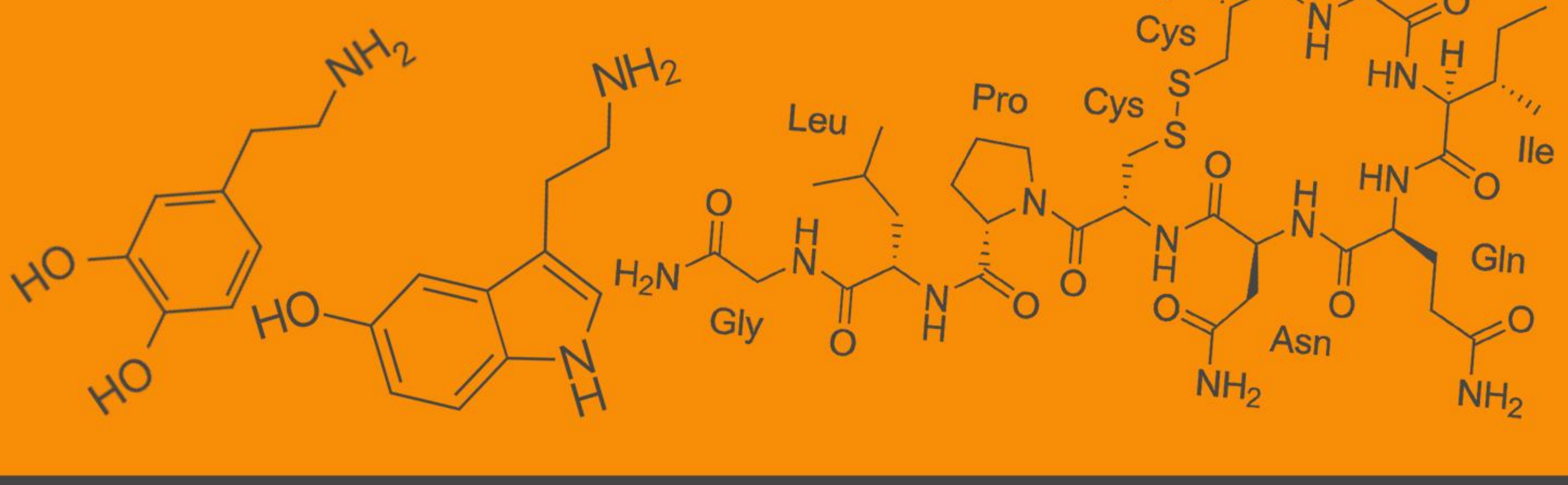


MEDICINE438's CNSPHYSIOLOGY

Lecture XVII: Physiology of Postural Reflexes

EDITING FILE GSLIDES

IMPORTANT MALE SLIDES EXTRA FEMALE SLIDES LECTURER'S NOTES

1 PHYSIOLOGY OF POSTURAL REFLEXES

Lecture Seventeen

OBJECTIVES

- Able to define human posture.
- Explain/define the concepts of " center of gravity '' and " support base ".
- Explain what are postural reflexes and their overall function .
- Know the centers of integration of postural reflexes .
  Explain the structure and function of the vestibular apparatus (utricle, saccule & semicircular canals) in maintenance of balance.
- Describe decorticate rigidity and decerbrate rigidity and explain the mechanisms underlying them .

POSTURE & EQUILIBRIUM

- Posture is the attitude taken by the body in any particular situation like standing posture, sitting posture, etc. even during movement, there is a continuously changing posture.
- The basis of posture is the ability to keep certain group of muscles in sustained contraction for long periods.
- Variation in the degree of contraction and tone in different groups of muscle decides the posture of the individual.

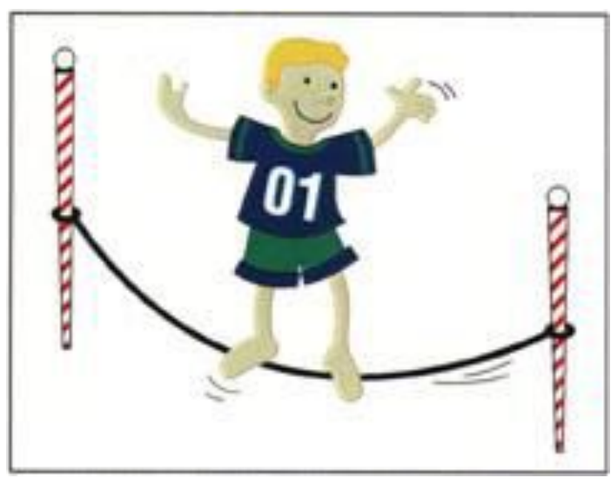


Figure 17-1

Postural Reflexes

Postural reflexes are reflexes that resist displacement of the body caused by gravity or acceleratory forces, and they have the following functions:

1. Maintenance of the upright posture of the body.
2. Restoration of the body posture if disturbed.
3. Providing a suitable postural background for performance of voluntary movements.

Pathways Of Postural Reflexes

The main pathways concerned with posture are:

1. Medial tracts control proximal limbs & axial muscles for posture & gross movements.
2. Lateral pathways as (corticospinal – rubrospinal) control distal limbs.

