Aquatic Vertebrates 493
	21.8 A Cost-Benefit Analysis of Behavior 419		25.3 The Mammalian Respiratory System 494
	21.9 Migratory Behavior 420		25.4 How Respiration Works: Gas Exchange 496
	21.10 Reproductive Behaviors 422		Lung Cancer and Smoking 498
	Social Behavior 424		25.5 The Nature of Lung Cancer 498
	21.11 Communication Within Social Groups 424	-	
	21.12 Altruism and Group Living 426	20	The Path of Food Through the Animal
	21.13 Animal Societies 428 21.14 Human Social Behavior 429		Body 503
	21.14 Human Social Benavior 429		Food Energy and Essential Nutrients 504
2	How Humans Influence the Living		26.1 Food for Energy and Growth 504
	World 433		Digestion 506
	Global Change 434		
	22.1 Pollution 434		<b>26.2</b> Types of Digestive Systems 506 <b>26.3</b> Vertebrate Digestive Systems 507
	22.2 Acid Precipitation 435		26.4 The Mouth and Teeth 508
	22.3 Global Warming 436		26.5 The Esophagus and Stomach 510
	22.4 Loss of Biodiversity 437		26.6 The Small and Large Intestines 512
	22.5 The Ozone Hole 439		26.7 Accessory Digestive Organs 514

27 Maintaining the Internal Environment 519
Homeostasis 520
27.1 How the Animal Body Maintains Homeostasis 520
Osmoregulation 522
<ul><li>27.2 Regulating the Body's Water Content 522</li><li>27.3 The Mammalian Kidney 524</li></ul>
27.4 Eliminating Nitrogenous Wastes 527
28 How the Animal Body Defends Itself 531
Three Lines of Defense 532
28.1 Skin: The First Line of Defense 532
28.2 Cellular Counterattack: The Second Line of
Defense 534
28.3 Specific Immunity: The Third Line of Defense 536
The Immune Response 537
28.4 Initiating the Immune Response 537
28.5 T Cells: The Cellular Response 538
28.6 B Cells: The Humoral Response 539
28.7 Active Immunity Through Clonal Selection 541 28.8 Vaccination 543
28.9 Antibodies in Medical Diagnosis 544
Defeat of the Immune System 545
28.10 Overactive Immune System 545
28.11 AIDS: Immune System Collapse 546
29 The Nervous System 551
Neurons and How They Work 552
29.1 The Animal Nervous System 552
29.2 Neurons Generate Nerve Impulses 553
29.3 The Synapse 555
The Central Nervous System 558
29.4 How the Brain Works 558
29.5 The Spinal Cord 562
The Peripheral Nervous System 563
29.6 Voluntary and Autonomic Nervous Systems 563
The Sensory Nervous System 565
29.7 Sensory Perception 565
29.8 Sensing Gravity and Motion 567
29.9 Sensing Chemicals: Taste and Smell 568
29.10 Sensing Sounds: Hearing 569 29.11 Sensing Light: Vision 570
30 Chemical Signaling Within the Animal

Body 577

The Neuroendocrine System

30.2 How Hormones Target Cells 580

30.3 The Hypothalamus and the Pituitary 582

30.5 The Thyroid, Parathyroid, and Adrenal Glands 586

The Major Endocrine Glands 582

**30.1** Hormones 578

30.4 The Pancreas 584

# 31 Reproduction and Development 593

Modes of Reproduction 594

31.1 Asexual and Sexual Reproduction 594

# The Human Reproductive System 596

31.2 Males 596

31.3 Females 598

31.4 Hormones Coordinate the Reproductive Cycle 600

# The Course of Development 602

31.5 Embryonic Development 602

31.6 Fetal Development 604

# Birth Control and Sexually Transmitted Diseases 609

31.7 Contraception and Sexually Transmitted
Diseases 609

# Part 7

# **Plant Life**

# 32 Plant Form and Function 615

# Structure and Function of Plant

Tissues 616

32.1 Organization of a Vascular Plant 616

32.2 Plant Tissue Types 617

### The Plant Body 620

32.3 Roots 620

32.4 Stems 622

32.5 Leaves 624

### Plant Transport and Nutrition 626

32.6 Water Movement 626

32.7 Carbohydrate Transport 629

# 33 Plant Reproduction and Growth 633

### Flowering Plant Reproduction 634

33.1 Angiosperm Reproduction 634

33.2 Seeds 637

33.3 Fruit 638

33.4 Germination 639

### Regulating Plant Growth 640

33.5 Plant Hormones 640

33.6 Auxin 642

33.7 Other Plant Hormones 644

### Plant Responses to Environmental Stimuli 646

33.8 Photoperiodism and Dormancy 646

33.9 Tropisms 647

Appendix 651 Glossary 653 Credits 664 Index 667