

# Index

- A-current. *See* Transient potassium current
- Acetylcholine
  - comparative study, 230, 253
  - as neuromodulator. *See* Muscarinic agonists
  - receptors, 24–25, 242
  - as STG transmitter, 24, 72, 88, 242
- Action potentials, 32–33
- Adaptation, spike frequency, 59–64, 184
- AGR. *See* Anterior gastric receptor
- $\gamma$ -aminobutyric acid. *See* GABA
- 4-aminopyridine, 37, 68, 123–124
- Anatomy of foregut, 2–12
- Anomura, 224
- Anterior esophageal sensor (AOS), 14
- Anterior gastric receptor (AGR), 14, 96, 236
- Anterior pyloric modulator (APM) neuron
  - endogenous rhythmicity of, 102
  - identification of, 95–96
  - modeling, 186, 188
  - modulation by, 102, 105, 107, 108–109, 112, 116, 119, 125, 129, 130
- Antidromic action potentials and release, 164–168
- AOS. *See* Anterior esophageal sensor
- Apamin, 37
- APM. *See* Anterior pyloric modulator neuron
- Artificially electrically coupling cultured neurons, 181
- Astacidea, 225–226
- Attenuation, signal, 33–36
  
- Backpropagation, 164, 189–190
- Behavior, 139, 197–220. *See also individual behaviors*
  - endoscopic studies of, 200–201, 207–212
  - gastric mill, 5–6, 200–204
  - in intact animals, 7–10
  - pyloric rhythm, 204–206
  - relation to motor pattern, 212–216
  - swallowing, 3–4, 155–158
  - and tooth morphology, 247
- Bistability. *See* Plateau potentials
- Brachyura, 225–227
- Buccalin, 92
- Bursting. *See* Oscillation
  
- Cable properties, 164–168, 174
- Calcium current, 40, 43–44, 170
  - localization, 42
  - modeling, 168–170
  - role in bursting and plateau potentials, 52
- Calcium-dependent outward current ( $I_{O(Ca)}$ ,  $I_{K(Ca)}$ ), 37, 169–171, 177, 191
  - fingerprints of STG neurons, 69–70
  - localization, 40–41
  - modulation, 41
  - role in plateau potentials, 121
- Calcium imaging, 42–44
- cAMP, 131
- Cardiac sac, 2, 4, 198
  - network, 140–145, 152–155
  - rhythm, 15–16
- Cardiopyloric valve, 7, 140, 248, 253
- Caricatures, neuronal models, 163, 177–178, 184, 185, 186–193
- Cat, walking system, 271–272, 278
- CCAP. *See* Crustacean cardioactive peptide
- CCK. *See* Cholecystokinin
- Cell culture, 180
- Cell killing. *See* Photoinactivation
- Cell shape, and electrical properties, 36
- Cellular properties, of STG neurons, 44–70