RECEPTORS OF POSTURAL REFLEXES

Vestibular Apparatus Receptors

1. Maculae (utricle,saccule):
for linear acceleration & orientation of head in space
2. Semicircular canals cristae: for angular acceleration.

Proprioceptors

A. Neck proprioceptors which detect head position in relation to the trunk.
B. Body proprioceptors of antigravity muscles.
C. Pressure receptors of the sole of feet which initiate positive supporting reaction(magnet reflex)

Visual and Auditory receptors

Vision can compensate for loss of auditory, vestibular and proprioception receptors (Tabes dorsalis +ve Rombergism)

Table 17-1

INTEGRATION CENTERS OF POSTURAL REFLEXES

1. Spinal cord
2. Medulla
3. Midbrain
4. Cerebral cortex
5. Cerebellum

Table 17-2

STATIC POSTURAL REFLEXES

First: Spinal Static Reflexes

Center: Spinal Cord

Spinal reflexes can be studied in spinal animal with cut at neck below the spinal cord and brainstem, therefore the all of the spinal cord is intact.

1. **Local static reflexes: Confined to stimulated limb.**

A. Stretch reflex: This is the most important local static reflex which controls the tone in those extensor muscles which keep the body upright (antigravity muscles)

B. Positive supporting reaction (magnet reflex) (receptors are proprioceptors of flexors. Deep pressure on the sole lead to contraction of both flexors & extensors to convert the whole lower limb into a rigid column to support body weight

C. (BOX 17-1)

2. **Segmental static reflexes:**

Mediated by one segment of the spinal cord as:

A. Crossed extensor reflex

B. Negative supporting reaction: Disappearance of positive supporting reaction.

- Receptors are proprioceptors of extensors of the released limb

Second: Medullary Static Reflexes

Center: Medulla Oblongata

1. **Neck static reflexes (BOX 17-1)**

Studied in a decerebrated animal cut above medulla with labyrinth destroyed.
Stimulus: changing head position that stimulates neck proprioceptors.

A. Ventroflexion of head (Figure 17-2): Flexion of forelimb and extension of hindlimb (as in decortication).

B. Dorsiflexion of head (Figure 17-2): Extension of forelimb and flexion of hindlimb.

C. Turning head to one side:

Extension of limbs on that side and flexion of other side (as in decortication).

2. **Labyrinthine static reflex**

Studied in a decerebrated animal with elimination of neck proprioceptors and with the labyrinth intact

- Receptors: Otolith organs (maculae)
- Stimulus: Gravity

1. Placing the animal in prone position (Ventroflexion of head): 4 limbs flexion.
2. Placing the animal in supine position (Dorsiflexion of head): 4 limbs extended.

Third: Midbrain Static (Rightning) Reflexes

Discussed in next page.

BOX 17-1: Medical Physiology for Undergraduate Students

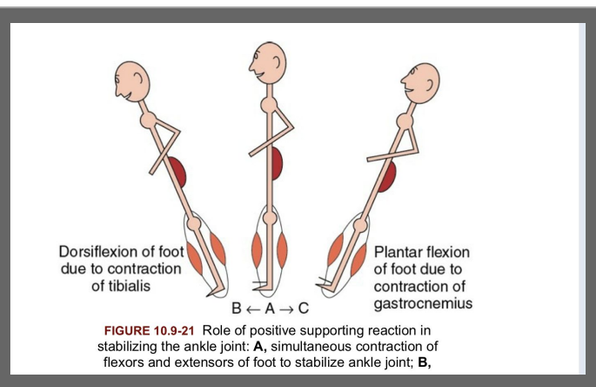


FIGURE 10.9-21 Role of positive supporting reaction in stabilizing the ankle joint: **A,** simultaneous contraction of flexors and extensors of foot to stabilize ankle joint; **B,**

Figure 17-2: Positive supportive reaction is seen here, note that pure flexion of the flexor compartment of the leg (plantar flexion) will throw the body backwards. Pure flexion of the extensor compartment (dorsiflexion) will throw the body to the front. Simultaneous contraction of both causes the legs to be fixed in the middle.

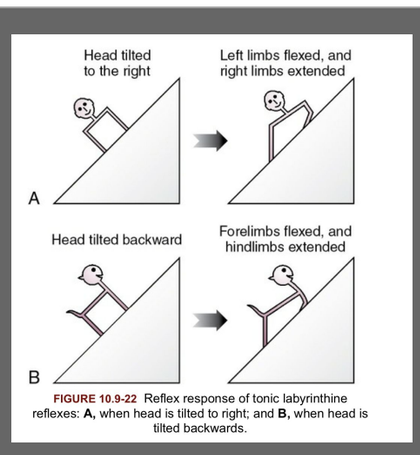


FIGURE 10.9-22 Reflex response of tonic labyrinthine reflexes: **A,** when head is tilted to right; and **B,** when head is tilted backwards.

Figure 17-3: Showing neck static reflexes.

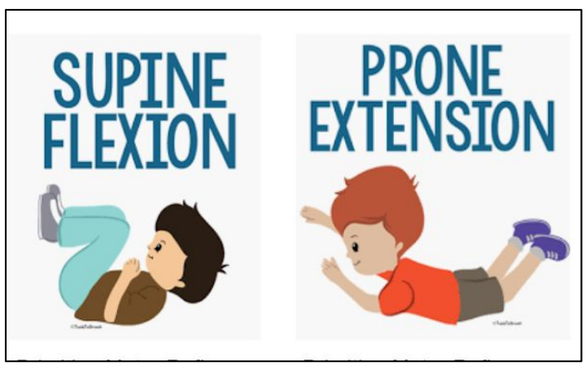


Figure 17-4: Showing labyrinthine static reflexes.

