




# Spinal Cord

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## Outline of the Lecture

NRS 202 H

- Segmental nature of the vertebrate body
- The spinal cord is segmented
- The spinal cord is protected by the vertebral column
- Spinal cord segments are named for their associated vertebrae
- Developmental "ascent" of the cord – cauda equina
- Internal structure of the cord
- Variations in grey and white matter in different regions of the spinal cord

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## Learning Objectives

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- When you have learned the material in this lecture you should be able to:
  - Name the segments of the spinal cord and describe what general body areas they supply
  - Describe the components of a spinal nerve
  - Describe the cauda equina and explain how it forms in the fetus.
  - Distinguish between grey and white matter in the spinal cord.
  - Explain why grey and white matter in different segments of the spinal cord vary in amount and distribution and identify spinal levels from their appearance.
  - Identify the locations of sensory and motor neurons in the grey matter.

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## Segmental nature of the vertebrate body

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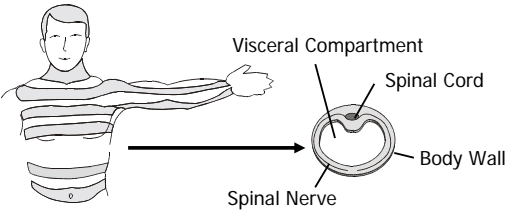
- The vertebrate body evolved as a stack of nearly identical segments.
- Specializations in various segments, e.g. the evolution of the limbs, makes the segmental nature difficult to discern, but...
- It can still be seen in the ribs and in the spinal cord.

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## Segmental nature of the vertebrate body, continued

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Each segment of the body is innervated by a single pair of spinal nerves.

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## The spinal cord is segmented

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- Each spinal segment has one pair of spinal nerves
- Each spinal segment supplies sensory innervation for its own area of body wall (dermatomes)
  - The dermatomes overlap somewhat
- Each spinal segment supplies motor innervation of its own target muscles (myotome)
  - The myotomes are not as anatomically obvious as the dermatomes
- There are 31-32 spinal segments in the human body.

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## The spinal cord is protected by the vertebral column

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- The vertebral column is formed by a stack of bones called vertebrae.
- Each vertebra has a *body* – a weight-bearing part, and a *neural arch* that houses the spinal cord
- The neural arches of stacked the vertebrae forms the spinal (or vertebral) canal.
- The spinal nerves leave the spinal canal through foramina (openings) between the vertebrae.

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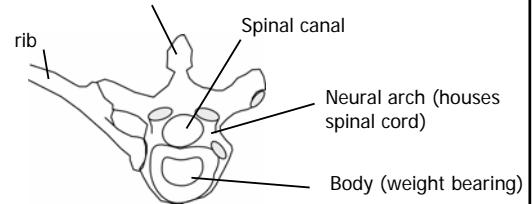
7



## Vertebra – viewed from above

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Vertebral spine (the knobs you feel in your back)



The grey areas are articular facets where the vertebra forms joints with the ribs and with vertebrae above and below

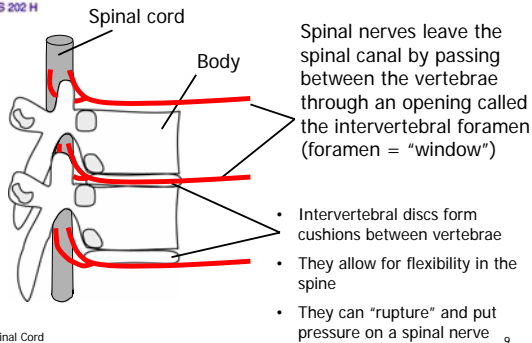
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8



## Two Vertebrae viewed from the side

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Spinal nerves leave the spinal canal by passing between the vertebrae through an opening called the intervertebral foramen (foramen = "window")

- Intervertebral discs form cushions between vertebrae
- They allow for flexibility in the spine
- They can "rupture" and put pressure on a spinal nerve

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9



## Spinal nerves are named for the vertebrae they are associated with

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- There are 7 cervical vertebrae (cervical = neck)
- They are named C1-C7 starting at the top
- There are 8(?) cervical spinal nerves.
  - (a small spinal nerve, C1 emerges above vertebrae C1)
  - The remaining cervical nerves, C2-C8 emerge below vertebrae C1-C7

