

ninth edition

BIOPSYCHOLOGY



John P.J.
PINEL

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Biopsychology

Ninth Edition

John P.J. Pinel

University of British Columbia

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To Maggie, the love of my life.

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Brief Contents

Part One

What Is Biopsychology?

- 1 Biopsychology as a Neuroscience** 1
What Is Biopsychology, Anyway?

Part Two

Foundations of Biopsychology

- 2 Evolution, Genetics, and Experience** 20
Thinking about the Biology of Behavior
- 3 Anatomy of the Nervous System** 51
Systems, Structures, and Cells That Make Up Your Nervous System
- 4 Neural Conduction and Synaptic Transmission** 76
How Neurons Send and Receive Signals
- 5 The Research Methods of Biopsychology** 100
Understanding What Biopsychologists Do

Part Three

Sensory and Motor Systems

- 6 The Visual System** 129
How We See
- 7 Mechanisms of Perception: Hearing, Touch, Smell, Taste, and Attention** 161
How You Know the World
- 8 The Sensorimotor System** 188
How You Move

Part Four

Brain Plasticity

- 9 Development of the Nervous System** 213
From Fertilized Egg to You

- 10 Brain Damage and Neuroplasticity** 233
Can the Brain Recover from Damage?

- 11 Learning, Memory, and Amnesia** 259
How Your Brain Stores Information

Part Five

Biopsychology of Motivation

- 12 Hunger, Eating, and Health** 287
Why Do Many People Eat Too Much?
- 13 Hormones and Sex** 314
What's Wrong with the Mamawawa?
- 14 Sleep, Dreaming, and Circadian Rhythms** 341
How Much Do You Need to Sleep?
- 15 Drug Addiction and the Brain's Reward Circuits** 368
Chemicals That Harm with Pleasure

Part Six

Disorders of Cognition and Emotion

- 16 Lateralization, Language, and the Split Brain** 393
The Left Brain and the Right Brain
- 17 Biopsychology of Emotion, Stress, and Health** 423
Fear, the Dark Side of Emotion
- 18 Biopsychology of Psychiatric Disorders** 446
The Brain Unhinged

Contents

Preface	xvi
To the Student	xxiii
About the Author	xxiii

Part One

What Is Biopsychology?

1		Biopsychology as a Neuroscience	1
		What Is Biopsychology, Anyway?	
		<i>The Case of Jimmie G., the Man Frozen in Time</i>	3
		Four Major Themes of This Text	3
1.1		What Is Biopsychology?	4
1.2		What Is the Relation between Biopsychology and the Other Disciplines of Neuroscience?	4
1.3		What Types of Research Characterize the Biopsychological Approach?	4
		Human and Nonhuman Subjects	5
		Experiments and Nonexperiments	5
		Pure and Applied Research	7
1.4		What Are the Divisions of Biopsychology?	8
		Physiological Psychology	8
		Psychopharmacology	9
		Neuropsychology	9
		<i>The Case of Mr. R., the Brain-Damaged Student Who Switched to Architecture</i>	9
		Psychophysiology	9
		Cognitive Neuroscience	10
		Comparative Psychology	11
1.5		Converging Operations: How Do Biopsychologists Work Together?	12
1.6		Scientific Inference: How Do Biopsychologists Study the Unobservable Workings of the Brain?	13
1.7		Critical Thinking about Biopsychological Claims	14
		<i>Case 1: José and the Bull</i>	15

<i>Case 2: Becky, Moniz, and Prefrontal Lobotomy</i>	15
Themes Revisited	17
Think about It	18
Key Terms	18
Quick Review	18

Part Two

Foundations of Biopsychology

2		Evolution, Genetics, and Experience	20
		Thinking about the Biology of Behavior	
2.1		Thinking about the Biology of Behavior: From Dichotomies to Interactions	21
		Is It Physiological, or Is It Psychological?	21
		Is It Inherited, or Is It Learned?	22
		Problems with Thinking about the Biology of Behavior in Terms of Traditional Dichotomies	22
		<i>The Case of the Man Who Fell Out of Bed</i>	23
		<i>Case of the Chimps with Mirrors</i>	23
		<i>The Case of the Thinking Student</i>	24
2.2		Human Evolution	24
		Evolution and Behavior	26
		Course of Human Evolution	27
		Thinking about Human Evolution	30
		Evolution of the Human Brain	32
		Evolutionary Psychology: Understanding Mate Bonding	33
		Thinking about Evolutionary Psychology	34
2.3		Fundamental Genetics	35
		Mendelian Genetics	35
		Chromosomes: Reproduction and Recombination	36

Chromosomes: Structure and Replication	37		
Sex Chromosomes and Sex-Linked Traits	38		
Genetic Code and Gene Expression	38		
Mitochondrial DNA	40		
Human Genome Project	41		
Modern Genetics: Growth of Epigenetics	41		
2.4 Epigenetics of Behavioral Development: Interaction of Genetic Factors and Experience	43		
Selective Breeding of “Maze-Bright” and “Maze-Dull” Rats	43		
Phenylketonuria: A Single-Gene Metabolic Disorder	44		
Development of Birdsong	45		
2.5 Genetics of Human Psychological Differences	46		
Development of Individuals versus Development of Differences among Individuals	46		
Minnesota Study of Twins Reared Apart	47		
A Look into the Future: Two Kinds of Twin Studies	47		
Themes Revisited	49		
Think about It	49		
Key Terms	49		
Quick Review	50		
3			
		Anatomy of the Nervous System	51
		Systems, Structures, and Cells That Make Up Your Nervous System	
3.1 General Layout of the Nervous System	52		
Divisions of the Nervous System	52		
Meninges, Ventricles, and Cerebrospinal Fluid	53		
Blood–Brain Barrier	54		
3.2 Cells of the Nervous System	56		
Anatomy of Neurons	56		
Glia: The Forgotten Cells	56		
3.3 Neuroanatomical Techniques and Directions	61		
Neuroanatomical Techniques	61		
Directions in the Vertebrate Nervous System	62		
3.4 Spinal Cord	64		
3.5 Five Major Divisions of the Brain	64		
		3.6 Major Structures of the Brain	65
		Myelencephalon	65
		Metencephalon	65
		Mesencephalon	66
		Diencephalon	66
		Telencephalon	68
		Limbic System and the Basal Ganglia	70
		Themes Revisited	74
		Think about It	74
		Key Terms	75
		Quick Review	75
	4		Neural Conduction and Synaptic Transmission
			How Neurons Send and Receive Signals
		<i>The Lizard, a Case of Parkinson’s Disease</i>	77
	4.1	Resting Membrane Potential	78
		Recording the Membrane Potential	78
		Ionic Basis of the Resting Potential	78
	4.2	Generation and Conduction of Postsynaptic Potentials	79
	4.3	Integration of Postsynaptic Potentials and Generation of Action Potentials	79
	4.4	Conduction of Action Potentials	82
		Ionic Basis of Action Potentials	82
		Refractory Periods	83
		Axonal Conduction of Action Potentials	83
		Conduction in Myelinated Axons	83
		The Velocity of Axonal Conduction	84
		Conduction in Neurons without Axons	84
		The Hodgkin-Huxley Model in Perspective	85
	4.5	Synaptic Transmission: Chemical Transmission of Signals among Neurons	85
		Structure of Synapses	85
		Synthesis, Packaging, and Transport of Neurotransmitter Molecules	86
		Release of Neurotransmitter Molecules	87
		Activation of Receptors by Neurotransmitter Molecules	87
		Reuptake, Enzymatic Degradation, and Recycling	89
		Glia, Gap Junctions, and Synaptic Transmission	90

