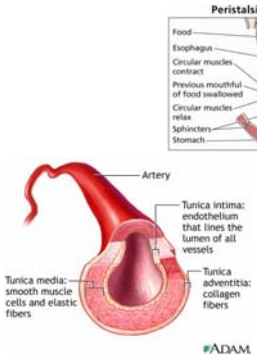
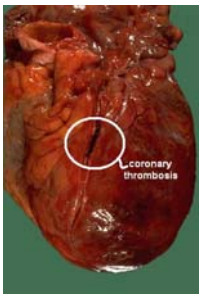
Other Kinds of Vertebrate Muscle





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Smooth Muscle

-Lacks sarcomeres, isn't striated

-Walls of hollow organs – visceral functions
(GI tract, urinary bladder, uterus, blood vessels)

-Heterogeneous

-Innervated by autonomic NS

-Each fiber is individual cell with one nucleus

-No T-tubules

-Organized into bundles of actin and myosin anchored to dense bodies or to the plasma membrane

-Can be single-unit or multi-unit → Neurogenic (walls of blood vessels, iris)

-Myogenic and electronically linked via gap junctions
(peristaltic waves in GI tract)

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Smooth Muscle

-Autonomic NT released from varicosities along axon, not at motor endplate, affecting many cells

-Poorly developed SR, calcium mostly across plasma membrane

-Several ways to regulate calcium concentration (no troponin)

-One is via calcium-calmodulin complex that then binds to caldesmon, removing caldesmon from blocking actin binding sites

-Some smooth muscle responds to stretch (vessels, GI)

-Processes all very slow and require little energy

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Smooth Muscle

-Latch state
prolonged contraction, low energy use (0.3% striated)

Low rate of cross-bridge cycling

Mechanism not well-understood

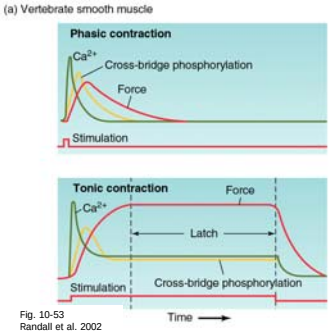

Fig. 10-53
Randall et al. 2002

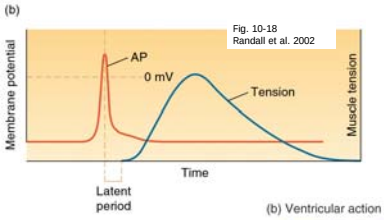

Fig. 10-18
Randall et al. 2002

Skeletal muscle

Cardiac muscle

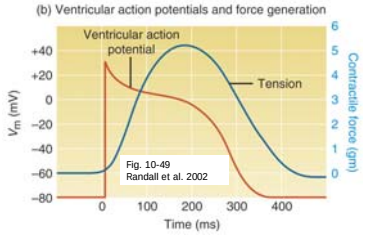

Fig. 10-49
Randall et al. 2002

TABLE 17.3 Characteristics of the three major types of muscles in vertebrates *(Part 1)*

	Skeletal	Multiunit smooth
Structure	Large, cylindrical, multinucleate fibers	Small, spindle-shaped, uninucleate cells
Visible striations	Yes	No
Mechanism of contraction	Thick myosin and thin actin filaments slide by each other	Thick myosin and thin actin filaments slide by each other
Cross-bridge action regulated by Ca^{2+} ions	Yes	Yes
Innervation	Somatic nervous system initiates contractions	Autonomic nervous system initiates contractions
Spontaneous production of action potentials by pacemakers	No	No

Sources: After Silverthorn 2004; Randall et al. 2002; and Sherwood 2004.

TABLE 17.3 Characteristics of the three major types of muscles in vertebrates *(Part 2)*

	Single-unit smooth	Cardiac
Structure	Small, spindle-shaped, uninucleate cells	Branched uninucleate fibers, shorter than skeletal muscle fibers
Visible striations	No	Yes
Mechanism of contraction	Thick myosin and thin actin filaments slide by each other	Thick myosin and thin actin filaments slide by each other
Cross-bridge action regulated by Ca^{2+} ions	Yes	Yess
Innervation	Autonomic nervous system modulates contractions	Autonomic nervous system modulates contractions
Spontaneous production of action potentials by pacemakers	Yes	Yes

Sources: After Silverthorn 2004; Randall et al. 2002; and Sherwood 2004.

TABLE 17.3 Characteristics of the three major types of muscles in vertebrates *(Part 3)*

	Skeletal	Multiunit smooth
Hormones influence function	No	Yes
Gap junctions present	No	No (few)
Transverse tubules	Yes	No
Sarcoplasmic reticulum	Abundant	Sparse
Source of Ca^{2+} ions for regulation	Sarcoplasmic reticulum	Extracellular fluid and sarcoplasmic reticulum
Troponin and tropomyosin	Both present	Tropomyosin only
Ca regulation	Ca and troponin; tropomyosin–troponin complex moves to expose myosin-binding sites on actin	Ca and calmodulin; phosphorylation of myosin light chains
Speed of contraction (reflecting myosin ATPase activity)	Varies from fast to slow depending on fiber type	Very slow

Sources: After Silverthorn 2004; Randall et al. 2002; and Sherwood 2004.

