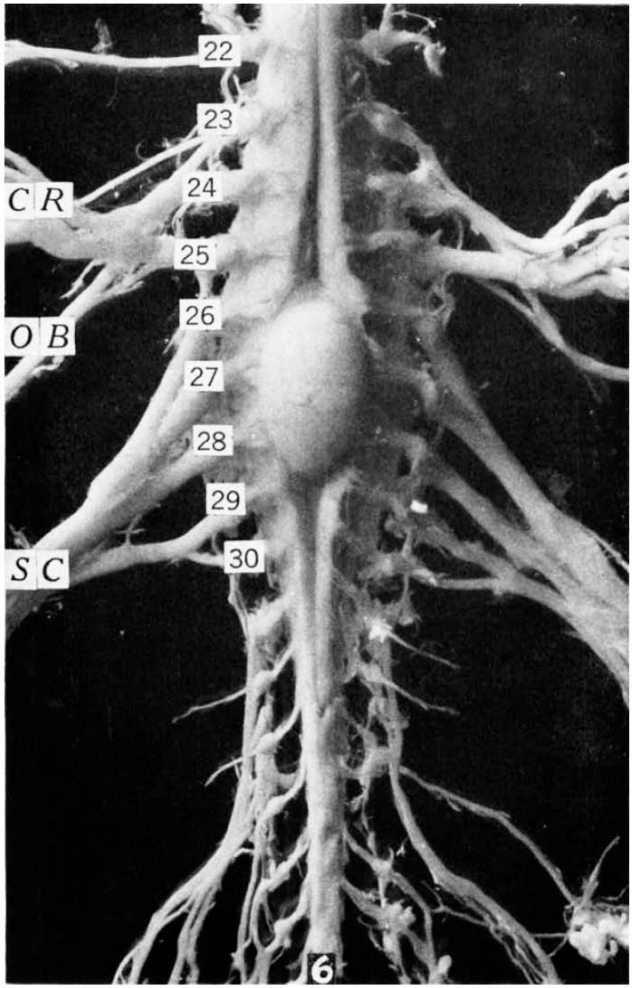
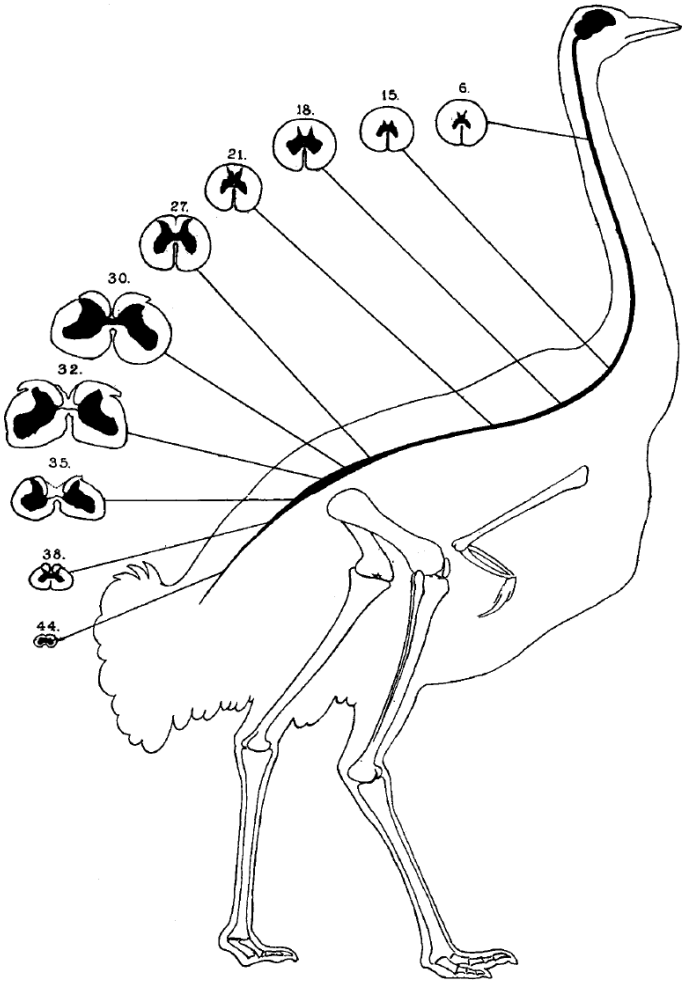
Avian lumbosacral spinal cord specializations





