Introduction to Neuroscience

E.J. Neafsey, Ph.D.
Loyola University Chicago Stritch School of Medicine

Neuroscience 2010

1. Why study neuroscience in medical school?
2. Who are the faculty?
3. What is the course schedule?
4. What textbooks do you need?
5. What are the learning objectives?
6. What about the lecture exams?
7. What about the 6 labs?
8. What about small groups?
9. What about Review Sessions?
10. What is Evidence-Base Neurology (EBN)?
11. How is the final grade determined?
12. What are some examples of what I will be learning?
13. What is taking Neuroscience like?
14. What does it mean to know neuroscience?
15. Grad Students

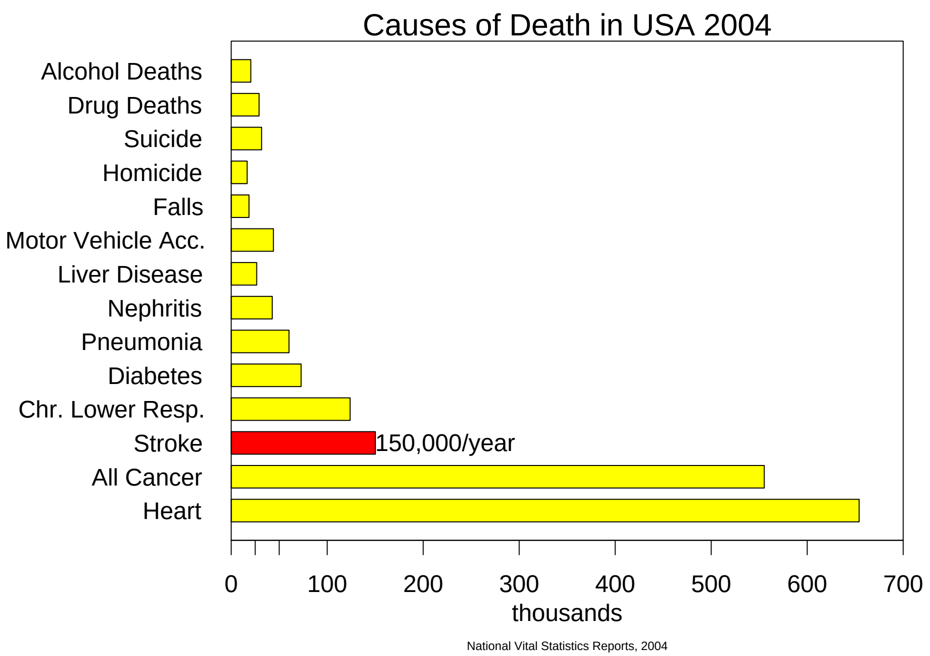
Why study neuroscience in medical school?

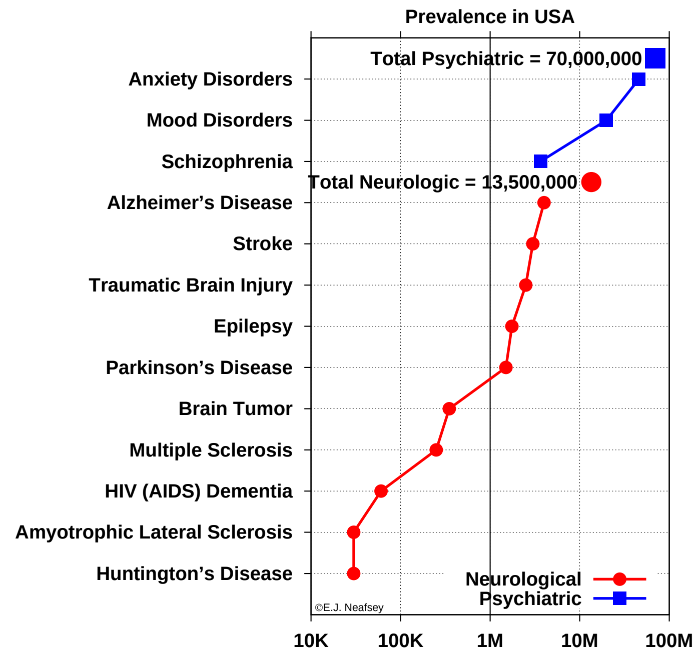
The Burden of Brain Disorders

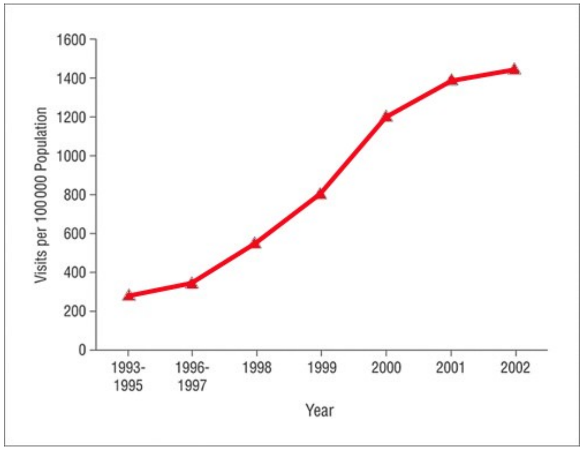
. . . Taken as a whole, **disorders of the nervous system account for at least 15% of the global burden of disease and at least 27% of average years lived with % disability**.

Marcelo Cruz, Rachel Jenkins, and Donald Silberberg
Science 312:53, 2006

Stroke is the third leading cause of death in the United States.

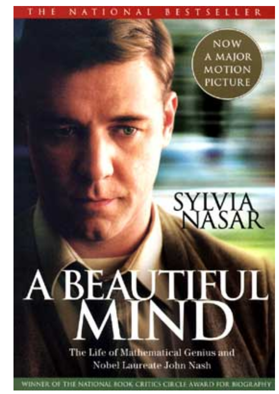




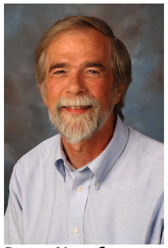


Increase in office visits with antipsychotic treatment by children and adolescents from 1993 to 2002.
(Adapted from Olfson et al., Arch Gen Psych 63: 679-685, 2006)

Name Each Picture's Brain Disorder or Disease



Who are the faculty?


Dr. Neafsey
eneafse@lumc.edu


Dr Merchut
mmerchu@lumc.edu


Dr. DonCarlos
ldoncar@lumc.edu


Dr. Piedras
epiedra@lumc.edu

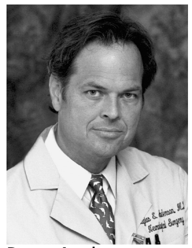

Dr. Lee
jlee2@lumc.edu


Dr. Dauzvardis
mdauzva@lumc.edu


Dr. Shea
jshea3@lumc.edu


Dr. Cukierman
scukier@lumc.edu


Dr. Scrogin
kscrogi@lumc.edu


Dr. Anderson
dander1@lumc.edu


Dr. Letarte
peter.letarte@med.va.gov


Dr. Kartje
wendy.kartje@med.va.gov


Dr. Primeau
mprimea@lumc.edu


Dr. Chawla
jchawla@lumc.edu


Dr. Jones
kjones1@lumc.edu


Dr. Holtman
fwhite@lumc.edu


Dr. Stubbs
evan.stubbs@med.va.gov


Dr. Melian
emelian@lumc.edu


Dr. Gruener
ggruene@lumc.edu


Dr. Kristopaitis
tkristo@lumc.edu


Dr. Asconapé
jasconape@lumc.edu

What is the course schedule?

August 2010

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2 15:30 IntroNeuro,EJN	3 09:30 BrainOverview,EJN 10:30 Nhisto,Jones	4 LAB1+2 09:30 Devel1,Jones 10:30 LAB1+2:BrNrvBV-LL	5 09:30 SpCord,Dauz 10:30 RecAscDesc,Dauz	6 09:30 SkelMusSpC1,Pied 10:30 SkelMusSpC2,Pied	7
8	9 PATIENT 08:30 CC:SpCord,MM 09:30 CC:NMJun+Pt,MM 11:30 SmGrp1:NExamSen	10 09:30 Medulla,EJN 10:30 NeuMPAP,Cuk	11 Mass of Holy Spirit/LAB3 09:30 Pons,EJN 13:00 LAB3:MedPons-LC3	12 09:30 Mid,EJN 10:30 TrigAud,EJN 11:30 SynTran,Cuk	13 09:30 Vest1,Gruener 10:30 Vest2Eyes,Gruener	14
15	16 09:30 EyeMove,Stubbs 10:30 SmGrp2:NExamMot	17 09:30 RetFor,Gruener 10:30 Cbellum1,Gruener	18 LAB4 09:30 Cbellum2,Gruener 10:30 LAB4:PonsMid-LC3	19 09:30 CC:CrNerv,MM90 11:00 PostFossa,Ander	20 08:30 SmGrp3:SpCord 10:00 REV,EJN	21
22	23 09:30 ANS1,Scrogin 10:30 ANS2,Scrogin	24 09:30 Cortex1,EJN 10:30 Cortex2,EJN	25 LabQUIZ 08:30 NeurLabQuiz 09:30 Chnopathies,Cuk 10:30 Coma,Letarte	26 PATIENT 09:30 CC:Lang,MM 10:30 MS+Pt,MM	27 08:30 SmGrp4:Coma 10:00 Cortex3,EJN	28
29	30 EXAM1 13:00 NeuPhaBehEXAM1	31 09:30 Dien,EJN 10:30 BG,EJN				
					July 2010	September 2010

medns2010-Tue Jun 22 09:54:10 CDT 2010

In General:

- Lectures daily at 9:30 and 10:30
- Labs on Wednesdays
- Small Groups on Fridays

September 2010

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 LAB5 09:30 MotorSys,EJN90 11:00 LAB5:CxCb-LL	2 09:30 CC:MoveDis,MM 10:30 BrImgEss,MM 11:30 EndofLife,MM 30	3 08:30 SmGrp5:Stroke 11:00 Hypo1,DonC	4
5	6 Labor Day	7 09:30 Hypo2,DonC 10:30 Limbic,EJN90	8 LAB6 09:30 Pain1,Holtman 10:30 LAB6:DienBG-LC3	9 (Rosh Hash.) 09:30 CC:Headache,MM 10:30 Epilep,Asc+EJN90	10 (Rosh Hash.) 09:30 VisSys1,Stubbs 13:00 SmGrp6:Epi	11
12	13 PATIENT 09:30 VisSys2,Stubbs 10:30 CC:BgCb+Pt,MM90	14 09:30 VisSys3,Stubbs 10:30 Sleep,DonC90	15 LAB7+LABREV 09:30 AudSys1,Pied 10:30 LAB7:BrainCut-LL 16:00 LABREV	16 LabEXAMA 08:30 NeurLabEXAM2a 09:30 AudSys2,Pied 10:30 CC:EyeEar,MM	17 EBN 08:30 TumorPath,Lee 09:30 CxHemis,EJN90 11:00 EBN, Schneck	18 Yom Kippur
19	20 09:30 CC:CortFunc,MM 10:30 CC:IntoxInf,MM90 13:00 SmGrp7:NPath1	21 09:30 CC:BrTumor,Shea 10:30 TumRadOnc,Melian	22 LabEXAMB 08:30 NeurLabEXAM2b 09:30 CN:Trauma,Shea 10:30 CN:DegDis,Lee 90	23 PATIENT 09:30 CC:CerVasDis1,MM 10:30 CN:NPthy+Pt,MM90	24 09:30 CC:CerVasDis2,Lee 10:30 CSFVasBBB,Letarte 13:00 SmGrp8:NPath2	25
26	27 09:30 Neuropsych,Prim 10:30 Devel2,Jones	28 09:30 InjRegen,Jones 10:30 RepairPlas,Kartje	29 09:30 BasicREV,EJN 10:30 ClinicalREV,MM	30		
					August 2010	October 2010

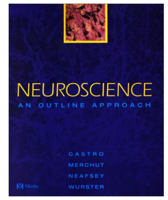
medns2010-Tue Jun 22 09:54:10 CDT 2010

October 2010

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1 EXAM2 13:00 NeuPhaBehEXAM2	2
3	4	5	6	7	8	9
10	11 Columbus Day	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31 DST ends Halloween					September 2010	November 2010

medns2010-Tue Jun 22 09:54:10 CDT 2010

What are the required textbooks?



1. Castro AJ, Merchut MP, Neafsey EJ, and Wurster RD. *Neuroscience: An Outline Approach*. Mosby, St. Louis, 2002.
2. Haines DE. *Neuroanatomy: An Atlas of Structures, Sections, and Systems, Seventh Edition*. Lippincott Williams & Wilkins Publishers, Philadelphia, 2007.
3. Netter FH. *The CIBA Collection of Medical Illustrations, Vol 1. The Nervous System. Part II. Neurologic and Neuromuscular Disorders* CIBA, 1983.
4. Robbins SL. *Pathologic basis of Disease, Sixth Edition*. Saunders, Philadelphia, 1999.
5. Nolte J. *The Human Brain: An Introduction to its Functional Anatomy, Sixth Edition*. Mosby, St. Louis, 2008.

The Nolte book is written in full sentences and paragraphs. Some students find they like this better than the "outline approach."

What are the learning objectives?

Medical Knowledge Competency:
Students will understand the structure and function of the nervous system in health and disease, including the following subject matter.

1. the embryonic development of the brain
2. the cells composing the brain, including neurons, the three types of CNS glia (astrocytes, oligodendrocytes, and microglia), and PNS Schwann cells
   (a) the structure of the neuron, including dendrites, axons, and synapses
   (b) the ionic basis of the resting membrane potential
   (c) the ionic basis of the action potential
   (d) synaptic neurotransmission by neurotransmitters and receptors
   (e) the structure and function of myelin
3. the meninges of the brain (pia, arachnoid, and dura)
4. the formation and circulation of cerebrospinal fluid
5. the structure and function of the blood brain barrier
6. the blood supply of the brain
7. the main sensory pathways and systems in the brain, including
   (a) somatosensory (touch, pain, proprioception) pathways
   (b) the muscle spindle and monosynaptic stretch reflex pathway
   (c) spinocerebellar pathways
   (d) visceral reflex pathways (baroreflex, pulmonary stretch receptor, etc.)
   (e) auditory pathways
   (f) vestibular pathways
   (g) visual pathways
   (h) taste pathways
   (i) olfactory pathways
8. the main motor pathways and systems in the brain, including
   (a) corticospinal (pyramidal) tract
   (b) vestibulospinal, reticulospinal, tectospinal, and rubrospinal tracts
   (c) eye movement control
   (d) cerebellar control of movement
   (e) basal ganglia (extrapyramidal) control of movement
9. the organization of the brain stem, especially the cranial nerve nuclei.
10. the autonomic nervous system and its control by hypothalamus, amygdala, and cerebral cortex
11. the hypothalamic-pituitary neuroendocrine system
12. hypothalamic control of appetite and feeding
13. thalamocortical relations, especially those related to main sensory and motor pathways
14. the limbic system, stress responses, and emotion
15. higher cognitive functions such as learning, memory, attention, and language and their relation to the cerebral cortex and hippocampal formation
16. brain stem and hypothalamic systems regulating sleep and wakefulness
17. the relations between various neurological diseases or disorders and the brain's structure and function, including pain, stroke, spinal cord injury, epilepsy, multiple sclerosis, amyotrophic lateral sclerosis and it genetics, myasthenia gravis, neuropathy, myopathy, Parkinson's disease, Huntington's disease and its genetics, Alzheimer's disease, headache, alcohol and drug intoxication, cerebrovascular disease, and brain tumors, among others
18. End of Life issues related to Alzheimer's disease and ALS
19. the neuroanatomical basis of the neurological exam
20. the basic neuropathology of stroke, brain tumors, multiple sclerosis, and neurodegenerative diseases
21. the basics of interpreting brain MRIs, CT scans, and angiograms
22. the use of knowledge of basic neuroanatomy, together with patient symptoms and signs, to help localize nervous system lesions and their most likely pathology
23. the new and exciting research areas in neuroscience that may lead to better treatment of and improved recovery from neurological damage and disease

What about the Lecture exams?

- "National Board" multiple choice questions

Lecture Exam Schedule 2009

- Lecture Exam 1: 1:00 PM Monday Aug 30
- Lecture Exam 2: 1:00 PM Friday Oct 1
- Both also cover material from the Therapeutics course and from the Behavioral Medicine and Development course!
- Both Lecture Exams will be ONLINE!!!

Lecture Exam Grading

- Lecture Exam 1 counts for 30% of Final Grade
- Lecture Exam 2 counts for 45% of Final Grade

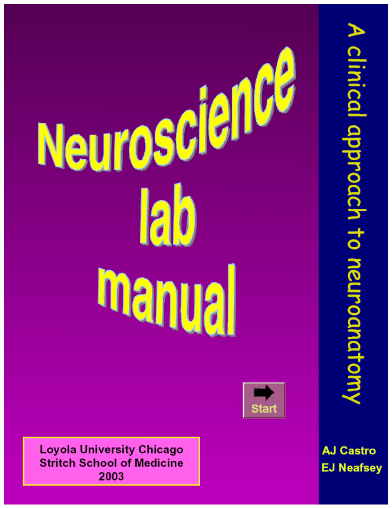
Professionalism competency:

Graduates must demonstrate a combination of knowledge, skills and attitudes, and behaviors necessary to function as a respected member of the medical profession. They must know the obligations of medical professionals as members of healthcare team, as members of a healthcare and educational institution, and as leaders in our society in bringing about the common good. Our graduates will be able to: Demonstrate respect, compassion, and integrity; a responsiveness to the needs of patients and society that supercedes self-interest; and accountability to patients, society, and the profession.

Students will be able to converse appropriately and behave with personal integrity in all course activities.

Evaluation: Students who conspicuously fail to meet this objective will be informed verbally and in writing by the course director and/or faculty member who observes such behavior. If a serious infraction such as cheating on an exam occurs, SSOM policies will be followed.

What about the 6 Labs?



Lesion Lessons
Subject Matter
Patient Puzzles

- Labs meet on Wednesdays. Lab faculty include five professors (Drs. E.J. Neafsey, John Shea, Jack Lee, Sam Cukierman, and Mike Dauzvardis).
- Three "Wet Labs" (Lab Manual chapters 1-2,5,7) in Anatomy Lab in Lower Level.
- Three "Dry Labs" (Lab Manual chapters 3,4,6) in Learning Clusters on Third Floor.
- Lab groups of 3–5 are formed by the students.
- Neuroscience Lab Manual is on the CD.
- Lab exercises work best when you use Adobe Reader to open lab manual on the CD. To use Lab Manual on CD, start Adobe Reader and open the file `startlabmanual07.pdf` in the ns_lab_manual folder on the CD. You can also get at the lab manual through LUMEN, but it is slower and doesn't work as well. You should set up Adobe Reader Preferences as described in Introduction to Lab Manual.
- Also on the CD:
  - *folder labeled ns_lectures contains as many of the course lecture pdf or powerpoint files as were available when CD was burned; each professor has a separate folder.*
  - *folder labeld ns_smgrps contains material for the small group sessions.*
  - *folder labeled lumen_for_cd contains other teaching material from Lumen website related to brain sections studied in labs 3,4, and 6, along with a neurovascular (blood supply) tutorial, and a labeled brain MRI atlas*

Lab Exams

One Lab Quiz (25 questions) and **Two Lab Final Exams** (50 questions each) — but only one lab final is required and only the "best" lab final grade is counted!!!

Lab Quiz	25Q	8:30 AM	Wed	Aug 25
Lab Final 1	50Q	8:30 AM	Thu	Sept 16
Lab Final 2	50Q	8:30 AM	Wed	Sept 22

Lab Exam Format:

- A slide show with a multiple choice answer sheet

Lab Exam Grading:

- Lab Quiz counts for 7% of Final Grade.
- Best Lab Final counts for 18% of Final Grade.
- Both Lab exams (Quiz and Final) together count for 25% of Final Grade.

What about small groups?

- 8 small group sessions.
  - *Groups 1 and 2 introduce Neurological Exam (groups=class/2)*
  - *Groups (class/8) 3, 4, 5, 6 discuss cases. Attendance mandatory (sign-in sheet). (groups=class/8)*
  - *Groups 7 and 8 introduce Neuropathology (groups=class/2)*
- Meet Monday (1, 2) or Wednesday (7) or Fridays (3, 4, 5, 6, 8) at various times
- Small groups take place in learning clusters or case method rooms
- Material is found in **yellow pages in handout**.

Interpersonal and Communication Skills Competency:
Graduates must demonstrate knowledge of the principles of communication and the skills and attitudes that allow effective communication with patients, families, healthcare workers, and others who affect the health and well-being of patients; and to create and sustain a therapeutic and ethically sound relationship with patients.

Students will communicate effectively with their peers and faculty, as judged by their ability to participate actively and effectively in the small group discussions.

Evaluation: Small Group Faculty will report to Course Director any students who notably fail to participate in discussion or who consistently act inappropriately during discussions.

What about Review Sessions?

There are 4 Review Sessions scheduled:

1. A REV on Friday at end of 3rd week before first lecture exam
2. A BasicREV on Wednesday before final exam
3. A ClinicalREV on Wednesday before final exam

What is Evidence-based Neurology (EBN)?

On Tuesday September 17 at 11:00 AM Dr. Michael Schneck from Neurology will moderate an exercise on Evidence-based Neurology (EBN) related to treatment with carotid endarterectomy.

- *All students will receive via email a description of the cases two weeks before the EBN exercise; this is also found on the course CD in the EBN folder. In addition, all the relevant papers related to the indications for and against carotid endarterectomy will be posted on the Neuroscience Course website.*
- *Each of the small groups should meet* ***on their own*** *to discuss the cases, answer the questions, and select a representative of the group. The answers must be submitted to Dr. Schneck via email the day before the EBN exercise.* ***This email submission will be the basis for all members of the group receiving 0.5 point added to their final, overall course average; failure to submit answers will result in no points added to final average for all members of the group.***
- *On September 17 for the EBN session the 8 small group representatives will act as a panel for a discussion with Dr. Schneck of the cases.* ***All students must attend this session (sign-in sheet).***

Lifelong Learning, Problem-Solving, and Personal Growth Competency: *Graduates should demonstrate the knowledge, skills, and attitudes needed to be able to begin to evaluate their method of practice, use appropriate tools of evidence to analyze clinical practice, include research-based findings into their clinical practice, and understand concepts of quality in health care and quality improvement. They recognize and thoroughly characterize both personal and professional problems and develop an informed plan of action. They recognize that self-awareness, self-care, and personal growth are essential components of professional development. Our graduates will be able to develop a commitment to excellence and ongoing professional development.*

Medical Neuroscience Final Grade:

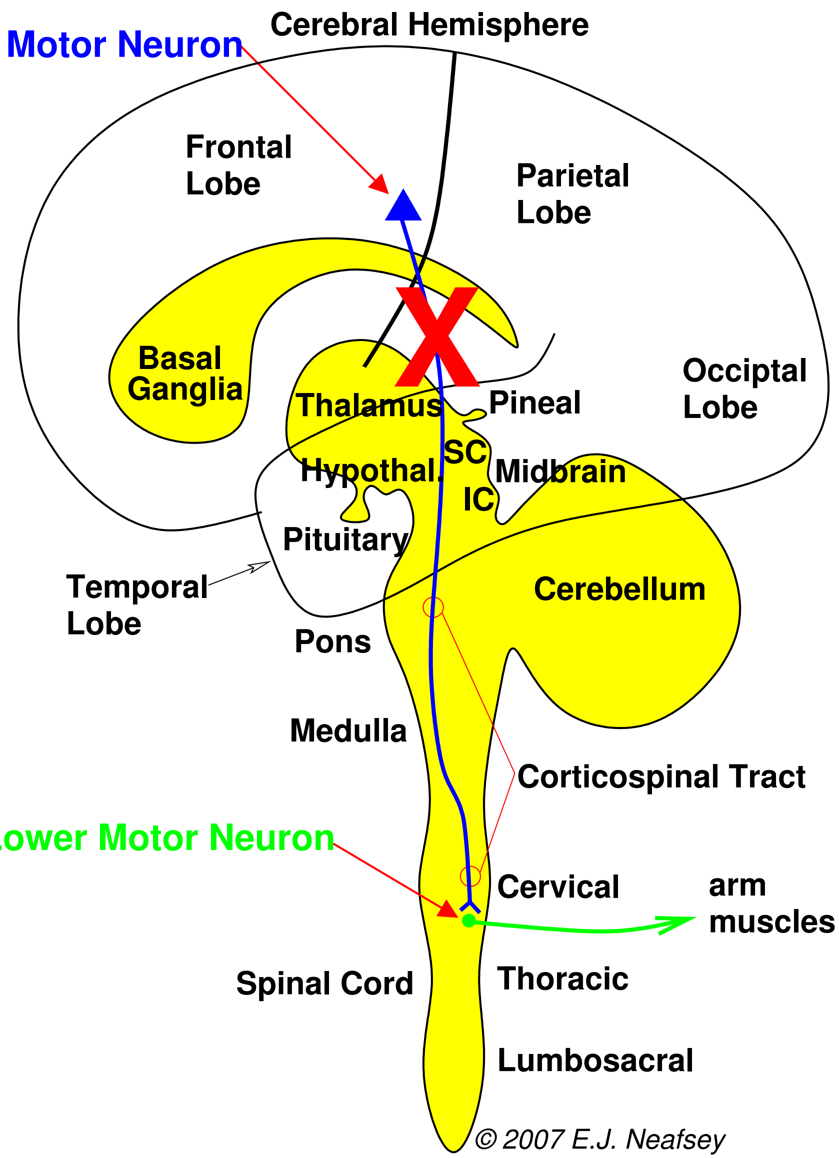
Exam	Percent
Midterm Lecture	30
Final Lecture	45
Lab Quiz	7
"Best" Lab Final	18

Mean defines Pass/High Pass line; mean + 1SD defines High Pass/Honors line; Fail/Pass line is determined by mean - 2SD or 70%, whichever is lower.

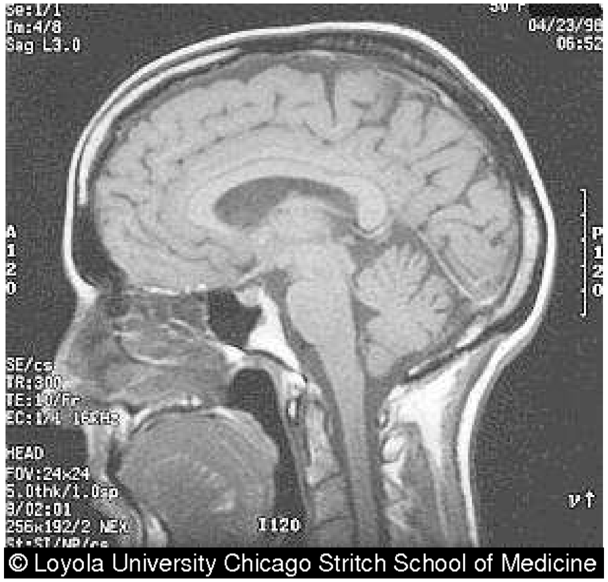
How do I do well?