4.6	Neurotransmitters	92	5.4	Pharmacological Research Methods	113
	Amino Acid Neurotransmitters	92		Routes of Drug Administration	113
	Monoamine Neurotransmitters	92		Selective Chemical Lesions	113
	Acetylcholine	93		Measuring Chemical Activity of the Brain	113
	Unconventional Neurotransmitters	93		Locating Neurotransmitters and Receptors in the Brain	113
	Neuropeptides	94	5.5	Genetic Engineering	115
4.7	Pharmacology of Synaptic Transmission and Behavior	94		Gene Knockout Techniques	115
	How Drugs Influence Synaptic Transmission	95		Gene Replacement Techniques	115
	Behavioral Pharmacology: Three Influential Lines of Research	96		Fantastic Fluorescence and the Brainbow	115
	Themes Revisited	98	PART TWO	Behavioral Research Methods of Biopsychology	
	Think about It	98	5.6	Neuropsychological Testing	117
	Key Terms	99		Modern Approach to Neuropsychological Testing	117
	Quick Review	99		Tests of the Common Neuropsychological Test Battery	118
				Tests of Specific Neuropsychological Function	119
5		The Research Methods of Biopsychology		Frontal-Lobe Function	120
		Understanding What Biopsychologists Do			
			5.7	Behavioral Methods of Cognitive Neuroscience	121
	<i>The Ironic Case of Professor P.</i>	101			
PART ONE	Methods of Studying the Nervous System		5.8	Biopsychological Paradigms of Animal Behavior	122
5.1	Methods of Visualizing and Stimulating the Living Human Brain	102		Paradigms for Assessment of Species-Common Behaviors	122
	Contrast X-Rays	102		Traditional Conditioning Paradigms	123
	X-Ray Computed Tomography	102		Seminatural Animal Learning Paradigms	124
	Magnetic Resonance Imaging	103		Themes Revisited	126
	Positron Emission Tomography	103		Think about It	126
	Functional MRI	104		Key Terms	127
	Diffusion Tensor Imaging	105		Quick Review	128
	Transcranial Magnetic Stimulation	106			
5.2	Recording Human Psychophysiological Activity	106	Part Three		
	Scalp Electroencephalography	106		Sensory and Motor Systems	
	Magnetoencephalography	108	6		The Visual System
	Muscle Tension	108		How We See	129
	Eye Movement	108		<i>The Case of Mrs. Richards: Fortification Illusions and the Astronomer</i>	130
	Skin Conductance	109	6.1	Light Enters the Eye and Reaches the Retina	131
	Cardiovascular Activity	109		Pupil and the Lens	132
5.3	Invasive Physiological Research Methods	109		Eye Position and Binocular Disparity	133
	Stereotaxic Surgery	110			
	Lesion Methods	110			
	Electrical Stimulation	111			
	Invasive Electrophysiological Recording Methods	111			

6.2	Retina and Translation of Light into Neural Signals	133
	Cone and Rod Vision	135
	Spectral Sensitivity	137
	Eye Movement	138
	Visual Transduction: The Conversion of Light to Neural Signals	139
6.3	From Retina to Primary Visual Cortex	140
	Retinotopic Organization	141
	The M and P Channels	141
6.4	Seeing Edges	142
	Lateral Inhibition and Contrast Enhancement	142
	Receptive Fields of Visual Neurons	143
	Receptive Fields: Neurons of the Retina-Geniculate-Striate System	144
	Receptive Fields: Simple Cortical Cells	145
	Receptive Fields: Complex Cortical Cells	146
	Organization of Primary Visual Cortex	146
	<i>The Case of Mrs. Richards, Revisited</i>	147
	Changing Concept of Visual Receptive Fields: Contextual Influences in Visual Processing	147
6.5	Seeing Color	147
	Component and Opponent Processing	148
	Color Constancy and the Retinex Theory	149
6.6	Cortical Mechanisms of Vision and Conscious Awareness	151
	Damage to Primary Visual Cortex: Scotomas and Completion	152
	<i>The Case of the Physiological Psychologist Who Made Faces Disappear</i>	152
	Damage to Primary Visual Cortex: Scotomas, Blindsight, and Conscious Awareness	152
	<i>The Case of D.B., the Man Confused by His Own Blindsight</i>	153
	Functional Areas of Secondary and Association Visual Cortex	153
	Dorsal and Ventral Streams	154
	<i>The Case of D.F., the Woman Who Could Grasp Objects She Did Not Consciously See</i>	156
	<i>The Case of A.T., the Woman Who Could Not Accurately Grasp Unfamiliar Objects That She Saw</i>	156
	Prosopagnosia	156
	<i>R.P., a Typical Prosopagnosic</i>	157
	Akinetopsia	157
	<i>Two Cases of Drug-Induced Akinetopsia</i>	157
	Conclusion	158

Themes Revisited	158
Think about It	159
Key Terms	159
Quick Review	160

7



Mechanisms of Perception: Hearing, Touch, Smell, Taste, and Attention 161

How You Know the World

The Case of the Man Who Could See Only One Thing at a Time 162

7.1	Principles of Sensory System Organization	162
	Hierarchical Organization	163
	<i>The Case of the Man Who Mistook His Wife for a Hat</i>	163
	Functional Segregation	163
	Parallel Processing	163
	Summary Model of Sensory System Organization	164
7.2	The Auditory System	164
	The Ear	165
	From the Ear to the Primary Auditory Cortex	167
	Subcortical Mechanisms of Sound Localization	168
	Auditory Cortex	168
	Effects of Damage to the Auditory System	170
7.3	Somatosensory System: Touch and Pain	171
	Cutaneous Receptors	171
	Dermatomes	172
	Two Major Somatosensory Pathways	173
	Cortical Areas of Somatosensation	174
	Effects of Damage to the Primary Somatosensory Cortex	175
	Somatosensory System and Association Cortex	175
	<i>The Case of W.M., Who Reduced His Scotoma with His Hand</i>	175
	Somatosensory Agnosias	176
	<i>The Case of Aunt Betty, Who Lost Half of Her Body</i>	176
	Rubber-Hand Illusion	177
	Perception of Pain	177
	<i>The Case of Miss C., the Woman Who Felt No Pain</i>	177
	Neuropathic Pain	179

7.4	Chemical Senses: Smell and Taste	179		
	Olfactory System	180		
	Gustatory System	181		
	Brain Damage and the Chemical Senses	182		
	Broad Tuning vs. Narrow Tuning	182		
7.5	Selective Attention	184		
	Change Blindness	184		
	Neural Mechanisms of Attention	185		
	Simultanagnosia	186		
	Themes Revisited	186		
	Think about It	186		
	Key Terms	187		
	Quick Review	187		
8			The Sensorimotor System	188
			How You Move	
			<i>The Case of Rhonda, the Dexterous Cashier</i>	189
8.1	Three Principles of Sensorimotor Function	190		
	The Sensorimotor System Is Hierarchically Organized	190		
	Motor Output Is Guided by Sensory Input	190		
	<i>The Case of G.O., the Man with Too Little Feedback</i>	190		
	Learning Changes the Nature and Locus of Sensorimotor Control	191		
	General Model of Sensorimotor System Function	191		
8.2	Sensorimotor Association Cortex	191		
	Posterior Parietal Association Cortex	191		
	<i>The Case of Mrs. S., the Woman Who Turned in Circles</i>	192		
	Dorsolateral Prefrontal Association Cortex	193		
8.3	Secondary Motor Cortex	194		
	Identifying the Areas of Secondary Motor Cortex	194		
	Mirror Neurons	195		
8.4	Primary Motor Cortex	196		
	<i>Belle: The Monkey That Controlled a Robot with Her Mind</i>	197		
8.5	Cerebellum and Basal Ganglia	198		
	Cerebellum	198		
	Basal Ganglia	198		
8.6	Descending Motor Pathways	199		
	Dorsolateral Corticospinal Tract and Dorsolateral Corticorubrospinal Tract	199		
	Ventromedial Corticospinal Tract and Ventromedial Cortico-Brainstem-Spinal Tract	199		
	Comparison of the Two Dorsolateral Motor Pathways and the Two Ventromedial Motor Pathways	200		
8.7	Sensorimotor Spinal Circuits	202		
	Muscles	202		
	Receptor Organs of Tendons and Muscles	203		
	Stretch Reflex	204		
	Withdrawal Reflex	205		
	Reciprocal Innervation	205		
	Recurrent Collateral Inhibition	205		
	Walking: A Complex Sensorimotor Reflex	206		
8.8	Central Sensorimotor Programs and Learning	207		
	Central Sensorimotor Programs Are Capable of Motor Equivalence	208		
	Sensory Information That Controls Central Sensorimotor Programs Is Not Necessarily Conscious	208		
	Central Sensorimotor Programs Can Develop without Practice	209		
	Practice Can Create Central Sensorimotor Programs	209		
	Functional Brain Imaging of Sensorimotor Learning	209		
	<i>The Case of Rhonda, Revisited</i>	211		
	Themes Revisited	211		
	Think about It	211		
	Key Terms	211		
	Quick Review	212		
	Part Four			
	Brain Plasticity			
9			Development of the Nervous System	213
			From Fertilized Egg to You	
			<i>The Case of Genie</i>	214
9.1	Phases of Neurodevelopment	214		
	Induction of the Neural Plate	215		
	Neural Proliferation	215		
	Migration and Aggregation	216		
	Axon Growth and Synapse Formation	217		
	Neuron Death and Synapse Rearrangement	220		