- Central pattern generator, 26–29, 88. *See also individual networks*  
interactions between, 115, 133–134, 139–160  
maintenance, 100  
modeling, 190  
modulation, 98, 101–104, 132, 133  
relation to movement, 212–216  
role of reciprocal inhibition, 183  
role of sensory afferents, 273–278  
CG neuron. *See* Commissural gastric neuron  
Channels. *See* Currents  
Charybdotoxin, 37  
Chemotonic transmission. *See* Graded synaptic transmission  
Cholecystokinin (CCK), 92, 209  
activation of cardiac sac rhythm, 198  
activation of gastric mill rhythm, 102–104, 207–209  
coactivation of gastric mill and cardiac sac, 211  
and feeding behavior, 94, 217–219  
as locally released neuromodulator, 218–219, 240  
modulation by, 208–209  
as neurohormone, 94, 217–218, 240  
phylogenetic variability, 209, 238–239  
Classification  
of crustacea, 249–250  
of decapods, 223–227  
CoG. *See* Commissural ganglion  
Commissural ganglion (CoG), 8, 10–12, 15, 91  
Commissural gastric neuron (CG), 18, 29, 96, 229  
Commissural pyloric oscillator (CPO), 29, 100, 105–106, 113–114, 229. *See also* CP neuron, P neuron  
Comparative studies of STNS, 221–261  
Compartmental models, 162, 164–168, 174, 181, 191  
Computer reconstruction, 165  
Conditional burster. *See* Oscillation  
Conductance-based models of STG neurons, 162–163, 168–175  
Conjoint rhythm, 152  
Connectionist models, 164, 185  
Cotransmission, 95, 98, 114, 128–129, 130  
Coupling coefficient, 81. *See also* Electrical coupling  
CP neuron, 95–96, 100–102  
CPG. *See* Central pattern generator  
CPO. *See* Commissural pyloric oscillator  
Crayfish, 225, 278  
Crustacean cardioactive peptide (CCAP), 92  
Currents, in STG neurons, 36–44, 170–174. *See also individual currents*  
Cut and grind movement, 5–6, 200, 204, 207–209  
Cut and squeeze movement, 200, 202, 204, 207–209  
DA. *See* Dopamine  
Delayed rectifier ( $I_K$ ,  $I_D$ ) potassium current, 37, 38, 42, 169, 170  
Delaying mechanisms, 66–68  
Dendrobranchiata, 223–224  
Depression, synaptic, 80–81  
Digestive gland, 3, 7  
Dopamine (DA), 93  
control of oscillation, 105, 117–118  
effect on muscles, 243–244  
modeling, 168–170, 183  
modulation of cat locomotion, 272  
modulation of pyloric rhythm, 108, 117–118, 122, 124, 126–128, 130, 241  
Driver potentials, 54–55, 185, 256, 265. *See also* Oscillation  
Dual transmitters, in modulatory neurons. *See* Cotransmission  
Duty cycle, 176–178  
Electrical coupling, 28, 81–83  
in cell culture, 180  
comparative studies, 230, 255  
mixed electrical/chemical synapses, 83, 180–183  
modeling in pyloric network, 176–183  
morphology, 81–82  
Electron microscopy, 32  
Electronic length, 35–36  
Endoscope measurements, 200–201, 207–214  
E neuron, 96  
Entrainment of networks, 105–106  
Esophageal ganglion (OG), 10, 12, 91  
Esophageal rhythm, 3–4, 12, 15, 139, 156  
Esophagus, 3–4  
Eucarida, 249  
Eukyphida, 223  
Eumalocostraca, 249  
Euzygida, 223  
Evolution  
of foregut structure, 224–225  
homology in, 227–228  
of motor patterns, 131–132, 221–261  
Eyestalk hormones, 199, 206