- **Keep up!!!** Study each day's material and then glance at the chapter for the next day's lecture.
- Come to all the lab sessions. Prepare for labs by looking over the Lab Manual **before** the lab takes place. Ask the Faculty and TAs for help on the *Lesion Lessons* and *Patient Puzzles*.
- Prepare the small group cases **before** the small group takes place.

Example 1 — Stroke Paralysis: Damage to Origin or Fibers of Corticospinal TRACT



Example 2 — Midsagittal MRI:



What is taking Neuroscience like?

"... the process of learning is marked
by an initial period of darkness
in which one gropes about insecurely,
in which one cannot see where one is going,
in which one cannot grasp what all the fuss is about;
and only gradually, as one begins to catch on,
does the initial darkness yield to a subsequent period
of increasing light, confidence, interest, absorption."

Insight, Bernard Lonergan

What does it mean to know neuroscience?

Knowing

Knowing = **understanding correctly**

This means being able to **explain** the subject and being able to correctly **answer questions** about it.

Therefore, **knowing neuroscience** means **understanding it correctly**, so you can explain it to others (your colleagues and patients) and answer their questions about it.

The process of coming to understand a complex subject like neuroscience involves accumulating many "Aha!" experiences of insight into various aspects of the subject that allow you to finally "see the big picture" and "get it."

What does "Aha!" feel like? See if you can figure out the following puzzles. Pay attention to the feeling you have when you "get" one!

Insights

- M. + M. + N.H. + V. +C. + R.I. = N.E.
- "IB. in the H. = 2 in the B."
- C. + 6D. = N.Y.E.
- N.N. = G.N.
- 1 + 6Z. = 1M.
- H.H. & M.H. at 12 = N. or M.
- T. = L.S. State

From: *Aha: A Puzzle Approach To Creative Thinking* by Morgan Worthy. iUniverse, Inc. Book Publisher, Lincoln NE, 1999.

How Should I Study?

- Read the chapter several times.
- Close the book.
- Recall.
- Write it down or say it out loud
- Talk to your friends about it.
- If you just read it several times, it's easy to think you know it when you really don't.
- **TRY TO EXPLAIN IT TO SOMEONE ELSE!**

August 2010

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2 15:30 IntroNeuro,EJN	3 09:30 BrainOverview,EJN 10:30 Nhisto,Jones	4 LAB1+2 09:30 Devel1,Jones 10:30 LAB1+2:BrNrvBV-LL	5 09:30 SpCord,Dauz 10:30 RecAscDesc,Dauz	6 09:30 SkelMusSpC1,Pied 10:30 SkelMusSpC2,Pied	7
8	9 PATIENT 08:30 CC:SpCord,MM 09:30 CC:NMJun+Pt,MM 11:30 SmGrp1:NExamSen	10 09:30 Medulla,EJN 10:30 NeuMPAP,Cuk	11 Mass of Holy Spirit/LAB3 09:30 Pons,EJN 13:00 LAB3:MedPons-LC3	12 09:30 Mid,EJN 10:30 TrigAud,EJN 11:30 SynTran,Cuk	13 09:30 Vest1,Gruener 10:30 Vest2Eyes,Gruener	14
15	16 09:30 EyeMove,Stubbs 10:30 SmGrp2:NExamMot	17 09:30 RetFor,Gruener 10:30 Cbellum1,Gruener	18 LAB4 09:30 Cbellum2,Gruener 10:30 LAB4:PonsMid-LC3	19 09:30 CC:CrNerv,MM90 11:00 PostFossa,Ander	20 08:30 SmGrp3:SpCord 10:00 REV,EJN	21
22	23 09:30 ANS1,Scrogin 10:30 ANS2,Scrogin	24 09:30 Cortex1,EJN 10:30 Cortex2,EJN	25 LabQUIZ 08:30 NeurLabQuiz 09:30 Chnopathies,Cuk 10:30 Coma,Letarte	26 PATIENT 09:30 CC:Lang,MM 10:30 MS+Pt,MM	27 08:30 SmGrp4:Coma 10:00 Cortex3,EJN	28
29	30 EXAM1 13:00 NeuPhaBehEXAM1	31 09:30 Dien,EJN 10:30 BG,EJN				

July 2010

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September 2010

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

medns2010-Tue Jun 22 09:54:10 CDT 2010

September 2010

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 LAB5 09:30 MotorSys,EJN90 11:00 LAB5:CxCb-LL	2 09:30 CC:MoveDis,MM 10:30 BrImgEss,MM 11:30 EndofLife,MM 30	3 08:30 SmGrp5:Stroke 11:00 Hypo1,DonC	4
5	6 Labor Day	7 09:30 Hypo2,DonC 10:30 Limbic,EJN90	8 LAB6 09:30 Pain1,Holtman 10:30 LAB6:DienBG-LC3	9 (Rosh Hash.) 09:30 CC:Headache,MM 10:30 Epilep,Asc+EJN90	10 (Rosh Hash.) 09:30 VisSys1,Stubbs 13:00 SmGrp6:Epi	11
12	13 PATIENT 09:30 VisSys2,Stubbs 10:30 CC:BgCb+Pt,MM90	14 09:30 VisSys3,Stubbs 10:30 Sleep,DonC90	15 LAB7+LABREV 09:30 AudSys1,Pied 10:30 LAB7:BrainCut-LL 16:00 LABREV	16 LabEXAMA 08:30 NeurLabEXAM2a 09:30 AudSys2,Pied 10:30 CC:EyeEar,MM	17 EBN 08:30 TumorPath,Lee 09:30 CxHemis,EJN90 11:00 EBN, Schneck	18 Yom Kippur
19	20 09:30 CC:CortFunc,MM 10:30 CC:IntoxInf,MM90 13:00 SmGrp7:NPath1	21 09:30 CC:BrTumor,Shea 10:30 TumRadOnc,Melian	22 LabEXAMB 08:30 NeurLabEXAM2b 09:30 CN:Trauma,Shea 10:30 CN:DegDis,Lee 90	23 PATIENT 09:30 CC:CerVasDis1,MM 10:30 CN:NPthy+Pt,MM90	24 09:30 CC:CerVasDis2,Lee 10:30 CSFVasBBB,Letarte 13:00 SmGrp8:NPath2	25
26	27 09:30 Neuropsych,Prim 10:30 Devel2,Jones	28 09:30 InjRegen,Jones 10:30 RepairPlas,Kartje	29 09:30 BasicREV,EJN 10:30 ClinicalREV,MM	30		

August 2010

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

October 2010

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

medns2010-Tue Jun 22 09:54:10 CDT 2010

October 2010

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1 EXAM2 13:00 NeuPhaBehEXAM2	2
3	4	5	6	7	8	9
10	11 Columbus Day	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31 DST ends **Halloween**						

September 2010

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

November 2010

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

medns2010-Tue Jun 22 09:54:10 CDT 2010

Grad Students

- Please stop by and see me after class to make sure I have all of your names and email addresses.

Brain Overview

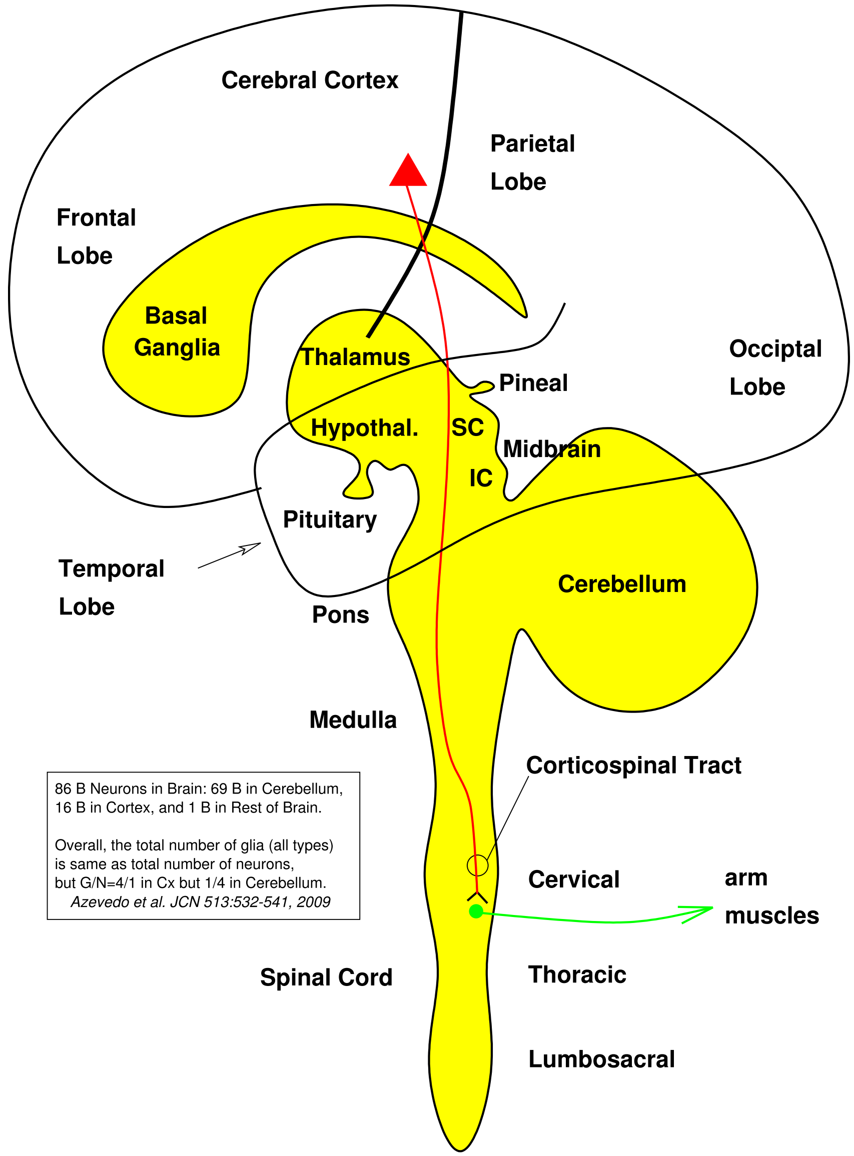
(Covered in party by Chapter 3 of *Neuroscience: An Outline Approach*)

E.J. Neafsey, Ph.D.
Loyola University Stritch School of Medicine

Outline

1. Brain Subdivisions in Various Views
2. Circulation (anterior and posterior)
3. Ventricles
4. Meninges
5. Choroid Plexus and CSF
6. Blood Brain Barrier

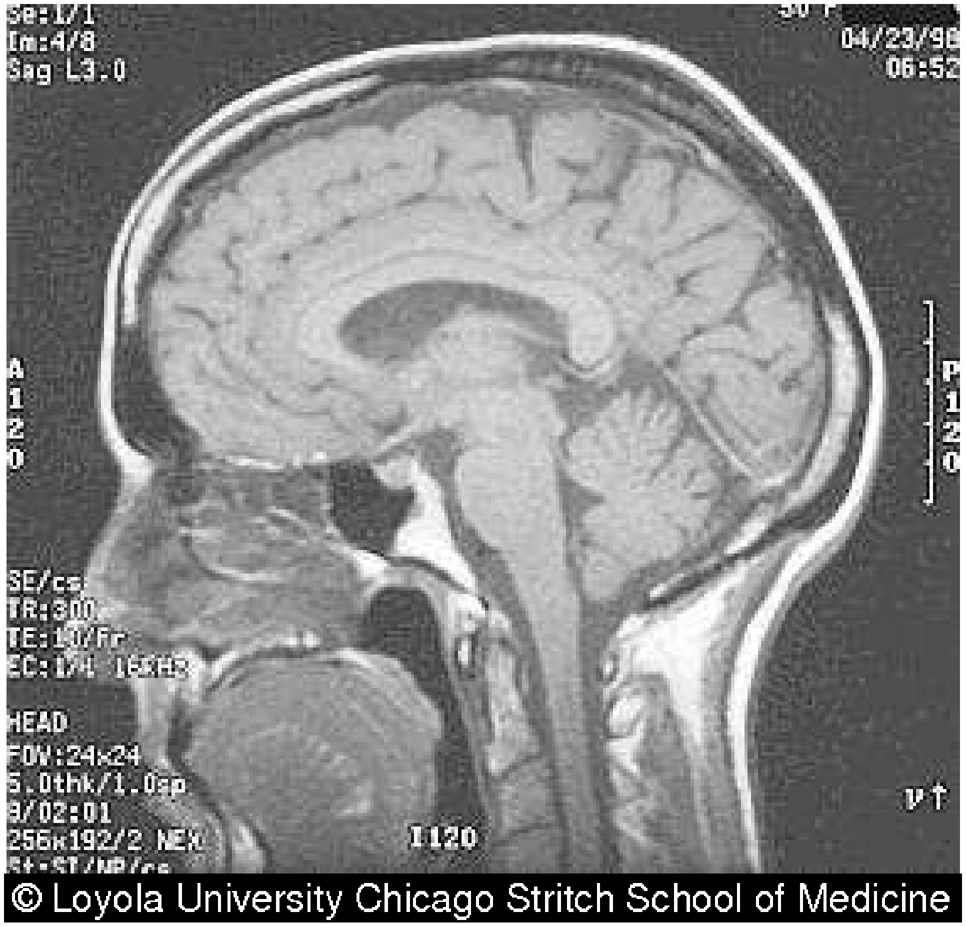
Brain Overview



86 B Neurons in Brain: 69 B in Cerebellum, 16 B in Cortex, and 1 B in Rest of Brain.

Overall, the total number of glia (all types) is same as total number of neurons, but G/N=4/1 in Cx but 1/4 in Cerebellum.
Azevedo et al. JCN 513:532-541, 2009

Mid-Sagittal View



Region	*Mass (g)*	*Neurons (B)*	*Non-Neurons (B)*
Brain	1500	86	85
Cortex	1200	16	60
Cerebellum	150	69	16
Remainder	118	1	8

(from *Azevedo et al., J Comp Neurol 513:532-541, 2009*)

Identify

- spinal cord
- medulla
- pons
- midbrain
- cerebellum
- 4th ventricle
- aqueduct
- tectum
- 3rd ventricle
- thalamus
- hypothalamus
- corpus callosum
- cerebral hemisphere

Ventral View

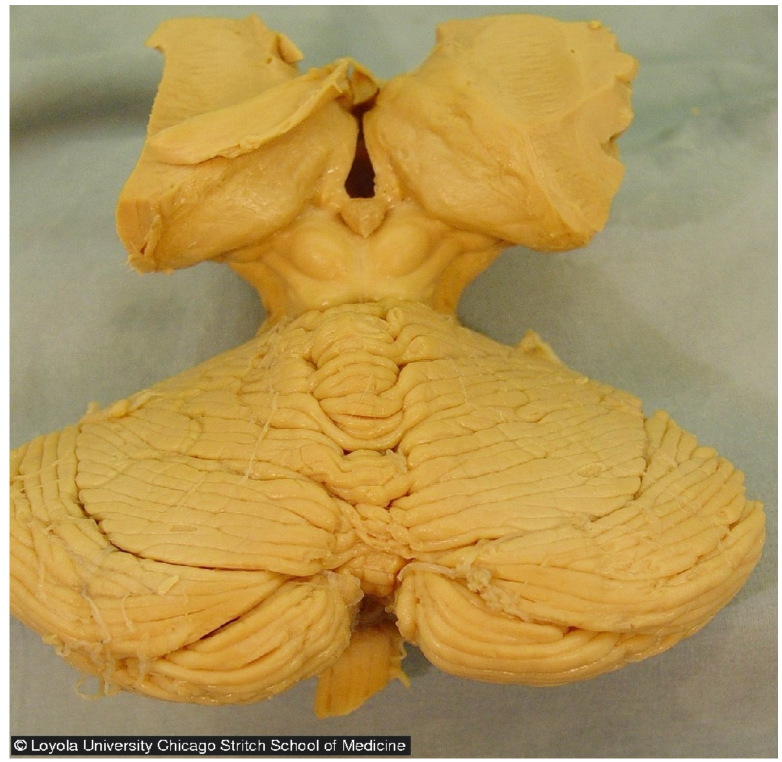
Identify

- medulla
- pons
- midbrain
- cerebellum
- temporal lobe
- mammillary bodies
- optic chiasm
- pia mater
- cranial nerves
- blood vessels

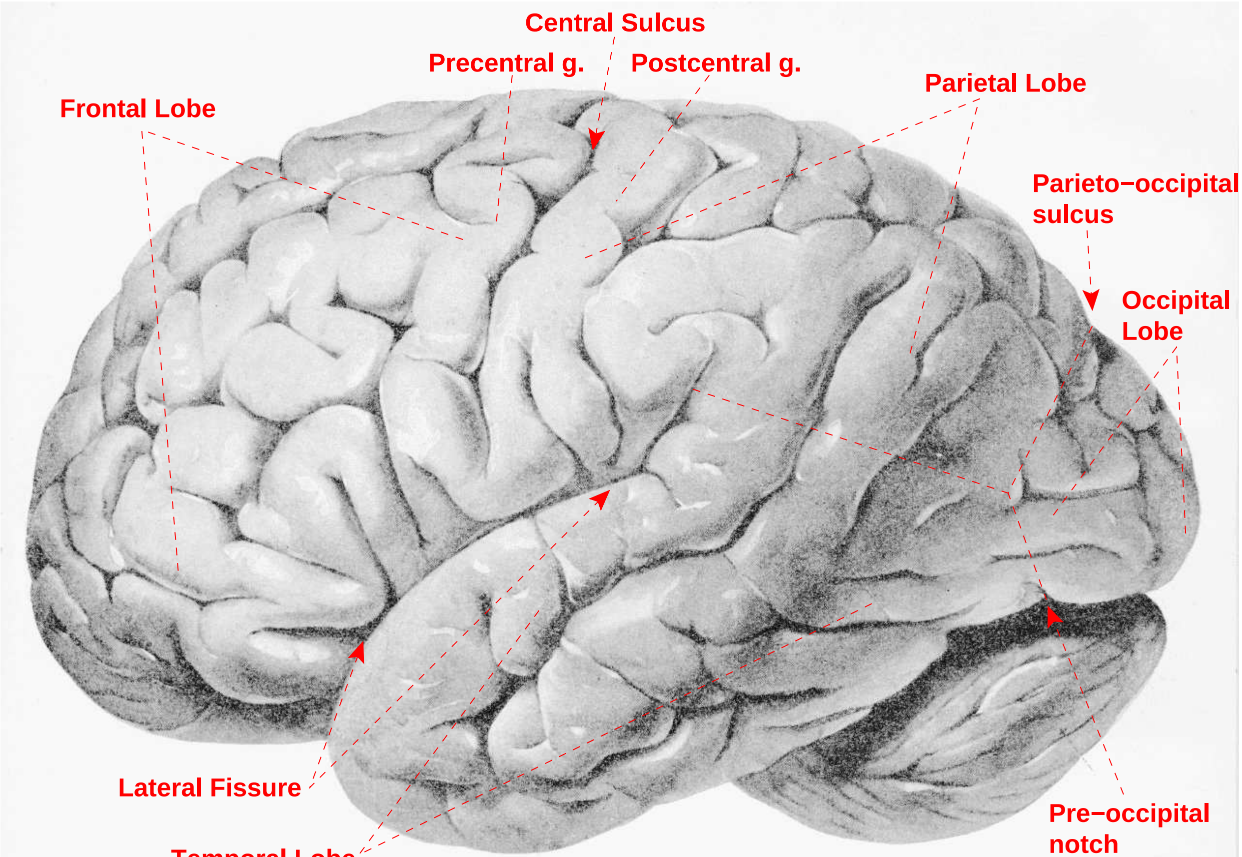
Dorsal View

Identify:

- floor of fourth ventricle
- cerebellar peduncles
- superior and inferior colliculi
- pineal gland
- thalamus



Lateral View



Spalteholz, W. Handatlas der Anatomie des Menschen. Leipzig, S. Hirzel, 1903
(In public domain, published before 1923)

Identify

- central sulcus
- lateral fissure
- frontal lobe
- parietal lobe
- occipital lobe
- temporal lobe
- cerebellum

Anterior and Posterior Circulations

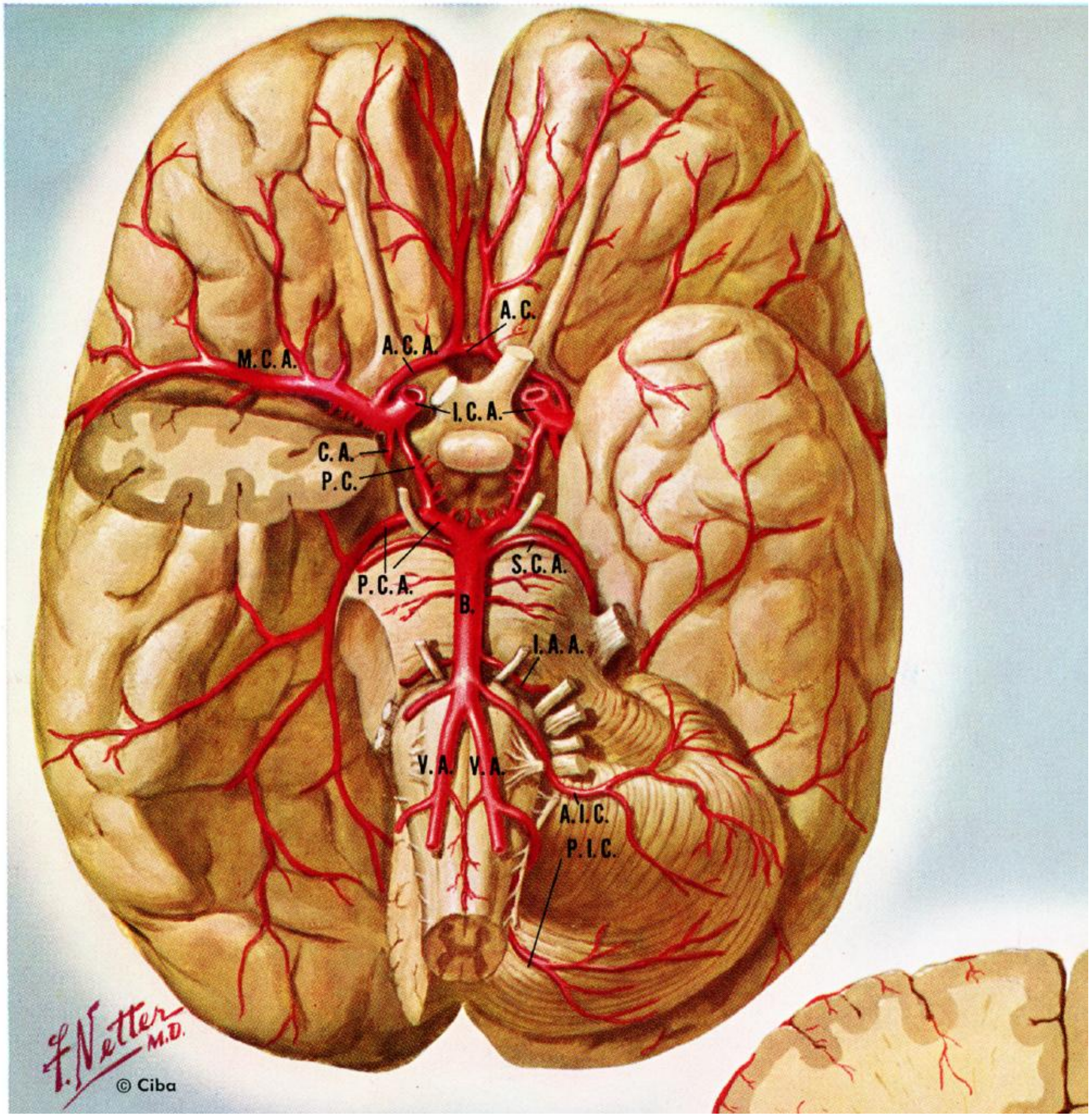


Plate 16 from *The CIBA Collection of Medical Illustrations. Volume I. Nervous System*. Frank Netter. CIBA:1953.