9.2 Postnatal Cerebral Development in Human Infants 221
 Postnatal Growth of the Human Brain 221
 Development of the Prefrontal Cortex 222

9.3 Effects of Experience on Postnatal Development of Neural Circuits 223
 Early Studies of Experience and Neurodevelopment: Deprivation and Enrichment 223
 Competitive Nature of Experience and Neurodevelopment: Ocular Dominance Columns 223
 Effects of Experience on Topographic Sensory Cortex Maps 224
 Experience Fine-Tunes Neurodevelopment 224

9.4 Neuroplasticity in Adults 225
 Neurogenesis in Adult Mammals 225
 Effects of Experience on the Reorganization of the Adult Cortex 226

9.5 Disorders of Neurodevelopment: Autism and Williams Syndrome 227
 Autism 227
The Case of Alex: Are You Ready to Rock? 227
Cases of Amazing Savant Abilities 228
 Williams Syndrome 229
The Case of Anne Louise McGarrah: Uneven Abilities 229
 Epilogue 230
Themes Revisited 231
Think about It 231
Key Terms 231
Quick Review 231

10  **Brain Damage and Neuroplasticity** 233
 Can the Brain Recover from Damage?
The Ironic Case of Professor P. 234

10.1 Causes of Brain Damage 235
 Brain Tumors 235
 Cerebrovascular Disorders: Strokes 235
 Closed-Head Injuries 237
The Case of Jerry Quarry, Ex-Boxer 238
 Infections of the Brain 238
 Neurotoxins 239
 Genetic Factors 239
 Programmed Cell Death 239

10.2 Neurological Diseases 240
 Epilepsy 240
The Subtlety of Complex Partial Seizures: Two Cases 241
 Parkinson's Disease 242
 Huntington's Disease 243
 Multiple Sclerosis 243
 Alzheimer's Disease 244

10.3 Animal Models of Human Neurological Diseases 246
 Kindling Model of Epilepsy 246
 Transgenic Mouse Model of Alzheimer's Disease 246
 MPTP Model of Parkinson's Disease 247
The Cases of the Frozen Addicts 247

10.4 Responses to Nervous System Damage: Degeneration, Regeneration, Reorganization, and Recovery 247
 Neural Degeneration 247
 Neural Regeneration 248
 Neural Reorganization 250
 Recovery of Function after CNS Damage 251

10.5 Neuroplasticity and the Treatment of CNS Damage 252
 Neurotransplantation as a Treatment for CNS Damage: Early Research 253
The Case of Roberto Garcia d'Orta: The Lizard Gets an Autotransplant 253
 Modern Research on Neurotransplantation 254
 Promoting Recovery from CNS Damage by Rehabilitative Training 254
The Cases of Tom and Philip: Phantom Limbs and Ramachandran 256
The Ironic Case of Professor P.: Recovery 256
Themes Revisited 257
Think about It 257
Key Terms 258
Quick Review 258

11  **Learning, Memory, and Amnesia** 259
 How Your Brain Stores Information

11.1 Amnesic Effects of Bilateral Medial Temporal Lobectomy 260
The Case of H.M., the Man Who Changed the Study of Memory 260
 Formal Assessment of H.M.'s Anterograde Amnesia: Discovery of Unconscious Memories 261

Three Major Scientific Contributions of H.M.'s Case	262
Medial Temporal Lobe Amnesia	263
Semantic and Episodic Memories	264
<i>The Case of K.C., the Man Who Can't Time Travel</i>	264
<i>The Case of the Clever Neuropsychologist: Spotting Episodic Memory Deficits</i>	265
Effects of Global Cerebral Ischemia on the Hippocampus and Memory	265
<i>The Case of R.B., Product of a Bungled Operation</i>	265
11.2 Amnesia of Korsakoff's Syndrome	266
<i>The Up-Your-Nose Case of N.A.</i>	267
11.3 Amnesia of Alzheimer's Disease	267
11.4 Amnesia after Concussion: Evidence for Consolidation	267
Posttraumatic Amnesia	267
Gradients of Retrograde Amnesia and Memory Consolidation	268
Hippocampus and Consolidation	269
Reconsolidation	269
11.5 Evolving Perspective of the Role of the Hippocampus in Memory	270
Monkey Model of Object-Recognition Amnesia: The Delayed Nonmatching-to Sample Test	270
Delayed Nonmatching-to-Sample Test for Rats	271
Neuroanatomical Basis of the Object-Recognition Deficits Resulting from Medial Temporal Lobectomy	272
11.6 Neurons of the Medial Temporal Lobes and Memory	273
Two Tests of Rodent Spatial Memory	274
Hippocampal and Entorhinal Grid Cells	275
Comparative Studies of the Hippocampus and Spatial Memory	276
Jennifer Aniston Neurons: Concept Cells	277
11.7 Where Are Memories Stored?	277
Inferotemporal Cortex	278
Amygdala	278
Prefrontal Cortex	279
<i>The Case of the Cook Who Couldn't</i>	279
Cerebellum and Striatum	279
11.8 Synaptic Mechanisms of Learning and Memory	280
Long-Term Potentiation	280
Induction of LTP: Learning	281

Maintenance and Expression of LTP: Storage and Recall	282
Variability of LTP	283

11.9 Conclusion: Biopsychology of Memory and You	284
Infantile Amnesia	284
Smart Drugs: Do They Work?	284
Posttraumatic Amnesia and Episodic Memory	285
<i>The Case of R.M., the Biopsychologist Who Remembered H.M.</i>	285
Themes Revisited	285
Think about It	285
Key Terms	286
Quick Review	286

Part Five

Biopsychology of Motivation

12		Hunger, Eating, and Health	287
		Why Do Many People Eat Too Much?	
		<i>The Case of the Man Who Forgot Not to Eat</i>	289

12.1 Digestion, Energy Storage, and Energy Utilization	289
Digestion	289
Energy Storage in the Body	289
Three Phases of Energy Metabolism	289
12.2 Theories of Hunger and Eating: Set Points versus Positive Incentives	291
Set-Point Assumption	291
Glucostatic and Lipostatic Set-Point Theories of Hunger and Eating	291
Problems with Set-Point Theories of Hunger and Eating	293
Positive-Incentive Perspective	293
12.3 Factors That Determine What, When, and How Much We Eat	294
Factors That Determine What We Eat	294
Factors That Influence When We Eat	294
Factors That Influence How Much We Eat	295
12.4 Physiological Research on Hunger and Satiety	297
Role of Blood Glucose Levels in Hunger and Satiety	297