Streeter 1904: fig 1

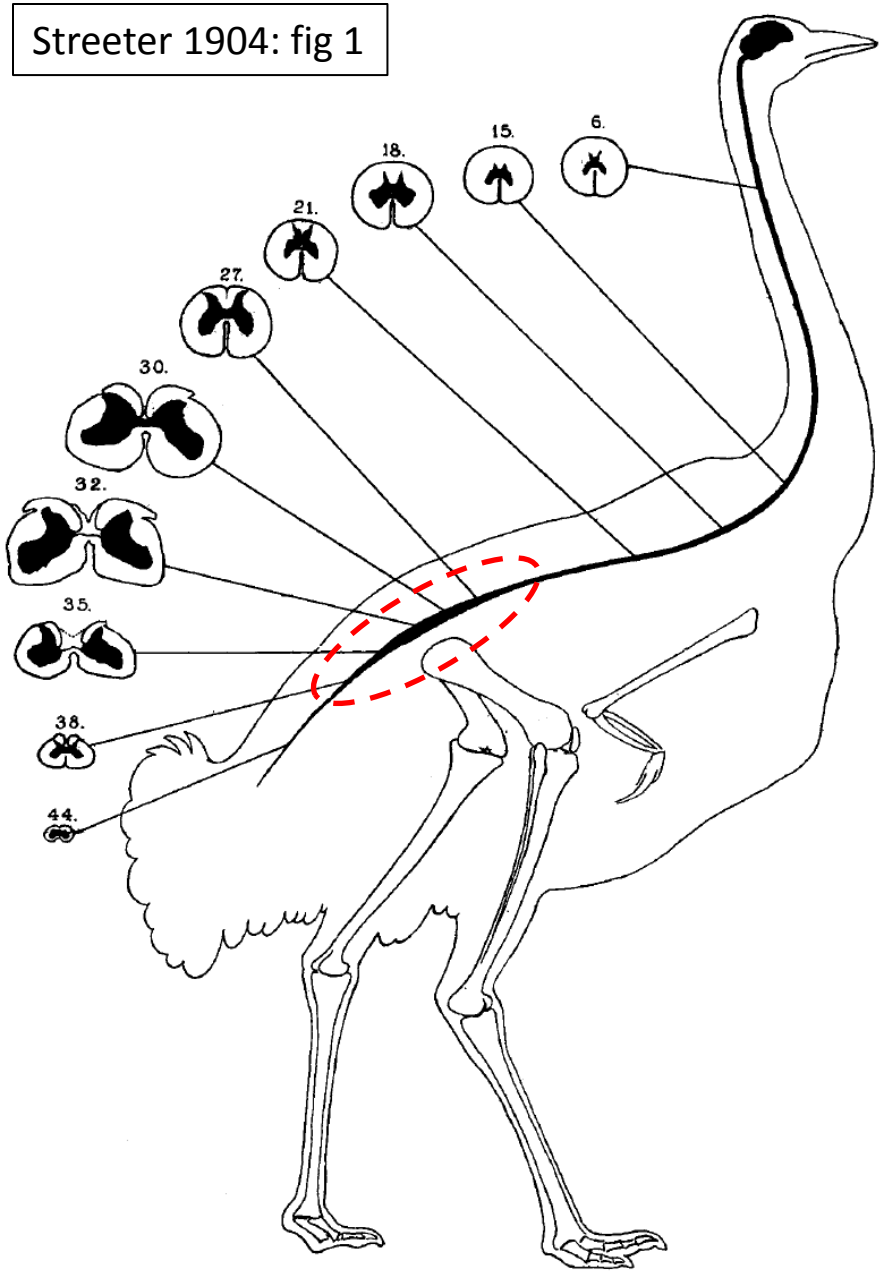


Fig. 3. Topography of the spinal cord of the ostrich. The transverse sections are all made on the same scale of enlargement and their proper levels are indicated on the drawing.

1. **Lumbosacral expansion** of gray and white matter of the cord in the spinal levels that serve the hindlimbs.

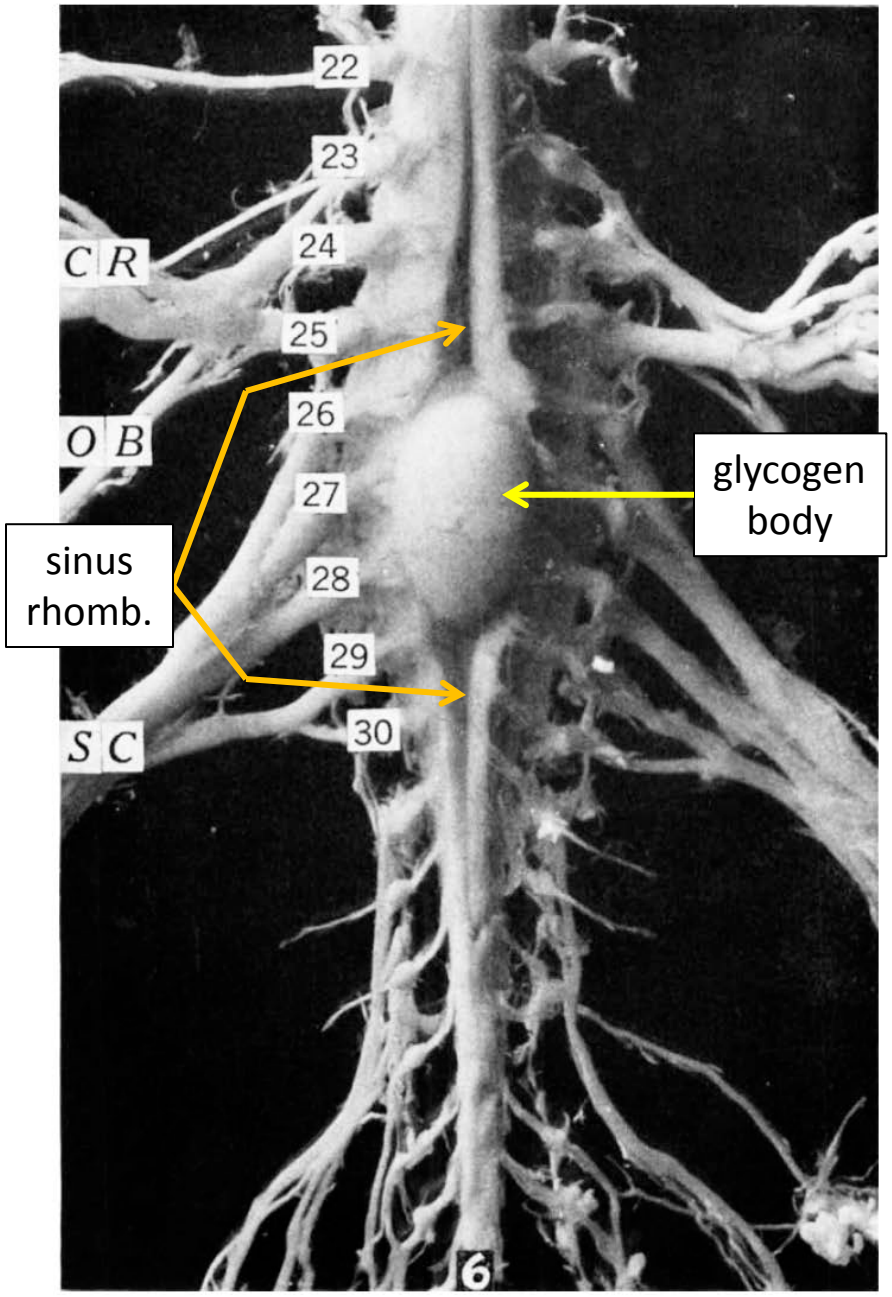
- Present in all limbed tetrapods, and in some fishes with sensitive fins.

- Cord expands and contracts gradually, over many segments.

- Even though the cord does not fill the diameter of the neural canal, the swellings adjacent to the limbs are reflected in increased neural canal diameter at those levels (Giffin 1990).

2. The **glycogen body**: a mass of specialized, glycogen-rich glial cells that occurs only in birds.

- Occupies a trough, the *sinus rhomboidalis*, that separates the dorsal halves of the spinal cord.



3-week-old chick, Watterson 1949: pl. 1

6 Dissection of the vertebral column and meninges of a chick three weeks post-hatching. CR = nervus cruralis; OB = obturator nerve; SC = sciatic (ischiadicus) nerve. × 5.