Anterior Circulation:

- *internal carotid a.*
- *middle cerebral a.*
- *anterior cerebral a.*

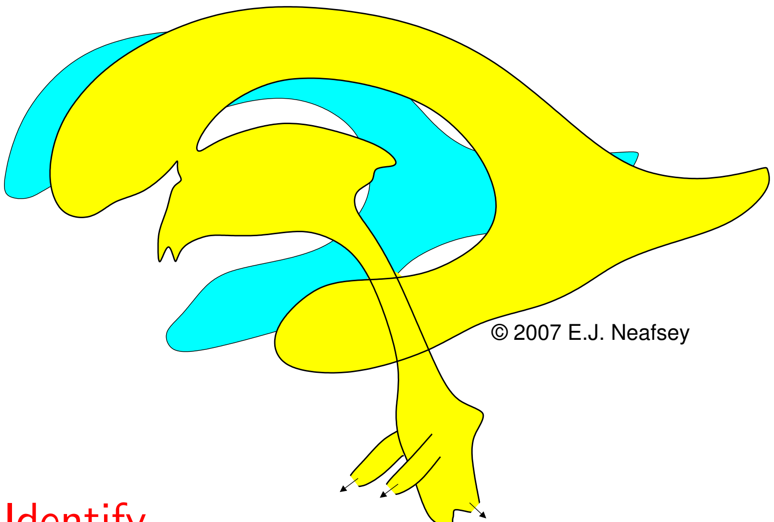
Posterior Circulation:

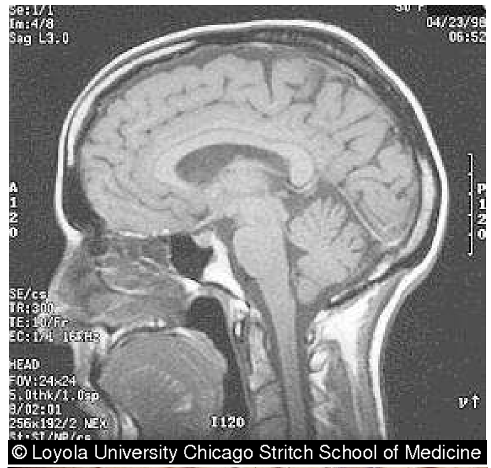
- *vertebral a.*
- *basilar a.*
- *posterior cerebral a.*

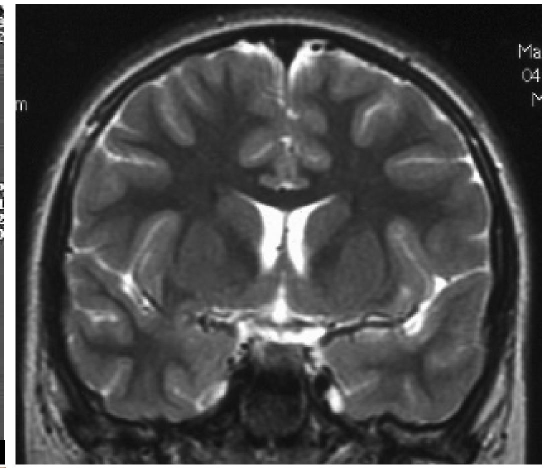
Circle of Willis

- *post. communicating a.*
- *ant. communicating a.*

Ventricles







Identify

- lateral ventricles
- foramen of Monro
- 3rd ventricle
- aqueduct
- 4th ventricle
- foramen of Magendie
- foramina of Luschka
- central canal

Meninges: Dura, Arachnoid, and Pia

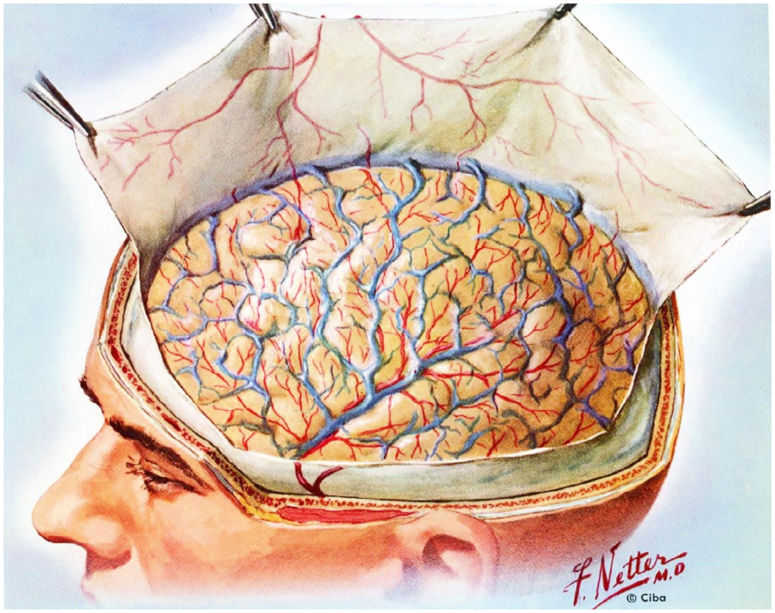
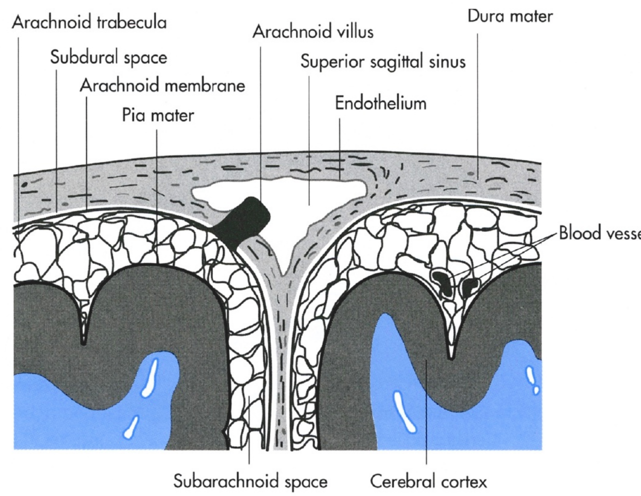


Plate 13 from *The CIBA Collection of Medical Illustrations. Volume I. Nervous System*. Frank Netter. CIBA: 1953.



(Fig 3-1, *Neuroscience: An Outline Approach*)

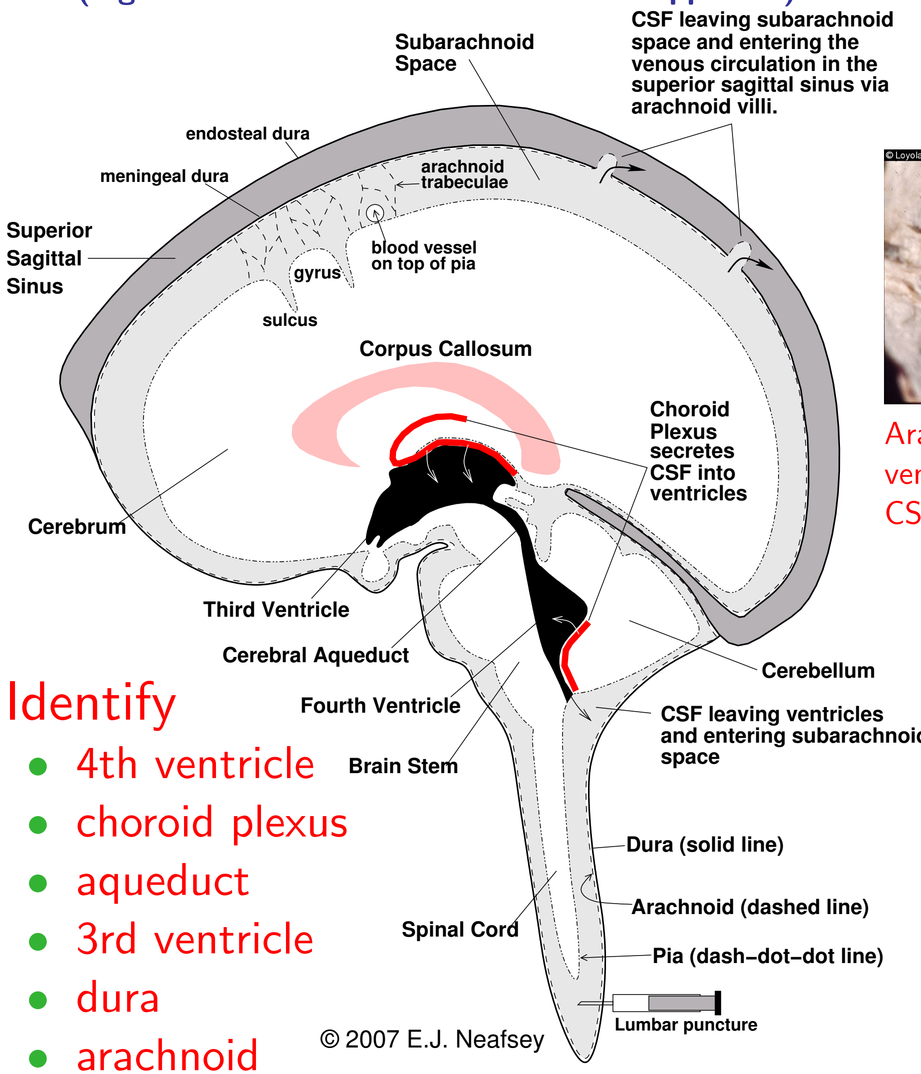
Identify:

- dura
- arachnoid
- pia
- subarachnoid space
- arachnoid villus
- superior sagittal sinus

Choroid Plexus and CSF

(Fig. 3.2 of Neuroscience: An Outline Approach)

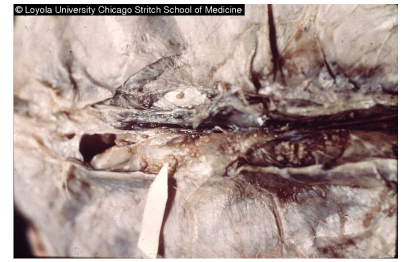
Choroid plexus filters blood plasma and secretes CSF into ventricles.



Identify

- 4th ventricle
- choroid plexus
- aqueduct
- 3rd ventricle
- dura
- arachnoid
- pia

Fig. 3-2 of *Neuroscience: An Outline Approach*



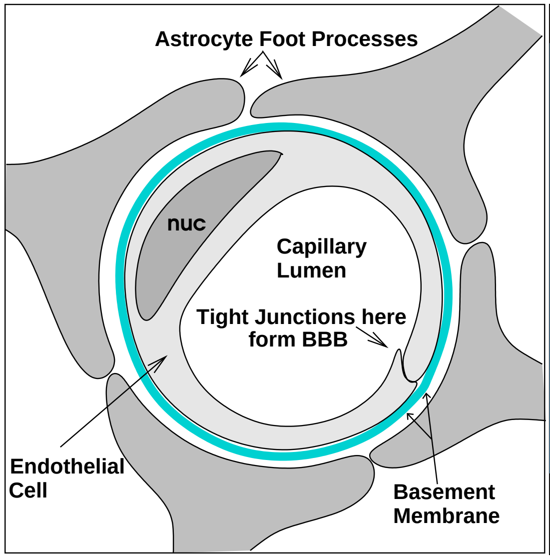
Arachnoid villi empty into venous sinuses and return CSF to circulation.

CSF is formed INSIDE the brain within the ventricles, leaves via openings in fourth ventricle, circulates around brain in subarachnoid space, and then returns to circulation via arachnoid villi into superior sagittal sinus.

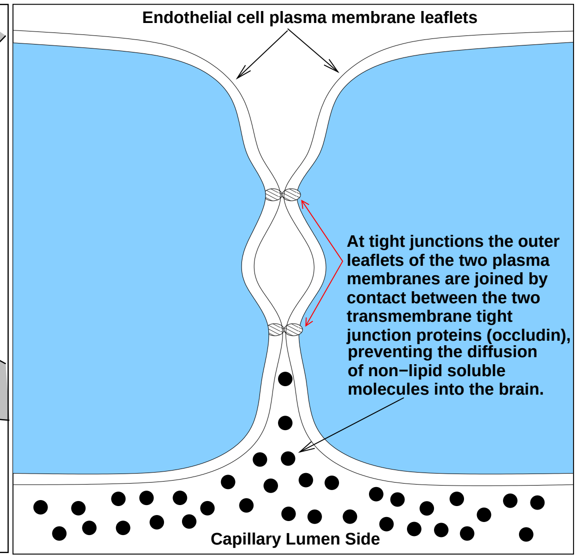
csf.mov

BBB = Tight Junctions Between Brain Capillary Endothelial Cells

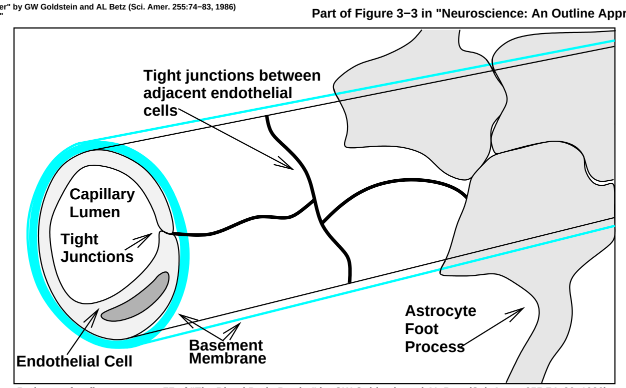
(Fig. 3-3 of *Neuroscience: An Outline Approach*)



Redrawn after figure on page 76 of "The Blood Brain Barrier" by GW Goldstein and AL Betz (Sci. Amer. 255:74−83, 1986)
Part of Figure 3−3 in "Neuroscience: An Outline Approach"



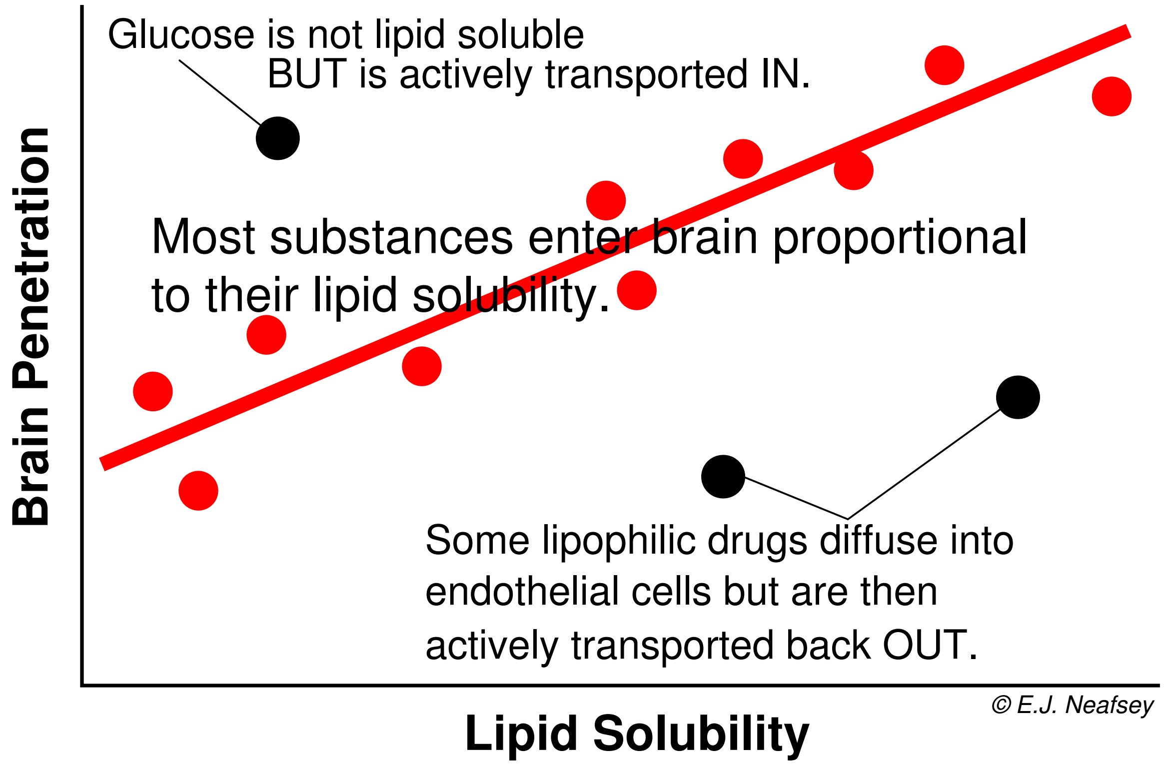
Part of Figure 3−3 in "Neuroscience: An Outline Approach"



Redrawn after figure on page 77 of "The Blood Brain Barrier" by GW Goldstein and AL Betz (Sci. Amer. 255:74−83, 1986)
Part of Figure 3−3 in "Neuroscience: An Outline Approach"

Astrocytes induce brain endothelial cells to form tight junctions, which creates the blood-brain barrier. Existence of this barrier mean that only lipid soluble substances that can diffuse through the endothelial cell membrane OR substances that are actively transported across the endothelial cell membrane can enter the brain.

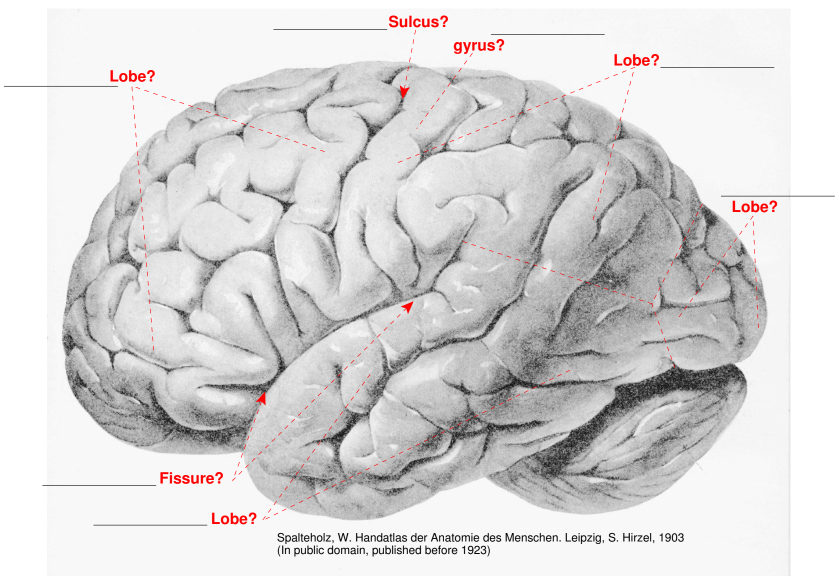
Lipid Soluble Substances Cross BBB



Quiz

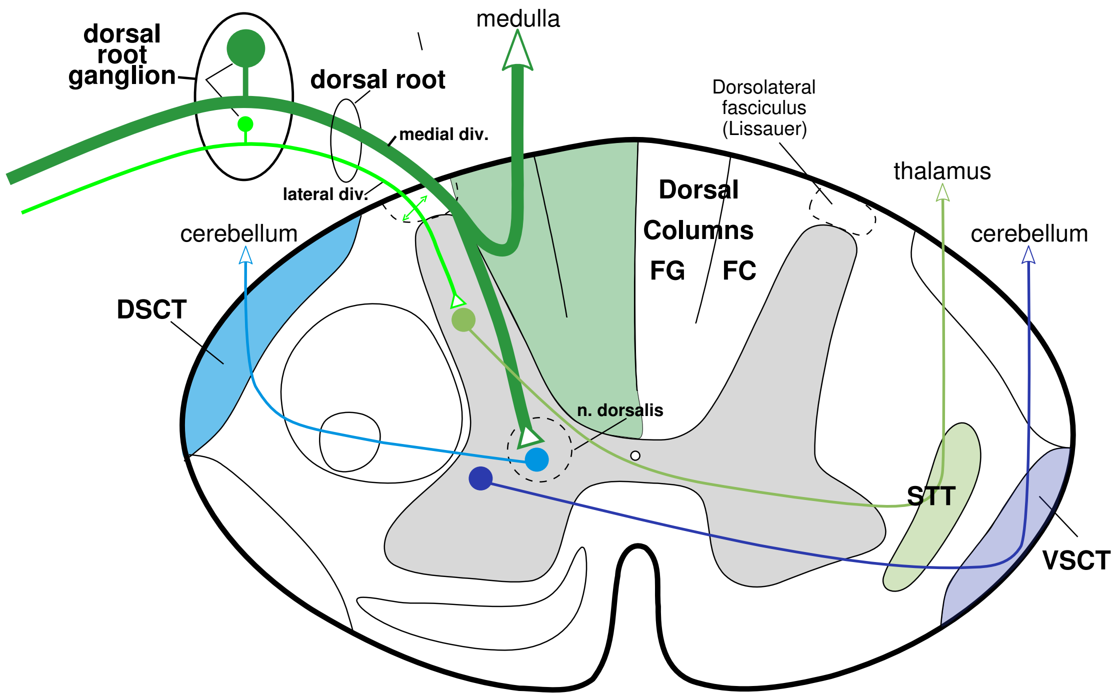
Identify

- medulla
- pons
- midbrain
- cerebellum
- 4th ventricle
- aqueduct
- 3rd ventricle
- tectum



1. Describe the anterior circulation of the brain.
2. Describe the posterior circulation of the brain.

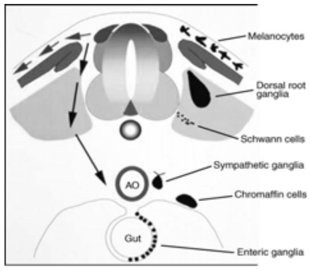
Spinal Cord: Sensory Inputs and Tracts



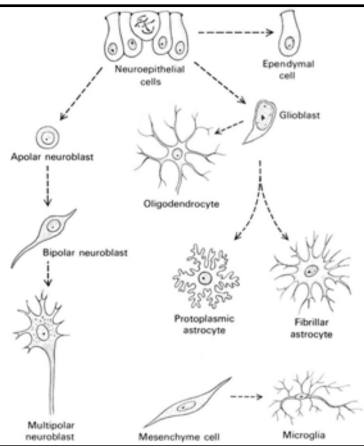
- *Identify the fasciculus gracilis (FG) and fasciculus cuneatus (FC), spinothalamic tract (STT), dorsal spinocerebellar tract (DSCT), and ventral spinocerebellar tract (VSCT).*
- *Note that there are NO SYNAPSES in the dorsal root ganglion. The primary sensory axons simply pass through on their way from the periphery to the spinal cord. Each dorsal root ganglion cell body located there sustains its single axon (remember these are pseudoUNIPOLAR neurons) by way of metabolism, protein synthesis, etc. NOTHING ELSE HAPPENS THERE!*

Blastocyst
↓
Inner cell mass
↓
Ectoderm

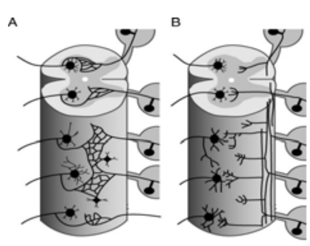
Neural plate/ectoderm
↓
Neural tube



Neural epithelium
Neural crest



The Neuron Doctrine-the cell theory applies to the NS



Neuron=structural unit

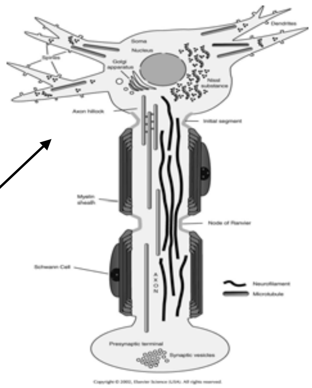
- Cell body
- Dendrites
- Axon

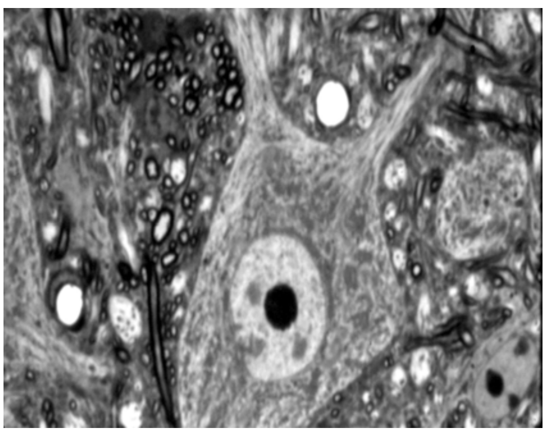
<u>Classifications:</u>

Multipolar-most cells

Pseudounipolar-DRG

bipolar-rods and cones
olfactory receptor
vest/coch ganglia

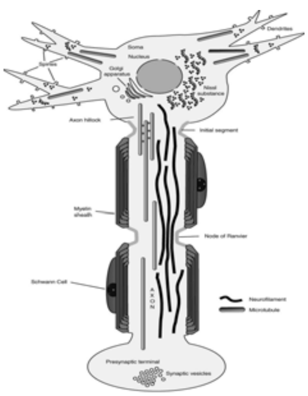


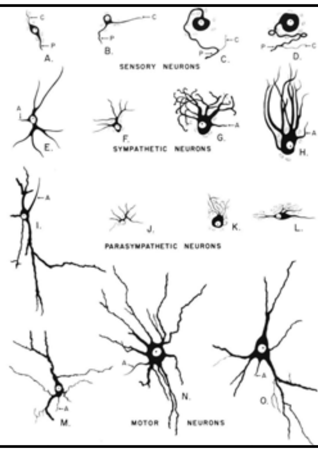


<u>Cell body:</u>
nucleus
Golgi apparatus
Nissl substance
cytoskeleton
mitochondria
lysosomes

<u>Dendrites:</u>
many per neuron
receive majority synapses
mitochondria/cyto/RER
covered with spines
unmyelinated

<u>Axon:</u>
arises from axon hillock
mitochondria/cyto
myelinated or unmyelinated
bidirectional axonal transport





<u>Synapses:</u>

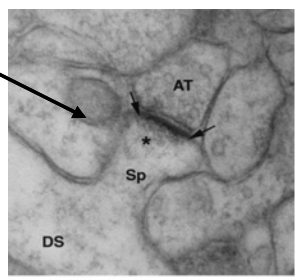
axo-dendritic

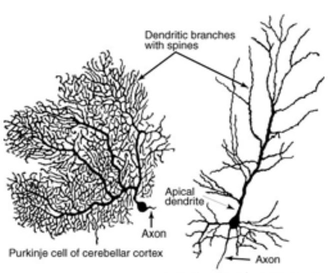
axo-somatic
axo-axonal

neuromuscular

asymmetrical
symmetrical

excitatory
inhibitory

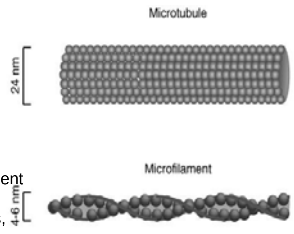




Cytoskeletal Elements: Tubulin, Actin, Intermediate Filaments
dynamic structures; unique complement/cell
aggregate properties - basis of cell morphology and plasticity

cell architecture
intracellular transport
10% brain protein

responsive to environment
concentrated in growth cones,presynaptic sites, dendritic spines



Vimentin, GFAP, NF triplet

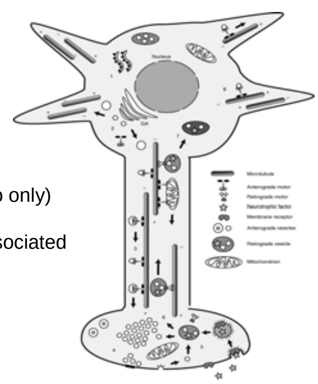
Axonal transport

Anterograde
Retrograde

Slow: growth (antero only)

Fast: membrane-associated
retro and antero

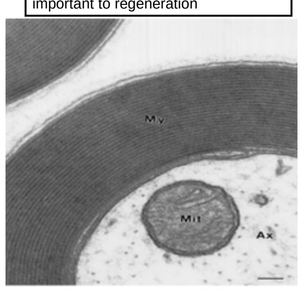
building/maintaining



Schwann cell (Neural crest)-myelinating cell of PNS

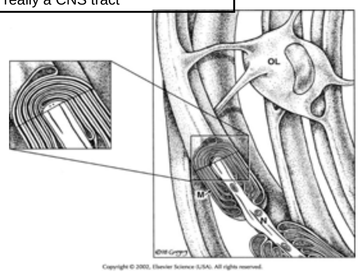
1 Schwann cell wraps 1 axon segment
React after peripheral nerve damage
important to regeneration

PMP-22 protein
over/underexpression
myelin deficiencies
peripheral neuropathies



Oligodendrocytes:myelinating cell of the CNS

myelinates up to 40-50 nearby axonal segments
involved in MS
optic "nerve"- really a CNS tract