Myth of Hypothalamic Hunger and Satiety Centers	297	Classes of Hormones	316
Role of the Gastrointestinal Tract in Satiety	299	Sex Steroids	317
Hunger and Satiety Peptides	299	Hormones of the Pituitary	317
Serotonin and Satiety	301	Female Gonadal Hormone Levels Are Cyclic; Male Gonadal Hormone Levels Are Steady	318
Prader-Willi Syndrome: Patients with Insatiable Hunger	301	Neural Control of the Pituitary	318
<i>Prader-Willi Syndrome: The Case of Miss A.</i>	301	Control of the Anterior and Posterior Pituitary by the Hypothalamus	318
12.5 Body Weight Regulation: Set Points versus Settling Points	301	Discovery of Hypothalamic Releasing Hormones	319
Set-Point Assumptions about Body Weight and Eating	302	Regulation of Hormone Levels	320
Set Points and Settling Points in Weight Control	303	Pulsatile Hormone Release	320
12.6 Human Obesity: Causes, Mechanisms, and Treatments	305	Summary Model of Gonadal Endocrine Regulation	320
Who Needs to Be Concerned about Obesity?	306	13.2 Hormones and Sexual Development of the Body	320
Why Is There an Epidemic of Obesity?	306	Puberty: Hormones and Development of Secondary Sex Characteristics	323
Why Do Some People Become Obese While Others Do Not?	306	13.3 Hormones and Sexual Development of Brain and Behavior	324
Why Are Weight-Loss Programs Often Ineffective?	307	Sex Differences in the Brain	324
Leptin and the Regulation of Body Fat	307	Development of Sex Differences in Behavior	326
<i>The Case of the Child with No Leptin</i>	309	13.4 Three Cases of Exceptional Human Sexual Development	328
Treatment of Obesity	309	<i>The Case of Anne S., the Woman Who Wasn't</i>	328
12.7 Anorexia and Bulimia Nervosa	309	<i>The Case of the Little Girl Who Grew into a Boy</i>	328
Relation between Anorexia and Bulimia	310	<i>The Case of the Twin Who Lost His Penis</i>	329
Anorexia and Positive Incentives	311	Do the Exceptional Cases Prove the Rule?	330
Anorexia Nervosa: A Hypothesis	312	13.5 Effects of Gonadal Hormones on Adults	330
<i>The Case of the Anorexic Student</i>	312	Male Reproduction-Related Behavior and Testosterone	330
Themes Revisited	312	<i>The Case of the Man Who Lost and Regained His Manhood</i>	331
Think about It	312	Female Reproduction-Related Behavior and Gonadal Hormones	331
Key Terms	313	Anabolic Steroid Abuse	333
Quick Review	313	13.6 Brain Mechanisms of Sexual Behavior	334
13		Cortex and Sexual Activity	334
		Hypothalamus and Sexual Activity	334
Hormones and Sex	314	Amygdala and Sexual Activity	335
What's Wrong with the Mamawawa?		Ventral Striatum and Sexual Activity	336
Men-Are-Men-and-Women-Are-Women Assumption	315	13.7 Sexual Orientation and Sexual Identity	336
Developmental and Activational Effects of Sex Hormones	315	Sexual Orientation and Genes	336
13.1 The Neuroendocrine System	315	Sexual Orientation and Early Hormones	336
Glands	316		
Gonads	316		

What Triggers the Development of Sexual Attraction? 337

Is There a Difference in the Brains of Homosexuals and Heterosexuals? 337

Sexual Identity 337

Independence of Sexual Orientation and Sexual Identity 338

Themes Revisited 339

Think about It 339

Key Terms 339

Quick Review 340

14



Sleep, Dreaming, and Circadian Rhythms 341

How Much Do You Need to Sleep?

The Case of the Woman Who Wouldn't Sleep 342

14.1 Stages of Sleep 343

Three Standard Psychophysiological Measures of Sleep 343

Four Stages of Sleep EEG 343

REM Sleep and Dreaming 344

Testing Common Beliefs about Dreaming 345

The Interpretation of Dreams 345

14.2 Why Do We Sleep, and Why Do We Sleep When We Do? 346

Comparative Analysis of Sleep 346

14.3 Effects of Sleep Deprivation 347

Interpretation of the Effects of Sleep Deprivation: The Stress Problem 347

Predictions of Recuperation Theries about Sleep Deprivation 348

Two Classic Sleep-Deprivation Case Studies 348

The Case of the Sleep-Deprived Students 348

The Case of Randy Gardner 348

Experimental Studies of Sleep Deprivation in Humans 348

Sleep-Deprivation Studies with Laboratory Animals 349

REM-Sleep Deprivation 350

Sleep Deprivation Increases the Efficiency of Sleep 351

14.4 Circadian Sleep Cycles 352

Free-Running Circadian Sleep–Wake Cycles 352

Jet Lag and Shift Work 353

A Circadian Clock in the Suprachiasmatic Nuclei 354

Neural Mechanisms of Entrainment 354

Genetics of Circadian Rhythms 354

The Case of Constantin von Economo, the Insightful Neurologist 355

14.5 Four Areas of the Brain Involved in Sleep 355

Two Areas of the Hypothalamus Involved in Sleep 355

Reticular Formation and Sleep 356

Reticular REM-Sleep Nuclei 357

14.6 Drugs That Affect Sleep 358

Hypnotic Drugs 358

Antihypnotic Drugs 359

Melatonin 359

14.7 Sleep Disorders 360

Insomnia 360

Mr. B., the Case of Iatrogenic Insomnia 360

Hypersomnia 361

REM-Sleep–Related Disorders 362

The Case of the Sleeper Who Ran Over Tackle 362

14.8 Effects of Long-Term Sleep Reduction 362

Differences Between Short and Long Sleepers 362

Long-Term Reduction of Nightly Sleep 363

Long-Term Sleep Reduction by Napping 363

Effects of Shorter Sleep Times on Health 364

Long-Term Sleep Reduction: A Personal Case Study 364

The Case of the Author Who Reduced His Sleep 365

Conclusion 365

Themes Revisited 366

Think about It 366

Key Terms 366

Quick Review 367

15



Drug Addiction and the Brain's Reward Circuits 368

Chemicals That Harm with Pleasure

The Case of the Drugged High School Teachers 369

15.1 Basic Principles of Drug Action 369

Drug Administration and Absorption 369

Drug Penetration of the Central Nervous System 370

Mechanisms of Drug Action 370

Drug Metabolism and Elimination	370	16.1 Cerebral Lateralization of Function: Introduction	395
Drug Tolerance	370	Discovery of the Specific Contributions of Left-Hemisphere Damage to Aphasia and Apraxia	395
Drug Withdrawal Effects and Physical Dependence	371	Tests of Cerebral Lateralization	395
Drug Addiction: What Is It?	371	Discovery of the Relation between Speech Laterality and Handedness	396
15.2 Role of Learning in Drug Tolerance	372	Sex Differences in Brain Lateralization	396
Contingent Drug Tolerance	372	16.2 The Split Brain	397
Conditioned Drug Tolerance	372	Groundbreaking Experiment of Myers and Sperry	397
Thinking about Drug Conditioning	374	Commissurotomy in Human Epileptics	399
15.3 Five Commonly Abused Drugs	374	Evidence That the Hemispheres of Split-Brain Patients Can Function Independently	400
Tobacco	374	Cross-Cuing	400
Alcohol	375	Doing Two Things at Once	401
Marijuana	377	The Z Lens	401
Cocaine and Other Stimulants	379	Dual Mental Functioning and Conflict in Split-Brain Patients	402
The Opiates: Heroin and Morphine	380	<i>The Case of Peter, the Split-Brain Patient Tormented by Conflict</i>	402
“Interpreting Studies of the Health Hazards of Drugs”	382	Independence of Split Hemispheres: Current Perspective	403
Comparison of the Hazards of Tobacco, Alcohol, Marijuana, Cocaine, and Heroin	382	16.3 Differences between the Left and Right Hemispheres	403
15.4 Early Biopsychological Research on Addictions	384	Examples of Cerebral Lateralization of Function	404
Physical-Dependence and Positive-Incentive Perspectives of Addiction	384	What Is Lateralized—Broad Clusters of Abilities or Individual Cognitive Processes?	405
Intracranial Self-Stimulation and the Mesotelencephalic Dopamine System	384	Anatomical Asymmetries of the Brain	406
Early Evidence of the Involvement of Dopamine in Drug Addiction	385	16.4 Evolutionary Perspective of Cerebral Lateralization and Language	407
Nucleus Accumbens and Drug Addiction	386	Theories of the Evolution of Cerebral Lateralization	407
15.5 Current Approaches to the Mechanisms of Addiction	387	<i>The Case of W.L., the Man Who Experienced Aphasia for Sign Language</i>	408
Initial Drug Taking	387	When Did Cerebral Lateralization Evolve?	408
Habitual Drug Taking	388	What Are the Survival Advantages of Cerebral Lateralization?	408
Drug Craving and Addiction Relapse	389	Evolution of Human Language	409
Current Concerns about the Drug Self-Administration Paradigm	390	16.5 Cortical Localization of Language: Wernicke-Geschwind Model	410
15.6 A Noteworthy Case of Addiction	390	Historical Antecedents of the Wernicke-Geschwind Model	410
<i>The Case of Sigmund Freud</i>	390	The Wernicke-Geschwind Model	411
Themes Revisited	391	16.6 Wernicke-Geschwind Model: The Evidence	412
Think about It	391	Effects of Cortical Damage on Language Abilities	413
Key Terms	392		
Quick Review	392		
Part Six			
Disorders of Cognition and Emotion			
16		Lateralization, Language, and the Split Brain	393
		The Left Brain and the Right Brain	