- Feeding, 199, 204, 217–219
- Filtering properties of stomatogastric neurons, 59–62, 164–168
- Fingerprints, ionic, 69–70
- Fitzhugh equations, 163, 177, 178
- FMRFamide-like peptides, 92
- effects on muscle, 244
- and gastric mill movement, 207
- modulation, 120, 148
- phylogenetic variability, 238
- Foregut anatomy, 1–10
- Frequency adaptation, 21
- Fusion, of CPGs, 152–158
- GABA ( $\gamma$ -aminobutyric acid), 11–12, 24, 93, 97, 237, 239–240, 242
- Gap junctions, 70, 75. *See also* Electrical coupling
- Gastric mill, 2, 4–7
- Gastric mill neurons, 8–9, 17–18, 20–24, 31–85
- Gastric mill rhythm, 27–28
- comparative study, 231, 234–235
- modeling, 183, 185, 189–194
- modulation of, 102–104, 105, 108–109, 156, 214–215
- movements of, 199–204, 207–210
- network of, 6, 8–9, 17–18, 183, 185, 189–194
- Gastropyloric interactions, 19–20, 145–152
- Gastropyloric receptor (GPR) neurons, 14–15, 96
- comparative studies of, 236–237
- cotransmission in, 129, 236, 240
- modulation by, 107, 114, 119–122, 149–151
- properties of, 95, 96, 102, 129, 217
- Glial cells, 32
- Glutamate
- comparative study, 230, 253
- receptors, 24, 25, 242
- as transmitter of STG neurons, 24, 72, 88, 242
- GN neurons (GABA-immunoreactive), 97
- GPR neurons. *See* Gastropyloric receptor neurons
- Graded synaptic transmission, 32, 77–81, 125
- depression in, 80–81
- input/output curves, 79–80
- modeling, 174, 187
- modulation, 125–128
- threshold for, 42, 79
- Gradient descent algorithm, 187, 189
- Half-center oscillator, 27, 184
- Hepatic duct (HD) receptors, 15
- Hierarchical oscillators, 29
- Hindgut, 2, 7
- Histamine, 13, 93, 239
- Homology, 227–228, 244–245, 255
- Hoplocarida, 249, 251–258
- Hormone. *See* Neurohormones
- Hyperpolarization-activated inward current ( $I_h$ ), 38–40, 69, 121–123, 170–172, 184
- Hyperpolarizing afterpotential, 55
- $I_A$ . *See* Transient potassium current
- $I_{Ca}$ . *See* Calcium current
- $I_D$ . *See* Delayed rectifier potassium current
- $I_h$ . *See* Hyperpolarization-activated inward current
- $I_j$ . *See* Calcium-dependent outward current
- $I_K$ . *See* Delayed rectifier potassium current
- $I_{K(Ca)}$ . *See* Calcium-dependent outward current
- $I_{Na}$ . *See* Sodium current
- $I_{O(Ca)}$ . *See* Calcium-dependent outward current
- Inhibitory synapses. *See* Synapses
- Inputs to STG. *See also individual modulatory neurons*
- anatomy, 8, 10–15, 90–91
- modulatory, 83–84, 95–98
- phylogenetic variability, 237–239, 257–258
- sensory, 13–15
- Interactions between CPGs, 115, 133–134, 139–160
- comparative study of, 235–236
- gastropyloric interactions, 145–152
- principles of, 158–160
- Isolation of STG neurons, 115–116
- Isopotential models, 168–175
- IVN (inferior ventricular nerve) neuron, 13, 95–96, 129
- J-current. *See* Calcium-dependent outward current
- Lamprey, swimming generator, 268–269
- Leech, heartbeat generator, 268
- Ligand-sensitive channels, 24, 44, 242
- Local computing in neuropil, 73–74
- Locust flight, 263, 271, 273–278
- LP neuron, currents in, 170–174
- Lucifer yellow, 40, 82, 115–116
- Lymnaea, feeding generator, 268