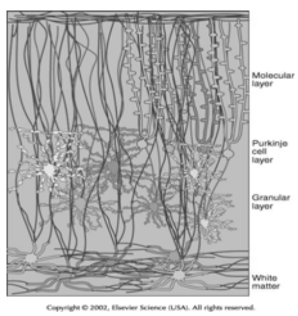


Astrocytes: Important role in CNS homeostasis

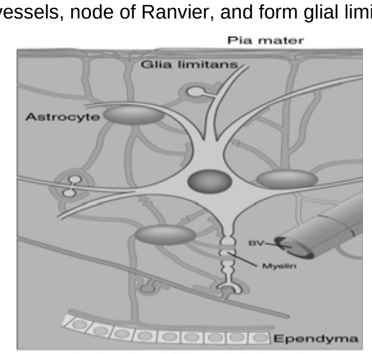
(20-50% of volume)

Functions:
- migration/guidance of neurons
- source of adhesion molecules
- help form aggregates of neurons
- produce large # trophic factors
- regulate NT uptake/inactivation
- soak up K+ ions
- CNS detoxification
- BBB

CNS disorders:
- react-hypertrophy
- form scars-astrogliosis
- most gliomas



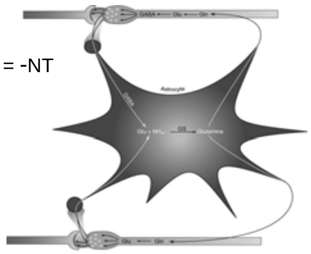
Astrocytic processes surround neurons and synapses, blood vessels, node of Ranvier, and form glial limitans



Glutamate-glutamine cycle
active coupling of NT metabolism between neurons and astrocytes

Glutamate = + NT
γ-aminobutyric acid = -NT

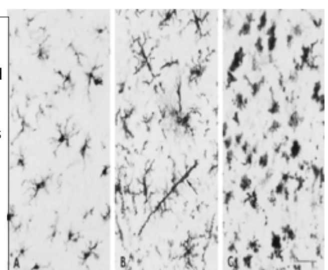
K+ ions soaked up
spatial buffering
detoxification



Microglia
mediators of immune responses in nervous tissue

Functions:
resident immune cells
Blood monocyte-derived
5-20% of cells
homeostasis ?
cytokines/trophic factors
immune activation

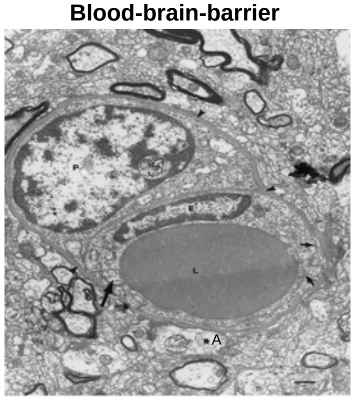
CNS disorders:
reactive
phagocytic
antigen presentation
neurodegeneration



Blood-brain-barrier

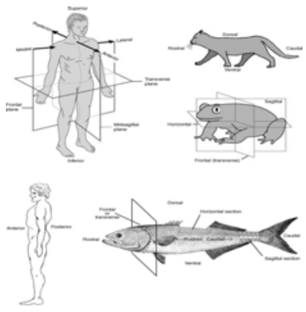
Endothelial cells
Tight junctions
Pericytes
Astrocytic endfeet

Basement membrane



Neural stem cells-
progenitor cells that give rise to more differentiated cells, but remain in cell cycle

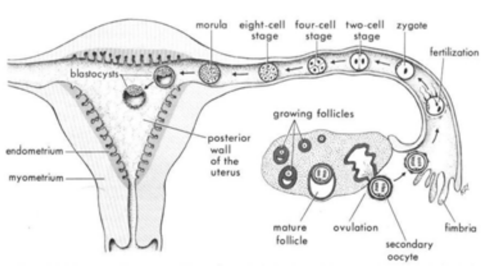
- Embryonic –
  - blastocyst source of true stem cell
  - neuroblast source of new neurons
- Adult –
  - subventricular zone throughout neuraxis
  - hematopoietic stem cells- may become neural



Topographical Organization of the Nervous System begins in the neural plate stage

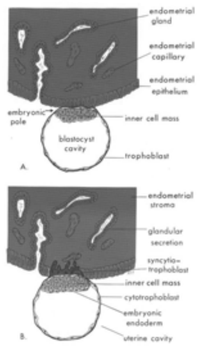
- **CNS develops as hollow tube**
- **Topographically flat sheet of cells = neural plate (originally ectoderm)**
- **Process of CNS development called neurulation**
- **Blastocyst-bilaminar-trilaminar (3rd week)**

Week 1 of Development - Blastocyst

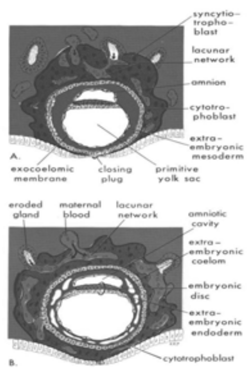


Inner cell mass

Embryonic stem cells



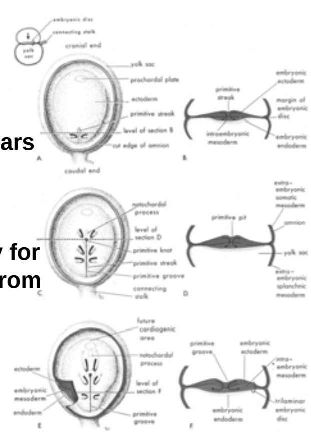
Week 2
inner cell mass
becomes
bilaminar embryo



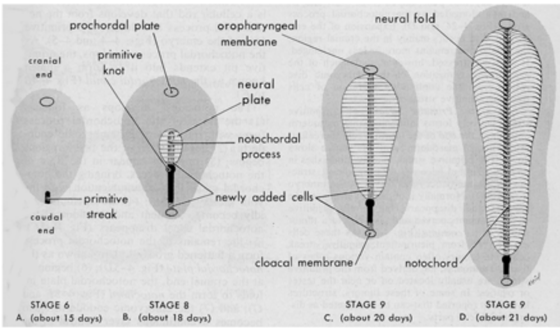
Week 3-trilaminar

Primitive streak appears = source of 3rd layer (mesoderm)

<u>Mesoderm</u> necessary for neural plate to form from ectoderm



Week 3-Trilaminar Embryo
Primitive Streak and the Neural Plate

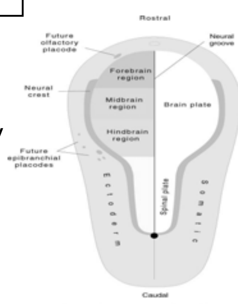


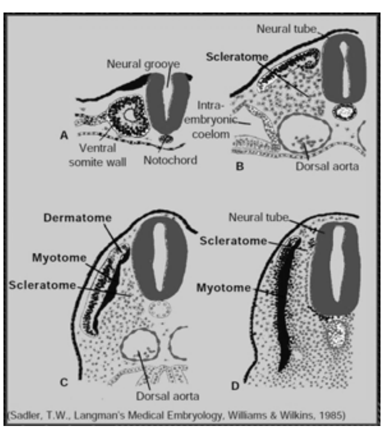
Neural Plate

Polarity

Bilateral symmetry

Regionalization





(Sadler, T.W., Langman's Medical Embryology, Williams & Wilkins, 1985)

Somites

- Blocks of mesodermal tissue along axis
- Begin to form by day 17
- Differentiate into:
  - sclerotome-forms axial skeleton/cartilage
  - dermatome-forms dermis and subcut.tissue
  - myotome-forms skeletal muscles
  - general somatic afferents (GSA)
  - general somatic efferents (GVE)

❖Regional Differentiation

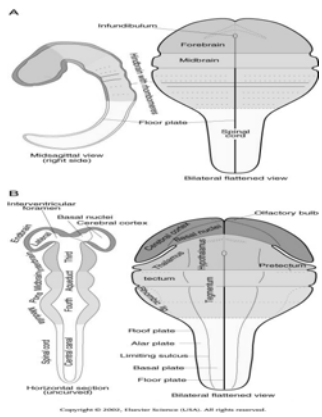
❖Brain Vesicles

❖Ventricular System

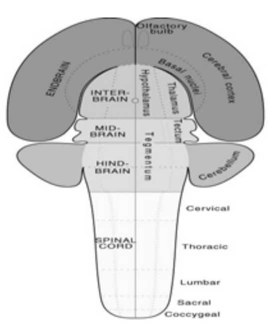
❖Neurogenesis and neural crest

Polarity
Bilateral symmetry
Regionalization

Ventricular system

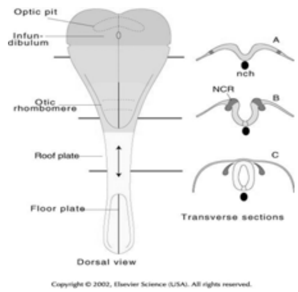


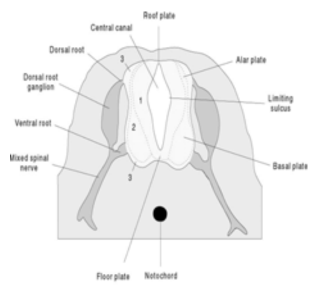
Initial vesicles	vesicle differentiation	regions	ventricle
prosencephalon	telencephalon	cerebral cortex basal nuclei	lateral
	diencephalon	thalamus hypothalamus	3rd
mesencephalon	mesencephalon	midbrain	aqueduct
rhombencephalon	metencephalon myelencephalon	pons/cerebellum medulla	4th



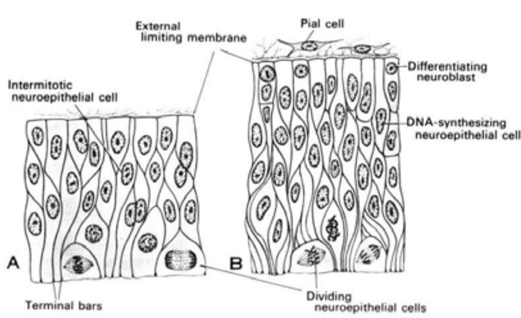
Neuroepithelium

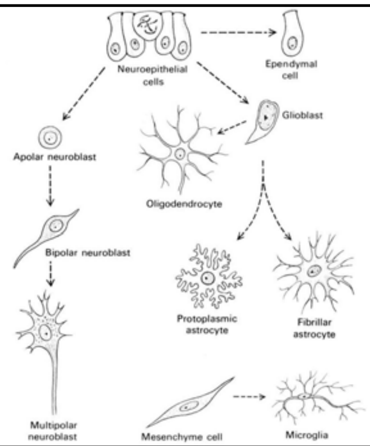
Neural crest



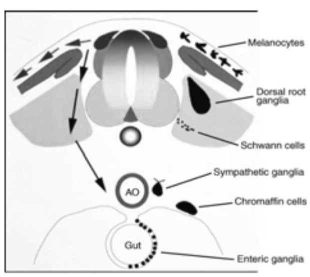


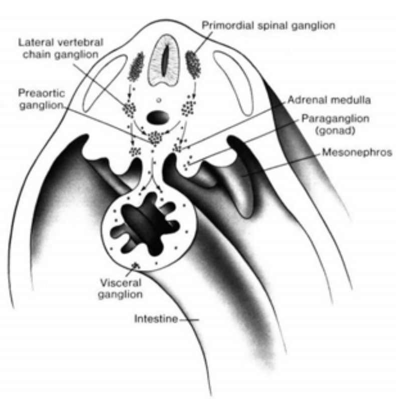
1= ventricular zone=source of CNS neurons and glia
2= mantle layer= gray matter
3= marginal layer=white matter



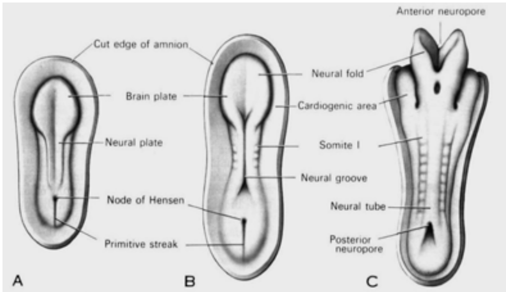


Neural crest derivatives



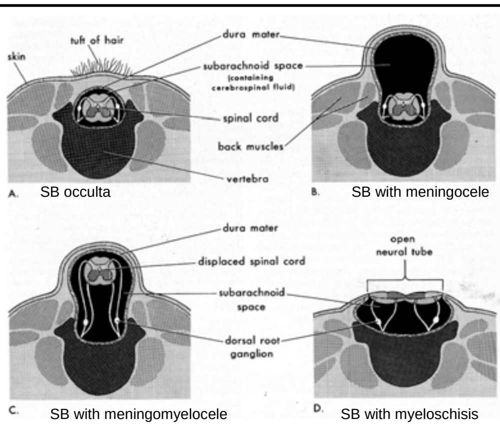


Congenital NS malformations:
defective formation of the neural tube in weeks 3 and 4



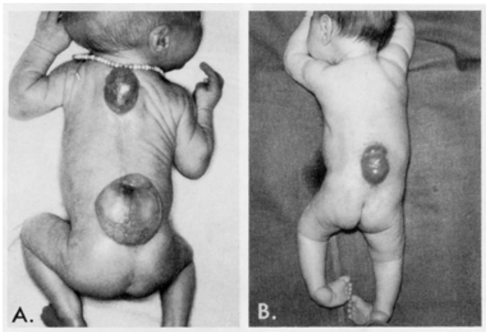
Congenital malformations of the nervous system

- ❖ Spinal cord abnormalities:
  - ❖ spinal bifida – vertebral column defect
  - ❖ many defective vertebrae=rachischisis
  - ❖ clinically- both neural and vertebral defects
  - ❖ most common- lower thoracic, lumbar, sacral
- ❖ Spinal bifida occulta- nonfusion of vertebral halves
  - ❖ most common and least severe
- ❖ Spinal bifida cystica=protrusion of s.c./meninges
  - ❖ with meningocele= only meninges and CSF
  - ❖ with meningomyelocele= sp cord, roots included



A. SB occulta
B. SB with meningocele
C. SB with meningomyelocele
D. SB with myeloschisis

SB cystica

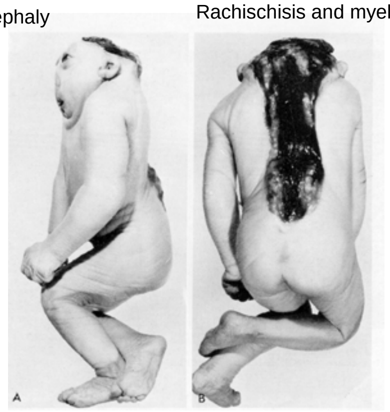


Congenital malformations of the nervous system

- Brain abnormalities
  - anencephaly- absence of the cranial vault
  - microcephaly- normal face size; tiny cranium
  - hydranencephaly-absent cerebral hemispheres
  - hydrocephalus-accumulation of CSF due to obstruction of flow
- Mental retardation
  - chromosomal abnormalities
  - disorders of protein, carbohydrate or fat metabolism
  - maternal infection
  - fetal irradiation

Anencephaly

Rachischisis and myeloschisis



Spinal Cord Anatomy

Gross anatomy

Dermatome

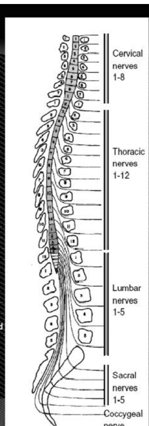
Functional components of spinal nerves

General internal features

Peripheral receptors & ascending tracts

Lower motor neuron & descending tracts

Segments



(From Barr, M.L. and Kiernan, J.A., The Human Nervous, Lippincott, 1988)

Cervical enlargement

- $C_5 - T_1$

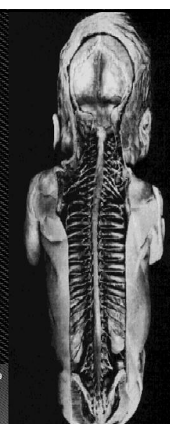
Lumbar enlargement

- $L_1 - S_{2-3}$

Note:

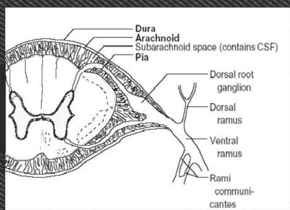
- spinal nerves in relation to vertebral numbers
- spinal cord levels in relation to vertebral levels
- course of spinal nerves enroute to intervertebral foramina

- vertebral extent of spinal cord
  - > neonate – L3
  - > adult – L1-2
- relative rostral shift of spinal cord due to differential growth of spinal cord and vertebral column
- relative shift results in the formation of the cauda equina

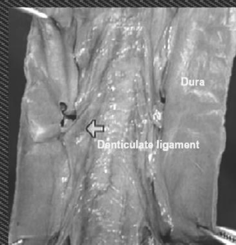


(From Gluhbegovic, N. and T.H. Williams, The Human Brain, Harper and Row, 1980)

Meninges



(From Hollingshead, WH, Textbook of Anatomy, 3rd ed., Harper and Row, 1974)

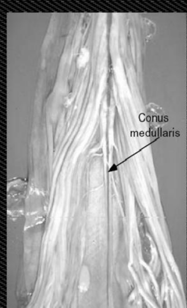


(Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; Diana Smith, LSU)

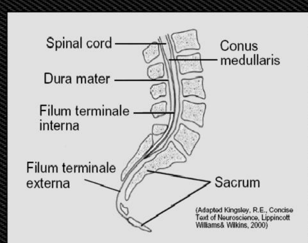
- spinal dura continuous with meningeal layer of cranial dura
- dura fuses with epineurium of peripheral nerves
- delicate arachnoid trabeculae attach to pia

?

Caudal spinal cord

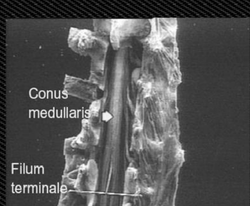


(From the E.Ross collection, Loyola School of Medicine)

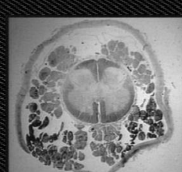


- pia extends caudally as the filum terminale
- fuses with dura to form the coccygeal ligament (filum terminale externa) - attaches to the coccyx
- lumbar cistern - subarachnoid space caudal to conus medullaris (L1-2 to S2-3)

Cauda equina

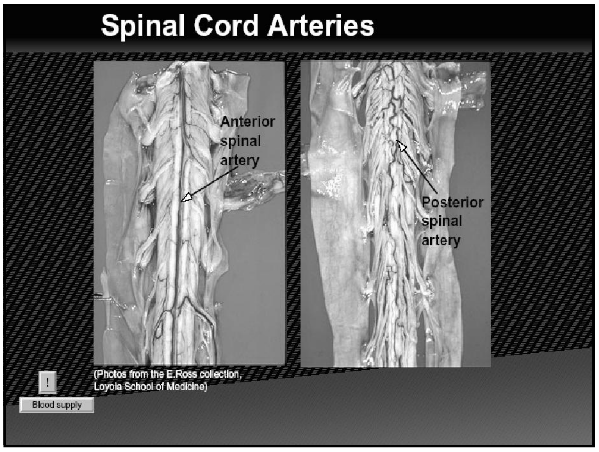


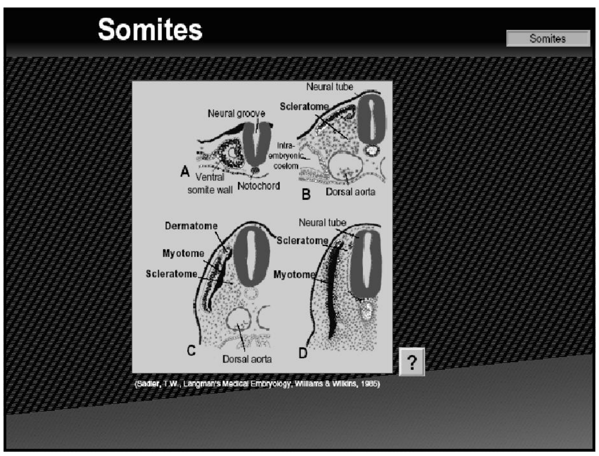
(Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; K.D. Peterson - Univ. of Utah)

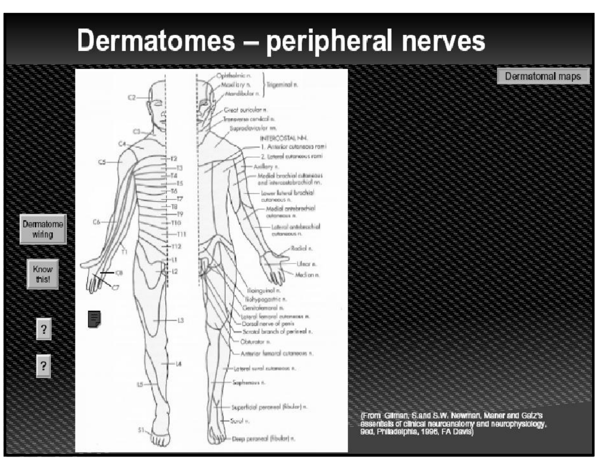


(Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; S. Stensaas, Cornell Univ.)

!


Spinal Cord Arteries
Anterior spinal artery
Posterior spinal artery
(Photos from the E.Ross collection, Loyola School of Medicine)
!
Blood supply

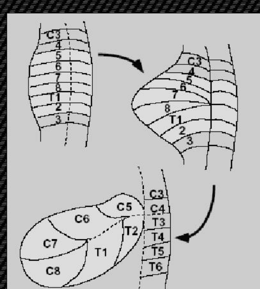

Somites
Somites
Neural tube
Neural groove
Scleratome
Intra-embryonic coelom
A
Ventral somite wall
Notochord
B
Dorsal aorta
Dermatome
Neural tube
Myotome
Scleratome
Scleratome
Myotome
C
Dorsal aorta
D
?
(Sadler, T.W., Langman's Medical Embryology, Williams & Wilkins, 1985)


Dermatomes – peripheral nerves
Dermatomal maps
Dermatome wiring
Know this!
?
?
(From Gilman, S.and S.W. Newman, Manter and Gatz's essentials of clinical neuroanatomy and neurophysiology, 9ed, Philadelphia, 1996, FA Davis)

BOX 8-1 Common Dermatomal References

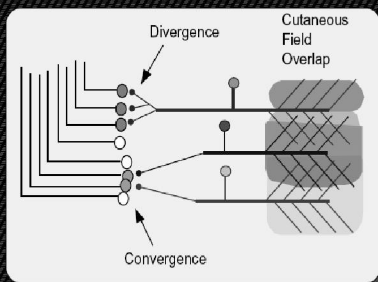
C2—back of head	T4—nipples	L3—kneecap
C7—thumb and index finger	T10—umbilicus	S1—lateral foot

Limb bud development

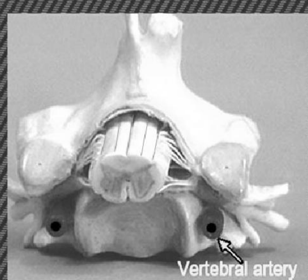


(From: Carpenter, MB, Core Text of Neuroanatomy, Williams & Wilkins, 1991)

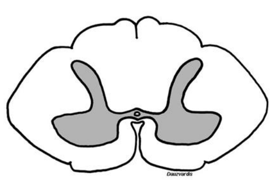
Dermatomal overlap

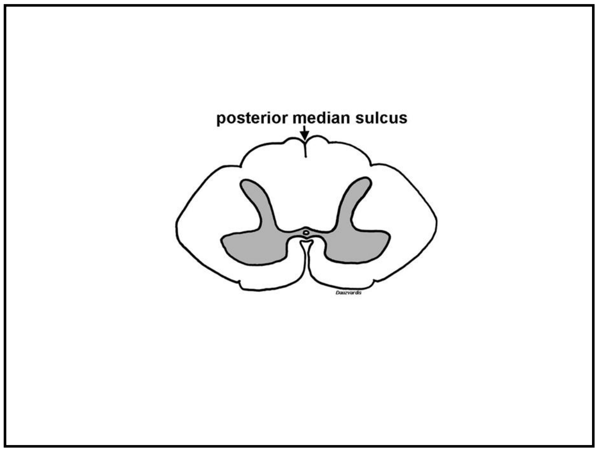


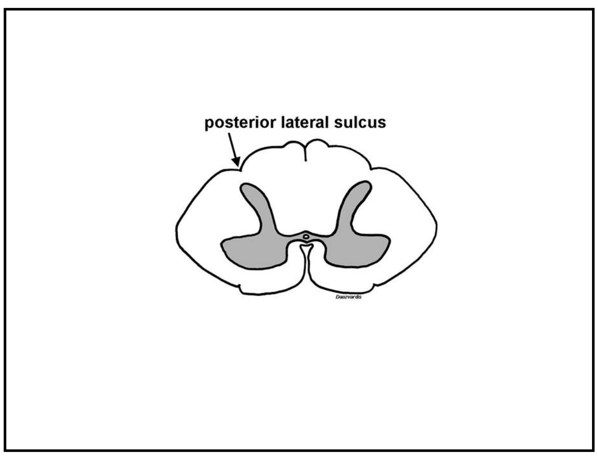
Spinal/vertebral segment

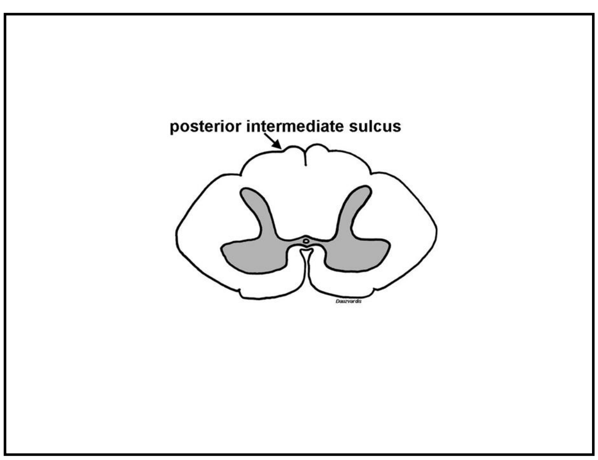


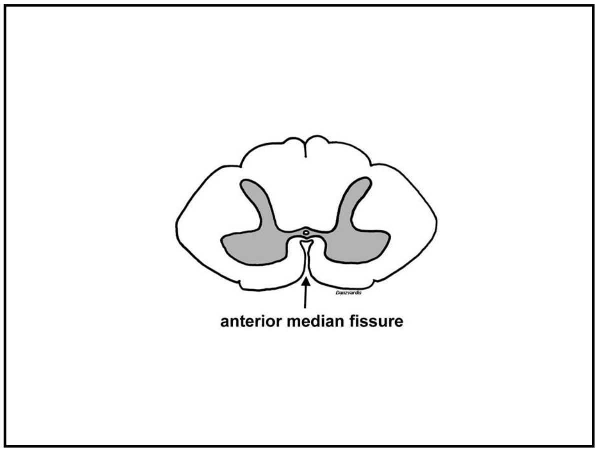
Slice of Brain © 1993 Univ. of Utah and Univ. of Washington (Marcus Sommer - Somso Modelle)