Effects of Electrical Stimulation to the Cortex on Language Abilities 414
 Current Status of the Wernicke-Geschwind Model 416

16.7 Cognitive Neuroscience of Language 416

Functional Brain Imaging and the Localization of Language 417

16.8 Cognitive Neuroscience of Dyslexia 418

Developmental Dyslexia: Causes and Neural Mechanisms 418
 Developmental Dyslexia and Culture 419
 Cognitive Neuroscience of Deep and Surface Dyslexia 419
The Case of N.I., the Woman Who Read with Her Right Hemisphere 420

Themes Revisited 420
Think about It 421
Key Terms 421
Quick Review 421

17  **Biopsychology of Emotion, Stress, and Health 423**
 Fear, the Dark Side of Emotion

17.1 Biopsychology of Emotion: Introduction 424

Early Landmarks in the Biopsychological Investigation of Emotion 424
The Mind-Blowing Case of Phineas Gage 424
A Human Case of Kluver-Bucy Syndrome 427
 Emotions and the Autonomic Nervous System 428
 Emotions and Facial Expression 428

17.2 Fear, Defense, and Aggression 431

Types of Aggressive and Defensive Behaviors 431
 Aggression and Testosterone 432

17.3 Neural Mechanisms of Fear Conditioning 433

Amygdala and Fear Conditioning 433
 Contextual Fear Conditioning and the Hippocampus 434
 Amygdala Complex and Fear Conditioning 434

17.4 Brain Mechanisms of Human Emotion 435

Cognitive Neuroscience of Emotion 435
 Amygdala and Human Emotion 436
The Case of S.P., the Woman Who Couldn't Perceive Fear 436
 Medial Prefrontal Lobes and Human Emotion 436

Lateralization of Emotion 437
 Neural Mechanisms of Human Emotion: Current Perspectives 438

17.5 Stress and Health 438

The Stress Response 438
 Animal Models of Stress 439
 Psychosomatic Disorders: The Case of Gastric Ulcers 439
 Psychoneuroimmunology: Stress, the Immune System, and the Brain 440
 Early Experience of Stress 442
 Stress and the Hippocampus 443
 Conclusion 443
The Case of Charles Whitman, the Texas Tower Sniper 443

Themes Revisited 444
Think about It 444
Key Terms 445
Quick Review 445

18  **Biopsychology of Psychiatric Disorders 446**
 The Brain Unhinged

18.1 Schizophrenia 447

The Case of Lena, the Catatonic Schizophrenic 447
 What Is Schizophrenia? 448
 Causal Factors in Schizophrenia 448
 Discovery of the First Antischizophrenic Drugs 449
 Dopamine Theory of Schizophrenia 449
 Schizophrenia: Current Research and Treatment 451
 Conclusions 453

18.2 Affective Disorders: Depression and Mania 453

The Case of P.S., the Weeping Widow 454
 Major Categories of Affective Disorders 454
 Causal Factors in Affective Disorders 455
 Discovery of Antidepressant Drugs 455
 Brain Pathology and Affective Disorders 457
 Theories of Depression 458
 Treatment of Depression with Brain Stimulation 458
 Conclusion 459

18.3 Anxiety Disorders 459

The Case of M.R., the Woman Who Was Afraid to Go Out 460

Five Classes of Anxiety Disorders	460	Effectiveness of Clinical Trials	467
Etiology of Anxiety Disorders	460	Conclusion	468
Pharmacological Treatment of Anxiety Disorders	461	<i>The Case of S.B., the Biopsychology Student Who Took Control</i>	468
Animal Models of Anxiety	461	Themes Revisited	469
Neural Bases of Anxiety Disorders	462	Think about It	469
18.4 Tourette Syndrome	462	Key Terms	470
<i>The Case of R.G.—Barking Mad</i>	462	Quick Review	470
What Is Tourette Syndrome?	463		
Neuropathology of Tourette Syndrome	463	Epilogue	471
Treatment of Tourette Syndrome	464	Appendixes	472
<i>The Case of P.H., the Neuroscientist with Tourette Syndrome</i>	464	Glossary	478
18.5 Clinical Trials: Development of New Psychotherapeutic Drugs	465	References	498
Clinical Trials: The Three Phases	465	Credits	533
Controversial Aspects of Clinical Trials	466	Name Index	535
		Subject Index	543

Preface

Welcome to the Ninth Edition of *Biopsychology*! This edition builds on the strengths of its predecessors, but it also takes important new steps: In addition to covering many new cutting-edge research topics, it sharpens its focus on the human element of biopsychology and on promoting student thinking. Most importantly, this is the first edition of *Biopsychology* to focus on epigenetics. It introduces this new field, summarizes current knowledge, and most importantly stresses the relevance of epigenetic concepts to issues of human brain and behavior.

The Ninth Edition of *Biopsychology* is a clear, engaging introduction to current biopsychological theory and research. It is intended for use as a primary text in one- or two-semester courses in biopsychology—variously titled Biopsychology, Physiological Psychology, Brain and Behavior, Psychobiology, Behavioral Neuroscience, or Behavioral Neurobiology.

The defining feature of *Biopsychology* is its unique combination of biopsychological science and personal, reader-oriented discourse. It is a textbook that is “un-textbooklike.” Instead of presenting the concepts of biopsychology in the usual textbook fashion, it addresses students directly and interweaves the fundamentals of the field with clinical case studies, social issues, personal implications, useful metaphors, and memorable anecdotes.

Key Features Maintained in the Ninth Edition

The following are features that have characterized recent editions of *Biopsychology* and have been maintained or expanded in this edition.

Emphasis on Broad Themes The emphasis of *Biopsychology* is “the big picture.” Four broad themes are highlighted throughout the text by distinctive tabs: (1) thinking creatively, (2) clinical implications, (3) evolutionary perspective, and (4) neuroplasticity. A Themes Revisited section at the end of each chapter briefly summarizes how each theme was developed in that chapter. The four major themes provide excellent topics for essay assignments and exam questions.



Effective Use of Case Studies *Biopsychology* features many carefully selected case studies, which are highlighted in the text. These provocative cases stimulate interest, promote retention, and allow students to learn how biopsychological principles apply to the diagnosis and treatment of brain disorders.

Remarkable Illustrations The illustrations in *Biopsychology* are special. Each one was conceptualized and meticulously designed to clarify and reinforce the text by a uniquely qualified scientist–artist team: Pinel and his artist/designer wife, Maggie Edwards.

Focus on Behavior In some biopsychological textbooks, the coverage of neurophysiology, neurochemistry, and neuroanatomy subverts the coverage of behavioral research. *Biopsychology* gives top billing to behavior: It stresses that neuroscience is a team effort and that the unique contribution made by biopsychologists to this effort is their behavioral expertise.

Emphasis on the Scientific Method *Biopsychology* emphasizes the scientific method. It portrays the scientific method as a means of answering questions that is as applicable in daily life as in the laboratory. And *Biopsychology* emphasizes that being a scientist is fun.

Discussion of Personal and Social Implications Several chapters of *Biopsychology*—particularly those on eating, sleeping, sex, and drug addiction—carry strong personal and social messages. In these chapters, students are encouraged to consider the relevance of biopsychological research to their lives outside the classroom.