Righting Reflexes

- When upright posture is disturbed as is in falling down.
- Studied in a decerebrated animal with cut above midbrain "Upper decerebration"
- Initiated by signal from otolith organs, neck proprioceptors , pressure receptors of the body as well as from visual receptors.

- All static labyrinthine reflexes have macula as receptors, but in statokinetic reflexes during motion semicircular canals act as receptors. (Macula act in linear acceleration & SCC receptors act in angular acceleration)

Reflex	Center	Stimulus	Receptors	Response
1. Visual Righting reflex Studied in an intact animal with cutting of upper theee cervical nerves and a destroyed labyrnith.	Cerebral cortex	Visual stimulus	Eye receptors	Correct position of head & body
2. Labyrinthine righting reflex	Midbrain	When the eyes are covered and the object is held in the air from pelvis. E.g: Tilting the head with covered eyes	Otolith organs	**Righting of head** by stimulating neck muscles to correct the head level, when the head is not in proper site
3. Body on head righting reflex		Pressure on side of body & head is free	Body pressure receptors	Reflex contraction of the head
4. Body on body righting reflex		Pressure on side of body, while head is FIXED	Body pressure receptors	Reflex contraction of the body
5. Neck righting reflex		- Correction of the head by B1 & B2 reflexes lead to twisting of the nick, this initiate reflex righting of the body. - **Stretch of neck muscles**, if head is corrected and body is tilted	Proprioceptors of neck muscles	Righting of body and shoulders

See next slide for illustrative pictures.