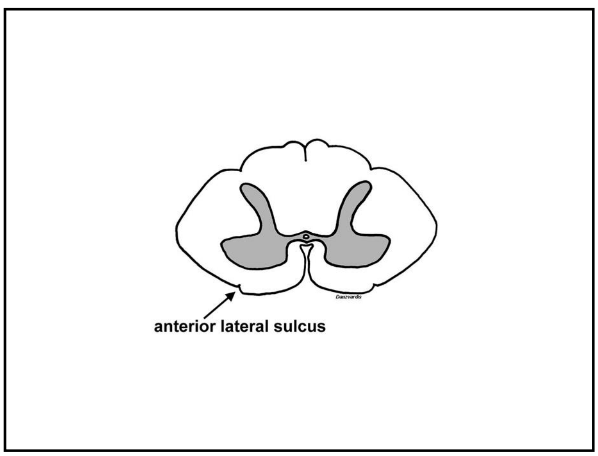


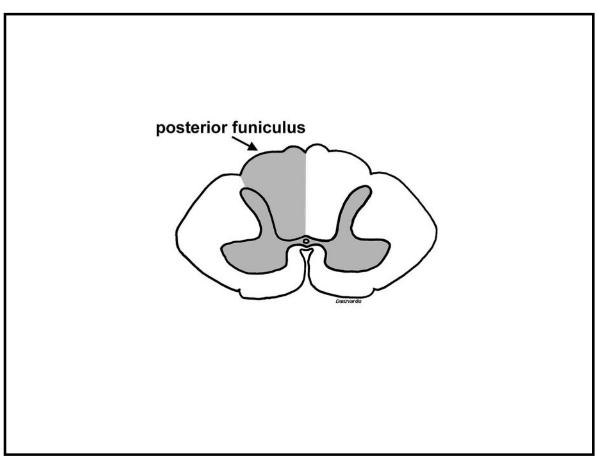

posterior median sulcus

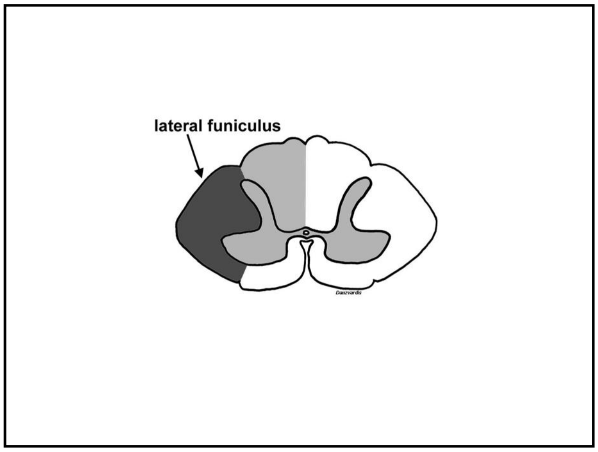

posterior lateral sulcus

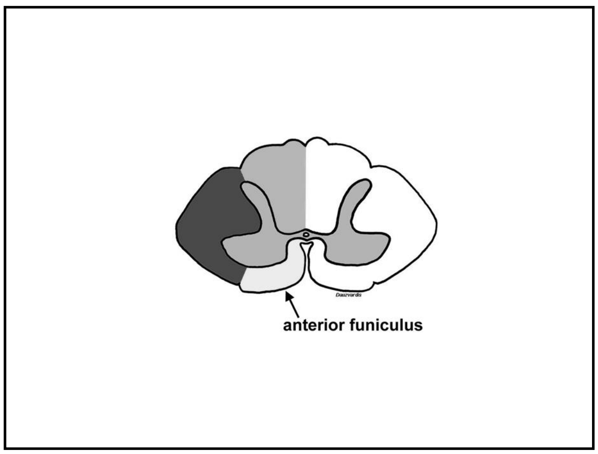

posterior intermediate sulcus

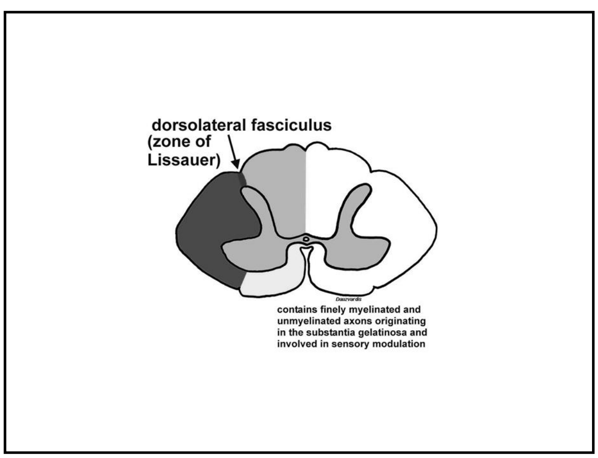

anterior median fissure

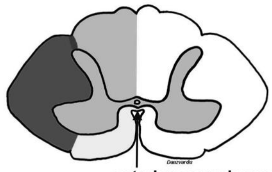

anterior lateral sulcus


posterior funiculus

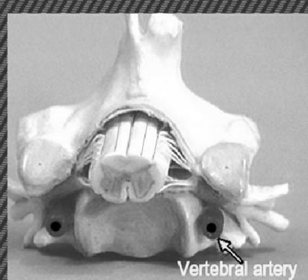

lateral funiculus


anterior funiculus


dorsolateral fasciculus
(zone of
Lissauer)
contains finely myelinated and
unmyelinated axons originating
in the substantia gelatinosa and
involved in sensory modulation

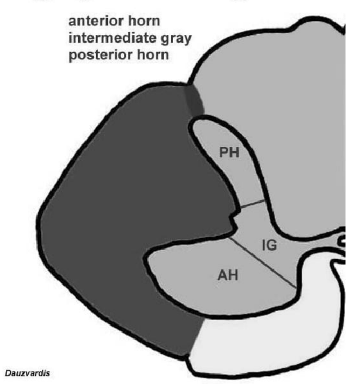


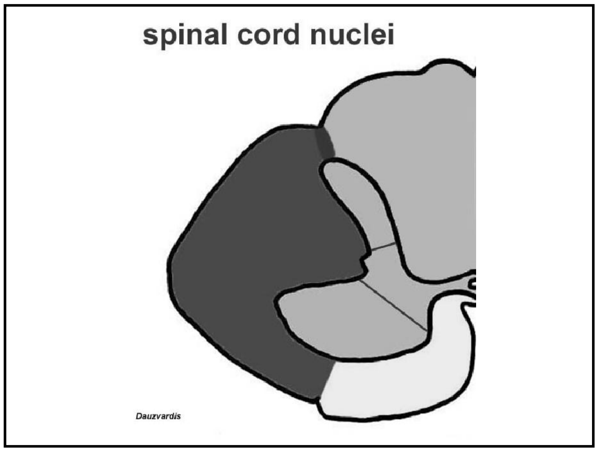
Spinal/vertebral segment

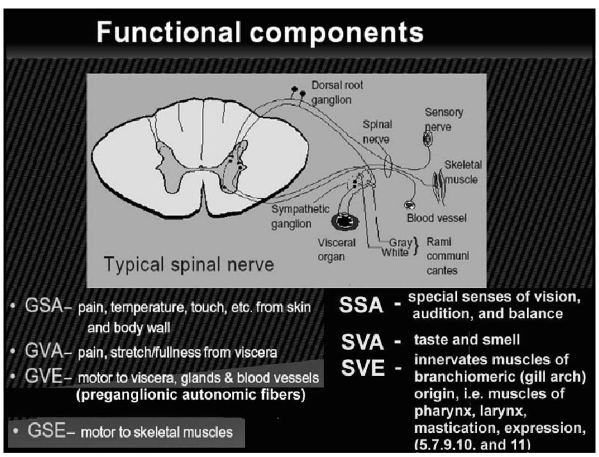


Slice of Brain © 1993 Univ. of Utah and Univ. of Washington (Marcus Sommer - Somso Modelle)

gray matter regions





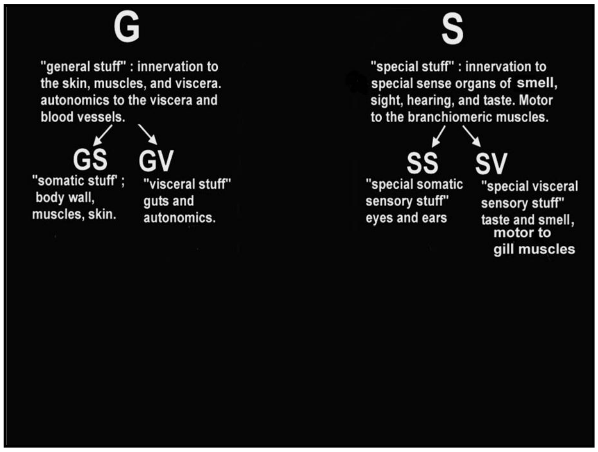


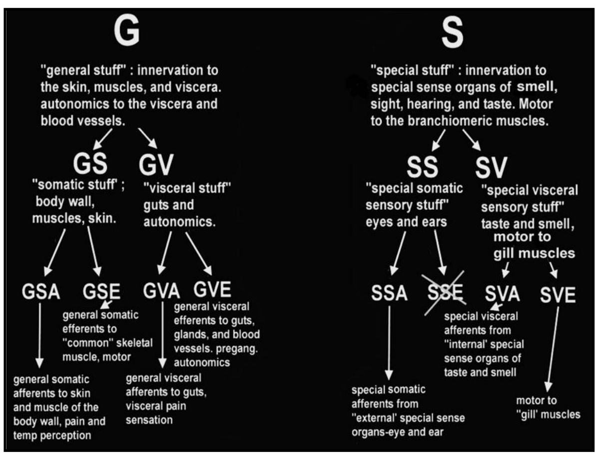
G

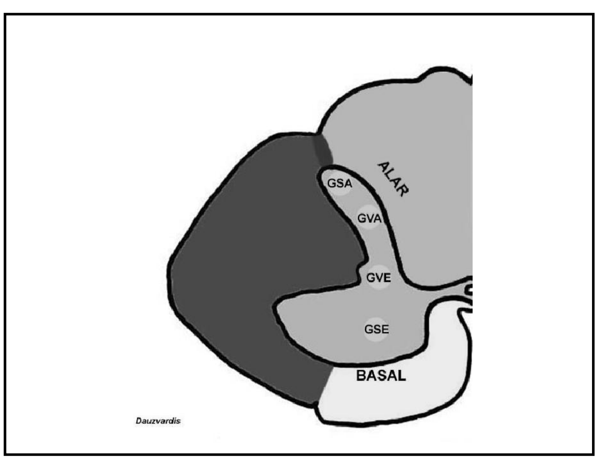
"general stuff" : innervation to the skin, muscles, and viscera. autonomics to the viscera and blood vessels.

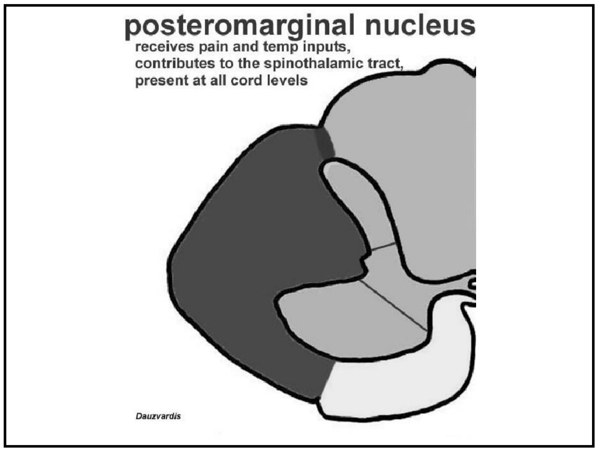
S

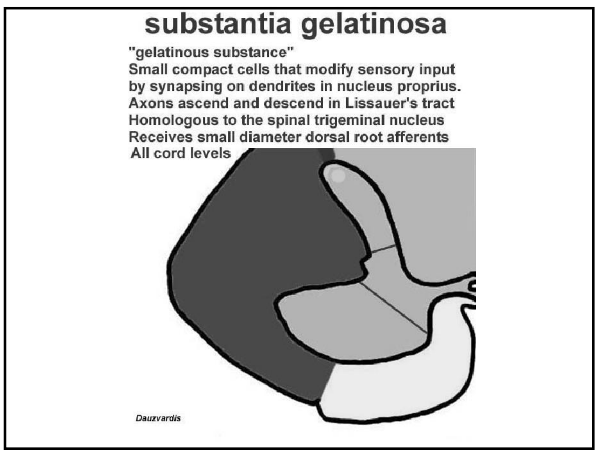
"special stuff" : innervation to special sense organs of smell, sight, hearing, and taste. Motor to the branchiomeric muscles.

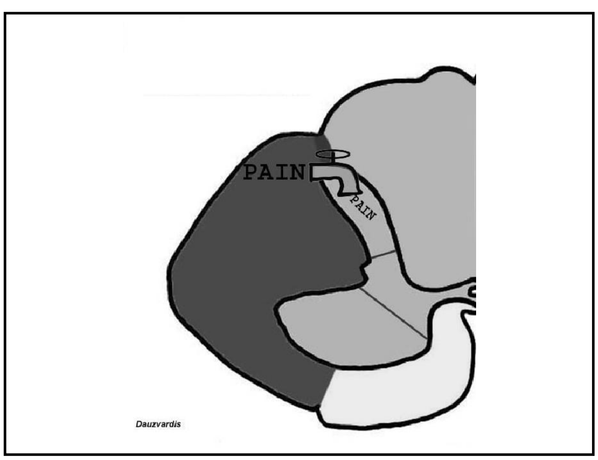

G
"general stuff" : innervation to the skin, muscles, and viscera. autonomics to the viscera and blood vessels.
GS
"somatic stuff" ; body wall, muscles, skin.
GV
"visceral stuff" guts and autonomics.
S
"special stuff" : innervation to special sense organs of smell, sight, hearing, and taste. Motor to the branchiomeric muscles.
SS
"special somatic sensory stuff" eyes and ears
SV
"special visceral sensory stuff" taste and smell, motor to gill muscles


G
"general stuff" : innervation to the skin, muscles, and viscera. autonomics to the viscera and blood vessels.
GS
"somatic stuff" ; body wall, muscles, skin.
GV
"visceral stuff" guts and autonomics.
GSA
general somatic afferents to skin and muscle of the body wall, pain and temp perception
GSE
general somatic efferents to "common" skeletal muscle, motor
GVA
general visceral afferents to guts, visceral pain sensation
GVE
general visceral efferents to guts, glands, and blood vessels. pregang. autonomics
S
"special stuff" : innervation to special sense organs of smell, sight, hearing, and taste. Motor to the branchiomeric muscles.
SS
"special somatic sensory stuff" eyes and ears
SV
"special visceral sensory stuff" taste and smell, motor to gill muscles
SSA
special somatic afferents from "external' special sense organs-eye and ear
SSE
SVA
special visceral afferents from "internal' special sense organs of taste and smell
SVE
motor to "gill' muscles


ALAR
GSA
GVA
GVE
GSE
BASAL
Dauzvardis

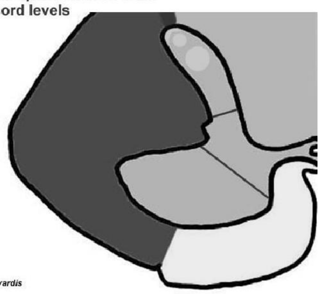

posteromarginal nucleus
receives pain and temp inputs,
contributes to the spinothalamic tract,
present at all cord levels
Dauzvardis


substantia gelatinosa
"gelatinous substance"
Small compact cells that modify sensory input
by synapsing on dendrites in nucleus proprius.
Axons ascend and descend in Lissauer's tract
Homologous to the spinal trigeminal nucleus
Receives small diameter dorsal root afferents
All cord levels
Dauzvardis


PAIN
PAIN
Dauzvardis

nucleus proprius

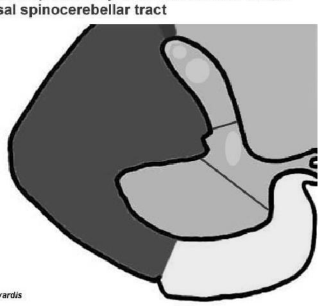
"proper sensory nucleus"
Receives many sensory inputs
Contains many interneurons
Contains "tract cells" that project contralaterally as the spinothalamic tract
All cord levels



Dauzvardis

nucleus dorsalis

"Clark's nucleus C8-L3
Homologous to the lateral (accessory) cuneate nucleus in the medulla
receives muscle spindle information
Projects ipsilaterally to the cerebellum as the dorsal spinocerebellar tract

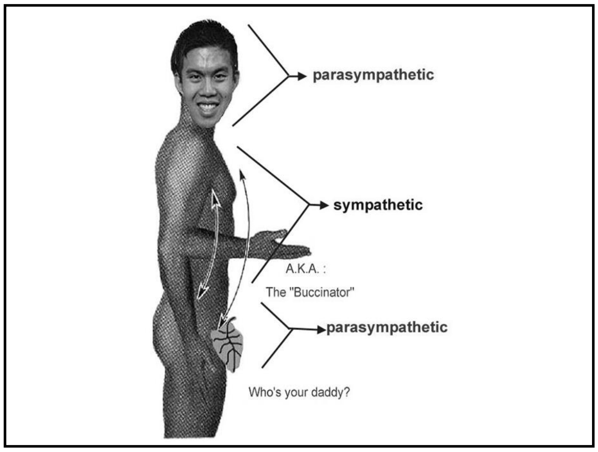


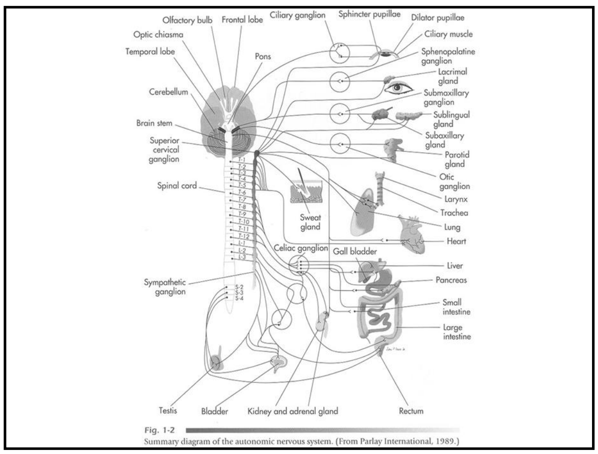
Dauzvardis

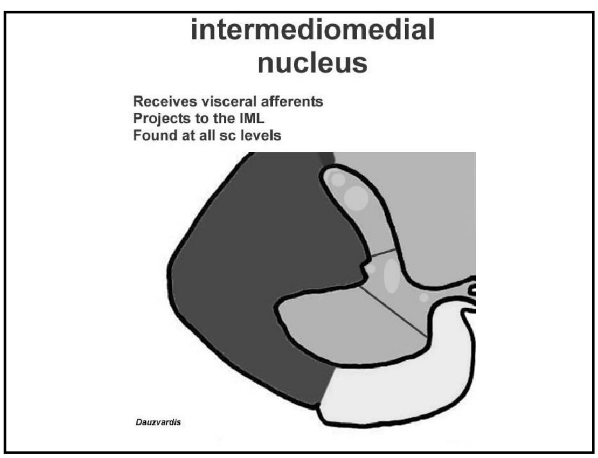
intermediolateral nucleus

Origin of preganglionic cholinergic sympathetic efferents
Found at levels T1-L3
GVE

At S2-S4, the sacral autonomic nucleus occupies the lateral horn area. It sends out preganglionic parasympathetic efferents.

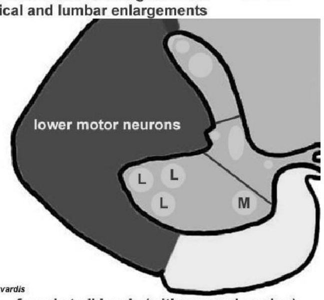

parasympathetic
sympathetic
A.K.A. :
The "Buccinator"
parasympathetic
Who's your daddy?


Olfactory bulb
Frontal lobe
Ciliary ganglion
Sphincter pupillae
Dilator pupillae
Optic chiasma
Ciliary muscle
Temporal lobe
Pons
Sphenopalatine ganglion
Lacrimal gland
Cerebellum
Submaxillary ganglion
Sublingual gland
Brain stem
Subaxillary gland
Superior cervical ganglion
Parotid gland
Otic ganglion
Spinal cord
Larynx
Trachea
Sweat gland
Lung
Heart
Celiac ganglion
Gall bladder
Liver
Pancreas
Sympathetic ganglion
Small intestine
Large intestine
Testis
Bladder
Kidney and adrenal gland
Rectum
Fig. 1-2
Summary diagram of the autonomic nervous system. (From Parlay International, 1989.)


intermediomedial nucleus
Receives visceral afferents
Projects to the IML
Found at all sc levels
Dauzvardis

medial and lateral motor nuclei

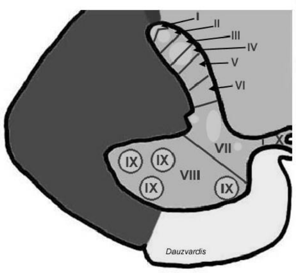
Made up of large alpha motor neurons that innervate skeletal muscle (i.e. radial-triceps)
The phrenic nucleus exists at C3-5 in the medial n
The spinal accessory n exists at C1-6 laterally
The motor nuclei are largest in the cervical and lumbar enlargements



found at all levels (with name changing)

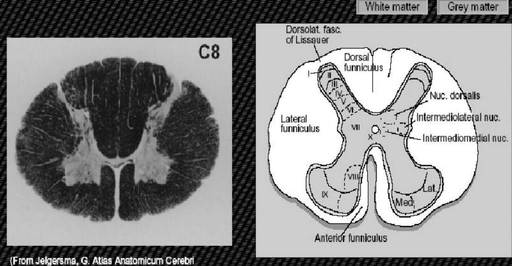
Rexed's Laminae

A system devised by Rexed in 1952 which organizes the spinal gray according to its cytoarchitecture. Used mainly in research

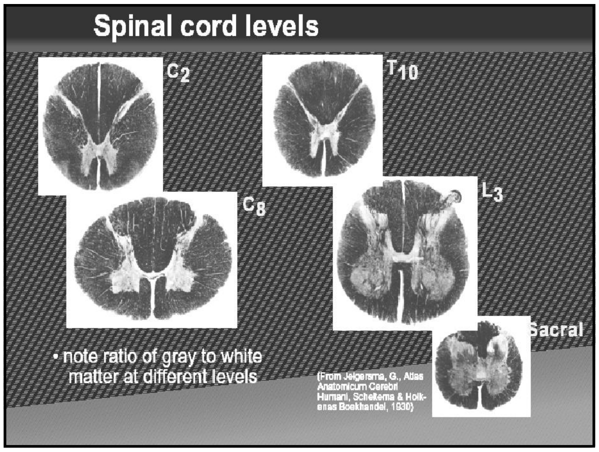


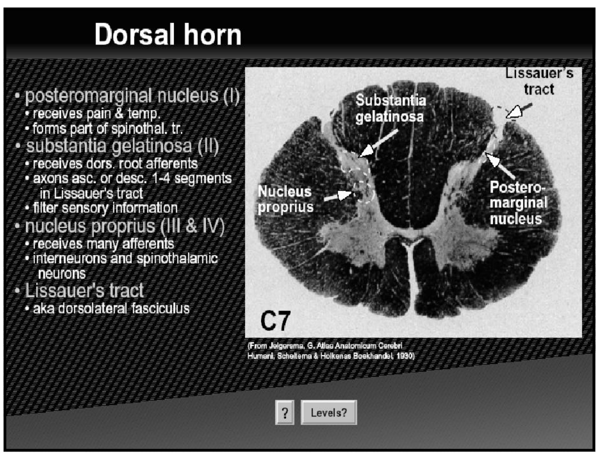
I. posteromarginal nucleus
II. substantia gelatinosa
III, IV. nucleus proprius
V, VI. interneurons
VII. IML, IMM, Clarks nucleus, sacral autonomic nucleus at S2-S4
VIII. coordinates intersegmental reflexes, receives inputs from major descending tracts from the visual, auditory, and reticular systems. projects bilaterally to laminae VII and IX
IX. alpha motor neurons, gamma motor neurons that innervate muscle spindle fibers, phrenic nucleus, spinal accessary nucleus, origin of lower motor neuron pathway
X. central canal region

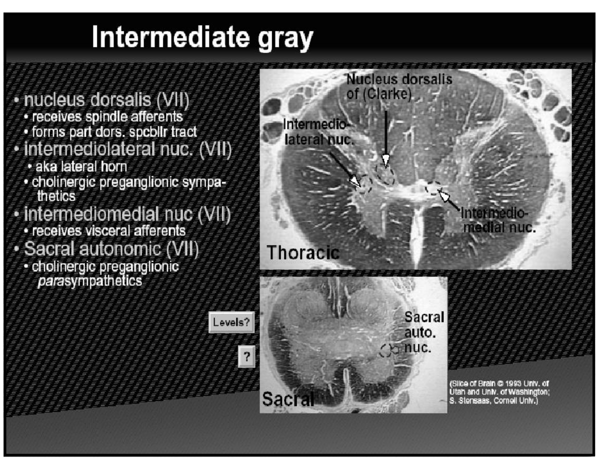
White/gray matter – Rexed's laminae



(From Jelgersma, G. Atlas Anatomicum Cerebri Humani, Scheltema & Holkenas Boekhandel, 1930)

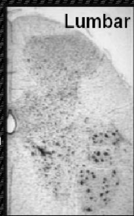

Spinal cord levels
C2
T10
C8
L3
Sacral
• note ratio of gray to white matter at different levels
(From Jelgersma, G., Atlas Anatomicum Cerebri Humani, Scheltema & Holkenas Boekhandel, 1930)


Dorsal horn
• posteromarginal nucleus (I)
• receives pain & temp.
• forms part of spinothal. tr.
• substantia gelatinosa (II)
• receives dors. root afferents
• axons asc. or desc. 1-4 segments in Lissauer's tract
• filter sensory information
• nucleus proprius (III & IV)
• receives many afferents
• interneurons and spinothalamic neurons
• Lissauer's tract
• aka dorsolateral fasciculus
Lissauer's tract
Substantia gelatinosa
Nucleus proprius
Postero-marginal nucleus
C7
(From Jelgersma, G. Atlas Anatomicum Cerebri Humani, Scheltema & Holkenas Boekhandel, 1930)
?
Levels?