Engaging, Inspiring Voice Arguably the strongest pedagogical feature of *Biopsychology* is its personal tone. Pinel addresses students directly and talks to them with warmth, enthusiasm, and good humor about recent advances in biopsychological science. Many students report being engaged and inspired by this approach.

Additions to the Ninth Edition

Four new or expanded features appear in the Ninth Edition of *Biopsychology*.

NEW! Chapter-Opening Study Objectives Each chapter begins with a list of study objectives designed to direct students’ reading and studying.

NEW! Blog-On! *Biopsychology* now comes with an accompanying author-run blog and website (www.biopsyc.com). The blog contains discussions of exciting new biopsychological research and theoretical issues not covered in the text. In addition to the blog, the website also contains a wide variety of links and materials to help students in their studying.

NEW! Even More MyPsychLab (www.mypsychlab.com) MyPsychLab is an online study resource that offers a wealth of animations and practice tests as well as additional study and research tools. This edition adds even more exciting content to MyPsychLab for students.

NEW! More Illustrations and Brain Images Building on *Biopsychology's* strong art package, a number of new illustrations and brain images have been added. These have been carefully selected, designed, and positioned to support interest, clarity, and memorability.

New Coverage in the Ninth Edition

Biopsychology remains one of the most rapidly progressing scientific fields. Like previous editions, the Ninth Edition of *Biopsychology* has meticulously incorporated recent developments in the field—it contains more than 750 citations of articles or books that did not appear in the preceding edition. These recent developments have dictated changes to many parts of the text. The following list presents some of the content changes to this edition, organized by chapter.

Chapter 1: Biopsychology as a Neuroscience

- 3 new citations

Chapter 2: Evolution, Genetics, and Experience

- New section on epigenetics
- A figure illustrating and emphasizing epigenetic mechanisms
- Summary of important recent discoveries of hominin fossils
- New summary of the human genome project, emphasizing the small number of human genes
- Clear statement of the failure to find major links between genes and neurological disorders
- Updated coverage of heritability estimates
- 50 new citations

Chapter 3: Anatomy of the Nervous System

- Updated coverage of glial function
- 15 new citations

Chapter 4: Neural Conduction and Synaptic Transmission

- Simplified explanation of the resting potential
- Recent discovery that action potentials originate in the axon initial segment
- Role of glia in synaptic transmission
- Additional coverage of gap junctions
- 22 new citations

Chapter 5: The Research Methods of Biopsychology

- Use of PET to determine the distribution in the brain of particular molecules
- Introduction of diffusion tensor imaging with a new illustration
- Simplified coverage of reversible brain lesions
- Updated coverage of gene replacement
- 19 new citations

Chapter 6: The Visual System

- Simplified coverage of the organization of neurons in the primary visual cortex
- Explanation of the role of context on the responses of visual neurons
- Improved discussion of dorsal and ventral streams
- Comparison of MT and fusiform face area
- 24 new citations

Chapter 7: Mechanisms of Perception: Hearing, Touch, Smell, Taste, and Attention

- Updated coverage of primary auditory cortex
- Statement of the role of cutaneous receptors in particular sensations
- More comparisons of auditory and visual cortex
- Discussion of rubber-hand illusion and bimodal neurons
- Improved coverage of the olfactory system
- Updated and clearer coverage of the gustatory system
- Updated coverage of attention
- 62 new citations

Chapter 8: The Sensorimotor System

- Shorter but clearer coverage of contralateral neglect
- Recent research on mirror neurons
- Discussion of evidence for mirror neurons in humans
- Updated discussion of functions of the cerebellum
- Simplified discussion of functional brain imaging studies of sensorimotor learning
- 37 new citations

Chapter 9: Development of the Nervous System

- Updated description of increased cell fate specification and related stem cell terminology

- New description of interaction of glial and neural development
- Discovery that radial glial cells develop into neurons
- Overall editing designed to shorten and simplify
- 59 new citations

Chapter 10: Brain Damage and Neuroplasticity

- Definition of gliomas
- Improved coverage of strokes
- Updated discussion of genetic factors and neurological disorders
- Introduction of the term *absence seizures*
- More concise coverage of the etiology of multiple sclerosis
- Concise summary of genes linked to Alzheimer's disease
- Role of microbleeds in Alzheimer's disease
- Importance of early diagnosis in the treatment of Alzheimer's disease
- Improved coverage of MPTP model
- Revised coverage of recovery of function
- Neurotransplantation is revised, updated, and out in a historical perspective
- 95 new citations

Chapter 11: Learning, Memory, and Amnesia

- Tightened up coverage of HM
- New discussion of transient global amnesia
- Tightened up and updated discussion of consolidation
- New section on evolving perspectives of the role of the hippocampus in memory
- New section on neurons of the medial temporal lobes and memory
- Updated coverage of place cells and grid cells
- Introduction and focus on Jennifer Aniston neurons
- Tightened up coverage of LTP
- 35 new citations

Chapter 12: Hunger, Eating, and Health

- Shortened and simplified by aggressive editing
- 10 new citations

Chapter 13: Hormones and Sex

- New section on the modern perspective of sex differences in the brain
- New section on development of sex differences in human behavior
- Discussion of sex differences in susceptibility to disease
- Updated coverage of anabolic steroid use
- New coverage of human sexual arousal and the brain
- 56 new citations

Chapter 14: Sleep, Dreaming, and Circadian Rhythms

- Updated coverage of the relationship between REM sleep and dreaming

- Circadian activity cycles of SCN neurons
- 33 new citations

Chapter 15: Drug Addiction and the Brain's Reward Circuits

- International statistics of drug use
- Increased coverage of the therapeutic effects of THC
- Increased coverage of the effects of MDMA
- Updated description of the treatment of heroin addiction
- Section on critical thinking about illegal drugs
- Major revision of discussion of early theories of addiction
- Major update of current approaches to the study of addiction
- 102 new citations

Chapter 16: Lateralization, Language, and the Split Brain

- Discussion of the interactions between the hemispheres of split brains
- Current status of the theory that right hemispheres are specialized for emotion
- Update of research on neuroanatomical asymmetries in the brain
- Improved coverage of the motor theory of speech perception
- 24 new citations

Chapter 17: Biopsychology of Emotion, Stress, and Health

- Chapter reorganized by moving *Stress and Health* to the end
- Reference to bullying
- Updated and simplified coverage of the neural mechanisms of emotion
- New section on current perspectives of neural mechanism of human emotion
- New description of the immune system
- 45 new citations

Chapter 18: Biopsychology of Psychiatric Disorders

- Introduction of the anticipated DSM-V and the need for continual refinement of diagnoses
- New section on the current research and treatment of schizophrenia
- Updated coverage of treatments for depression
- Updated discussion of the monoamine theory of depression
- New description of the neuroplasticity theory of depression
- Discussion of current treatments for anxiety
- Discussion of problems with current system of diagnosis

- Introduction to the idea that pharmaceutical companies suppress negative findings
- 60 new research citations

Pedagogical Learning Aids

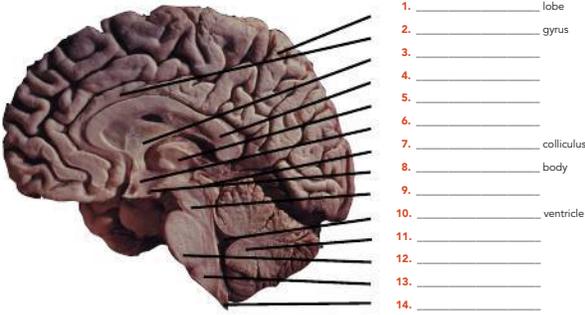
Biopsychology has several features expressly designed to help students learn and remember the material:

- **Scan Your Brain** study exercises appear within chapters at key transition points, where students can benefit most from pausing to consolidate material before continuing.

SCAN YOUR BRAIN

If you have not previously studied the gross anatomy of the brain, your own brain is probably straining under the burden of new terms. To determine whether you are ready to proceed, scan your brain by labeling the following midsagittal view of a real human brain. You may find it challenging to switch from color-coded diagrams to a photograph of a real brain.