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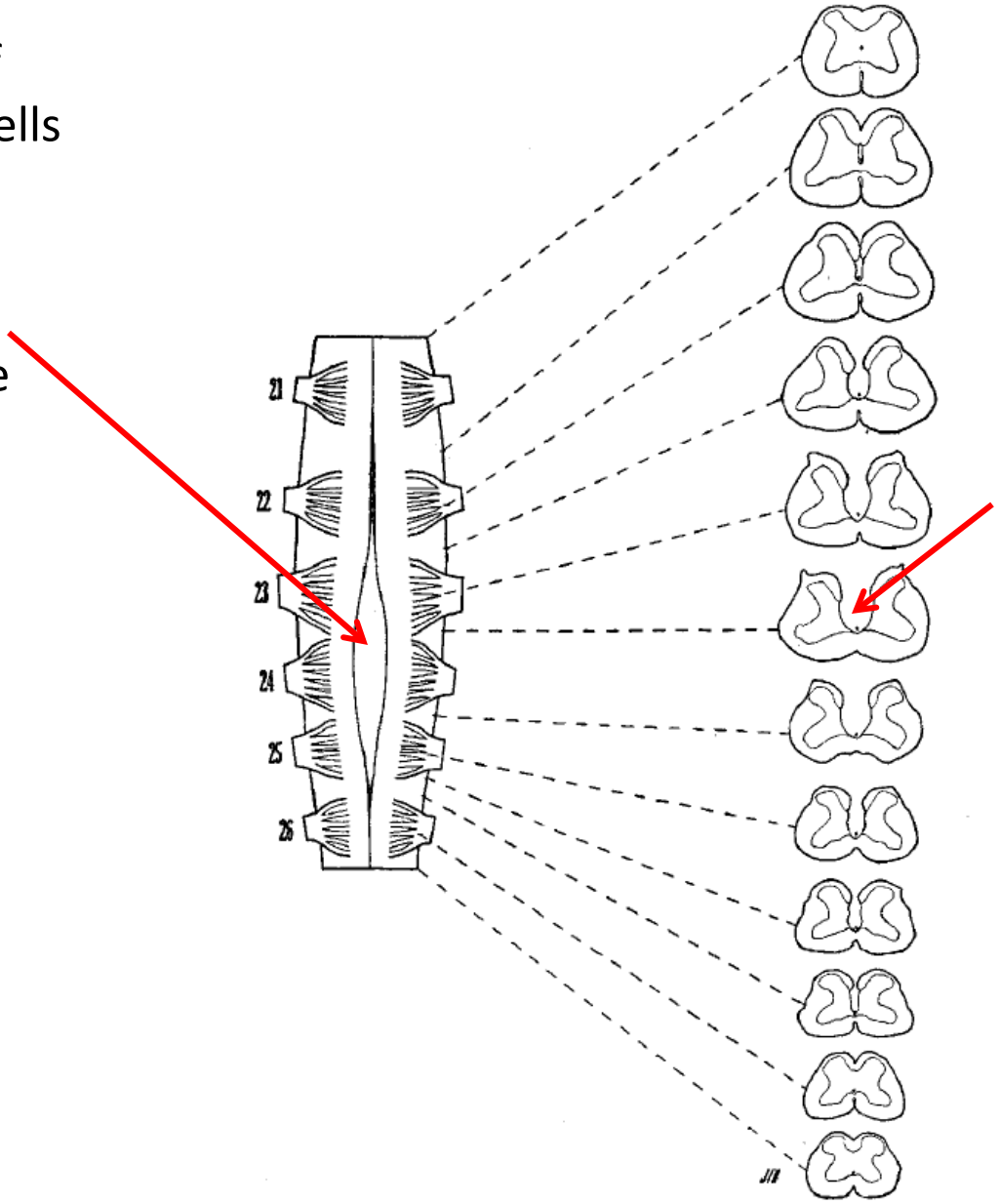


Fig. 3 Sinus rhomboidalis as shown in a dorsal view of the lumbo-sacral enlargement of pigeon's spinal cord and outlines of transverse sections at the indicated levels. Neither the contents of the sinus nor the 'accessory lobes' are included in the outlines. The two parts of the figure are drawn to the same scale. The numbers indicate the respective spinal nerves. × 5.

pigeon, from Huber 1936: fig 3

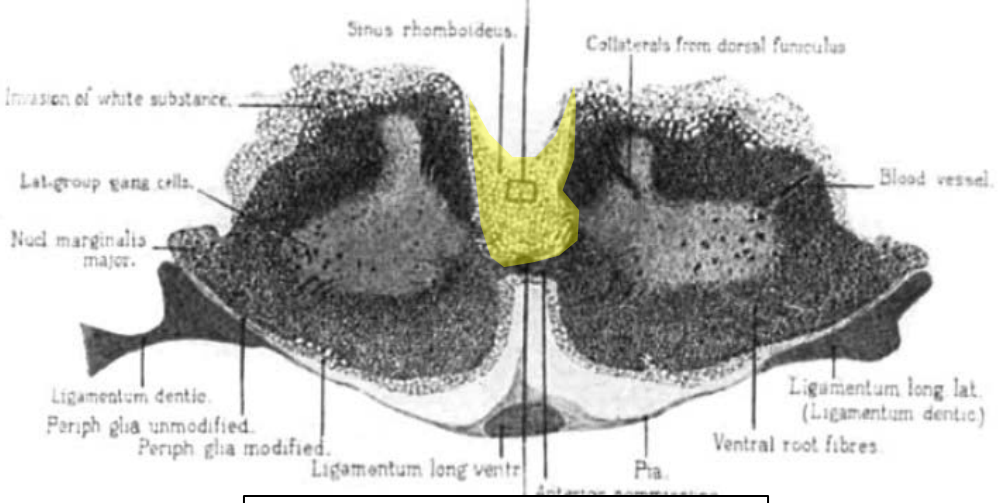
2. The **glycogen body**: a mass of specialized, glycogen-rich glial cells that occurs only in birds.

- Occupies a trough, the *sinus rhomboidalis*, that separates the dorsal halves of the spinal cord.

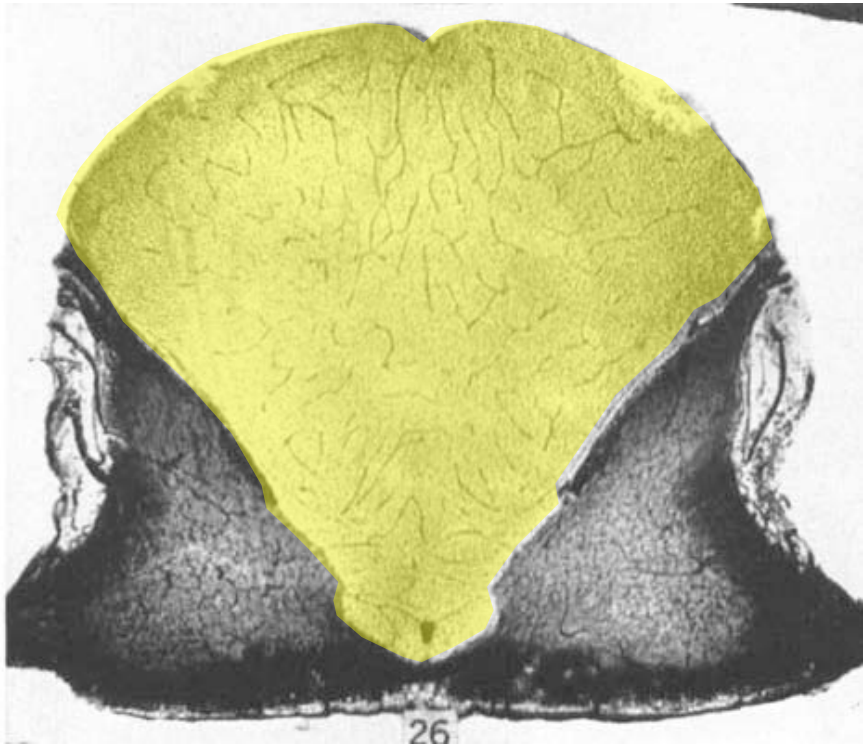
- Varies widely in size among taxa, from barely noticeable (e.g., ostriches) to larger in cross-section than the spinal cord itself (e.g., chickens, pigeons).