TABLE 17.3 Characteristics of the three major types of muscles in vertebrates *(Part 4)*

	Single-unit smooth	Cardiac
Hormones influence function	Yes	Yes
Gap junctions present	Yes	Yes
Transverse tubules	No	Yes
Sarcoplasmic reticulum	Sparse	Moderate
Source of Ca^{2+} ions for regulation	Extracellular fluid and sarcoplasmic reticulum	Extracellular fluid and sarcoplasmic reticulum
Troponin and tropomyosin	Tropomyosin only	Both present
Ca regulation	Ca and calmodulin; phosphorylation of myosin light chains	Ca and troponin; tropomyosin–troponin complex moves to expose myosin-binding sites on actin
Speed of contraction (reflecting myosin ATPase activity)	Very slow	Slow

Sources: After Silverthorn 2004; Randall et al. 2002; and Sherwood 2004.

Movement and Behavior

Nervous System and Muscle

integration, control, feedback

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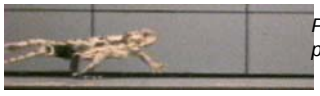
Dipsosaurus dorsalis

Callisaurus draconoides



Phrynosoma platyrhinos

Thanks to Duncan Irschick and Steve Reilly

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~Behavior Initiation

Animal Behavior, Neurobiology

Complex

Bring together nervous, endocrine, muscular systems, etc.

Respond to situation(s)
Parallel Processing

Reflexes / Learned / Plasticity

→ Complicated Neuronal Circuitry

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Simple Reflexes – basis of neuronal circuitry

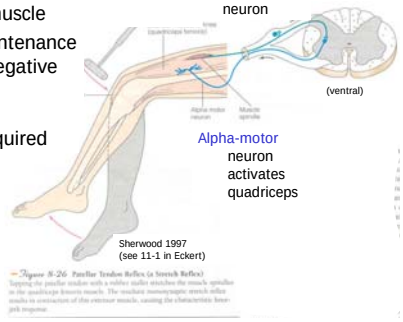
Reflex Arc, Stereotypic Behavior

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



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-efferent neurons innervate spindle

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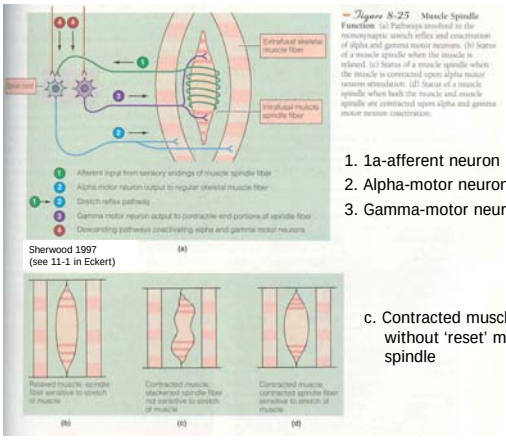


1. 1a-afferent neuron
2. Alpha-motor neuron
3. Gamma-motor neuron

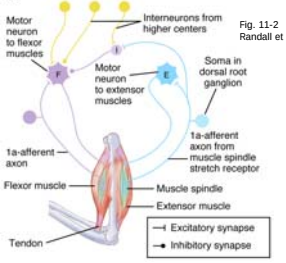
c. Contracted muscle without 'reset' muscle spindle

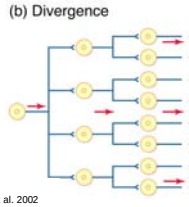
100

Simple Reflexes +

Other neurons become involved as well:

- 1a-afferents inhibit the antagonist muscle (Knee flexor ~hamstring)
- Conscious decision to bend leg etc.
- Limb





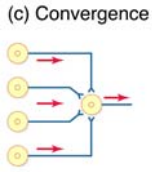


Fig. 11-2
Randall et al. 2002

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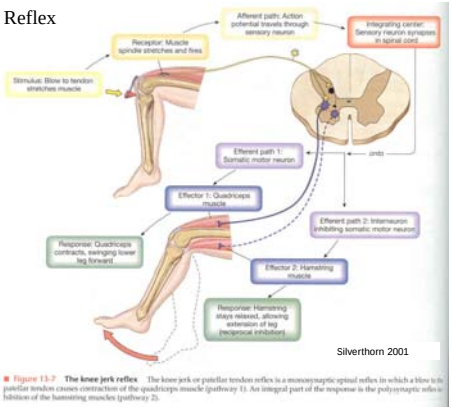
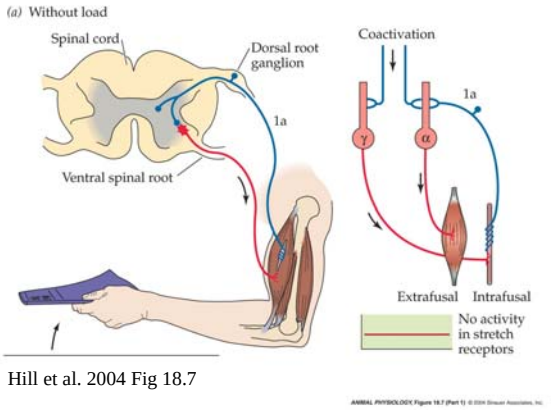
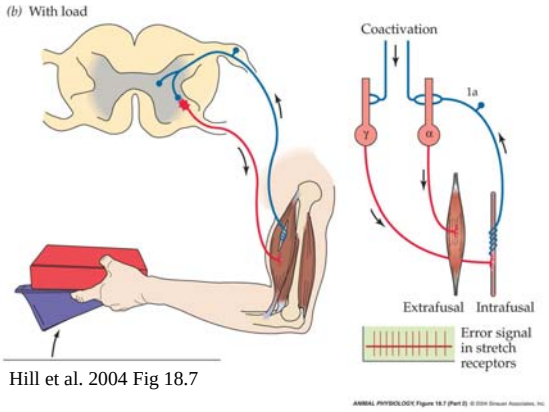
Stretch Reflex