Righting Reflexes

Jump to the 2nd half of the video

Righting/Equilibrium Reflexes

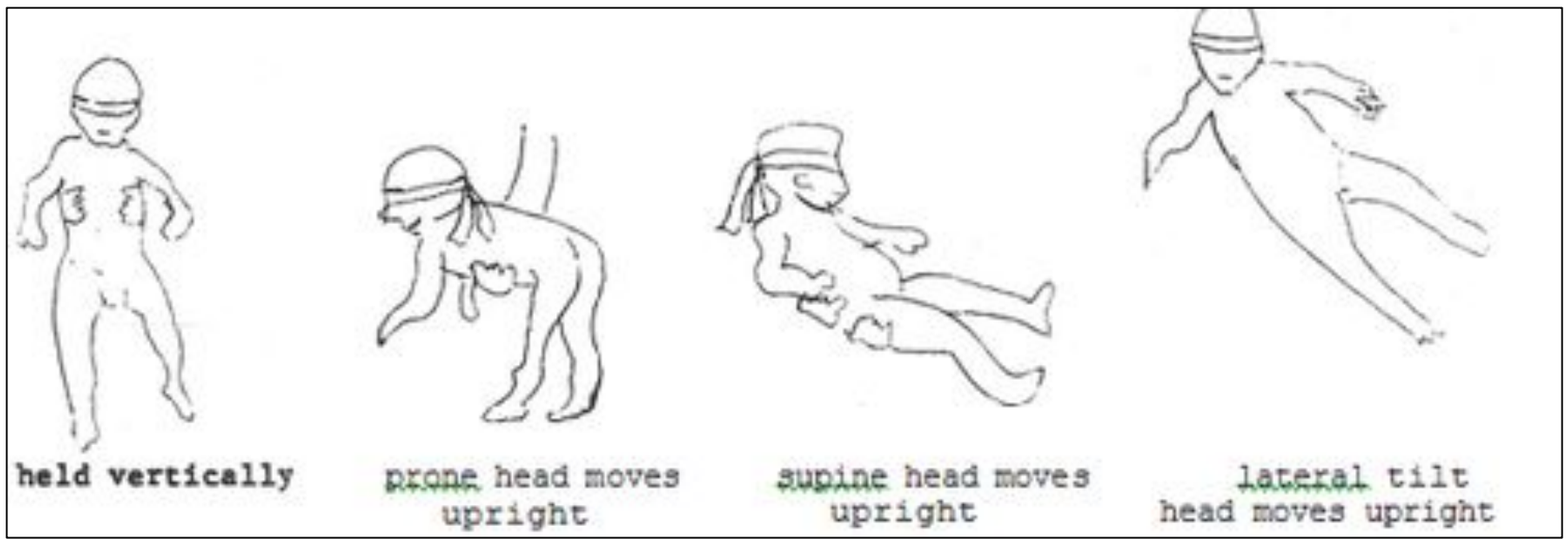


Figure 17-5 Labyrinthine righting reflexes

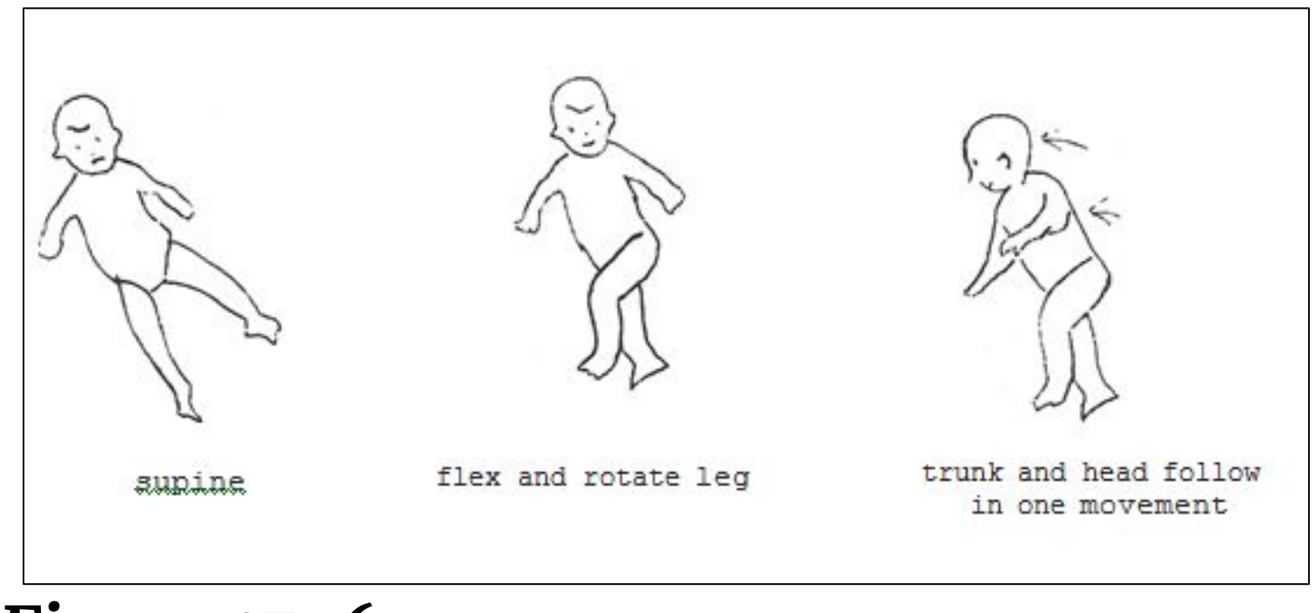


Figure 17-6. Body on head + Body on body righting reflexes

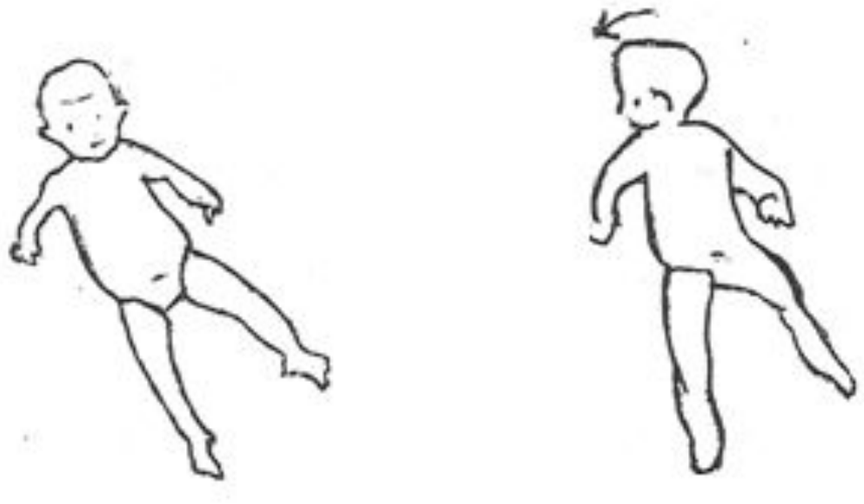


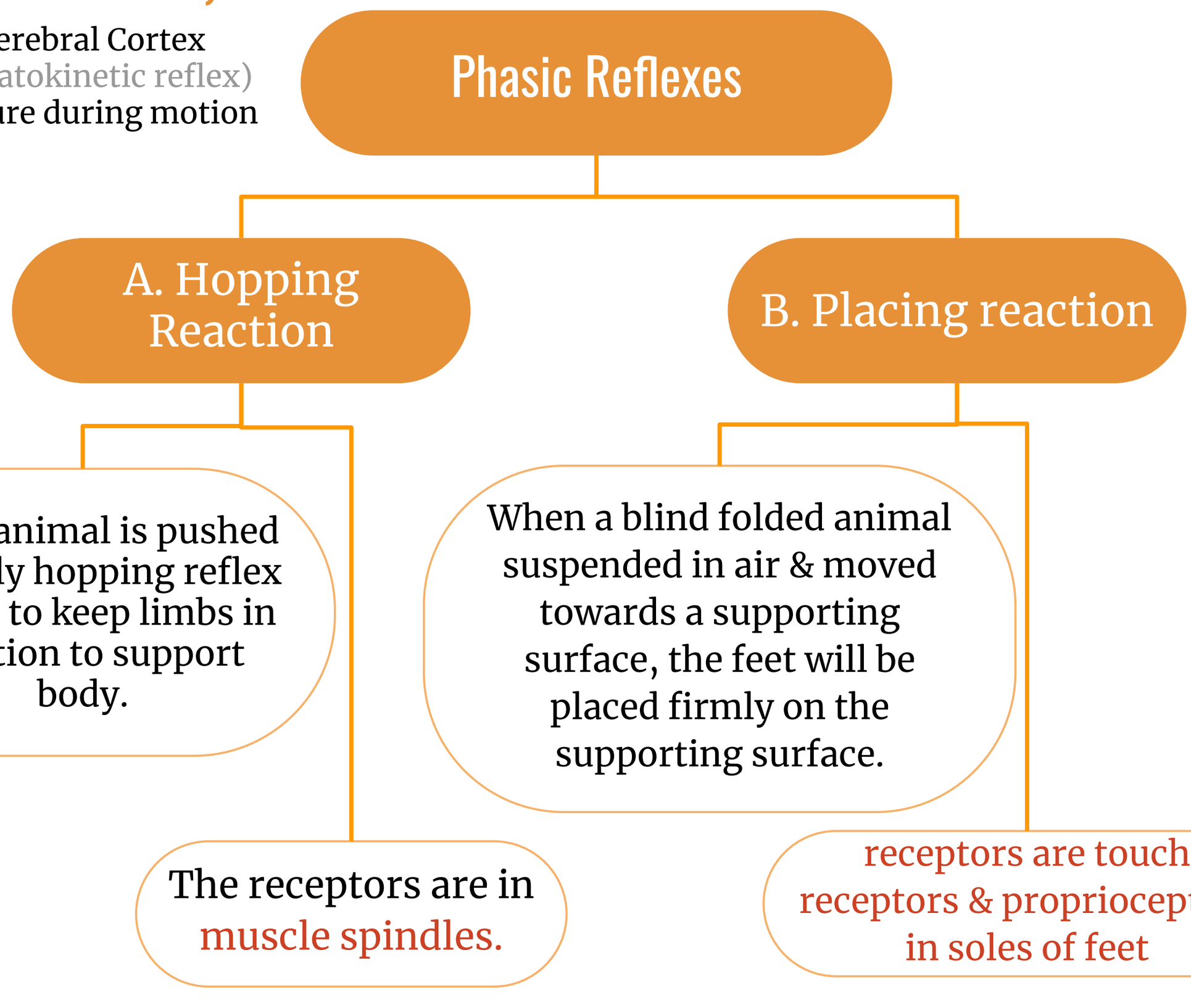
Figure 17-7. Neck righting reflexes

Phasic (statokinetic) Reflexes

- Center in Cerebral Cortex

(with motion) (statokinetic reflex)

- Maintain posture during motion



Decerebrate Rigidity

- **Site of lesion:** between the superior and inferior colliculi of the midbrain, lesion below Red Nucleus[1] (e.g. mid-collicular lesion).
- block normal inhibitory signals from brain & red nucleus in midbrain to tonically active **pontine reticular formations[2] & vestibular nucleus[3]** causing:

Extensive extensor posture of all extremities → Rigidity of all 4 limbs.

- All limbs extended, arms extended by the sides & rotated internally (outward).
- Hallmark → elbows extended.
- Head may be arched to the back, it is due to:

Increased general excitability of the motor neuron pool; especially Gamma efferent discharge (due to facilitatory effects of the un inhibited Vestibulospinal Tract)
"Hyperactivity of gamma discharges"

Decerebrate posture results from damage to the upper brain stem. In this posture, the arms are adducted and extended, with the wrists pronated and the fingers flexed. The legs are stiffly extended, with plantar flexion of the feet.

Figure 17-8. Decerebrate posture.

- **In a decerebrated animal:**
  - damage to level below red nucleus.

Features of decerebrate rigidity:

1. Hyperextension of all four limbs.
2. Dorsiflexion (hyperextension) of tail and head. (jaw may be clenched with the neck hyperextended)