- Serially, it expands and contracts rapidly, over just a few segments.

- If the glycogen body is large, the neural canal will be noticeably expanded to accommodate it.



ostrich, Streeter 1904: fig 5



3-week-old chick, Watterson 1949: pl. 5

Lumbosacral endocasts, Necker 2005: fig 12

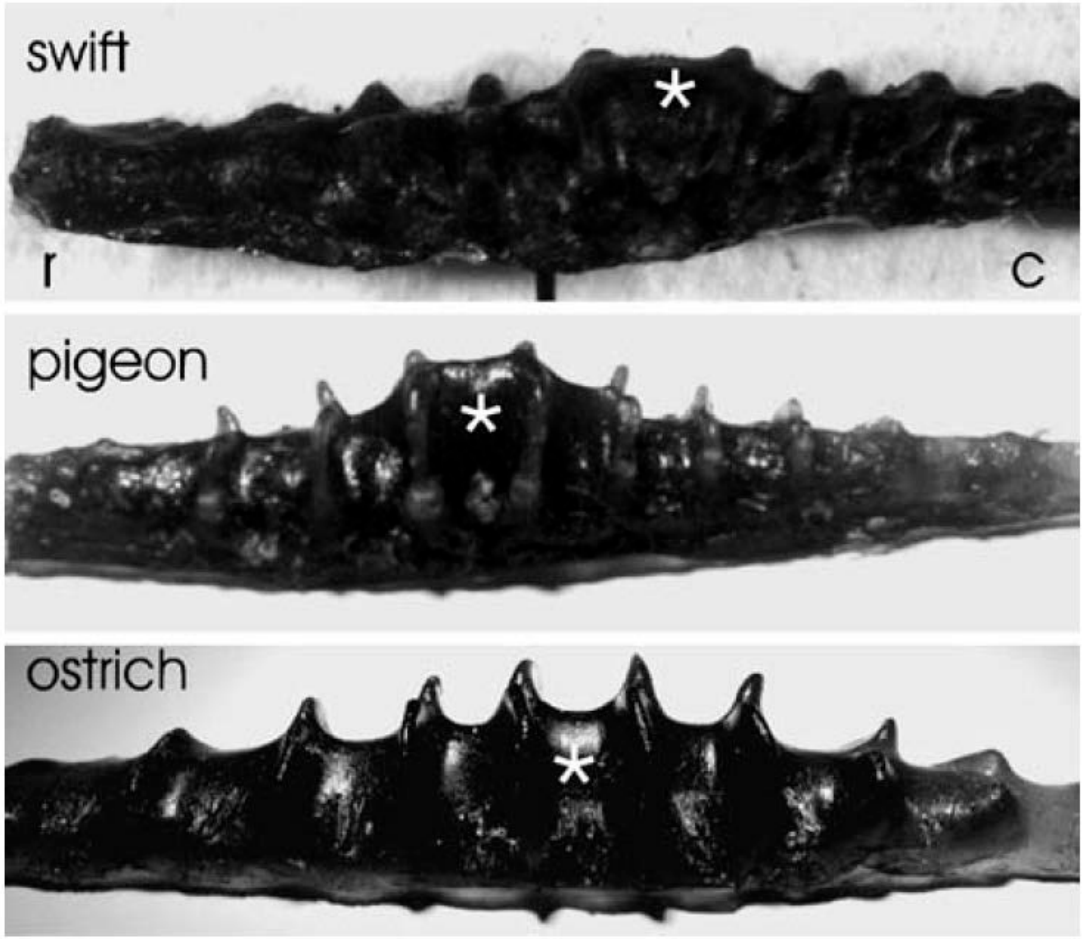


Fig. 12 Casts of the vertebral canal of three different avian species. Note differences in the heights of the lumbosacral canals. *Asterisks* indicate location of the glycogen body. *r* rostral, *c* caudal

3. **Lumbosacral canals**: transverse, fluid-filled meningeal tubes that arch dorsally over the spinal cord.

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- Present in most (all?) birds, Larger and earlier-developing in weak fliers and flightless taxa.

