

List of Figures	ix
Acknowledgments	xix
Introduction	xxi
Part I Getting to Sounds	1
1 The Speech System and Basic Anatomy	3
1.1 The Speech Chain	3
1.1.1 The speech production chain	6
1.2 The Building Blocks of Articulatory Phonetics	7
1.2.1 Materials in the body	9
1.3 The Tools of Articulatory Phonetics	10
Exercises	12
References	13
2 Where It All Starts: The Central Nervous System	15
2.1 The Basic Units of the Nervous System	15
2.1.1 The action potential: how the nervous system communicates	18
2.2 The Central Nervous System	19
2.2.1 Speech areas in the brain	22
2.3 Measuring the Brain: fMRI, PET, EEG, MEG, TMS	27
Exercises	30
References	31

3	From Thought to Movement: The Peripheral Nervous System	33
3.1	The Peripheral Nervous System	33
3.1.1	Cranial nerves	34
3.1.2	Spinal nerves	36
3.2	How Muscles Move	38
3.3	Measuring Muscles: EMG	41
3.3.1	The speed of thought to movement	43
	Exercises	45
	References	46
4	From Movement to Flow: Respiration	47
4.1	Breathing Basics	47
4.1.1	Two principles for respiration	47
4.1.2	Lung volumes	48
4.1.3	Measuring lung volume	50
4.2	The Anatomy of Breathing	51
4.2.1	The lungs	51
4.2.2	The hard parts: bones and cartilages of respiration	53
4.2.3	Passive forces of breathing	57
4.2.4	Inspiratory muscles	57
4.2.5	Expiratory muscles	61
4.2.6	The respiratory cycle revisited	64
4.3	Measuring Airflow and Pressure: Pneumotachograph	66
4.4	Sounds	67
4.4.1	/h/	67
4.4.2	Pitch and loudness	68
	Exercises	68
	References	69
5	From Flow to Sound	71
5.1	Intrinsic Laryngeal Anatomy	71
5.1.1	The hard parts	72
5.1.2	Intrinsic laryngeal muscles	74
5.2	Sounds: The Voice	78
5.2.1	Modal phonation	78
5.2.2	Theories of modal phonation	80
5.2.3	Pitch control	86
5.2.4	Voicelessness	89
5.3	Measuring the Vocal Folds: EGG	90
	Exercises	91
	References	94

Part II	Articulating Sounds	97
6	Articulating Laryngeal Sounds	99
6.1	Extrinsic Laryngeal Anatomy	100
6.1.1	The hard parts	100
6.1.2	Extrinsic laryngeal muscles	101
6.2	Sounds	106
6.2.1	Non-modal phonation types	106
6.2.2	The glottalic airstream mechanism	114
6.3	Measuring Laryngeal Articulations: Endoscopy	118
	Exercises	120
	References	122
7	Articulating Velic Sounds	125
7.1	Anatomy of the Velum	125
7.1.1	The hard parts	126
7.1.2	Muscles of the velum	129
7.2	Sounds	134
7.2.1	The oral-nasal distinction: more on the VPP	134
7.2.2	Uvular constrictions: the oropharyngeal isthmus	136
7.3	Measuring the Velum: X-ray Video	138
	Exercises	140
	References	141
8	Articulating Vowels	143
8.1	The Jaw and Extrinsic Tongue Muscles	146
8.1.1	The hard parts	146
8.1.2	Jaw muscles	148
8.1.3	Extrinsic tongue muscles	152
8.2	Sounds: Vowels	154
8.2.1	High front vowels	156
8.2.2	High back vowels	156
8.2.3	Low vowels	157
8.2.4	ATR and RTR	159
8.3	Measuring Vowels: Ultrasound	160
	Exercises	163
	References	164
9	Articulating Lingual Consonants	167
9.1	The Intrinsic Tongue Muscles	167
9.1.1	The transversus and verticalis muscles	168
9.1.2	The longitudinal muscles	170
9.2	Sounds: Lingual Consonants	171
9.2.1	Degrees of constriction and tongue bracing	171
9.2.2	Locations of constriction	176

9.3	Measuring Lingual Consonants: Palatography and Linguography	180
	Exercises	182
	References	186
10	Articulating Labial Sounds	189
10.1	Muscles of the Lips and Face	192
10.1.1	The amazing OO	192
10.1.2	Other lip and face muscles	194
10.2	Sounds: Making Sense of [labial]	196
10.3	Measuring the Lips and Face: Point Tracking and Video	198
	Exercises	202
	References	203
11	Putting Articulations Together	205
11.1	Coordinating Movements	205
11.1.1	Context-sensitive models	207
11.1.2	Context-invariant models	207
11.1.3	Unifying theories	209
11.2	Coordinating Complex Sounds	210
11.2.1	Lingual-lingual sounds	211
11.2.2	Other complex sounds	216
11.3	Coarticulation	217
11.3.1	Articulatory overlap	218
11.3.2	Articulatory conflict	219
11.3.3	Modeling coarticulation	220
11.4	Measuring the Whole Vocal Tract: Tomography	221
	Exercises	225
	References	225
	Abbreviations Used in this Book	229
	Muscles with Innervation, Origin, and Insertion	233
	Index	243