3. Extreme hyperextension of the spine (opisthotonus) produces concave configuration of the back.
4. The animal can be made to stand on four limbs but is easily toppled by slight push..

- **Reflexes that are lost/absent:**

1. Optical (visual) righting reflexes.

- **Reflexes that are retained/still present**: i.e. reflexes that don't depend primarily on cerebrum:

Maintained tonic static postural reflexes that support animal against gravity (medullary tonic & labyrinthine reflex).

1. Tonic Labyrinthine reflexes.
2. Tonic Neck Reflexes.
3. Other Righting Reflexes.

FOOTNOTES

1. Remember, the red nucleus gives the rubrospinal tract, the rubrospinal tract is excitatory for flexors and inhibitory for extensors. Also the red nucleus causes inhibition of pontine reticular formation through activation of medullary of reticular formation, which basically antagonize the action of pontine reticular formation.
2. Pontine reticular formation activates alpha and gamma discharge for extensors and antigravity muscles, they receive excitatory signals from the vestibular nuclei. However, they have natural degree of excitability either way . They are inhibited through the action of medullary reticular formations, the medullary reticular formations are activated by: (1) red nucleus, (2) basal ganglia, (3) paleocerebellum, (4) suppressor area 4 and 6.

Decorticate Rigidity

- In humans, where true decerebrate rigidity is rare, since the damage to the brain centers involved in it are lethal.
- Decorticate rigidity more common in human than decerebate rigidity, due to: Lesion in cerebral cortex, but brain stem is intact. However decorticate rigidity can be caused by bleeding in the internal capsule which causes Upper Motor Neuron Lesion "UMNL" (damage to upper motor neurons). As seen in hemiplegic patients after hemorrhage of internal capsule.