The correct answers are provided at the end of the exercise. Before proceeding, review material related to your errors and omissions. Notice that Figure 3.29 includes all the brain anatomy terms that have appeared in bold type in this section and thus is an excellent review tool.

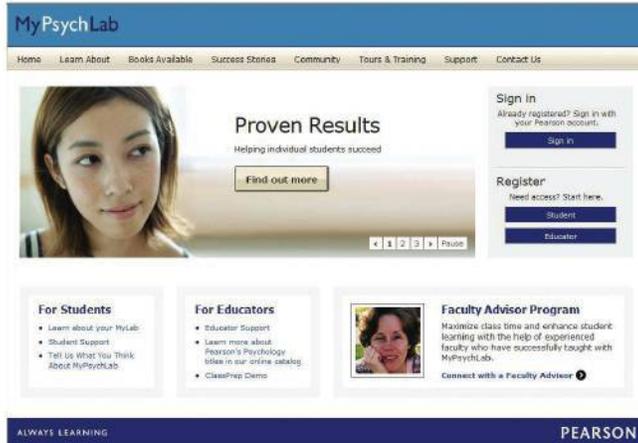


1. _____ lobe
2. _____ gyrus
3. _____
4. _____
5. _____
6. _____
7. _____ colliculus
8. _____ body
9. _____
10. _____ ventricle
11. _____
12. _____
13. _____
14. _____

Scan Your Brain answers: (1) parietal, (2) angular, (3) middle, or middle/occipital, (4) occipital, (5) cerebellum, (6) pons, (7) medulla, or medulla/oblongation, (8) brainstem, (9) brainstem, (10) corpus callosum, (11) thalamus, (12) hypothalamus, (13) superior, (14) mammillary, (15) tegmentum, (16) fourth, (17) cerebellum, (18) pons, (19) medulla, or medulla/oblongation, (20) brainstem, (21) corpus callosum, (22) thalamus, (23) hypothalamus, (24) superior, (25) mammillary, (26) tegmentum, (27) fourth, (28) cerebellum, (29) pons, (30) medulla, or medulla/oblongation, (31) brainstem, (32) corpus callosum, (33) thalamus, (34) hypothalamus, (35) superior, (36) mammillary, (37) tegmentum, (38) fourth, (39) cerebellum, (40) pons, (41) medulla, or medulla/oblongation, (42) brainstem, (43) corpus callosum, (44) thalamus, (45) hypothalamus, (46) superior, (47) mammillary, (48) tegmentum, (49) fourth, (50) cerebellum, (51) pons, (52) medulla, or medulla/oblongation, (53) brainstem, (54) corpus 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The customized study plan will focus on the student's strengths and weaknesses, based on the results of the diagnostic testing, and present a list of activities and resources for review and remediation, organized by chapter section. Some study resources intended for use with portable electronic devices, such as key terms flashcards and video clips, are made available exclusively through MyPsychLab. Students will be able to quickly and easily analyze their own comprehension level of the course material and study more efficiently, leading to exceptional exam results! An access code is required and can be purchased at www.pearsonhighered.com or at www.mypsychlab.com.

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A Colorful Introduction to the Anatomy of the Human Brain, Second Edition (0205548741) This book, written by John P. J. Pinel and Maggie Edwards, provides an easy and enjoyable means of learning or reviewing the fundamentals of human neuroanatomy through the acclaimed directed-coloring method.

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Two people deserve special credit for helping me create this edition of *Biopsychology*: Maggie Edwards and Steven Barnes. Maggie is an artist/designer/writer/personal trainer, who is my partner in life. She is responsible for the design of most of the illustrations in this book. Steven is a colleague/artist/computer wizard, whose contributions to this edition were immense. He kept my writing on schedule, prepared the manuscripts, compiled the reference list, did some editing and writing, designed all the new illustrations, created the author-run blog and website, and compiled all of the electronic links. It exhausts me just thinking about it.

Pearson Education did a remarkable job of producing this book. They shared my dream of a textbook that meets the highest standards of pedagogy but is also personal, attractive, and enjoyable. Thank you to Bill Barke, Stephen Frail, Susan Hartman, and other executives for having faith in *Biopsychology* and providing the financial and personal support necessary for it to stay at the forefront of its field. Special thanks also go to Joan Foley, Amber Chow, Diane Szulecki, and Judy Casillo at Pearson and Angel Chavez at Integra for coordinating the production—an excruciatingly difficult and often thankless job.

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 Margaret G. Ruddy, College of New Jersey
 Jeanne P. Ryan, SUNY–Plattsburgh
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To the Student

In the 1960s, I was, in the parlance of the times, “turned on” by an undergraduate course in biopsychology. I could not imagine anything more interesting than a field of science dedicated to studying the relation between psychological processes and the brain. My initial fascination led to a long career as a student, researcher, teacher, and writer of biopsychological science. *Biopsychology* is my attempt to share my fascination with you.

I have tried to make *Biopsychology* a different kind of textbook, a textbook that includes clear, concise, and well-organized explanations of the key points but is still interesting to read—a book from which you might suggest suitable sections to an interested friend or relative. To accomplish this goal, I thought about what kind of textbook I would have liked when I was a student, and I decided to avoid the stern formality and ponderous style of conventional textbook writing and to focus on ideas of relevance to your personal life.

I wanted *Biopsychology* to have a relaxed and personal style. In order to accomplish this, I imagined that you and I were chatting as I wrote, and that I was telling you—usually over a glass of something—about the interesting things that go on in the field of biopsychology. Imagining these chats kept my writing from drifting back

into conventional “textbookese,” and it never let me forget that I was writing this book for you.

Creative thinking is one of the major themes of this edition. Often science and creativity are considered to be opposites, but in my experience many of the major advances in biopsychological science have resulted from creative thinking. These major advances have been made by biopsychologists who have recognized that there are alternatives to the conventional ways of thinking about biopsychological issues that have been engrained in them by their culture and training and who have adopted creative new approaches. Two things in particular have fascinated me about the interplay between creative thinking and biopsychological science: how difficult it is to identify and shed conventional approaches even when they clearly haven’t been working, and how often solutions to long-standing problems become apparent when approached from a new perspective. The focus of this edition on creative thinking is intended to make the study of biopsychology more interesting for you and to encourage you become a more creative thinker.

I hope that *Biopsychology* teaches you much of relevance to your personal life and that reading it generates in you the same positive feelings that writing it did in me.

About the Author

John Pinel, the author of *Biopsychology*, obtained his Ph.D. from McGill University in Montreal and worked briefly at the Massachusetts Institute of Technology before taking a faculty position at the University of British Columbia in Vancouver, where he is currently Professor Emeritus. Professor Pinel is an award-winning teacher and the author of more than 200 scientific papers. However, he feels that *Biopsychology* is his major career-related accomplishment: “It ties together everything I love about my job: students, teaching, writing, and research.”

Pinel attributes much of his success to his wife, Maggie, who has at various times been a professional artist, designer, and personal trainer. Over the years, they have collaborated on many projects, and the high quality of *Biopsychology*’s illustrations is largely attributable to her skill and effort.

Pinel is an enthusiastic West African drummer who performs at local clubs, festivals, and drum circles with Nigerian drum master Kwasi Iruoje. For relaxation, he loves to cuddle his three cats: Rastaman, Sambala, and Squeak.

CHAPTER

1

Biopsychology as a Neuroscience

What Is Biopsychology, Anyway?



Explore the Visual
Brain in MyPsychLab.