- Malacostraca, 249
- M-current, 186, 188
- Midgut, 2, 7
- Mixed synapses, 83, 180–183
- Modeling, 161–196
  - compartmental, 162–163, 164–168
  - conductance-based, 162–163, 168–175
  - gastric network, 185, 189–194
  - pyloric network, 185–189
  - neural network, 163–164, 175–194
  - of reconstructed neurons, 33–35
- Modulatory neurons, 87–137. *See also individual neurons*
  - comparative studies of, 236–241, 257–258
  - cotransmission in, 98, 114
  - identification of, 95–98
  - interactions between, 102
  - modeling, 175, 180, 186
  - modulation by, 98–122, 125, 128–130
  - time course of action, 114, 130
- Modulatory proctolin neuron (MPN), 97, 98
  - cotransmission in, 129, 237
  - modulation by, 102–103, 105, 107, 110, 112, 114, 116, 117, 129, 130
  - properties of, 98, 129
- Multicompartmental models of STG neurons. *See* Compartmental models
- Multiple task processor, 88, 146–147, 151, 158. *See also* Central pattern generator
- Muscarinic agonists, 92, 95, 96, 98, 117, 177
- Muscle, 25–26
  - anatomy, 2, 244
  - bifunctional, 143
  - comparative studies of, 231–233, 241–245, 253
  - properties of, 24, 25, 74, 242–243
  - modulation of, 25, 75, 243–244, 253–254
- Negative resistance, 51, 191–192
- Network models, 163, 175–194
- Neural networks. *See also* Central pattern generators
  - organization of, 264–265
  - principles of function, 263
  - stability, 62–63
- Neurohormones, 91–94, 102–104, 217–219
- Neuromodulation, 87–137
- Neuromodulators, 87–137
  - activation of CPGs by, 98–104
  - concentration dependence, 130
  - control of active neurons, 108–114
  - control of firing frequency, 108
  - control of gastric mill frequency, 104–106
  - control of oscillation, 117–119
  - control of phasing and duty cycle, 106–108
  - control of plateau potentials, 119–122
  - control of pyloric frequency, 104–106
  - inputs to STG, 91
  - interactions between, 129
  - modeling, 168, 174
  - multiple responses to, 124
- Neuromuscular junction, 25, 166
- Neurons in stomatogastric ganglion, 31–85
  - ionic fingerprints, 69–70
  - properties, 31–85
  - structure, 31–34, 165
- Neuropil, stomatogastric, 32–36, 70–74
- Neurotransmitters in stomatogastric system, 24, 72, 230, 253
- Nonrectifying electrical coupling, 174
- Norepinephrine, 272
- Octopamine (Oct), 93
  - and cAMP, 131
  - comparative studies, 271
  - effect on muscle, 243
  - modeling, 168–170
  - modulation of gastric mill, 93, 207
  - modulation of pyloric rhythm, 105, 108, 117–118, 124, 126–128, 131
- OG. *See* Esophageal ganglion
- Organization of neural networks, 264
- Ossicles, 2, 4, 7, 202–203, 245–249
- Oscillation, 21, 28, 56–58, 265–266
  - ceiling frequency, 105
  - comparative studies, 53, 57–58, 256, 268–269
  - conditional, in STG neurons, 98, 106
  - driver potentials and, 265
  - duration, 266–267
  - ionic mechanisms, 51–53, 57–58, 67, 117–119
  - modulation of, 117–119, 156
  - modeling, 52, 57, 163, 168–170, 176–180, 187, 192
  - in muscles, 213, 243–244
  - and postinhibitory rebound, 65
  - role of  $I_A$ , 67–68
- Palaemon, 224–225, 227, 229, 230, 233
- Palinura, 225–226
- Patch clamp, 37
- Peripheral spike initiating zone, 165, 166
- Photoinactivation, 75–76, 115–116, 179, 190, 194

- Phyllocarida, 249
- Phylogenetic variability, 221–261
- Pigment-dispersing hormone (PDH), 92, 237–239
- Plateau potentials, 21–22, 28, 44–56, 265–266  
 comparative studies of, 53, 256–257, 271, 272  
 experimental tests for, 47–51  
 ionic mechanisms, 51–53, 120–122  
 modeling, 163, 171, 177–178, 192  
 modulation of, 45, 53–54, 119–122, 141–143, 148–149, 151
- Pleocyemata, 223
- P neuron, 95, 97, 100–102
- Posterior stomach receptors (PSR), 14, 236
- Postinhibitory rebound, 21, 58, 64–66  
 and bursting, 65  
 ionic mechanism, 66, 123–124  
 modeling, 184, 192, 194  
 modulation, 123–124  
 and reciprocal inhibition, 183–185
- Potassium currents, 37–39, 40–42, 52. *See also individual current*
- Principles  
 of evolution of stomatogastric system, 258–261  
 of modeling, 194–196  
 of network interactions, 158–160  
 of neural networks, 263, 278–281  
 of neuromodulation, 132–136, 259
- Proctolin, 92  
 activation of cardiac sac rhythm by, 198, 207  
 effect on muscle, 243–244  
 and gastropyloric interactions, 148–149  
 modulation of gastric mill rhythm, 207–209  
 modulation of pyloric rhythm, 105, 108, 114, 122–123, 130, 170–172, 178–180
- PSR. *See* Posterior stomach receptors
- Pyloric cells, 7, 9, 12–13  
 firing in gastric mill time, 145–152  
 homology between species, 228–230, 255  
 properties of, 20–23, 31–85  
 transmitters of, 24
- Pyloric rhythm, 28–29  
 cells in, 8–9, 12–13  
 comparative study, 228–230, 233–234, 255–257  
 interaction with gastric mill, 19–20, 145–152  
 models, 176–178, 185–189  
 modulation of, 100–114, 178–180  
 network, 18–19, 28–29, 183–185  
 movements of, 7–10, 204–206
- Pyloric suppressor (PS) neuron, 13, 97  
 activation of swallowing, 155–158  
 fusion of CPGs, 155–158  
 inactivation of pyloric rhythm, 104, 107, 113, 118–119, 156–158  
 properties, 95, 97, 240
- Pylorus, 2, 7, 248–249, 251–253
- Receptors, 24, 124
- Reciprocal inhibition, 180, 183–185, 189, 192–194
- Reconfiguration of networks, 156–158, 273–278  
 comparative studies, 273–278
- Rectification, 68–70, 170, 174
- Red pigment-concentrating hormone (RPCH), 92  
 and cardiac sac rhythm, 141–145, 198  
 fusion of gastric mill and cardiac sac, 152–155  
 movements, 210–211  
 as neurohormone, 94  
 phylogenetic variability, 238–239
- Relaxation oscillator, 56, 191
- Repetitive firing, 58–59
- Reptantia, 224, 225, 233
- Respiration, mammalian, 269
- RPCH. *See* Red pigment-concentrating hormone
- Sag current. *See* Hyperpolarization-activated inward current
- SDRNFLRFamide. *See* FMRFamide-like peptide
- Second messengers, 131, 174–175
- Sensory neurons, 13–15  
 comparative studies, 236–237, 260, 273–278  
 modulation, 270. *See also* Gastropyloric receptor neurons  
 role in organizing foregut movement, 11  
 and switching between networks, 140–143
- Serial synapses, 72–73
- Serotonin, 93  
 effect on muscle, 243–244  
 modeling, 165–170  
 modulation of cat locomotion, 272  
 modulation of pyloric rhythm, 105, 108, 114, 117–122, 124, 126–128, 269  
 as neurohormone, 91–94  
 and peripheral spike initiation, 165–168