- Symptoms & Signs: (Seen at rest)

- Flexion in the upper limbs. Arm lying across the chest, semiflexion at the elbow,slight pronation of forearm, flexion of wrist and fingers
- extension in the lower limbs. Why wouldn't we have flexion in the Lower limbs as in the upper limbs? **Because the excitatory influence in the LM is more than the inhibitory**
- Turning the head to one side initiates tonic reflexes, e.g. turning head to left → extension of limbs on the left side + flexion of the right side.

Decorticate posture results from damage to one or both corticospinal tracts. In this posture, the arms are adducted and flexed, with the wrists and fingers flexed on the chest. The legs are stiffly extended and internally rotated, with plantar flexion of the feet.

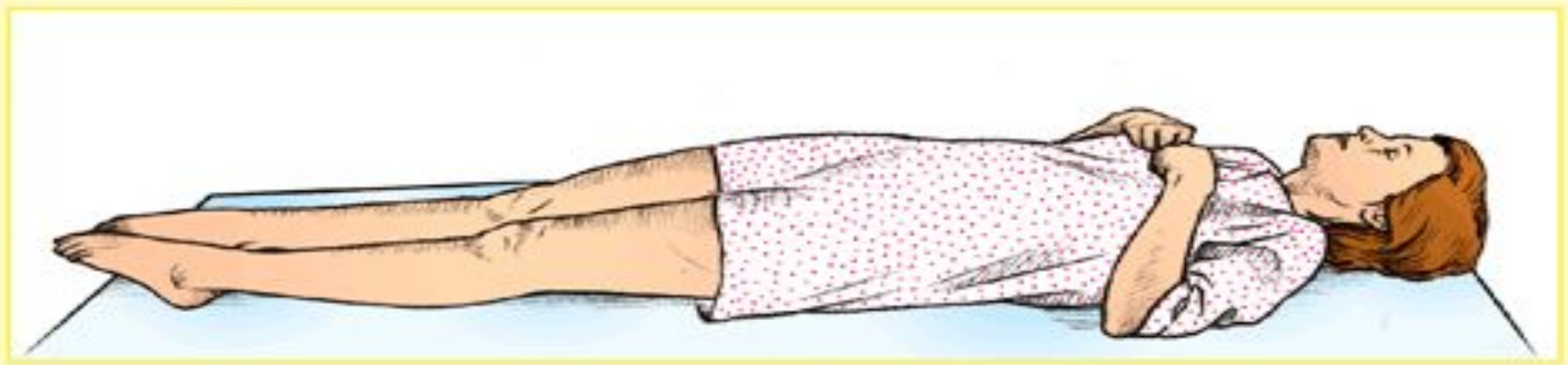


Figure 17-9. Decorticate posture.

- **In a decorticated animal:**

- Decorticate animal is one in whom the whole cerebral cortex is removed but the basal ganglia and brain stem are left intact.

- Characteristic features: moderate rigidity is present
- Cortex inhibit medullary reticulospinal tract. Therefore, removal of cortex results in facilitation of γ motor neuron discharge.

- **Reflexes that are lost/absent:**

1. Placing reaction, hopping reaction
2. Visual righting reflex

- **Reflexes that are retained/still present**: i.e. reflexes that don't depend primarily on cerebral cortex:

