Vertebrate Physiology 437

1. Behavior Initiation (CH11)

2. Announcements
   exam next Tuesday seminars etc.

3. Jokes from the audience...

Fig. 11-12
Randall et al. 2002
Chapter Eleven

~Behavior Initiation

Complex

Bring together nervous, endocrine, muscular systems, etc.

Respond to situation(s)
Parallel Processing

Reflexes / Learned / Plasticity

Complicated Neuronal Circuitry

Animal Behavior, Neurobiology
Simple Reflexes – basis of neuronal circuitry

Reflex Arc, Stereotyped Behavior
e.g., stretch reflex (patellar tendon)

- Tonic tension in muscle
- Important for maintenance of posture via negative feedback

- Only 2 neurons required

- monosynaptic reflex

Stretch receptor activates 1a-afferent neuron

Alpha-motor neuron activates quadriceps

Figure 8-26 Patellar Tendon Reflex (a Stretch Reflex)
Tapping the patellar tendon with a rubber mallet stretches the muscle spindles in the quadriceps femoris muscle. The resultant monosynaptic stretch reflex results in contraction of this extensor muscle, causing the characteristic knee-jerk response.

Sherwood 1997 (see 11-1 in Eckert)
Simple Reflexes

Stretch receptor = muscle spindle organ

- contains *intrafusal fibers* (as opposed to *extrafusal*)

- Sensitive to stretch (*stretch -> APs*)

- Need to be *reset* for new muscle length

- *Gamma-motor* neurons innervate spindle
1. 1a-afferent neuron
2. Alpha-motor neuron
3. Gamma-motor neuron

c. Contracted muscle without 'reset' muscle spindle
Simple Reflexes +

Other neurons become involved as well:
- 1a-afferents inhibit the antagonist muscle (Knee flexor ~ hamstring)
- Conscious decision to bend leg etc.

- Limb
Law of Nerve-Specific Energy

Action Potentials and Graded Potentials don’t convey specific information.

Rather, the geographic connections, summation of different inputs, and modulation are important for correct response.

Fig. 11-12
Randall et al. 2002
Sensory Neurons

Individual Receptors Variable

Process thousands of inputs to generate ‘scene’

Threshold energy

Sound frequency (kHz)

10 15 20 30 40 50 60 80 100

Randall et al. 2002
p. 441
Sensory Networks and Lateral Inhibition

Fig. 11-14
Randall et al. 2002

(a)

Helps define edges in vision
Horseshoe crab

Light pulse
Steady light

Optic nerve

Ommatidia
Lateral plexus

More APs from single ommatidia without lateral influence

Randall et al. 2002
Vertebrate Visual System
Retina --> Visual Cortex

(a) Optic chiasm
Tectum
Retina

(b) ipsilateral
Fields of vision
Nasal hemiretina
Optic chiasm
Temporal hemiretina
Optic nerve
Optic tract

(c) Retina
Lateral geniculate
Primary visual cortex

Layers of cells in between

Randall et al. 2002

Fig. 11-17
Convergence and Divergence

Processing in Retina and in Brain

1st, 2nd, 3rd Order

Photoreceptors

Bipolar Cells

Ganglion Cells (optic nerve)

Fig. 11-18
Randall et al. 2002

(11-18)

Lateral Interxns

Horizontal Cells

Amacrine Cells
Dark Current! (hyperpolarize in light)

- Hyper- or De-Polarizing
- Convergence/Divergence (minimal in fovea = acuity)
- Outside fovea, many photoreceptors per ganglion

1\textsuperscript{st} Order

2\textsuperscript{nd} Order

3\textsuperscript{rd} Order

Randall et al. 2002
Visual Receptive Field

Size and area innervating a given ganglion cell

1 or 2 photoreceptors → 2mm diameter

- 2 parts: Center, Surround
- 2 kinds: On or Off

(a) On-center ganglion cell
(b) Off-center ganglion cell

Fig. 11-20
Randall et al. 2002

Lots lateral inhibition

(11-20)
Visual Receptive Field

- Center, Surround
- On or Off

- Mediated by bipolar cells that either hyper- or de-polarize

Fig. 11-21
Randall et al. 2002
Simple Cells in Visual Cortex respond to linear arrangements of receptive fields in retina

‘On’ example:

Fig. 11-24
Randall et al. 2002
‘On’ example:

(b)

Stimulus 1 Stimulus 2

Light

Off On Off

1

2

Fig. 11-23
Randall et al. 2002
'On' example:

(c)

Stimulus 1

Stimulus 2

Stimulus 3

(11-23)

convergence

Fig. 11-23
Randall et al. 2002

Fig. 11-24
Randall et al. 2002
Integrate information from many simple cells...

Can detect movement orientation...

Fig. 11-25
Randall et al. 2002
Process and Respond...

Fig. 11-17
Randall et al. 2002

Fig. 11-22
Randall et al. 2002
Cortical Maps

One eye into monkey visual cortex

Fig. 11-27
Randall et al. 2002

(11-27)
Behavioral Examples

**Echolocation in bats**

- High frequency sound pulses
- Large auditory center in brain
- Sound pulse as energetic as jet 100m overhead or 20x jackhammer
- Sensitive auditory ossicles (desensitized briefly as sound pulse emitted)

- Sound intensity drops as square of distance; return signal weak

(tonotopic maps in space)
Behavioral Examples

**Navigation via Magnetic Fields**

- Pelagic Whales
- Homing Pigeons
- Cave salamanders
- Bacteria etc.

- often a *redundant* system

- *Magnetite* particles ($\text{Fe}_3\text{O}_4$) orient with magnetic field

- *Receptors* detect -> processed in *CNS*
CPG = central pattern generator
- neuronal network producing repetitive output

Walking, swimming, flying, breathing

Toad walking with no afferents
- awkward
- flaccid muscles

Sensory feedback
Higher centers can override

Some patterns at level of spinal cord if stimulate initially (cats on treadmill)
End