Intermediate gray
• nucleus dorsalis (VII)
• receives spindle afferents
• forms part dors. spcbllr tract
• intermediolateral nuc. (VII)
• aka lateral horn
• cholinergic preganglionic sympathetics
• intermediomedial nuc (VII)
• receives visceral afferents
• Sacral autonomic (VII)
• cholinergic preganglionic parasympathetics
Nucleus dorsalis of (Clarke)
Intermedio-lateral nuc.
Intermedio-medial nuc.
Thoracic
Sacral auto. nuc.
Sacral
Levels?
?
(Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; S. Stensaas, Cornell Univ.)

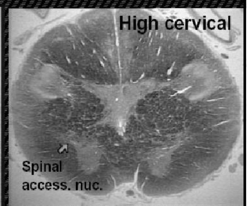
Ventral horn

- motor neurons (IX)
  - innervate skeletal muscle
  - large alpha motor neurons
  - "final common pathway"
- phrenic nucleus
  - medial ventral horn
  - C_{3-5} – "keeps the diaphragm alive" [Phrenic nuc]
- spinal accessory nuc.
  - lateral ventral horn
  - C_{1-6} - innervates the sterno-cleidomastoid and trapezius mm.



(From Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; John W. Sundsten)

[?]



(From Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; S. Stensaas - Cornell Univ.)

Sensory receptors & ascending tracts

Sensory modalities

Sensory receptors

Dorsal root afferents

Somatosensory pathways

Spinocerebellar pathways

!

Sensory modalities - Gen'l classification

GSA *(General Somatic Afferent)*
- exteroception (touch, temperature, pain (itch), vibration)
- proprioception (limb position and movement)

GVA *(General Visceral Afferent)*
- interoception (GI tract and bladder stretch, pH in blood, etc.)

SVA *(Special Visceral Afferent)*
- taste, olfaction

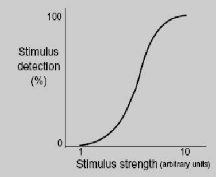
SSA *(Special Sensory Afferent)*
- teloception (vision, audition, balance)

[Spinal Nerve Components]

Intensity – Adaption

Transduction

Intensity (amt) of sensation depends on stimulus strength



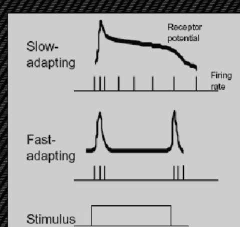
Transduction – conversion and amplification of a sensory stimulus into a neural signal

Detectability

Physiological classification of receptors

Adaption

- refers to a decrease in receptor sensitivity during a maintained stimulus

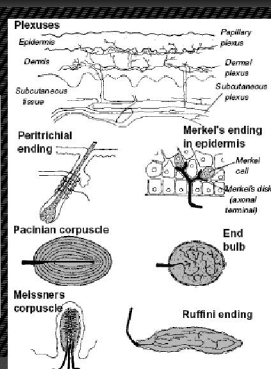


Sensory receptors

Histologic classification

Non-encapsulated
- free nerve endings
- Merkel's disc
- hair receptors

Encapsulated
- Meissner's corpuscles
- Pacinian corpuscles
- Ruffini endings
- others



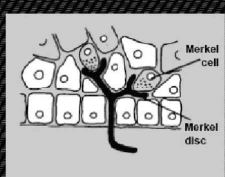
(From Barr, ML and JA Kiernan, The Human Nervous, Philadelphia, 1988, Lippincott)

Free nerve ending

Free nerve endings: epithelial papillae of tongue. Immunocytochemical stain for gene-related peptide. (From Slice of Brain I ©1993 Univ. of Utah & Univ. of Washington; J.W. Sundsten, U. Wash)

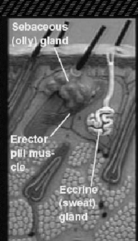
- pain and temperature (and touch)
- skin, viscera, etc
- slow adapting

Merkel's disc

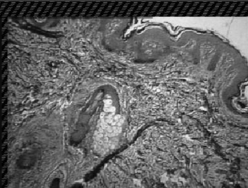


- touch
- distal extremities, lips, nipples, external genitalia
- slow adapting

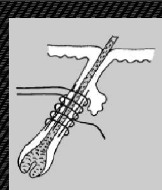
Hair follicle receptor



(From Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; Marcus Sommer - Somso Modelle)

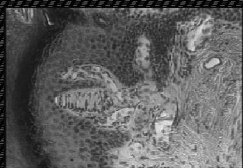


(Silver stain; From Slice of Brain © 1993 Univ. of Utah and Univ. of Washington)



- rapidly adapting

Meisner's corpuscle



Meissner corpuscle, Tactile nerve endings in skin. H & E stain. (J.W. Sundsten - Univ. of Washington)

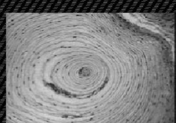
H & E stain. (J.F. Ash - Univ. of Utah)

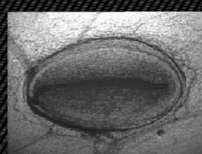
(Images from Slice of Brain © 1993 Univ. of Utah and Univ. of Washington)

- connective sheath surrounding a stack of flattened epithelial cells
- two-point discrimination
- fingers, toes, hands, feet, lips, tongue, genitalia, joint capsules, ligaments.
- rapidly adapting

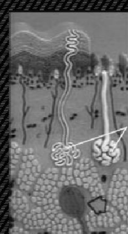
Sooo sensitive

Pacinian corpuscle



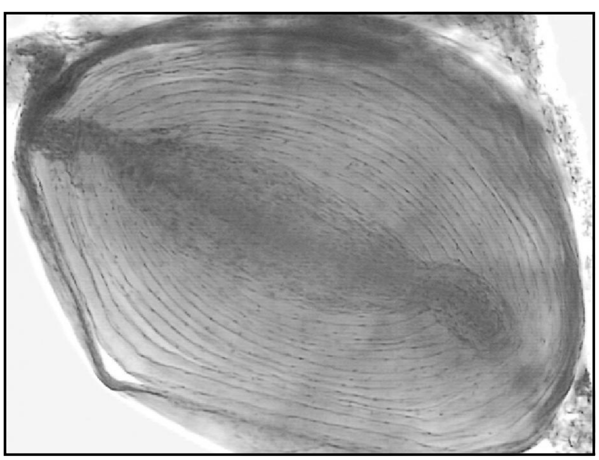


Pacinian corpuscle in longitudinal (above) and cross-section (below). H&E stain. (Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; O.E. Millhouse, Mayo Medical Group and J.A. Bettice, Case Westerun Reserve Univ.)



Slice of Brain © 1993 Univ. of Utah and Univ. of Washington (Marcus Sommer - Somso Modelle)

- afferent surrounded by concentric lamellae of flattened epithelial cells (3-4mm in size)
- light pressure, stretch, and esp. vibration
- fingers, toes, palms, soles, mesenteries, viscera, joint capsules
- rapidly adapting



Other encapsulated receptors

Ruffini ending
- widespread in dermis
- slow-adapting to stretch, deep pressure

Joint receptor endings
- free nerve endings and other histological forms
- slow -adapting, joint position and movement

Neuromuscular spindle
- muscle length (strectch)

Golgi tendon organ
- located at the muscle-tendon junction
- slow adapting

Functional terminology

Nociceptors
- respond to tissue damage
- pain is subjective

Thermoreceptors
- respond to cold (14-33º C) or warm (32-45º C)
- above 45º C is nociceptive

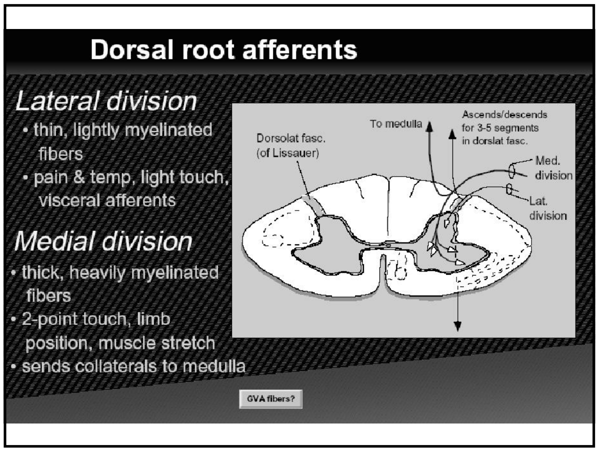
Normal skin temp?

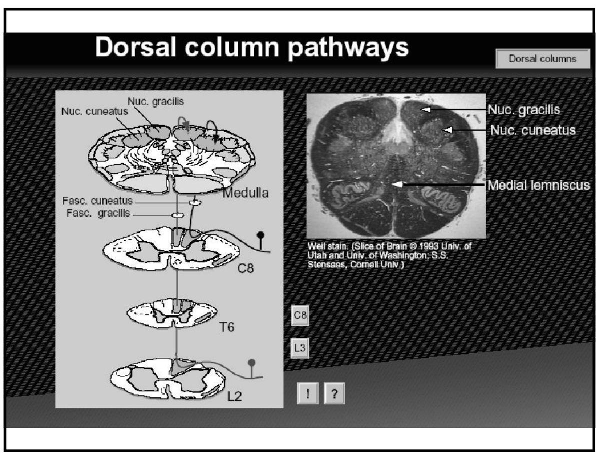
Mechanoreceptors
- respond to skin indentation, bending hair follicle, distention

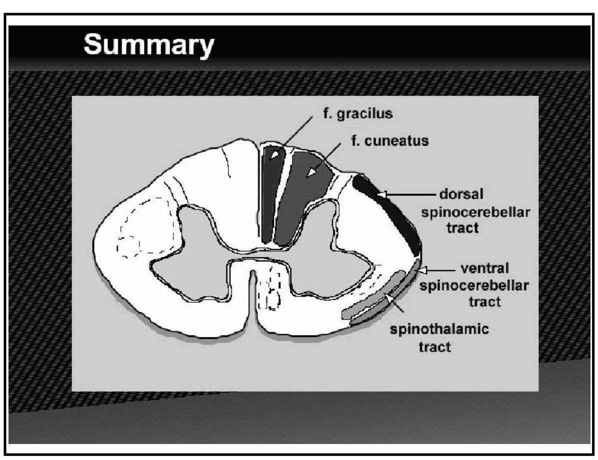
Chemoreceptors
- gustatory and olfactory; respond to pH or osmolarity

Photoreceptors
- transform light into neural signals

Name of Receptor	Nonencapsulated	Encapsulated	Fast Adapting	Slow Adapting	Function	Distribution
Free Nerve Endings	X			X	pain/temp	deep skin, viscera
Merkel's Disk	X			X	touch	feet, hands, genitalia, lips
Hair Follicle	X		X		touch	anywhere there is hair
Meissner's Corpuscle		X	X		2 point discrimination	hairless skin, fingertips, joints, ligaments
Pacinian Corpuscle		X	X		vibration	fingers, toes, palms, mesenteries, peritoneum
Ruffini Ending		X		X	stretch, pressure	dermis
Joint Receptor		X		X	joint position	joint capsules, ligaments
Neuromuscular spindle		X		X	limb muscle, stretch/length	muscles
Golgi Tendon Organs		X		X	muscle tension	muscle tendon junction


Dorsal root afferents
Lateral division
• thin, lightly myelinated fibers
• pain & temp, light touch, visceral afferents
Medial division
• thick, heavily myelinated fibers
• 2-point touch, limb position, muscle stretch
• sends collaterals to medulla
Dorsolat fasc. (of Lissauer)
To medulla
Ascends/descends for 3-5 segments in dorslat fasc.
Med. division
Lat. division
GVA fibers?


Dorsal column pathways
Dorsal columns
Nuc. gracilis
Nuc. cuneatus
Medulla
Fasc. cuneatus
Fasc. gracilis
C8
T6
L2
Nuc. gracilis
Nuc. cuneatus
Medial lemniscus
Weil stain. (Slice of Brain © 1993 Univ. of Utah and Univ. of Washington, S.S. Stensaas, Cornell Univ.)
C8
L3
!
?


Summary
f. gracilus
f. cuneatus
dorsal spinocerebellar tract
ventral spinocerebellar tract
spinothalamic tract

Dorsal column pathways

Dorsal columns

Information relayed:

2 point discrimination (stereognosis),

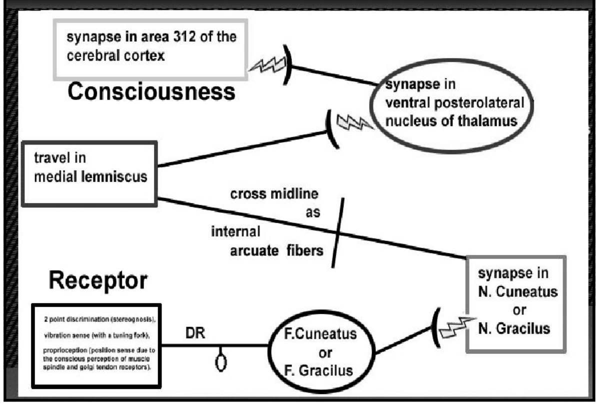
vibration sense (with a tuning fork),

proprioception (position sense due to the conscious perception of muscle spindle and golgi tendon receptors).

GSA

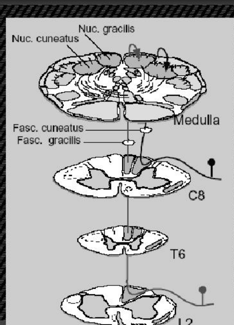
Dorsal column pathway

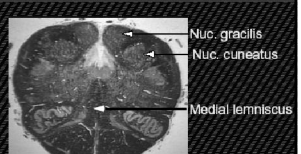
Dorsal columns



Dorsal column pathways

Dorsal columns



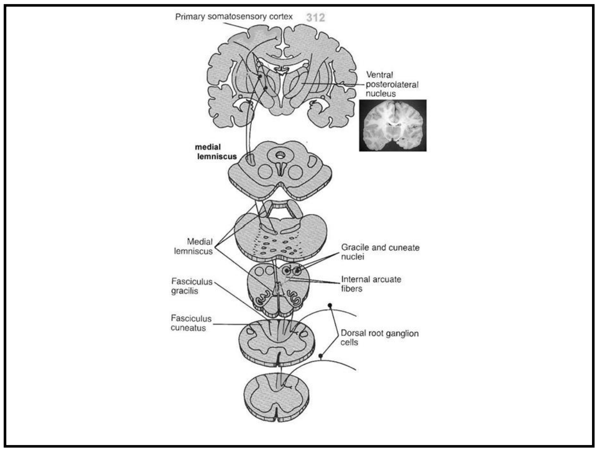


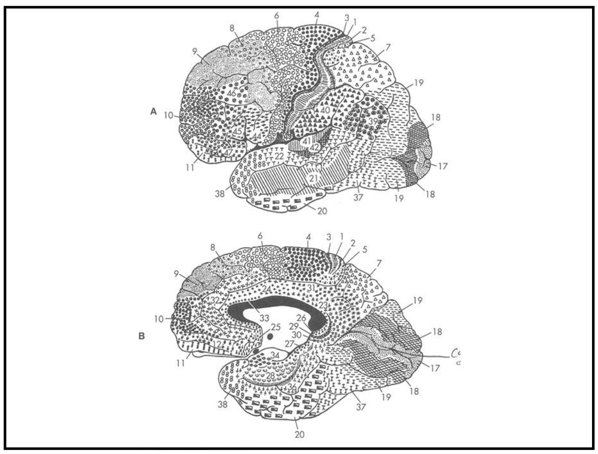
Weil stain. (Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; S.S. Stensaas, Cornell Univ.)

C8

L3

! ?





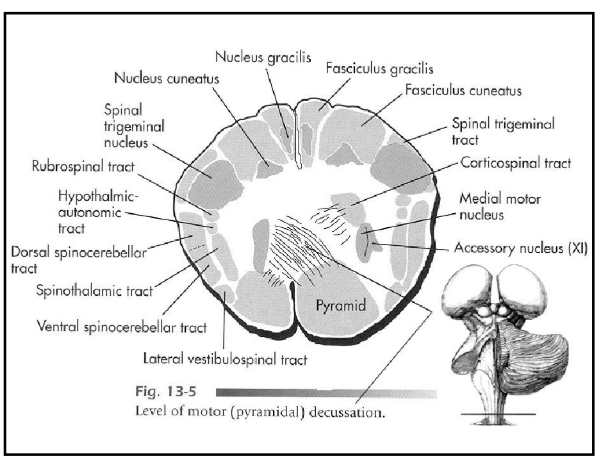


Fig. 13-5
Level of motor (pyramidal) decussation.

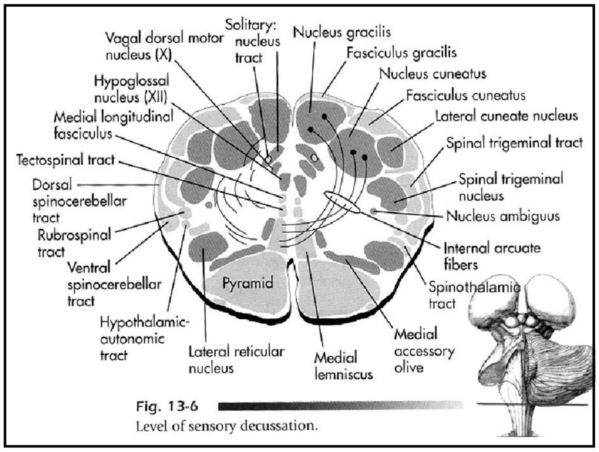
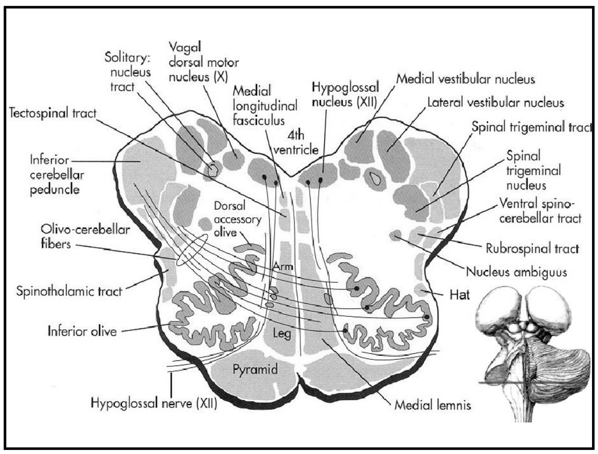


Fig. 13-6
Level of sensory decussation.



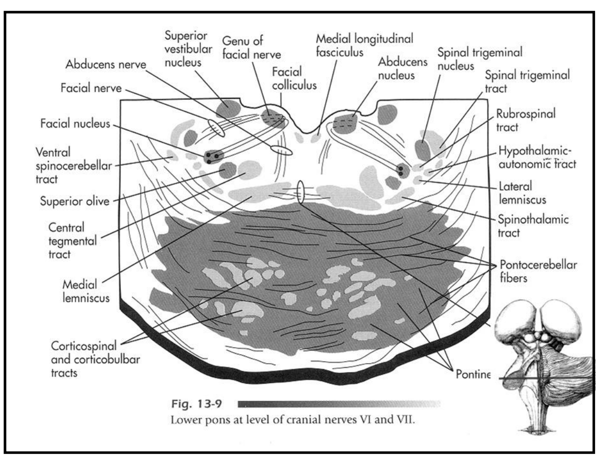


Fig. 13-9
Lower pons at level of cranial nerves VI and VII.

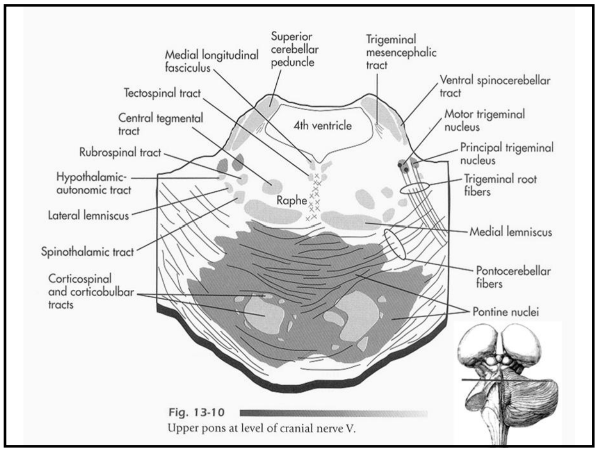


Fig. 13-10
Upper pons at level of cranial nerve V.

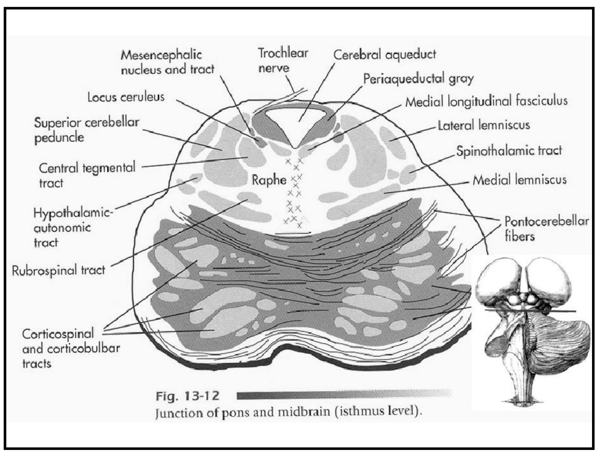


Fig. 13-12
Junction of pons and midbrain (isthmus level).

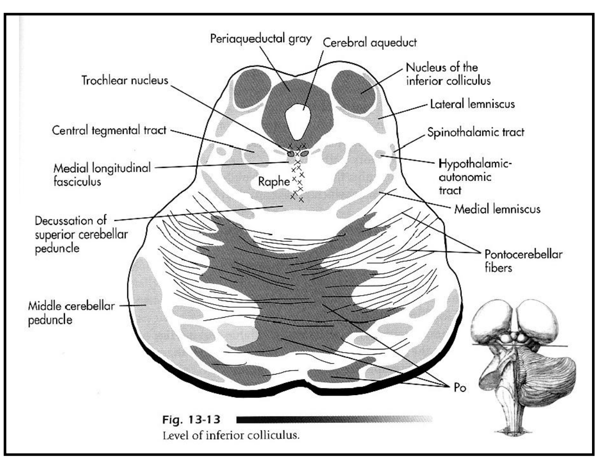


Fig. 13-13
Level of inferior colliculus.

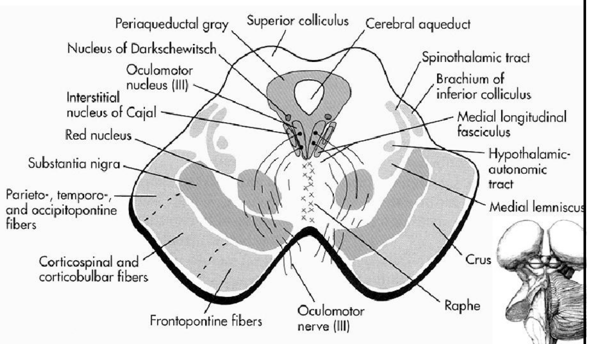
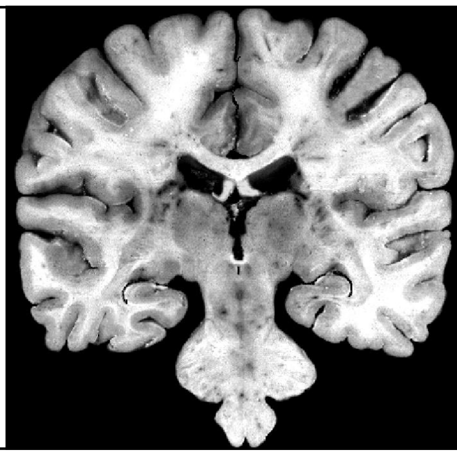


Fig. 13-14
Level of superior colliculus.



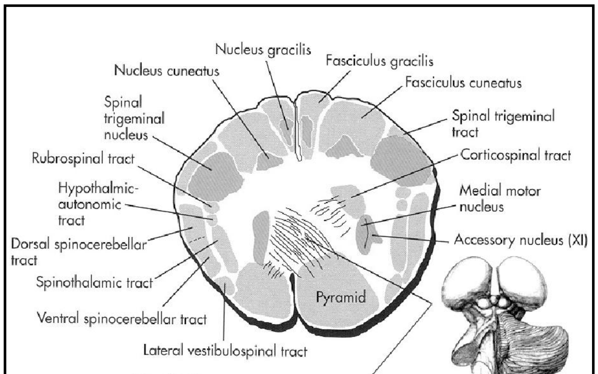


Fig. 13-5
Level of motor (pyramidal) decussation.

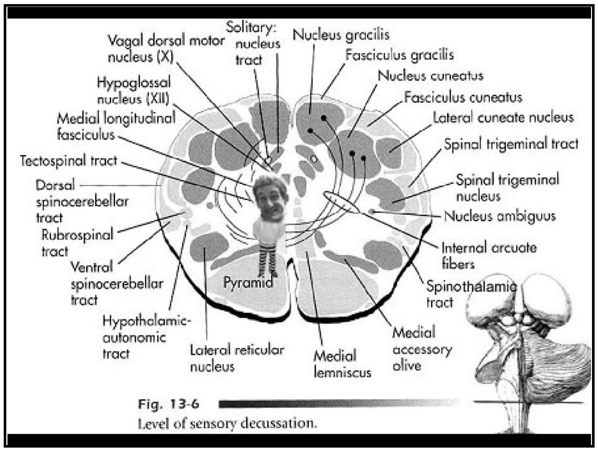
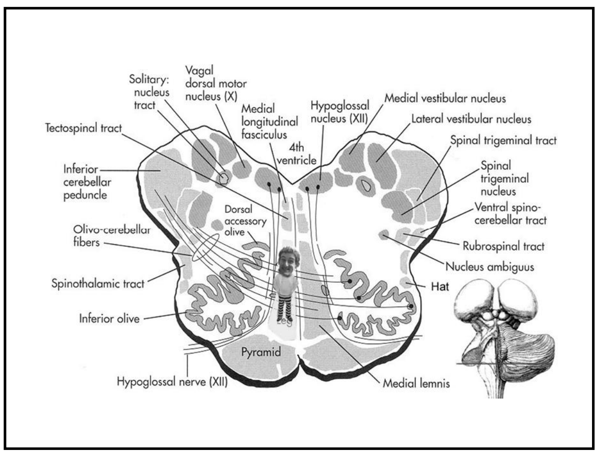


Fig. 13-6
Level of sensory decussation.