1. Tonic Labyrinthine reflexes.
2. Tonic Neck Reflexes.
3. Other Righting Midbrain Reflexes.

Decorticate Rigidity and Decerebrate Rigidity

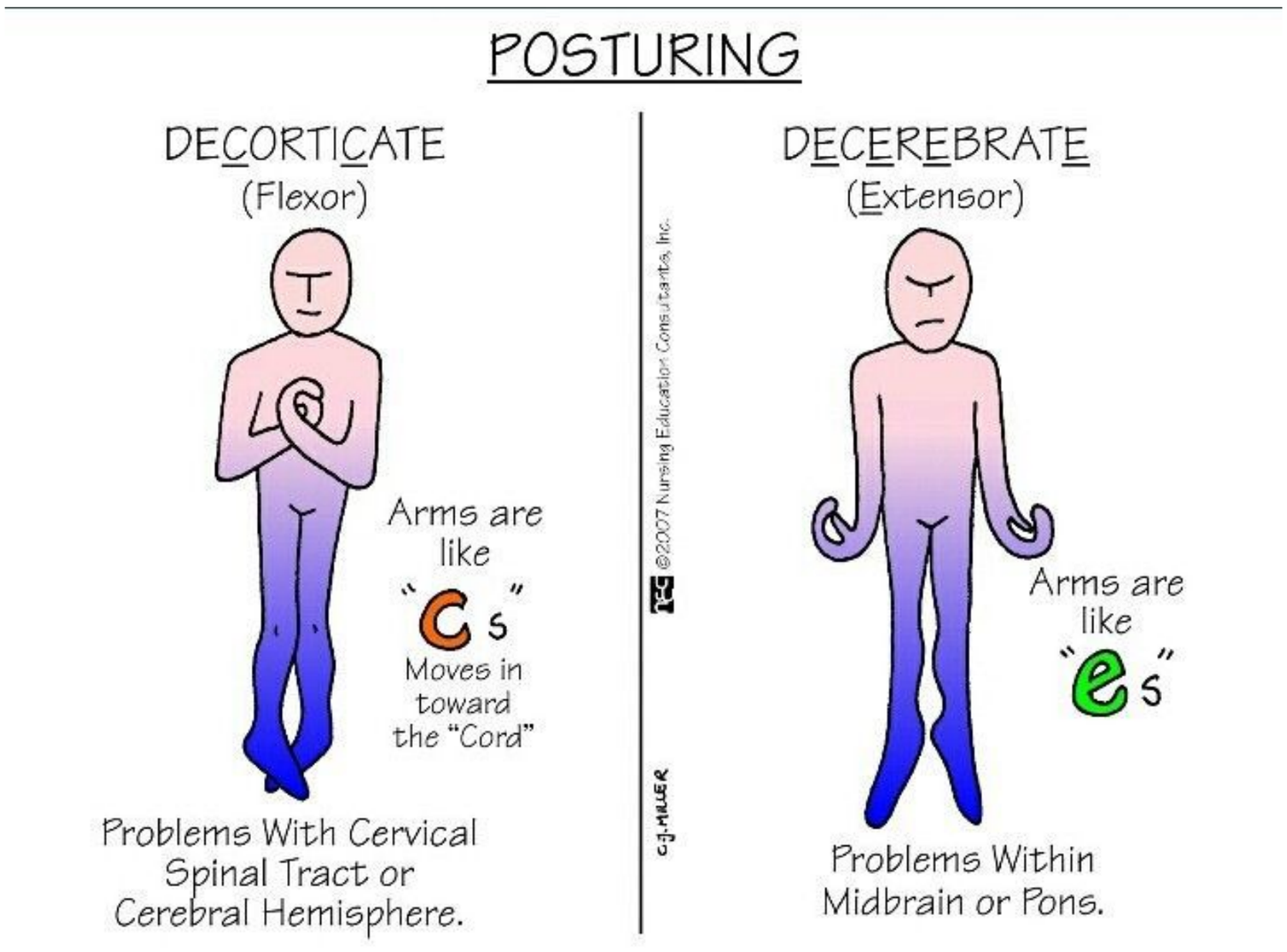


Figure 17-9

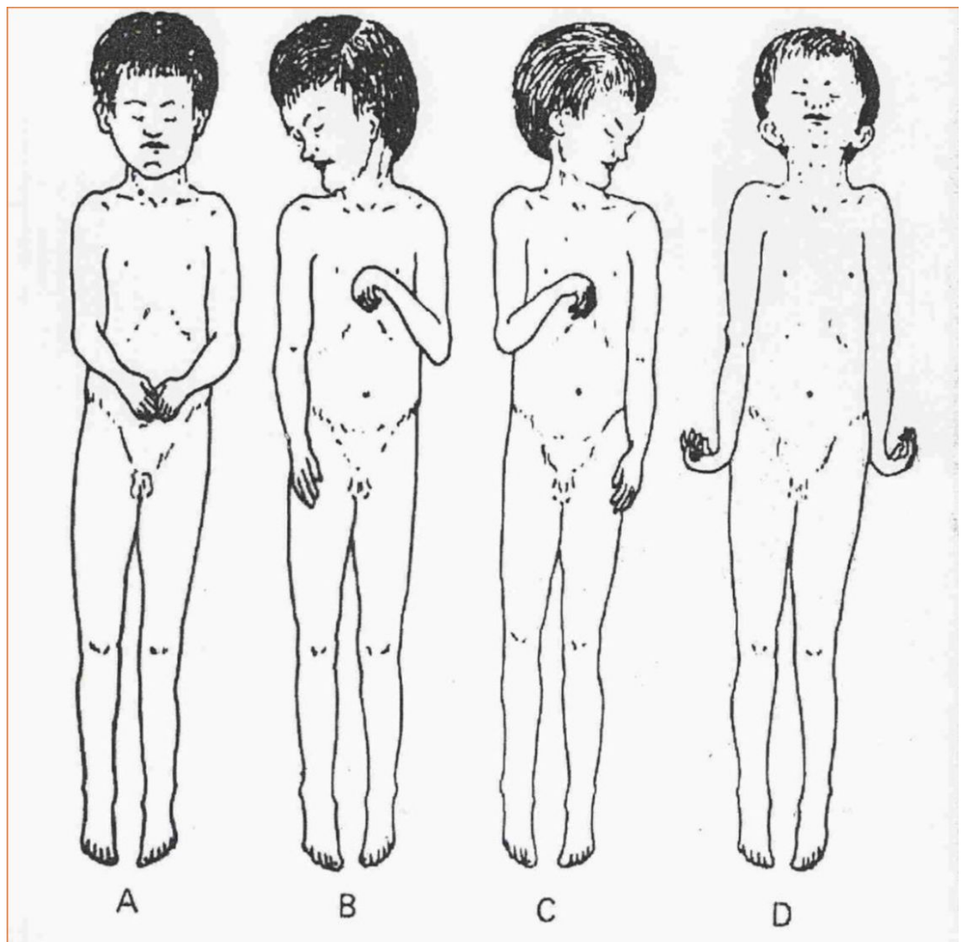


Figure 12–7. Human decorticate rigidity ***(A–C)*** and true decerebrate rigidity ***(D).*** In ***A*** the patient is lying supine with the head unturned. In ***B*** and ***C,*** the tonic neck reflex patterns produced by turning of the head to the right or left are shown. (Reproduced, with permission, from Fulton JF [editor]: *Textbook of Physiology,* 17th ed. Saunders, 1955.)