- 1.1** What Is Biopsychology?
- 1.2** What Is the Relation between Biopsychology and the Other Disciplines of Neuroscience?
- 1.3** What Types of Research Characterize the Biopsychological Approach?
- 1.4** What Are the Divisions of Biopsychology?
- 1.5** Converging Operations: How Do Biopsychologists Work Together?
- 1.6** Scientific Inference: How Do Biopsychologists Study the Unobservable Workings of the Brain?
- 1.7** Critical Thinking about Biopsychological Claims

LEARNING OBJECTIVES

- LO1** Define and discuss the field of biopsychology.
- LO2** Biopsychology is an integrative discipline. Explain.
- LO3** Describe six areas of neuroscience that are particularly relevant to biopsychological inquiry.
- LO4** Compare the advantages and disadvantages of humans and nonhumans as subjects in biopsychological research.
- LO5** Compare experiments, quasiexperimental studies, and case studies, emphasizing the study of causal effects.
- LO6** Describe and compare the six divisions of biopsychology.
- LO7** Explain how converging operations has contributed to the study of Korsakoff's syndrome.
- LO8** Explain scientific inference with reference to research on eye movement and the visual perception of motion.
- LO9** Explain critical thinking and its relation to creative thinking in science.
- LO10** Discuss Delgado's bull-ring demonstration, emphasizing its flawed interpretation.
- LO11** Describe the rise and fall of prefrontal lobotomy.

The appearance of the human brain is far from impressive (see Figure 1.1). The human brain is a squishy, wrinkled, walnut-shaped hunk of tissue weighing about 1.3 kilograms. It looks more like something you might find washed up on a beach than like one of the wonders of the world—which it surely is. Despite its disagreeable external appearance, the human brain is an amazingly intricate network of **neurons** (cells that receive and transmit electrochemical signals). Contemplate for a moment the complexity of your own brain's neural circuits. Consider the 100 billion neurons in complex array (see Azevedo et al., 2009), the estimated 100 trillion connections among them, and the almost infinite number of paths that neural signals can follow through this morass (see Zimmer, 2011). The complexity of the human brain is hardly surprising, considering what it can do. An organ capable of creating a *Mona Lisa*, an artificial limb, and a supersonic aircraft; of traveling to the moon and to the depths of the sea; and of experiencing the wonders of an alpine sunset, a newborn infant, and a reverse slam dunk *must* be complex. Paradoxically, **neuroscience** (the scientific study of the nervous system) may prove to be the brain's ultimate challenge: Does the brain have the capacity to understand something as complex as itself (see Gazzaniga, 2010)?

Neuroscience comprises several related disciplines. The primary purpose of this chapter is to introduce you to one of them: biopsychology. Each of this chapter's seven sections characterizes the neuroscience of biopsychology in a different way.

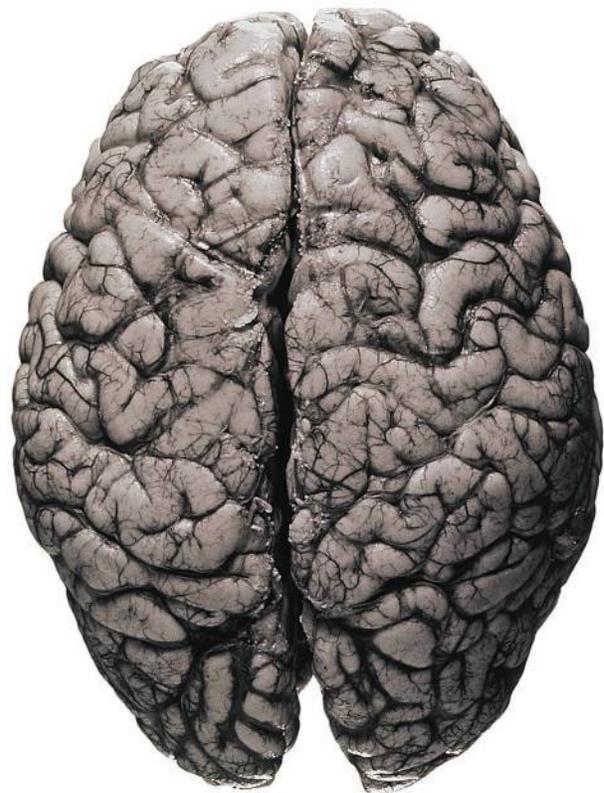


FIGURE 1.1 The human brain.

Before you proceed to the body of this chapter, I would like to tell you about two things: (1) the case of Jimmie G. (Sacks, 1986), which will give you a taste of the interesting things that lie ahead, and (2) the major themes of this text.

*The Case of Jimmie G., the Man Frozen in Time

Jimmie G. was a good-looking, friendly 49-year-old. He liked to talk about his school days and his experiences in the navy, which he was able to describe in detail. Jimmie was an intelligent man with superior abilities in math and science. In fact, it was not readily apparent why he was a resident of a neurological ward.

When Jimmie talked about his past, there was a hint of his problem. When he talked about his school days, he used the past tense; when he recounted his early experiences in the navy, however, he switched to the present tense. More worrisome was that he never talked about anything that happened to him after his time in the navy.

Jimmie G. was tested by eminent neurologist Oliver Sacks, and a few simple questions revealed a curious fact: The 49-year-old patient believed that he was 19. When he was asked to describe what he saw in a mirror, Jimmie became so frantic and confused that Dr. Sacks immediately took the mirror out of the room.

Returning a few minutes later, Dr. Sacks was greeted by a once-again cheerful Jimmie, who acted as if he had never seen Sacks before. Indeed, even when Sacks suggested that they had met recently, Jimmie was certain that they had not.

Then Dr. Sacks asked where Jimmie thought he was. Jimmie replied that all the beds and patients made him think that the place was a hospital. But he couldn't understand why he would be in a hospital. He was afraid that he might have been admitted because he was sick, but didn't know it.

Further testing confirmed what Dr. Sacks feared. Although Jimmie had good sensory, motor, and cognitive abilities, he had one terrible problem: He forgot everything that was said or shown to him within a few seconds. Basically, Jimmie could not remember anything that had happened to him since his early 20s, and he was not going to remember anything that happened to him for the rest of his life. Sacks was stunned by the implications of Jimmie's condition.

Jimmie G.'s situation was heart-wrenching. Unable to form new lasting memories, he was, in effect, a man frozen in time, a man without a recent past and no prospects for a future, stuck in a continuous present, lacking any context or meaning.

Remember Jimmie G.; you will encounter him again, later in this chapter.

FOUR MAJOR THEMES OF THIS TEXT

You will learn many new facts in this text—new findings, concepts, terms, and the like. But more importantly, many years from now, long after you have forgotten most of those facts, you will still be carrying with you

productive new ways of thinking. I have selected four of these for special emphasis: They are the major themes of this text.



To help give these themes the special attention they deserve and to help you follow their development as you progress through the text, I have marked relevant passages with tabs. The following are the four major themes and their related tabs.

Thinking Creatively about Biopsychology We are all fed a steady diet of biopsychological information, misinformation, and opinion—by television, newspapers, the Internet, friends, relatives, teachers, etc. As a result, you likely already hold strong views about many of the topics you will encounter in this text. Because these preconceptions are shared by many biopsychological researchers, they have often impeded scientific progress, and some of the most important advances in biopsychological science have been made by researchers who have managed to overcome the restrictive effects of conventional thinking and have taken creative new approaches. Indeed, **thinking creatively** (thinking in productive, unconventional ways) is the cornerstone of any science. The thinking creatively tab marks points in the text where I describe research that involves thinking “outside the box,” where I have tried to be creative in the analysis of the research that I am presenting, or where I encourage you to base your thinking on the evidence rather than on widely accepted views.

Thinking Creatively

Clinical Implications Clinical (pertaining to illness or treatment) considerations are woven through the fabric of biopsychology. There are two aspects to clinical implications: Much of what biopsychologists learn about the functioning of the normal brain comes from studying the diseased or damaged brain; and, conversely, much of what biopsychologists discover has relevance for the treatment of brain disorders.

Clinical Implications

This text focuses on the interplay between brain dysfunction and biopsychological research, and each major example is highlighted by a clinical implications tab.

The Evolutionary Perspective Although the events that led to the evolution of the human species can never be determined with certainty, thinking of the environmental pressures that likely led to the evolution of our brains and behavior often leads to important biopsychological insights. This approach is called the evolutionary perspective. An important component of the **evolutionary perspective** is the comparative approach (trying to understand biological phenomena by comparing them in different species). You will learn throughout the text that we humans have learned much

Evolutionary Perspective

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