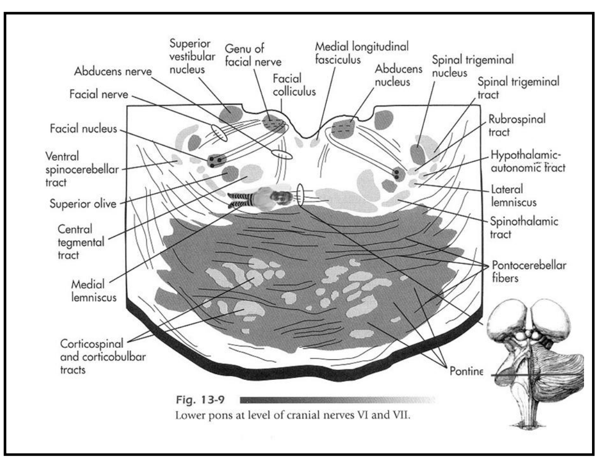


Fig. 13-9
Lower pons at level of cranial nerves VI and VII.

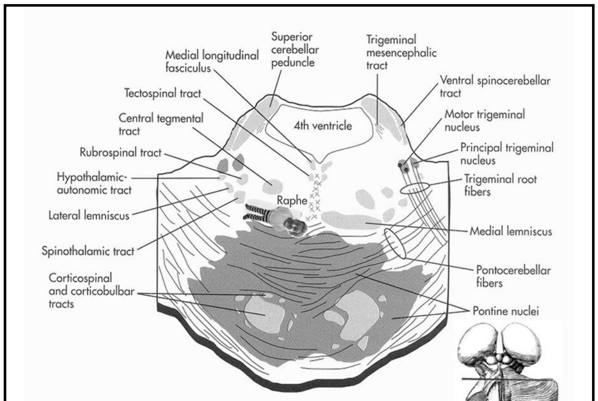


Fig. 13-10
Upper pons at level of cranial nerve V.

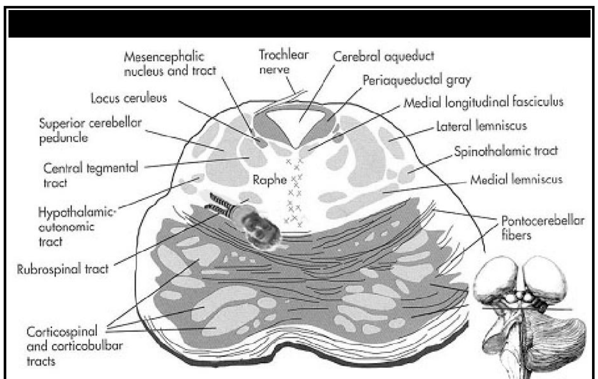


Fig. 13-12
Junction of pons and midbrain (isthmus level).

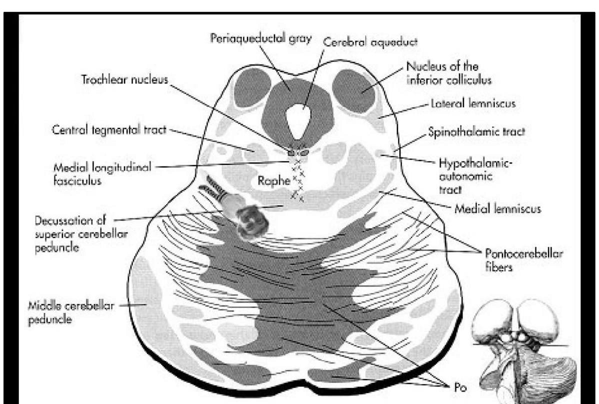


Fig. 13-13
Level of inferior colliculus.

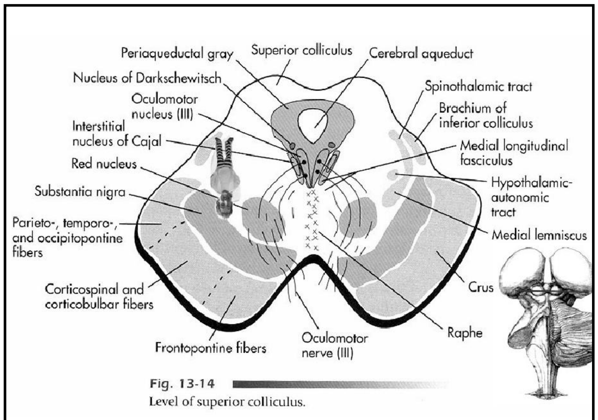
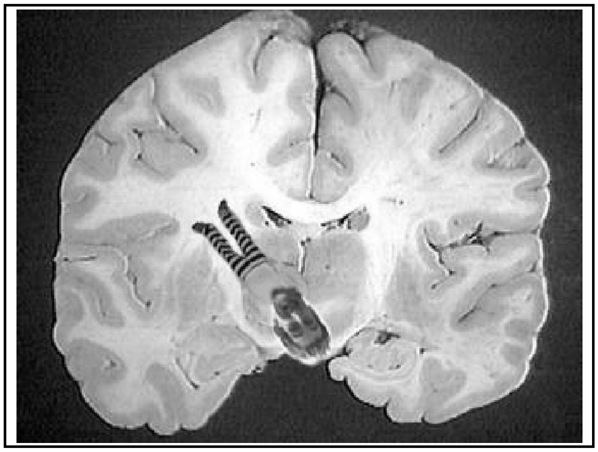
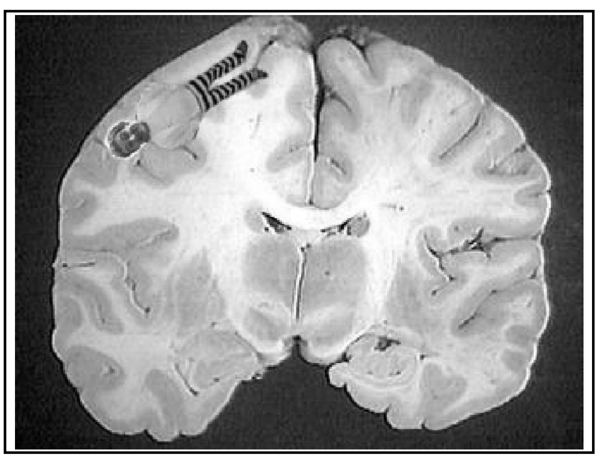
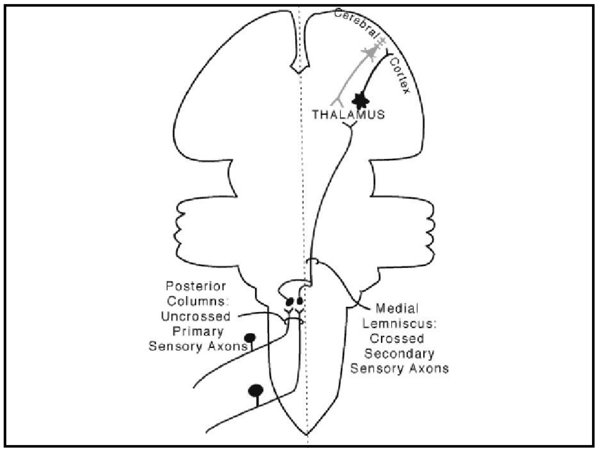


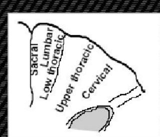
Fig. 13-14
Level of superior colliculus.





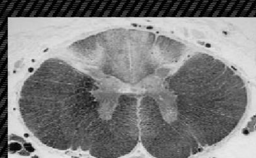


Dorsal columns cont'd



Localization

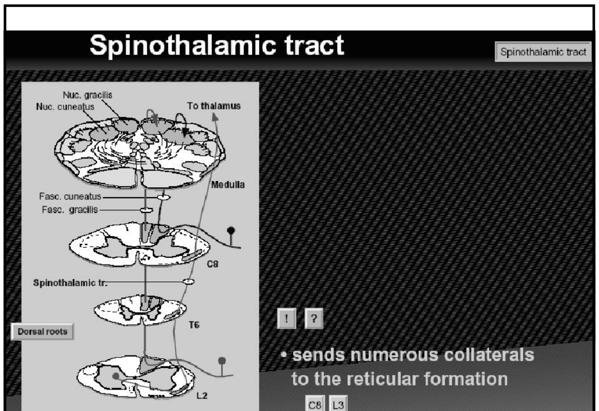
Romberg sign || Tabes dorsalis

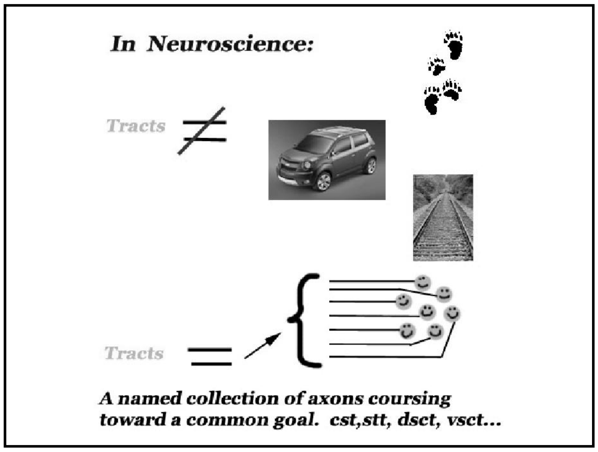


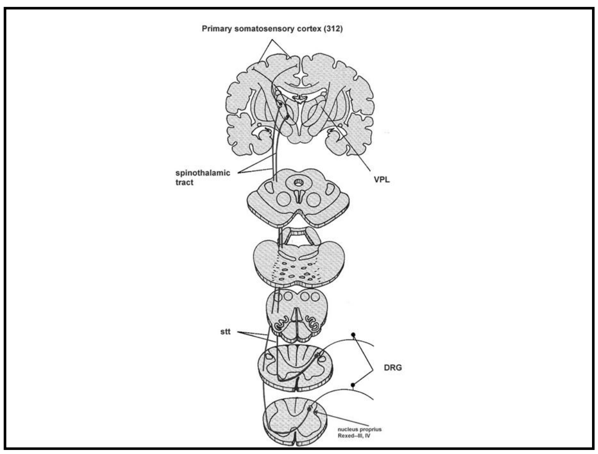
(From Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; J.W. Sundsten, Univ. of Washington)

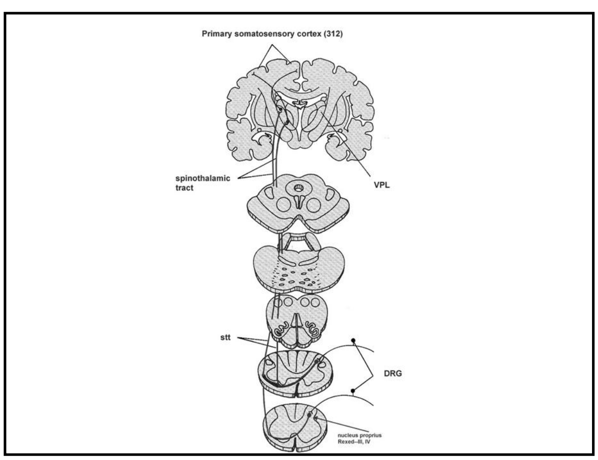
?

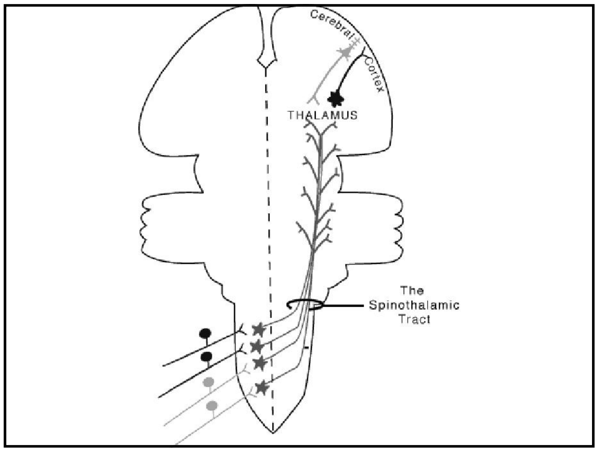
- Romberg's sign
- Romberg's sign is positive if the patient requires vision to stand steadily.
- The patient is asked to stand with the feet together. If the patient is steady with eyes open but unsteady with eyes closed then there are signs of Rombergism.
- Romberg's sign is said to be positive in patients with sensory ataxia and negative in cerebellar ataxia. In practise Romberg's sign has a low specificity.
- In cerebellar disease, the patient is often unsteady with the eyes open or closed.
-

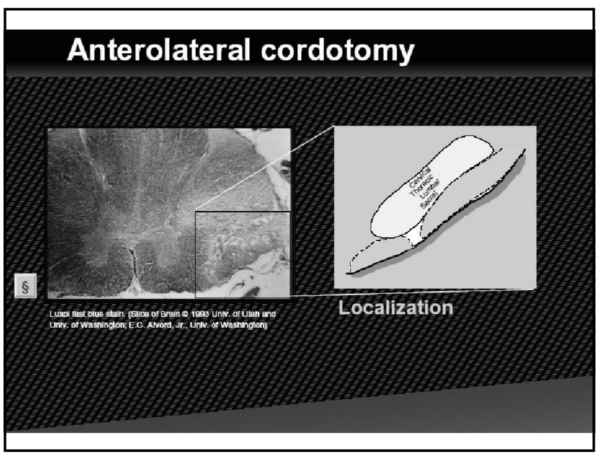


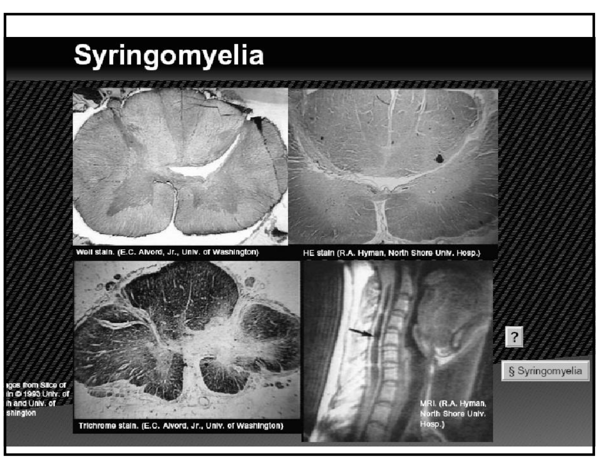

In Neuroscience:
Tracts ≠
Tracts =
A named collection of axons coursing toward a common goal. cst,stt, dsct, vsct...


Primary somatosensory cortex (312)
spinothalamic tract
VPL
stt
DRG
nucleus proprius
Rexed--III, IV

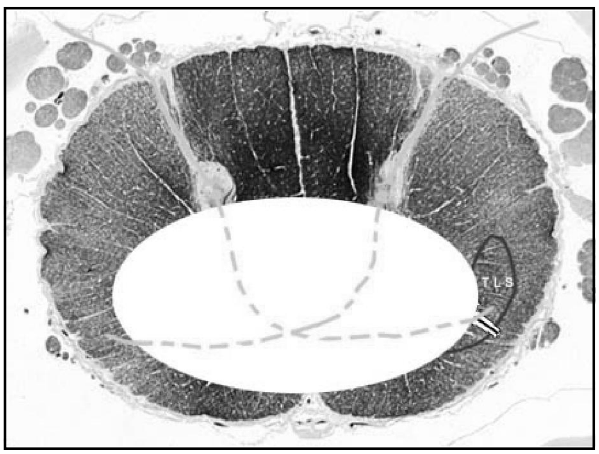

Primary somatosensory cortex (312)
spinothalamic tract
VPL
stt
DRG
nucleus proprius
Rexed--III, IV


Cerebral Cortex
THALAMUS
The Spinothalamic Tract


Anterolateral cordotomy
§
Luxol fast blue stain. (Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; E.C. Alvord, Jr., Univ. of Washington)
Localization


Syringomyelia
Weil stain. (E.C. Alvord, Jr., Univ. of Washington)
HE stain (R.A. Hyman, North Shore Univ. Hosp.)
Trichrome stain. (E.C. Alvord, Jr., Univ. of Washington)
MRI. (R.A. Hyman, North Shore Univ. Hosp.)
?
§ Syringomyelia


C T L S


T L S


[redacted]
Horn
Knee

Spinoreticular tract

- actually represents majority of fibers in spthalamic. tr.
- terminates in brain stem reticular formation
- relays light touch, pain and temperature
- phylogenetically old system

Spinotectal tract

- sends pain, temp. and touch info to the superior colliculus and periaqueductal gray

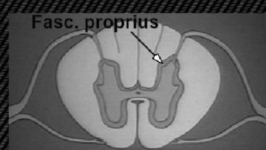
Anterolateral syst.

Spinothal trct Review

Other ascending tracts

Other ascend. paths | Lamina VIII

- Fasciculus proprius
  - originates from spinal gray, esp. LVII and VIII Flexed
  - ascend and descend several segments
  - coordinate intersegmental reflexes
  - polysynaptic pain pathway (?)
- Spinocervicothalamic pathway
- Spinohypothalamic tract
- Spinovestibular tract
- Spino-olivary tract
- Spinopontine fibres



(Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; IK Hawkins, Medical College of Georgia)

!

Spinocerebellar tracts

Dor & vent spcblr trcts

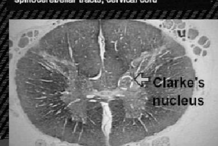
Dors. spinocerebellar tr.

- arises from Clarke's nucleus (C8–L2,3)
- relays muscle stretch

Vent. spinocerebellar tr.

- arises from dorsal horn and intermediate gray (laminae V – VII)
- relays info of spinal motor centers

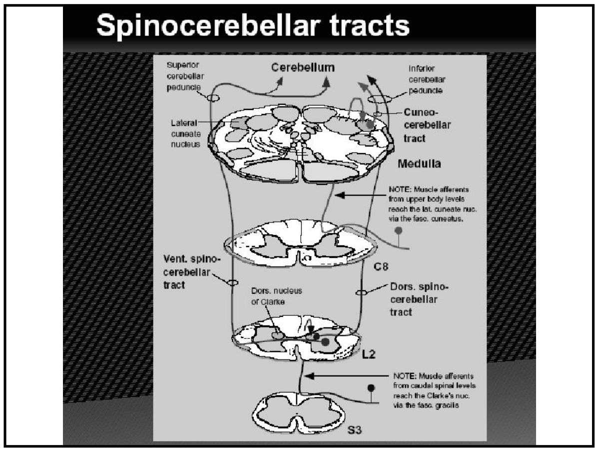
spinocerebellar tracts, cervical cord

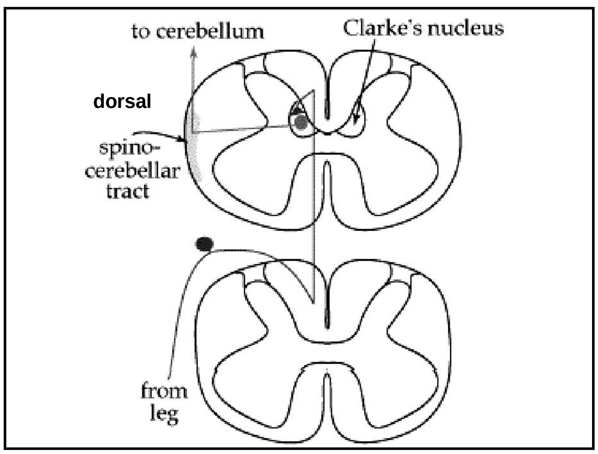


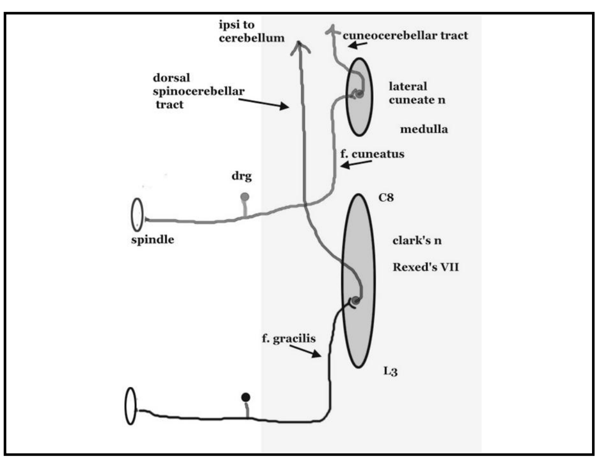
(From Slice of Brain © 1993; O.E. Millhouse, Mayo Medical Group)

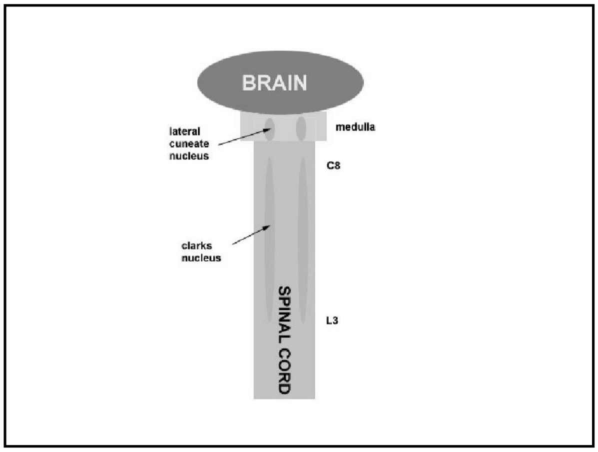
Cerebellum

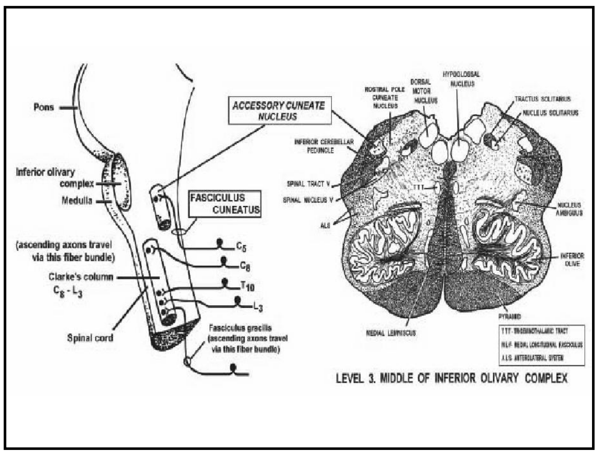
Dorsal roots

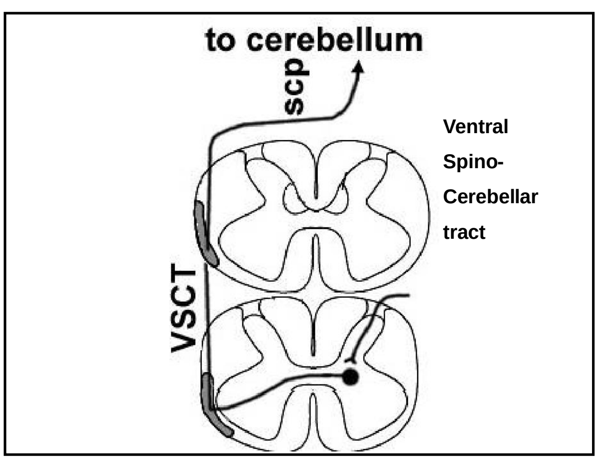

Spinocerebellar tracts
Superior cerebellar peduncle
Cerebellum
Inferior cerebellar peduncle
Lateral cuneate nucleus
Cuneo-cerebellar tract
Medulla
NOTE: Muscle afferents from upper body levels reach the lat. cuneate nuc. via the fasc. cuneatus.
Vent. spino-cerebellar tract
C8
Dors. nucleus of Clarke
Dors. spino-cerebellar tract
L2
NOTE: Muscle afferents from caudal spinal levels reach the Clarke's nuc. via the fasc. gracilis
S3


to cerebellum
Clarke's nucleus
dorsal
spino-cerebellar tract
from leg


ipsi to cerebellum
cuneocerebellar tract
dorsal spinocerebellar tract
lateral cuneate n
medulla
f. cuneatus
drg
C8
spindle
clark's n
Rexed's VII
f. gracilis
L3


BRAIN
lateral cuneate nucleus
medulla
C8
clarks nucleus
SPINAL CORD
L3


Pons
ACCESSORY CUNEATE NUCLEUS
Inferior olivary complex
Medulla
FASCICULUS CUNEATUS
(ascending axons travel via this fiber bundle)
Clarke's column
$C_8 - L_3$
C_5
C_8
T_{10}
L_3
Spinal cord
Fasciculus gracilis (ascending axons travel via this fiber bundle)
ROSTRAL POLE CUNEATE NUCLEUS
DORSAL MOTOR NUCLEUS
HYPOGLOSSAL NUCLEUS
TRACTUS SOLITARIUS
NUCLEUS SOLITARIUS
INFERIOR CEREBELLAR PEDUNCLE
SPINAL TRACT V
SPINAL NUCLEUS V
TTT
ALS
NUCLEUS AMBIGUUS
INFERIOR OLIVE
PYRAMID
MEDIAL LEMNISCUS
LEVEL 3. MIDDLE OF INFERIOR OLIVARY COMPLEX


to cerebellum
scp
VSCT
Ventral
Spino-
Cerebellar
tract

Clark’s nucleus only exists from C8—L2.

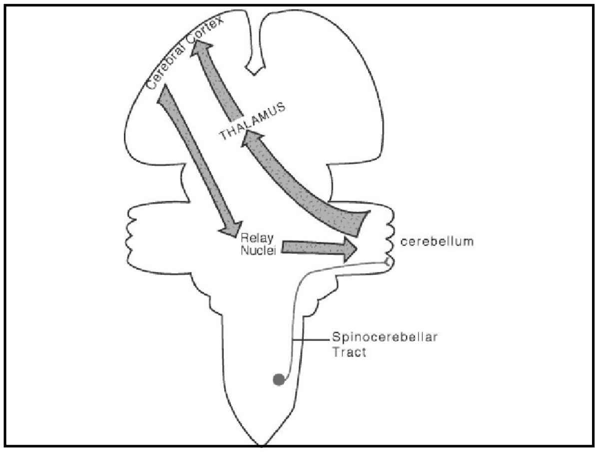
Muscle afferents from below L3 use f. gracilis to reach Clark’s N.