Necker 2005: fig 11

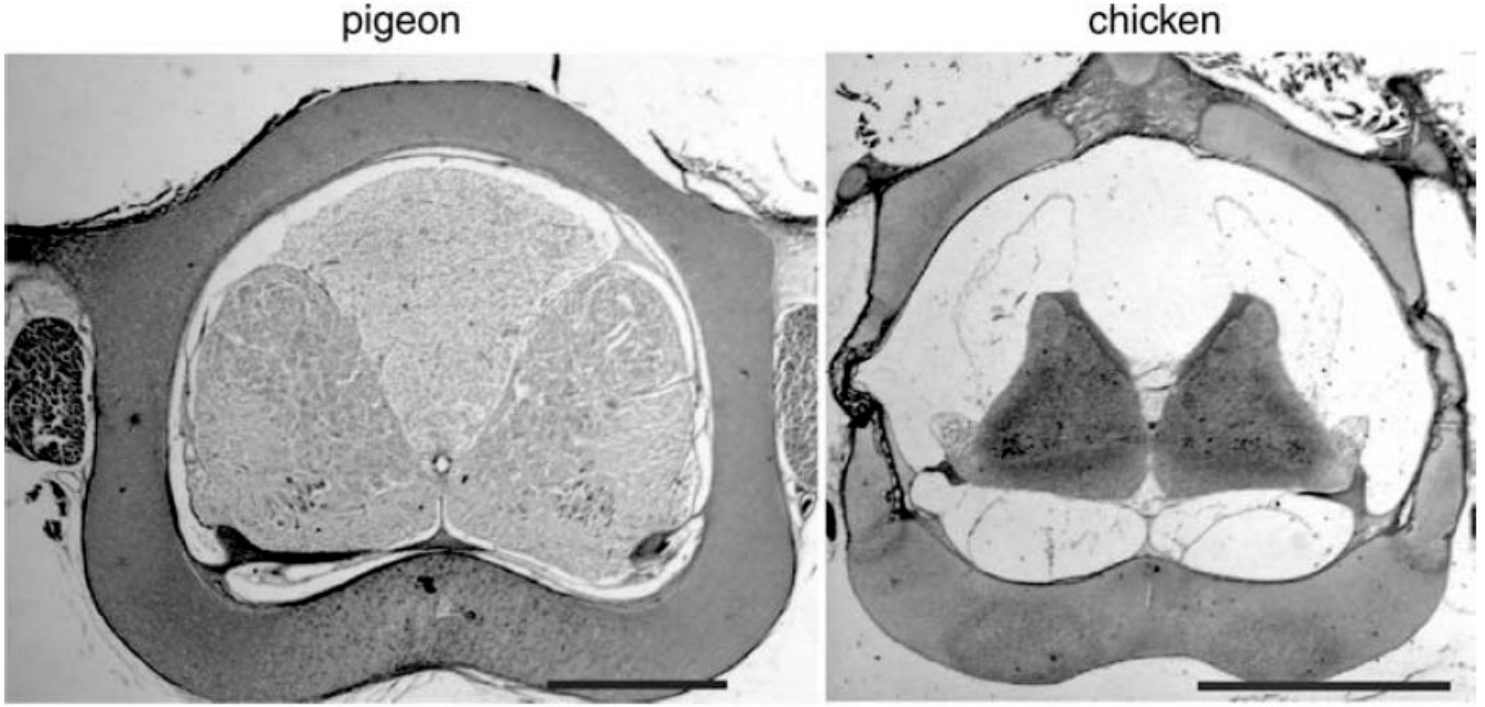
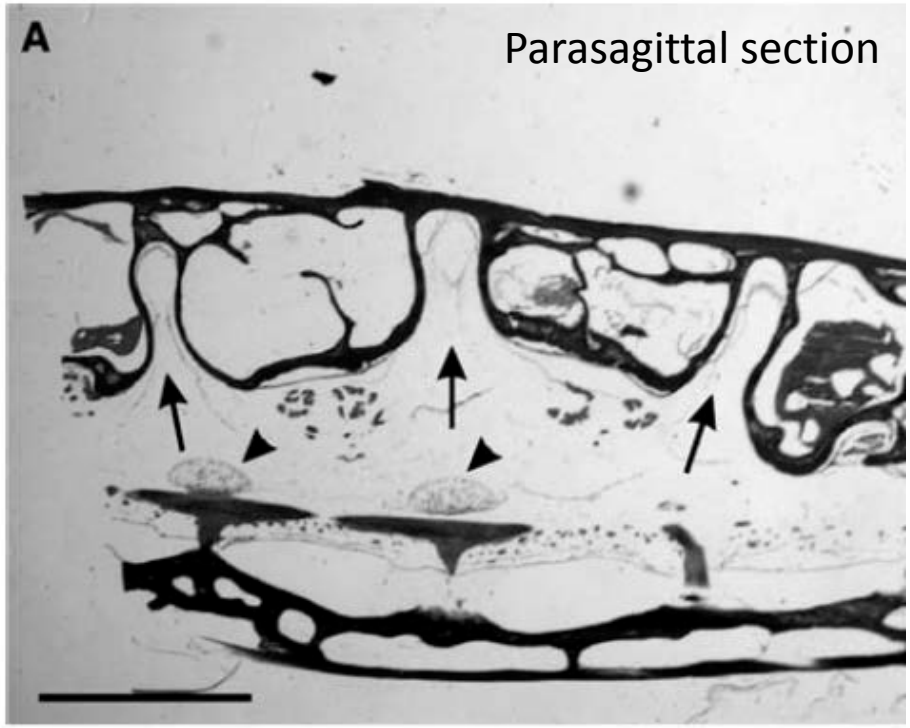
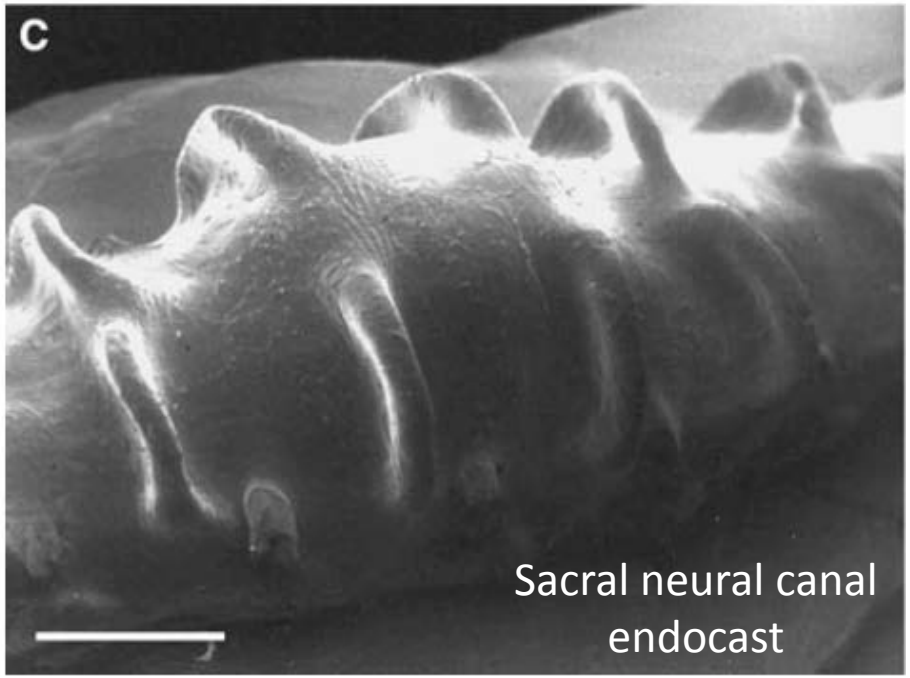


Fig. 11 Comparison of the vertebral canal of a pigeon and of a chicken at the time of hatching. Note large fluid spaces in the chicken. *Scale bars*, pigeon 1 mm, chicken 2 mm