Figure 17-10

Summary

Reflex	Stimulus	Response	Receptor	Integrated In
Stretch reflexes	Stretch	Contraction of muscle	Muscle spindles	Spinal cord, Medulla
Positive supporting (magnet) reaction	Contact with sole or palm	Foot extended to support body	Proprioceptors inn distal flexors	Spinal cord
Negative supporting reaction	Stretch	Release of positive supporting reaction	Proprioceptors in extensors	Spinal cord
Tonic labyrinthine reflexes	Gravity	Contraction of limb extensor muscles	Otolithic organs	Medulla
Tonic neck reflexes	Head turned: 1) To side 2) Up 3) down	Change in pattern of extensor contraction 1) Extension of limbs on side to which head if turned 2) Hind legs flex 3) Forelegs flex	Neck proprioceptors	Medulla
Labyrinthine righting reflexes	Gravity	Head kept level	Otolithic organs	Midbrain
Neck righting reflexes	Stretch of neck muscles	Righting of thorax and shoulders, then pelvis	Muscle spindles	Midbrain
Body on head righting	Pressure on side of body	Righting of head	Exteroceptors	Midbrain
Body on body righting	Pressure on side of body	Righting of body even when head held sideways	Exteroceptors	Midbrain
Optical righting reflexes	Visual cues	Righting of head	Eyes	Cerebral cortex
Placing reactions	Various visual, exteroceptive, and proprio-ceptive cues	Foot placed on supporting surface in position to support body	Various	Cerebral cortex
Hopping reactions	Lateral displacement while standing	Hops, maintaining limbs in position to support body	Muscle spindles	Cerebral cortex

QUIZ

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1. Posture depends on:
A) Gravity
B) Vision
C) Muscle tone
D) Hearing

2. For efficient well-coordinated posture we need:
A) Vestibular apparatus.
B) Basal ganglia
C) Cerebellum
D) All of them

3. Which of the following spinal reflexes is mediated by one segment of the spinal cord?
A) Stretch reflexes
B) Segmental static reflex
C) Local static reflex
D) Negative supporting reflex

4. Which of the following is a stimulus of neck static reflex?
A) Changing in position of head
B) Gravity
C) Raising limbs
D) Standing up

5. Which one of the following help in maintain of posture at rest

A) Medullary reflexes
B) Phasic reflexes
C) Hopping reaction
D) Placing reaction

SHORT ANSWER QUESTION

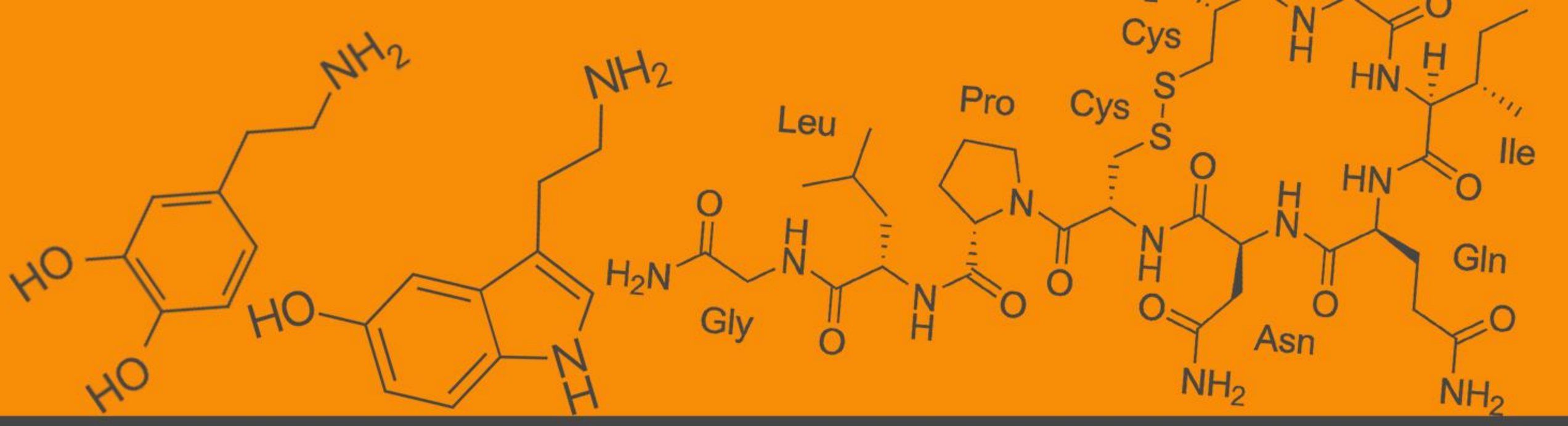
1. In what condition can you best study the labyrinthine static reflex?

2. List the two components of the spinal local static reflexes.

SAQ ANSWERS:

1. Decerebrated animal with elimination of neck proprioceptors.
2. Positive supporting reaction, static stretch reflex

ANSWER KEY: C. D, B, A, A



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REFERENCES

- Medical Physiology for Undergraduate Students