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10



## Spinal nerves are named for the vertebrae they are associated with

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- There are 12 thoracic vertebrae named T1-T12 from the top down
- There are 12 thoracic spinal nerves, named T1-T12, from the top down
  - Each spinal nerve is named for the vertebrae above which the nerve emerges
- There are 5 lumbar vertebrae, named L1-L5
- There are 5 Lumbar spinal nerves named L1-L5

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11



## Spinal nerves are named for the vertebrae they are associated with

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- There are 5 sacral vertebrae named S1-S5
- There are 5 sacral spinal nerves named S1-S5
- There are 2 (or 3) coccygeal vertebrae named Co1-Co 2(3)
- There are 2 (or 3) coccygeal spinal nerves named Co1-Co2(3)

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12



## Distribution of the spinal nerves to the body

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- Nerves C1-C4 supply the neck
- Nerves C5-T1 supply the upper limb
- Nerves T1-L1 supply the trunk
- Nerves L2-S2 supply the lower limb
- The remaining nerves supply areas around the buttocks

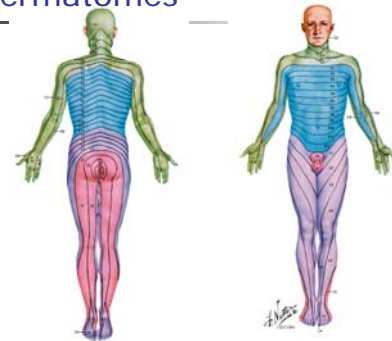
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13



## Dermatomes

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Image from Netter, The Nervous System, CIBA 1953 14



## The "ascent" of the cord

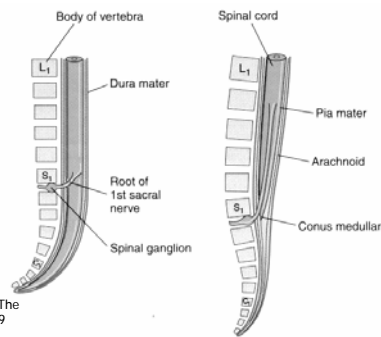
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During embryonic development the spinal nerves grow directly laterally and leave the spinal canal in the intervertebral foramen, but...

The spinal canal grows faster and longer than the spinal cord.

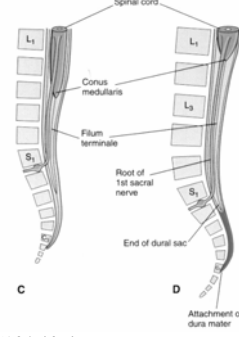
From Moore & Persaud, 1998, The Developing Human, Page 459

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## The "ascent" of the cord

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- This has two consequences:
  - The nerve roots elongate to stretch between their spinal segment and their foramen of exit.
  - The bottom 1/3 of the spinal canal contains only nerve roots and CSF. The bundle of nerve roots in the caudal canal are called the "cauda equina"

From Moore & Persaud, 1998, The Developing Human, Page 459

16

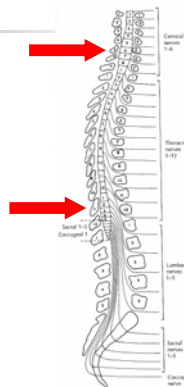


## Cervical and lumbosacral enlargements

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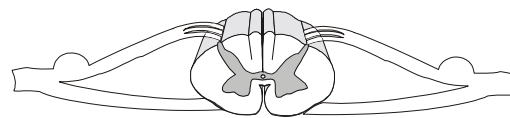
- Cervical segments (C5 -T1) and lumbosacral segments L2-S2 contain the sensory and motor neurons that supply the upper limbs.
- Because the limbs have a large muscle mass and a high density of sensory endings, more motor and sensory neurons are located in these segments than in other areas of the cord.