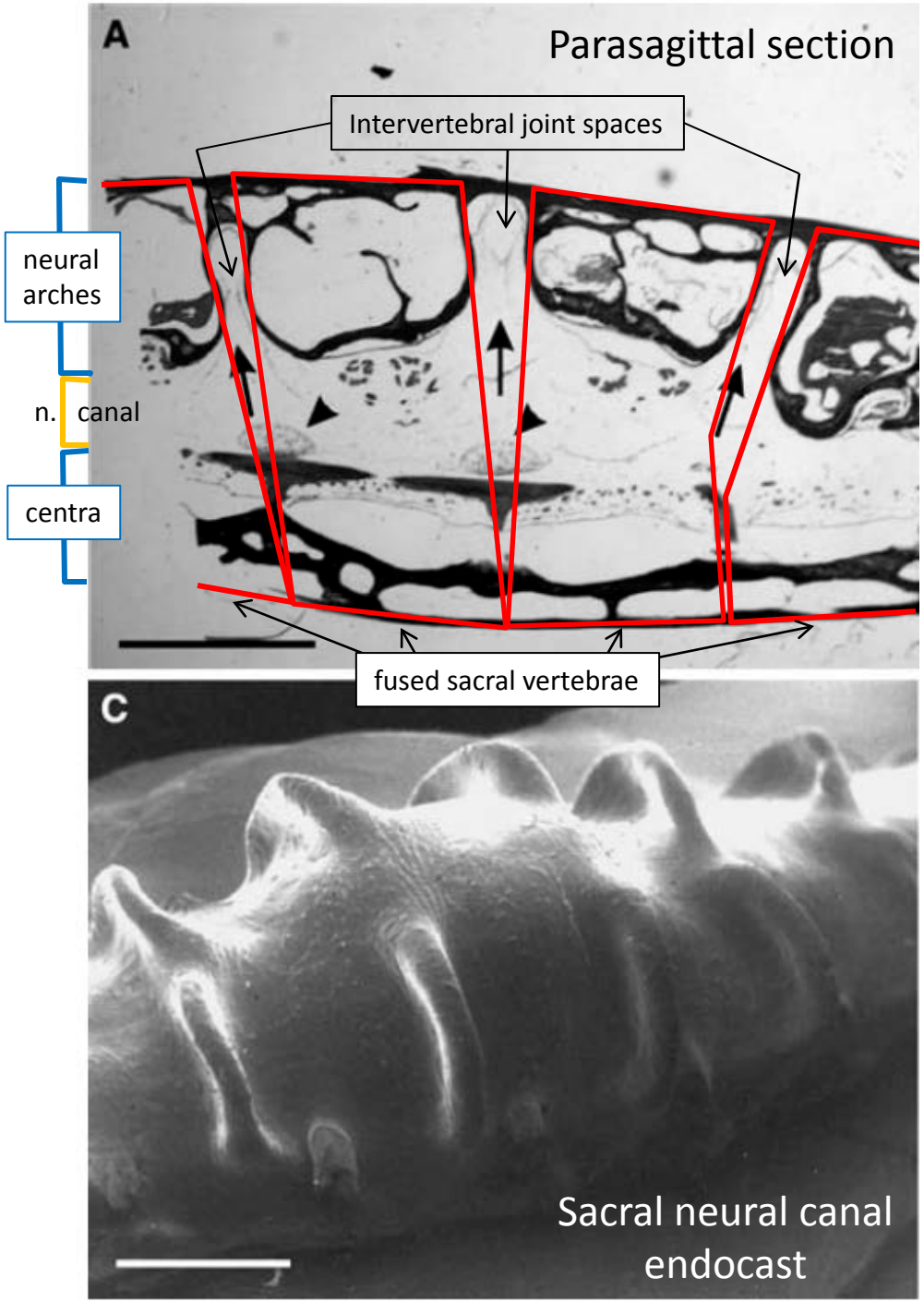


3. **Lumbosacral canals**: transverse, fluid-filled meningeal tubes that arch dorsally over the spinal cord.

- Present in most (all?) birds, Larger and earlier-developing in weak fliers and flightless taxa.

- These canals occupy expansions of the neural canal at former intervertebral joints in the synsacrum.

Necker 2005: fig 3



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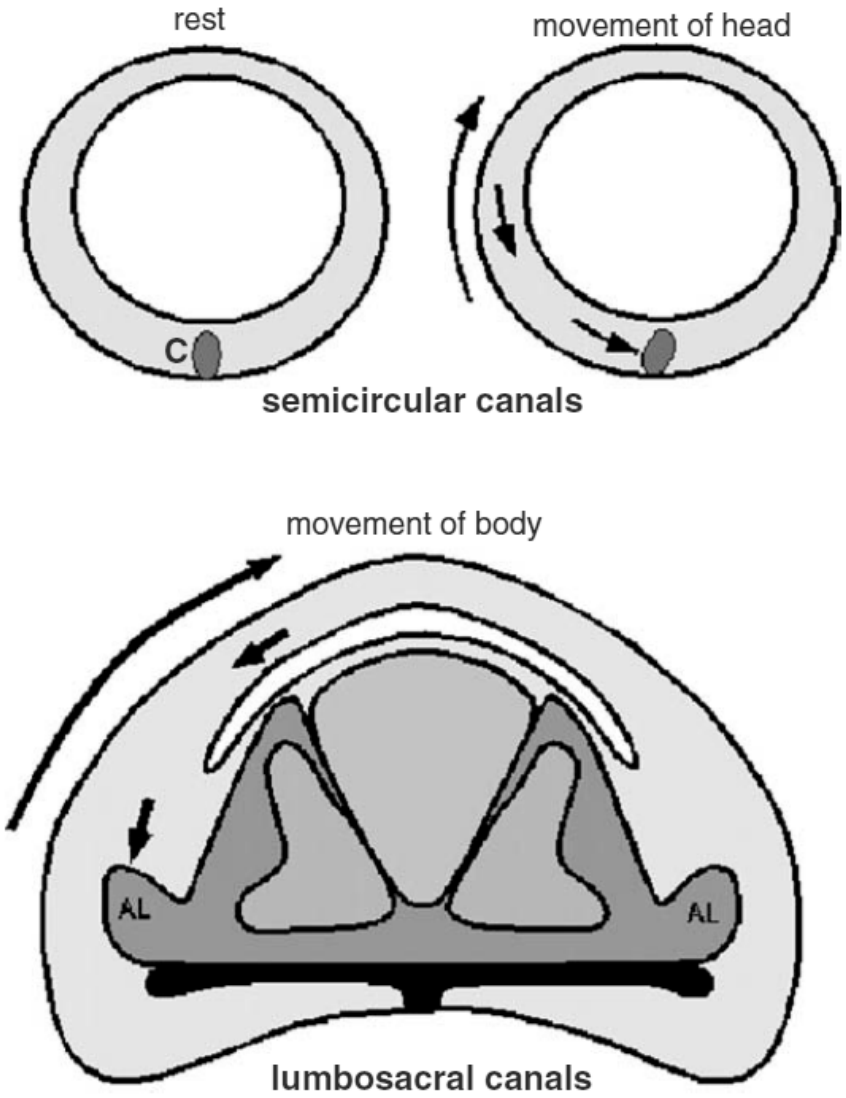

Fig. 6 Scheme of the possible function of the lumbosacral canals (*bottom*) as compared to the function of the semicircular canals (*top*). Movements of the head result in an inertia-driven bending of the cupula (*C*) which excites the sensory hair cells whose stereocilia reach into the cupula. Similarly, during rotations of the body inertia of the fluid in the lumbosacral canals and near the accessory lobes (*AL*) is thought to mechanically distort the lobes, which then results in a mechanical stimulation and excitation of the finger-like processes of the lobe neurons

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- These canals occupy expansions of the neural canal at former intervertebral joints in the synsacrum.

