Reflexes

Definition of Reflexes

- A reflex is a rapid, predictable motor response to a stimulus.

- Neural reflexes involve sensory fibers to CNS and motor fibers to effectors.
Nature of Reflexes

- Reflexes are classified according to
  - Development (acquired vs learned)
  - Type of motor response involved (somatic vs visceral)
  - Processing site (Spinal vs Cranial)
  - Complexity of the neuronal circuit (Monosynaptic vs polysynaptic)
Nature of Reflex Responses

- **Innate reflexes**: Result from connections that form between neurons during development and usually already present at birth (for ex: suckling behavior of babies; withdrawal from heat source)

- **Acquired reflexes**: Learned reflexes over time, and typically more complex (reactions that 'evolve' into reflexes)

The distinction between innate and acquired is not always absolute and some reflexes can be modified/enhanced by repetition, or inhibited if the situation so requires. (not withdrawing from a pain signal because it may cause more bodily harm...)

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Nature of Reflex Responses

- **Somatic Reflex**: Reflexes involving skeletal muscles and somatic motor neurons (one is thus conscious aware that this reflex happened)

- **Visceral Reflex**: Reflexes controlled by autonomic neurons
  - Heart rate, respiration, digestion, urination, etc
  - Usually unaware of the occurrence of this reflex
Nature of Reflex Responses

- **Cranial Reflex**: Reflexes processed in the brain

- **Spinal Reflex**: Interconnections and processing events occur in the spinal cord

- **Monosynaptic reflex**: Indicates only 1 (one) synapse is involved.
  This is when the incoming signal via the sensory neuron synapses directly with the outgoing motor neuron

- **Polysynaptic reflex**: At least one interneuron exists between sensory afferent and motor efferent

  The more synapses involved, the longer the ‘delay’ in action
Components of a Reflex Arc

- 1. Activation of a **Receptor**: site of stimulus
- 2. Activation of a **Sensory Neuron**: transmits the afferent impulse to spinal cord (CNS)
- 3. Information processing at the **Integration center**: via monosynapses or polysynapses (and interneurons) between the sensory and motor neurons.
  - In CNS, they thus form the spinal reflexes or cranial reflexes
### Components of a Reflex Arc

- **4. Activation of a Motor Neuron**: transmits the efferent (outgoing) impulse to effector organ

- **5. Response of a peripheral Effector**: Muscle or gland that responds

Note that the following diagram depicts an example of somatic, polysynaptic reflex. You also can see a collateral branch, crossing over to the other side of the SC, and providing an ascending signal to the brain, making a person aware that the stimulus and reflex happened.
Spinal Reflexes

- 4 important somatic spinal reflexes
  - Stretch
  - Tendon
  - Flexor(withdrawal)
  - Crossed extensor reflexes
Stretch Reflexes

- Stretch reflexes in general monitor skeletal muscle length
- The typical example is the patellar (knee jerk) reflex.
- The sensory receptors are muscle spindles that become activated when a muscle is stretched (see next diagram)

**Muscle spindles contain intrafusal fibers connected to afferent neurons. Stretching the muscle increasing the action potentials in those neurons, resulting in a feedback reflex and contraction of the muscle cells via motor neurons.**
Stretch Reflexes

- The knee jerk reflex is a somatic mono-synaptic reflex. (since you control skeletal muscle voluntarily, you can consciously decrease that reflex if you want to).
- An impulse is transmitted by afferent fibers to the spinal cord and motor neurons in the spinal cord cause the stretched muscle to contract
- But it also involves a polysynaptic reflex aspect, which acts to relax the antagonist muscle (this is called reciprocal innervation)
Stretch Reflex Example

Patellar Reflex

- Thus during the patellar reflex, a monosynaptic reflex arc causes the Quadriceps muscle to contract while a polysynaptic reflex inhibits (relaxes) the hamstring muscle.

- Lower leg kicks forward.

- Such reflexes are important as it allows for demonstration of a complete circuit of sensory and motor connections between muscle and spinal cord e.g. circuit is intact.)
Tendon Reflexes

- Monitors external tension produced during muscular contraction to prevent tendon damage
  - Controls muscle tension by causing muscle relaxation

- The receptor is in the tendon of the muscle and called a Golgi tendon organs (sensory receptor)
  - activated by stretching of tendon
  - For example: when a muscle is contracting against a load that is too heavy and thus may cause damage to the tendon (e.g. tendon may snap)

- The example shows a quadriceps contracting, and thus resulting in a forward motion of the lower leg. But another force is pulling the lower leg backwards, thus creating strain and tension in the quad tendon
- In this case we have two polysynaptic reflexes.
- Golgi tendon organs in tendon (sensory receptor) activates sensory neuron (1,2). In SC (3), via an interneuron, it activates an inhibitory neuron, resulting in hyperpolarization of the motor neuron(4) and the quads relax. (5)
- A second polysynaptic reflex activates the hamstrings.
- The result is that Both tendon & muscle are protected
Tendon Reflex
(notice lower leg is being pulled backwards while quads are contracting)

Golgi Tendon Reflex

Not shown in this figure is the reciprocal innervation, which will activate the triceps and help relieve the tension on the bicep tendon)
Flexor Reflex

- Withdrawal reflex

- When pain receptors are activated it causes automatic withdrawal of the threatened body part.

- It involves a polysynaptic ipsilateral (response on same side as stimulus) reflex arc

Flexor (withdrawal) reflex

STEP 1: Arrival of stimulus and activation of receptor

STEP 2: Activation of a sensory neuron

STEP 3: Information processing in CNS

STEP 4: Activation of a motor neuron

STEP 5: Response by effector

Receptor

Dorsal root

Ventral root

Effector

Sensation relayed to the brain by collateral
**Flexor (Withdrawal) Reflex**

- This figure shows that such reflexes can involve communication between several spinal cord segments.
- This depends on the number of muscles involved in the reflex action.

**Crossed Extensor Reflex**

- Complex reflex that consists of an ipsilateral withdrawal reflex and a contralateral extensor reflex.
- This keeps you from falling over, for example if you step on something painful. When you pull your foot back, the other leg muscles need to respond to hold you up.
- The next figure shows for example a flexor reflex in the right leg with a extension reflex in the left leg.
Superficial Reflexes

- Elicited by gentle cutaneous stimulation

- Important because they involve upper motor pathways (brain) in addition to spinal cord neurons
Superficial Reflexes

Plantar Reflex

- Tests spinal cord from L4 to S2
- Indirectly determines if the corticospinal tracts of the brain are working
- Draw a blunt object downward along the lateral aspect of the plantar surface (sole of foot)
- Normal: Downward flexion (curling) of toes

![Plantar Reflex Diagram](image)
Abnormal Plantar Reflex: Babinski’s Sign

- Great toe dorsiflexes (points up) and the smaller toes fan laterally
- Happens if the primary motor cortex or corticospinal tract is damaged
- Normal in infants up to one year old because their nervous system is not completely myelinated.