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## Internal structure of the cord

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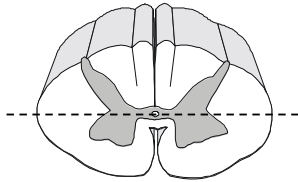
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18



## Internal structure of the cord

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19



## Internal structure of the cord

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- The white matter sleeve of the spinal cord is divided into three areas: the dorsal, lateral and ventral funiculi (funiculus = singular)
  - The dorsal funiculus is composed of ascending (sensory) axons carrying touch information from the body
  - The lateral funiculus is a mixture of ascending, sensory axons and descending, motor axons
  - The ventral funiculus consists almost exclusively of descending, motor axons

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20



## Internal structure of the cord

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- The Grey matter core of the spinal cord is butterfly-shaped in cross section.
  - It is divided into dorsal and ventral horns
  - The dorsal horn is composed of sensory neurons
  - The ventral horn is composed of motor neurons
  - In some regions of the cord (T1-L2), a lateral horn is added. The lateral horn is composed of preganglionic sympathetic neurons.

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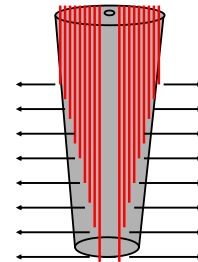
21



## Variations in White Matter

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- There is much more white matter at the rostral end of the cord than at the caudal end
  - All of the descending motor axons destined for different segments re present at the rostral end. They terminate in various levels until, at the caudal end of the cord, there are none left



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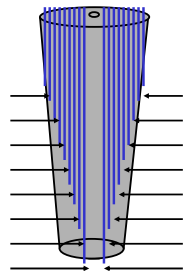
22



## Variations in White Matter

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- Similarly, sensory axons coming in from increasingly higher levels accumulate until, at the rostral end of the cord, all of the sensory axons are present.



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23

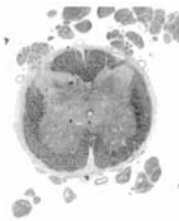


## Variations in White Matter

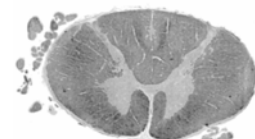
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Sacral level

High cervical level



Actual Size  
1 cm



Actual Size  
1 cm

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24



## Variations in Grey Matter

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- The dorsal and ventral horns extend the entire length of the spinal cord
- In the cervical and lumbosacral enlargements – the areas that innervate the limbs - there are more motor and sensory neurons present....
- Therefore the grey matter is more massive at these levels

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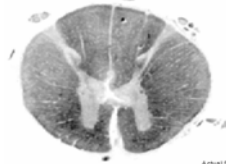
25



## Variations in Grey Matter

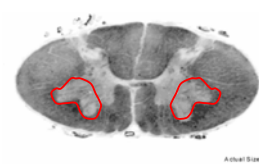
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Midthoracic Level



Actual Size  
1 cm

Cervical enlargement



Actual Size  
1 cm

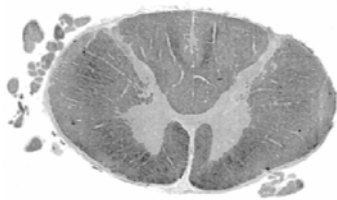
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26



## What level ?

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Actual Size  
1 cm

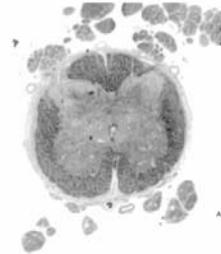
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27



## What level ?

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Actual Size  
1 cm

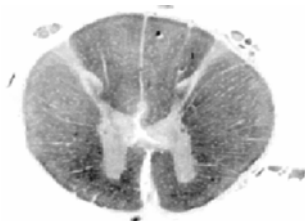
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28



## What level ?

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Actual Size  
1 cm

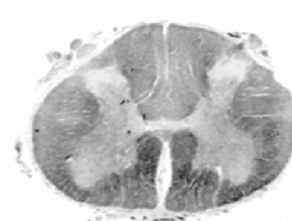
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29



## What level ?

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Actual Size  
1 cm

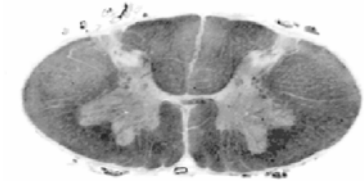
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30



## What level ?

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Actual Size  
  
1 cm

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31



## Summary of the Lecture

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- The vertebrate body and its spinal cord are segmented
- Spinal cord segments are named for their associated vertebrae
- During development the cord "ascends".
- The caudal spinal roots form the cauda equina
- The spinal cord has a core of grey matter and a sleeve of white matter.
- White matter increases in amount at higher levels of the cord
- Grey matter increases in amount in the areas of the cord that innervate the limbs

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32