- Many lines of evidence point to function as semicircular-canal analogues for maintaining equilibrium.

Necker 2005: fig 6

4. **Accessory lobes (of Lachi)**: small, segmental lobes that project from the lateral aspect of the spinal cord near the roots

- Present all along the cord, enlarged in the lumbosacral region

- Made up of neurons and glycogen cells

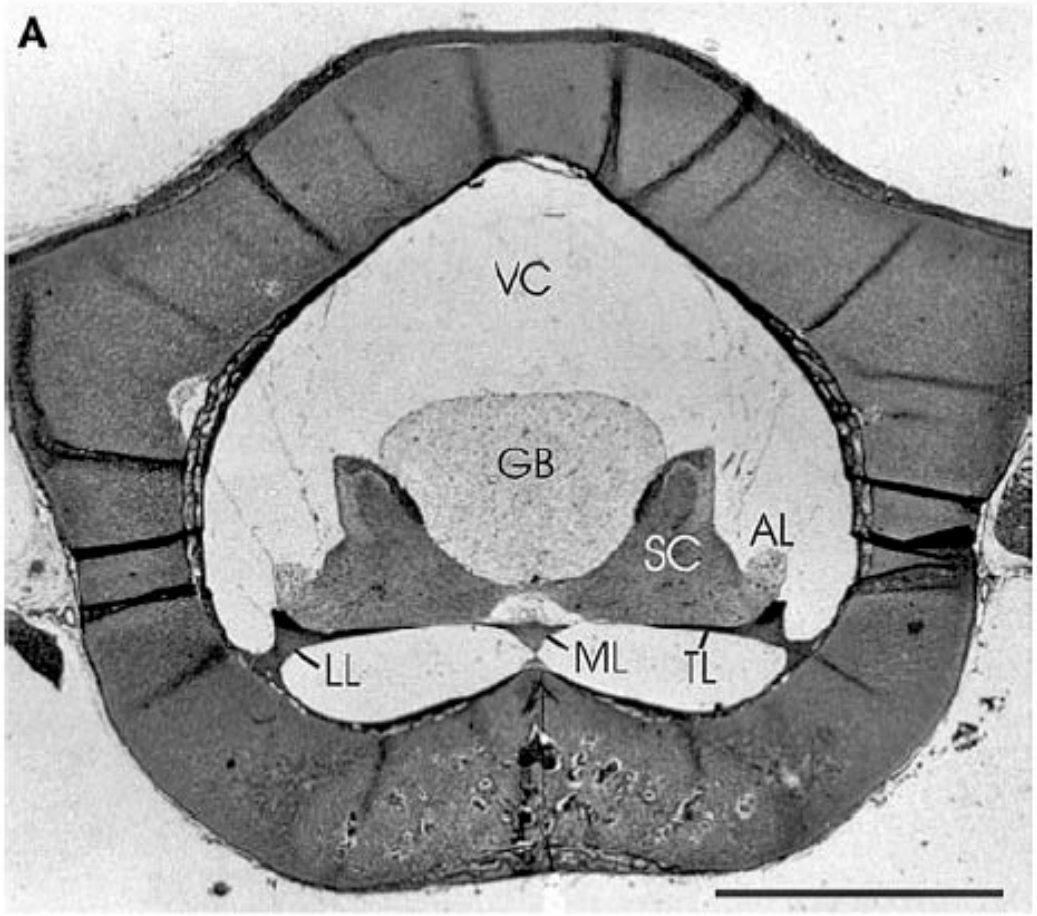


Fig. 1 **a** Transverse section of the lumbosacral vertebral column of a one-week-old pigeon at the level of the glycogen body. **b** Accessory lobe with neurons (*arrow*) and glycogen cells (*arrowhead*). *AL* accessory lobe, *GB* glycogen body, *ML* medial ligament, *LL* lateral (dentate) ligament, *TL* transverse ligament, *VC* vertebral canal, *VH* ventral horn. *Scale bars* 2 mm in **a**, 200 μm in **b**

Necker 2005: fig 1

4. **Accessory lobes (of Lachi)**: small, segmental lobes that project from the lateral aspect of the spinal cord near the roots

- Present all along the cord, enlarged in the lumbosacral region

- Made up of neurons and glycogen cells

- Associated with the lumbosacral canals

- Possibly function as lumbosacral canal receptors, to aid in maintaining equilibrium