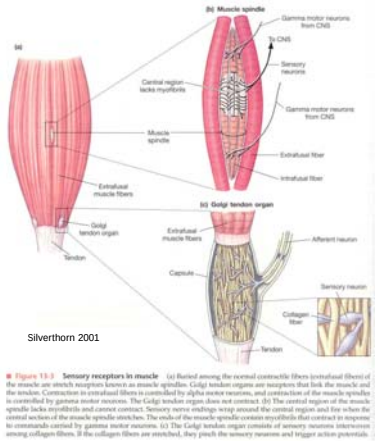




Hill et al. 2004 Fig 18.7



Hill et al. 2004 Fig 18.7



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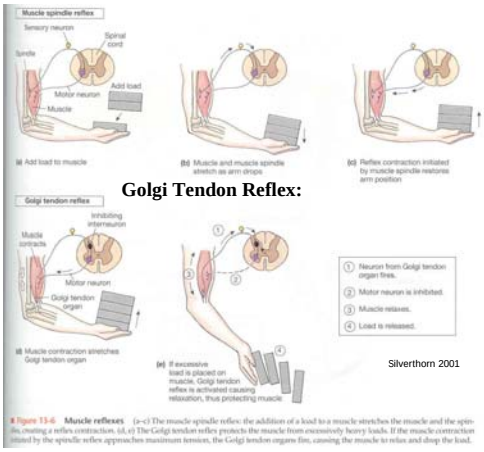

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Law of Nerve-Specific Energy

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

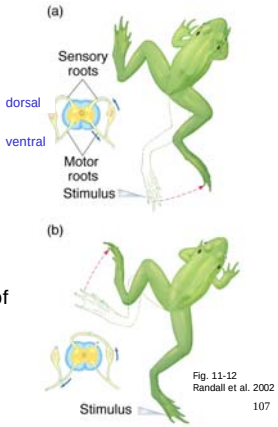

Fig. 11-12
Randall et al. 2002

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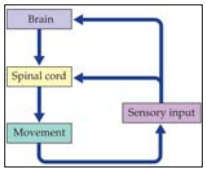
Peripheral vs. Central Control

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)

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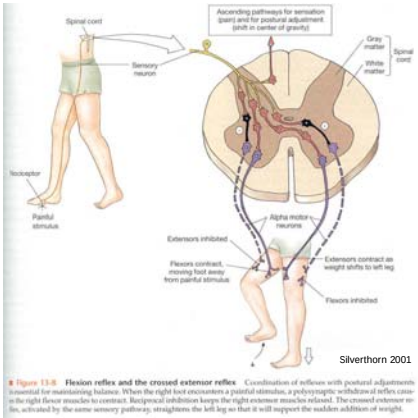

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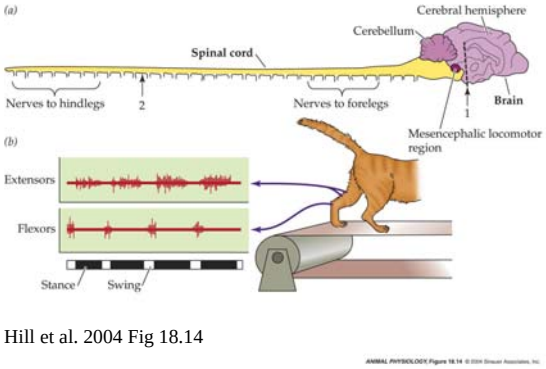
Central Pattern Generators in Cat Spinal Cord



Hill et al. 2004 Fig 18.14

Fixed Action Patterns...

Herring Gull Egg Retrieval

http://salmon.psy.plym.ac.uk/year1/ETHEXPT.HTM#Egg%20retrieval

Baerends & Kruijt found that herring gulls:
prefer the **larger** of two eggs of the same colour
prefer the **speckled** egg over an unspeckled egg of the same colour
- prefer natural coloured (brown speckled) eggs over brown unspeckled eggs
- prefer green speckled eggs over green unspeckled eggs

prefer **green** eggs over brown eggs