- Serotonin (*cont.*)
  - phylogenetic variability, 241
  - receptors, 124
- Silent neurons, 110–113
- Sodium current, 37, 40, 52, 166, 168–170
- Species, differences in STNS, 131–132, 221–261
- Spike-evoked synaptic transmission, 32, 74–77
- Spike frequency adaptation. *See* Adaptation, spike frequency
- Spike initiation zone, 21, 31, 165–168, 182
- Squeeze movement, 5, 200, 204, 207–209, 210
- Squilla oratoria, 251–258
- State dependence of neuromodulation, 114–115
- Stomatogastric ganglion
  - neural networks, 16–20
  - neurons, 8–9, 12–13
  - properties of neurons, 20–23, 31–85
- Stomatogastric nerve (strn), 91, 98, 175
- Stomatopoda, 251–258. *See also* Squilla oratoria
- Substance P, 92, 238–239
- Swallowing, 155–158, 210
- Switching, 139–160
  - and behavior, 214–216
  - cellular mechanisms of, 141–143
  - of single neurons between CPGs, 140–145, 210
- Synapses, 70–84
  - comparative study, 230–231
  - graded, 32, 77–81
  - mixed electrical/chemical, 126–127, 180–183
  - modeling, 72–74, 161, 164, 185–186, 190, 193, 196
  - properties, 23–25, 68–69, 70–72, 75–76
  - role in pattern generation, 26–29
- Synaptic isolation of STG neurons, 115–116
- Synaptic modulation, 125–128, 149, 154, 182–183
- Synaptic weights, 125–128, 190, 193, 196
- Syncarida, 249
- SYNETSIM-3, 174–175
  
- Teeth, 3, 4–7, 193, 194, 199–204, 245–248
- Temperature, 117–118, 170
- Tetrodotoxin, 37, 117–118, 168–170
- Thalassinidea, 224
- Threshold, for graded transmitter release, 42
  
- Training, models, 189, 190
- Transient potassium current ( $I_A$ ), 37–39
  - and bursting, 67
  - and delaying mechanisms, 66–68
  - localization, 41–42
  - modeling, 185
  - and postinhibitory rebound, 123–124
  - role in pyloric rhythm, 66–68, 123–124, 170, 172
- Unit CPG, 134
  
- Voltage clamp, 36–37, 120–121, 170
- Voltage-gated currents. *See* Currents
- Voltage spread in STG neurons, 32–36
  
- Williams-Zipser algorithm, 189