- No known osteological traces

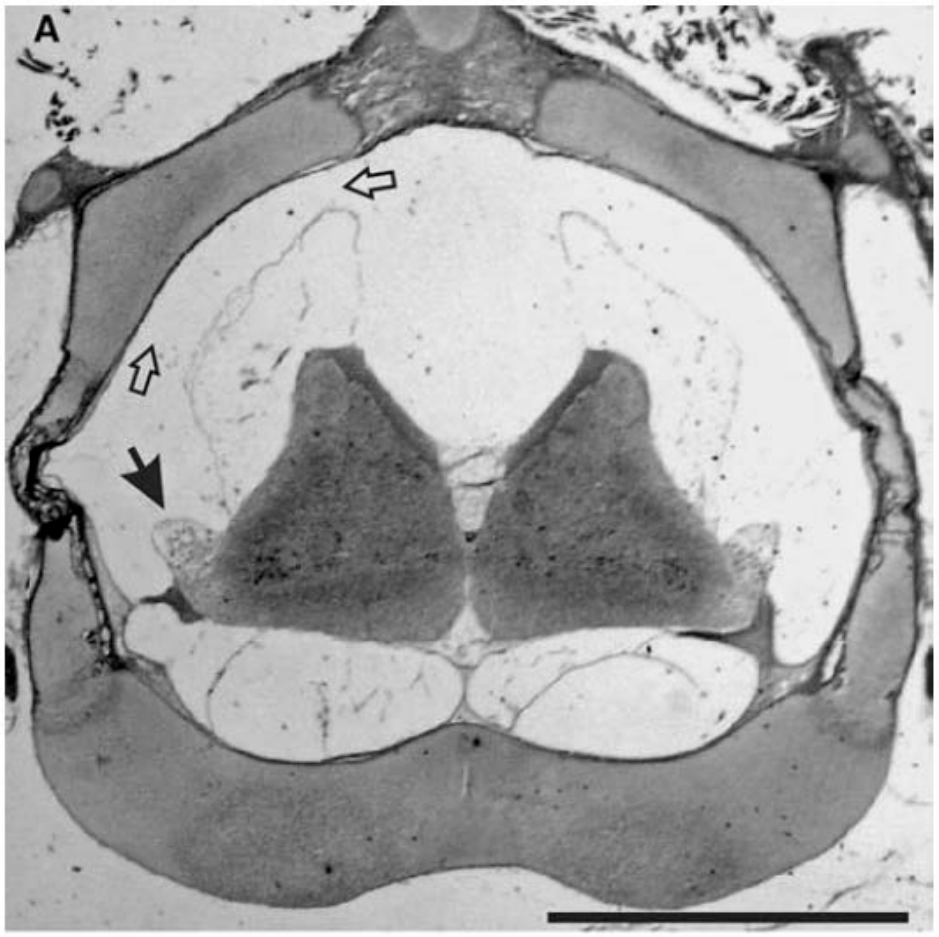
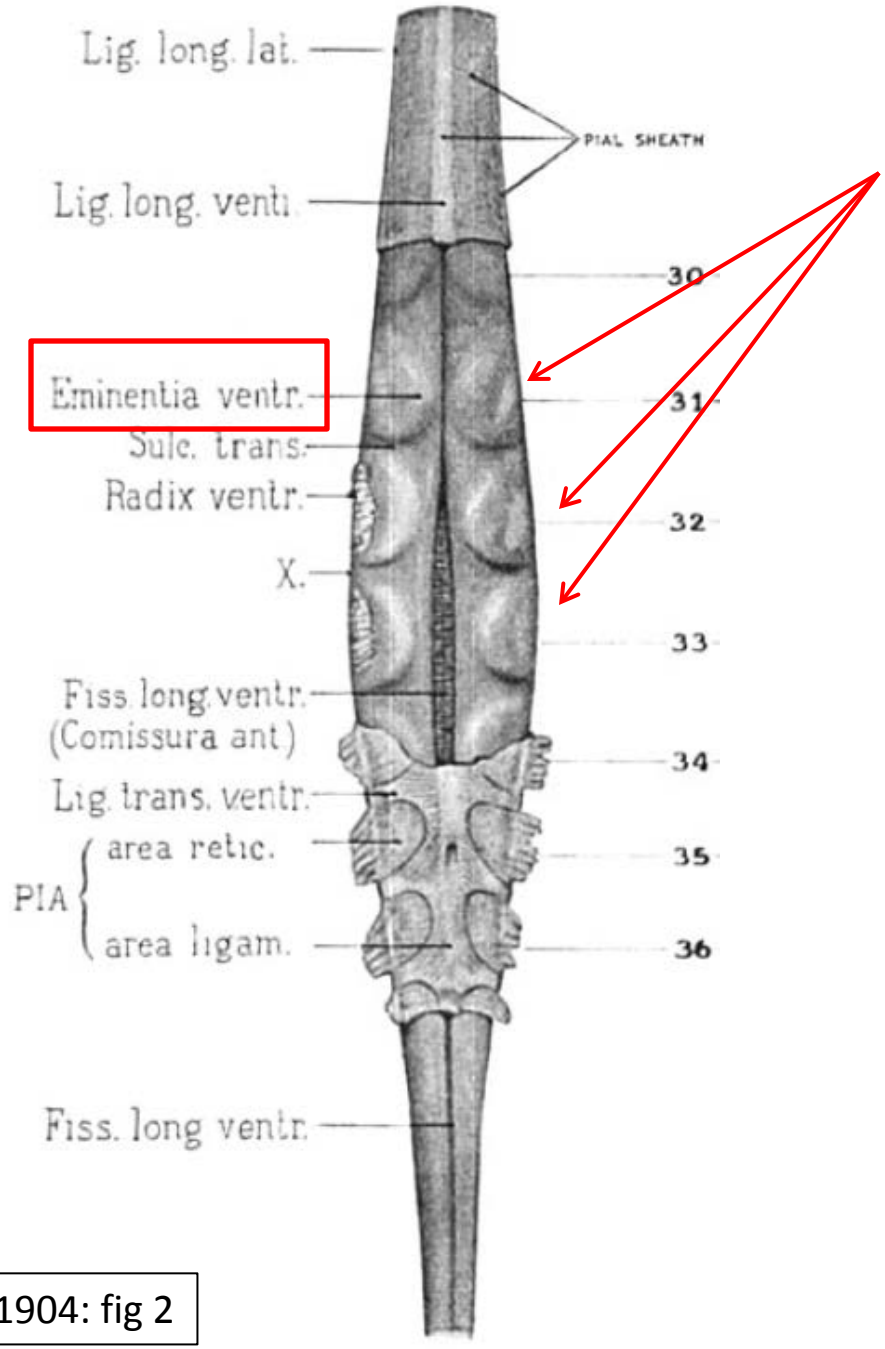


Fig. 4 **a** Transverse section of the vertebral column of a one-day-old chicken showing wide fluid spaces surrounding the accessory lobes (*solid arrow*); *open arrows* indicate the dorsolateral lumbosacral canals limited medially by meningeal membranes. **b** Transverse section of the vertebral canal of the common swift (*Apus apus*) showing an accessory lobe (*arrow*) with a laterally running arachnoidal trabecle (*arrowheads*) and the surrounding cerebrospinal fluid spaces. *Dashed box in inset* indicates section of the photomicrograph. *L* dentate ligament, *P* paragriseal cells. *Scale bars*, 1 mm in **a**,

Necker 2005: fig 4



Streeter 1904: fig 2

5. **Ventral eminences**: segmental bumps on the ventral surface of the spinal cord.

- Caused by increased cross-sectional area of ventral horn (motor neurons) adjacent to ventral roots of spinal nerves.

- Ventral roots emerge from the ventral eminences.

- Only lumbosacral specialization that projects ventrally instead of dorsally or laterally.

- Osteological correlates: these bumps fill cup-shaped vacuities in the floor of the neural canal in the sacral region.

Type	Made of	Occurs in	Segmental or continuous	Anatomical direction	Osteological correlate?
Lumbosacral enlargement	White and gray matter	Limbed tetrapods	Continuous, many segments	All directions (radially)	Neural canal expansion
Glycogen body	Glycogen cells (glia)	Birds	Continuous, few segments	Dorsal	Neural canal expansion
Lumbosacral canals	Meninges	Birds	Segmental	Dorsolateral	Neural canal expansion
Accessory lobes of Lachi	Neurons and glycogen cells	Birds	Segmental	Lateral	(none)
Ventral eminences	White and gray matter	Ostriches, other birds?	Segmental	Ventral	Neural canal expansion