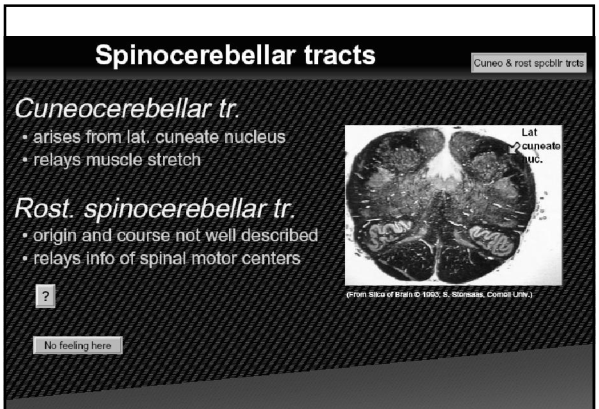
The lateral cuneate nucleus picks up the slack in the medulla. Muscle info from upper body reaches the Lateral cuneate n. via f. cuneatus.

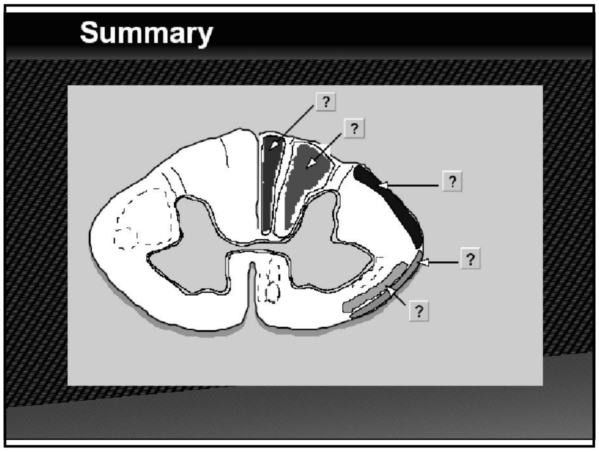
Dorsal spinocerebellar tract relays muscle spindle and golgi tendon organ info to cerebellum via inf cerebellar ped..

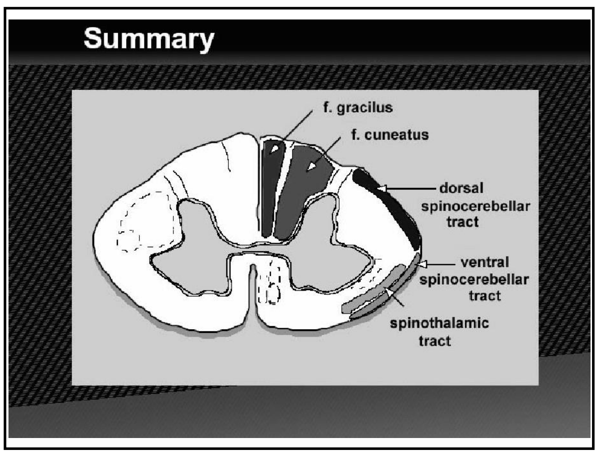
Ventral spinocerebellar tract relays spinal motor “interneuronal” info via superior cerebellar peduncle. It is double crossed.

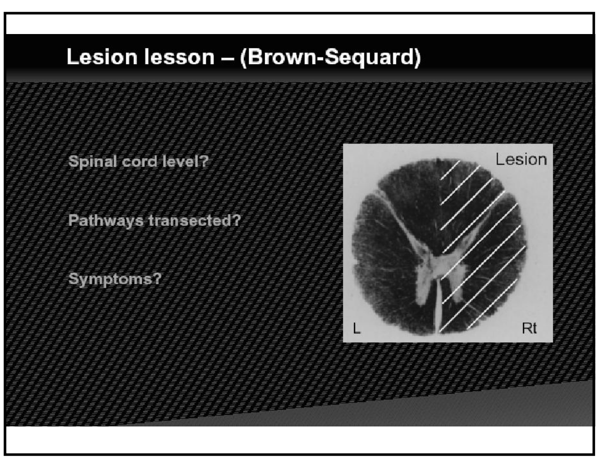
Nobody cares about the rostral sct.

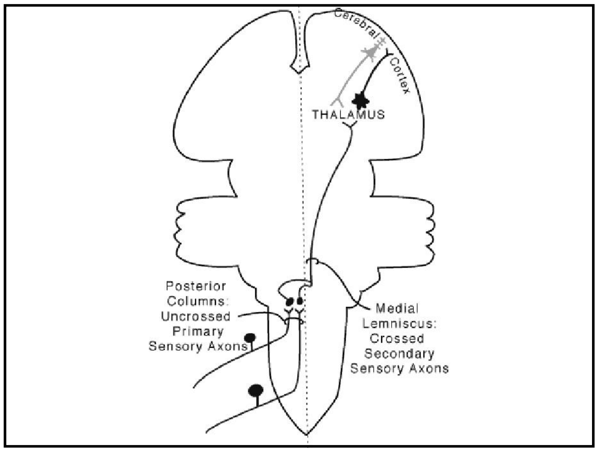


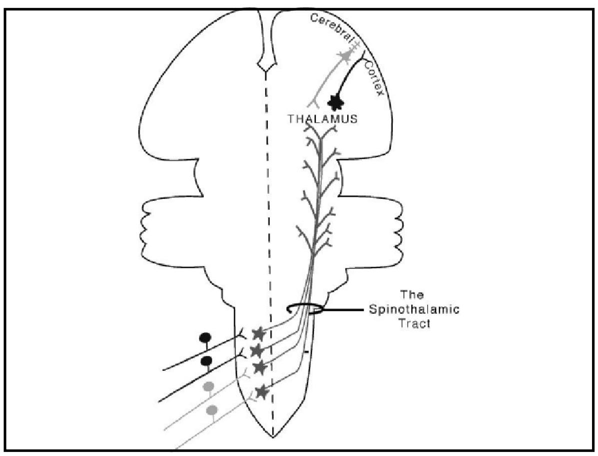


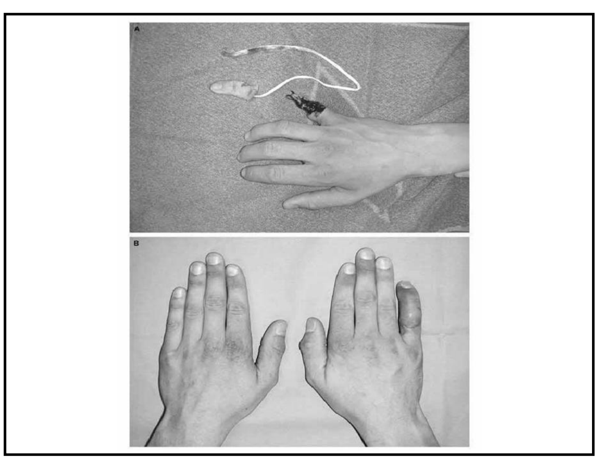

Summary
?
?
?
?
?


Summary
f. gracilus
f. cuneatus
dorsal spinocerebellar tract
ventral spinocerebellar tract
spinothalamic tract


Lesion lesson – (Brown-Sequard)
Spinal cord level?
Pathways transected?
Symptoms?
Lesion
L
Rt


Cerebral Cortex
THALAMUS
Posterior Columns: Uncrossed Primary Sensory Axons
Medial Lemniscus: Crossed Secondary Sensory Axons


Cerebral Cortex
THALAMUS
The Spinothalamic Tract


A
B

Lower motor neuron & desc. pathways

- Motor unit
- Organization of spinal motor neurons
- Influence on alpha motor neurons
- Descending pathways
- Functional classification

Lower motor neuron & desc. pathways

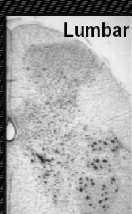
- Motor unit
- Organization of spinal motor neurons
- Influence on alpha motor neurons
- Descending pathways
- Functional classification

Ventral horn

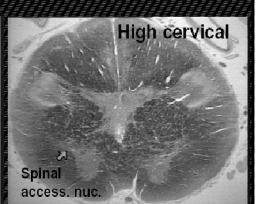
lamina IX

- motor neurons (IX)
  - innervate skeletal muscle
  - large alpha motor neurons
  - "final common pathway"
- phrenic nucleus
  - medial ventral horn
  - C_{3-5} – "keeps the diaphragm alive" Phrenic nuc
- spinal accessory nuc.
  - lateral ventral horn
  - C_{1-6} - innervates the sterno-cleidomastoid and trapezius mm.

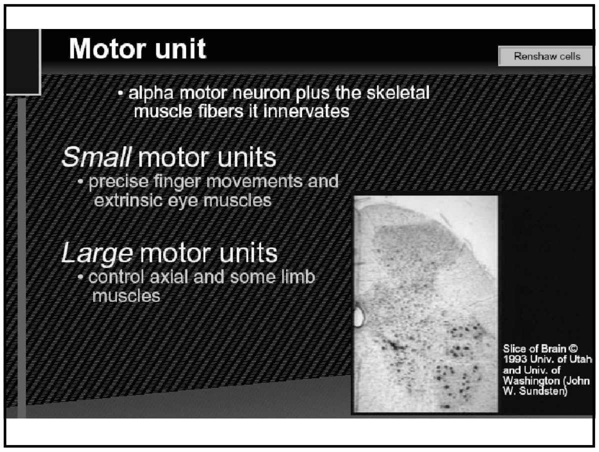
?

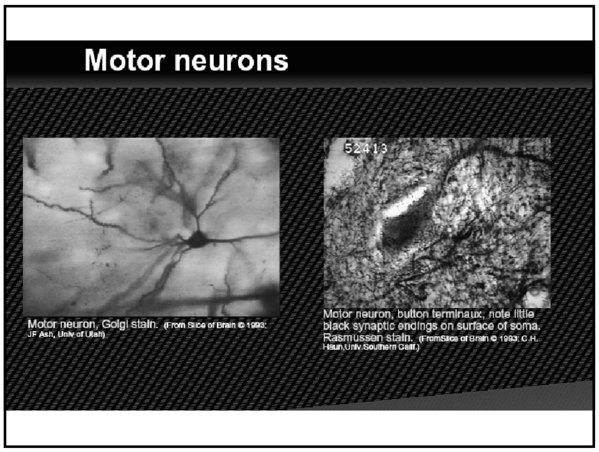


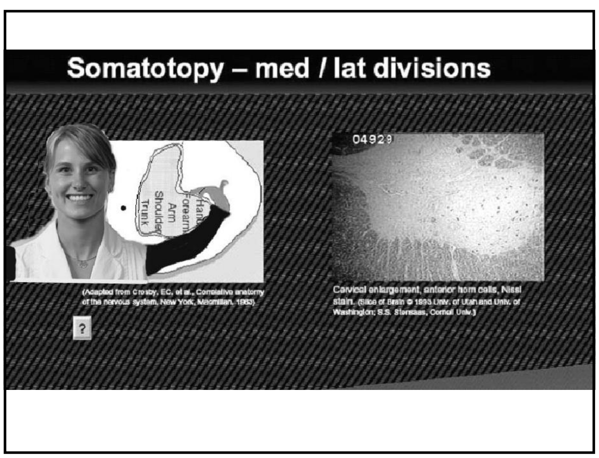
(From Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; John W. Sundsten)

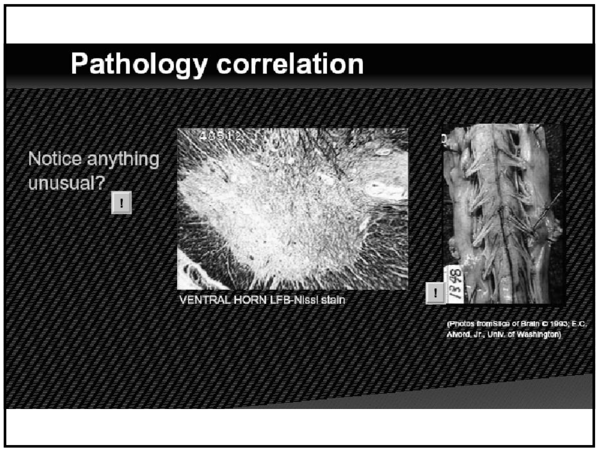


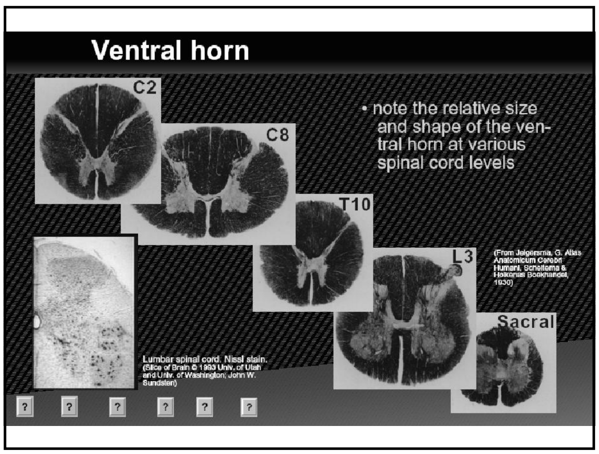
(From Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; S. Stensaas - Cornell Univ.)

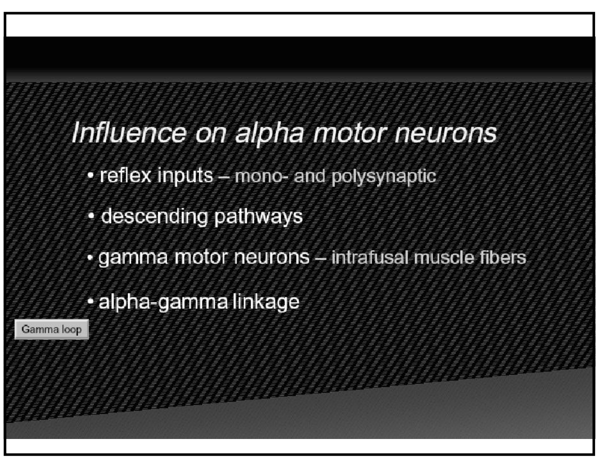

Motor unit
Renshaw cells
• alpha motor neuron plus the skeletal muscle fibers it innervates
Small motor units
• precise finger movements and extrinsic eye muscles
Large motor units
• control axial and some limb muscles
Slice of Brain © 1993 Univ. of Utah and Univ. of Washington (John W. Sundsten)

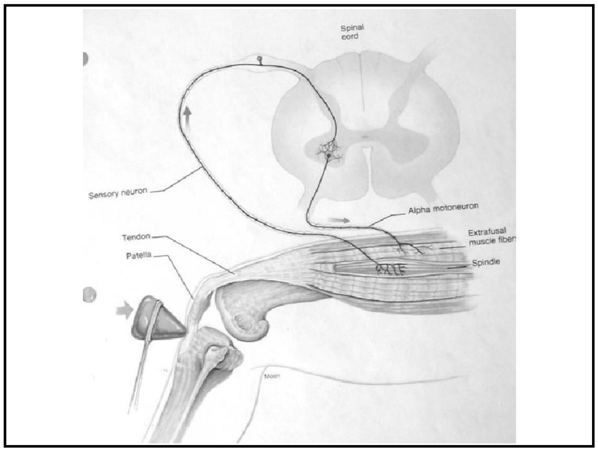

Motor neurons
52413
Motor neuron, Golgi stain. (From Slice of Brain © 1993; JF Ash, Univ of Utah)
Motor neuron, button terminaux; note little black synaptic endings on surface of soma. Rasmussen stain. (FromSlice of Brain © 1993; C.H. Haun,Univ.Southern Calif.)

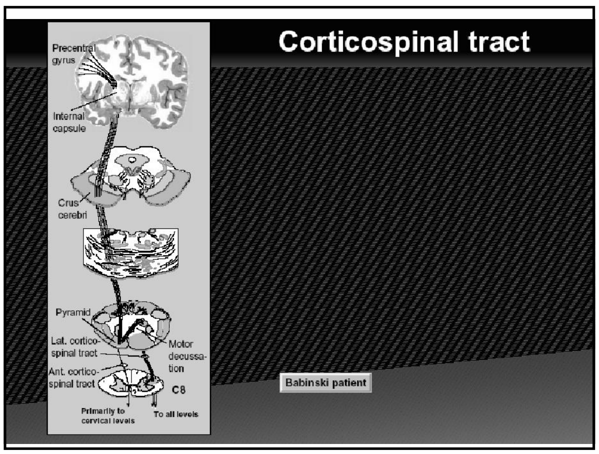

Somatotopy – med / lat divisions
Trunk
Shoulder
Arm
Forearm
04929
(Adapted from Crosby, EC, et al., Correlative anatomy of the nervous system, New York, Macmillan, 1963)
?
Cervical enlargement, anterior horn cells, Nissl stain. (Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; S.S. Stensaas, Cornell Univ.)

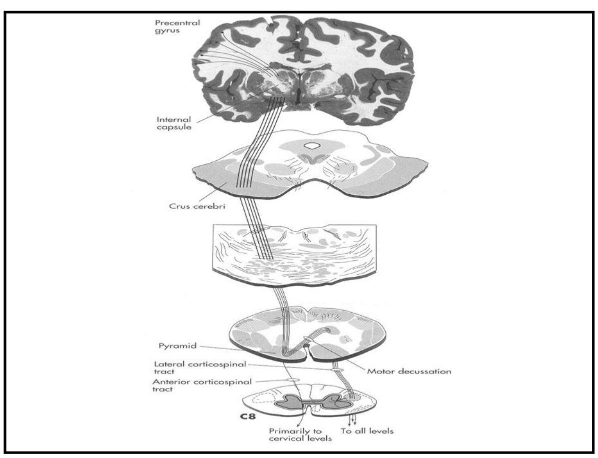

Pathology correlation
Notice anything unusual?
!
VENTRAL HORN LFB-Nissl stain
!
(Photos from Slice of Brain © 1993; E.C. Alvord, Jr., Univ. of Washington)

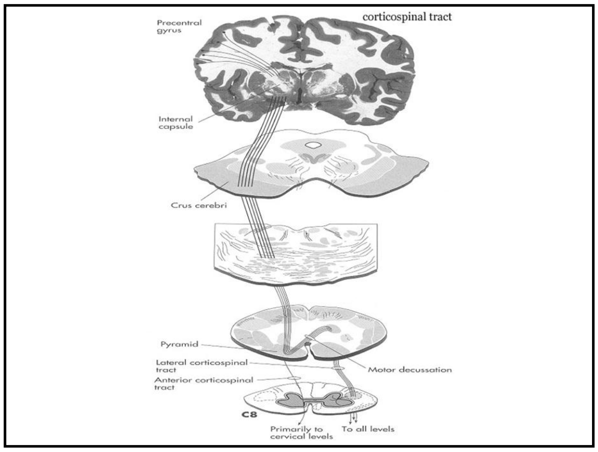

Ventral horn
C2
C8
T10
L3
Sacral
• note the relative size and shape of the ventral horn at various spinal cord levels
(From Jelgersma, G. Atlas Anatomicum Cerebri Humani, Scheltema & Holkenas Boekhandel, 1930)
Lumbar spinal cord. Nissl stain. (Slice of Brain © 1993 Univ. of Utah and Univ. of Washington; John W. Sundsten)

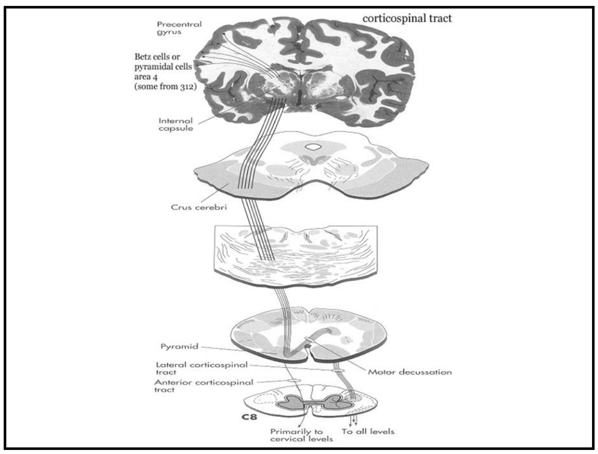

Influence on alpha motor neurons
• reflex inputs – mono- and polysynaptic
• descending pathways
• gamma motor neurons – intrafusal muscle fibers
• alpha-gamma linkage
Gamma loop

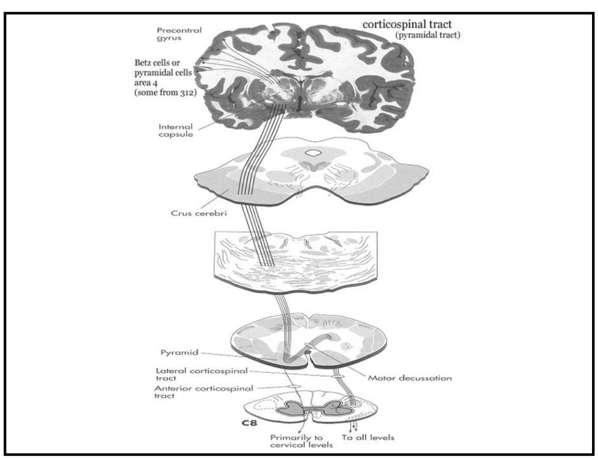

Spinal cord
Sensory neuron
Alpha motoneuron
Extrafusal muscle fiber
Tendon
Patella
Spindle

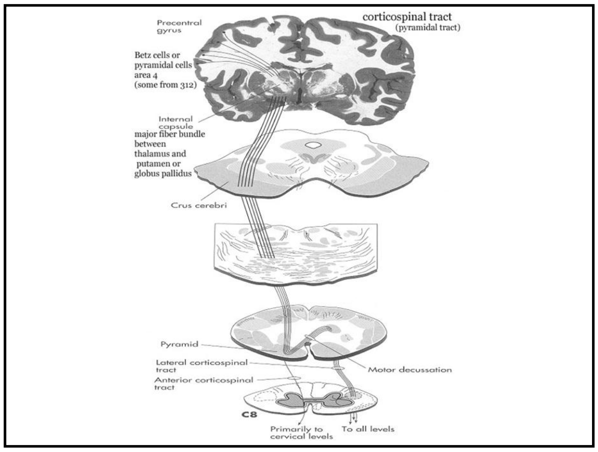

Corticospinal tract
Precentral gyrus
Internal capsule
Crus cerebri
Pyramid
Lat. cortico-spinal tract
Motor decussa-tion
Ant. cortico-spinal tract
C8
Primarily to cervical levels
To all levels
Babinski patient

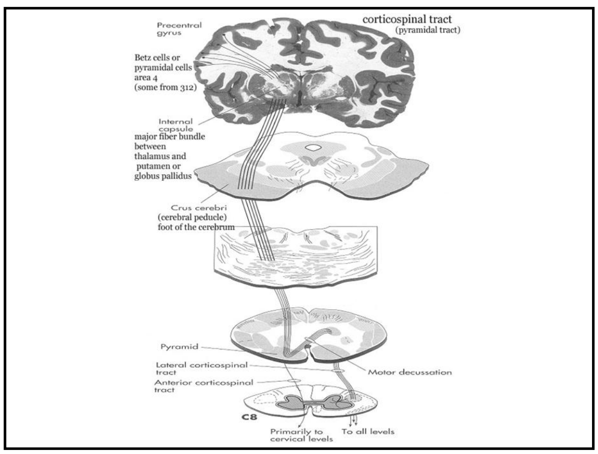

Precentral gyrus
Internal capsule
Crus cerebri
Pyramid
Lateral corticospinal tract
Motor decussation
Anterior corticospinal tract
C8
Primarily to cervical levels
To all levels

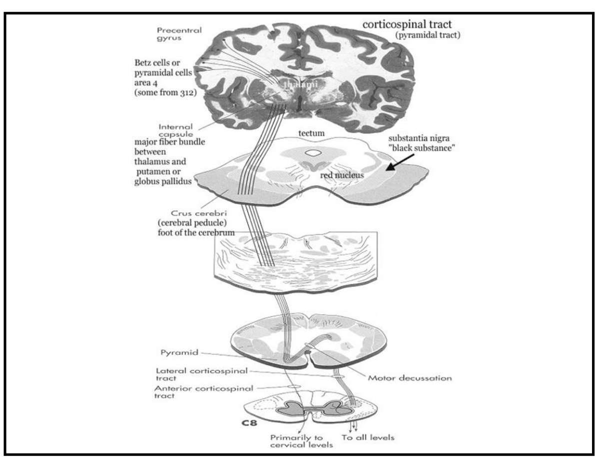

corticospinal tract
Precentral gyrus
Internal capsule
Crus cerebri
Pyramid
Lateral corticospinal tract
Anterior corticospinal tract
Motor decussation
C8
Primarily to cervical levels
To all levels

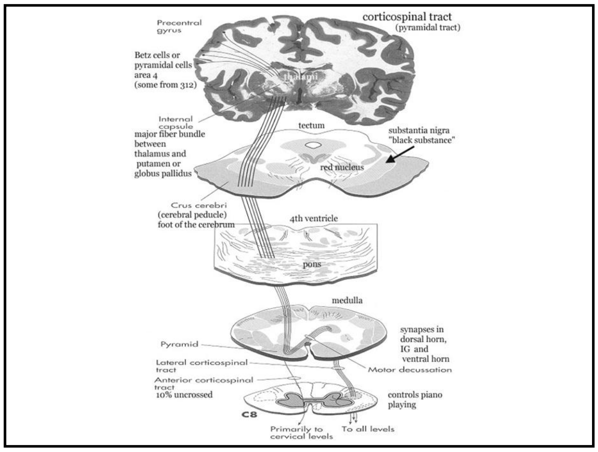

corticospinal tract
Precentral gyrus
Betz cells or pyramidal cells area 4 (some from 312)
Internal capsule
Crus cerebri
Pyramid
Lateral corticospinal tract
Anterior corticospinal tract
Motor decussation
C8
Primarily to cervical levels
To all levels

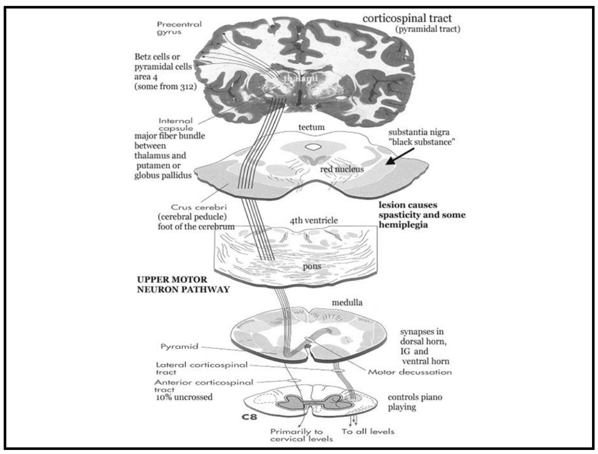

corticospinal tract
(pyramidal tract)
Precentral gyrus
Betz cells or pyramidal cells area 4 (some from 312)
Internal capsule
Crus cerebri
Pyramid
Lateral corticospinal tract
Anterior corticospinal tract
Motor decussation
C8
Primarily to cervical levels
To all levels

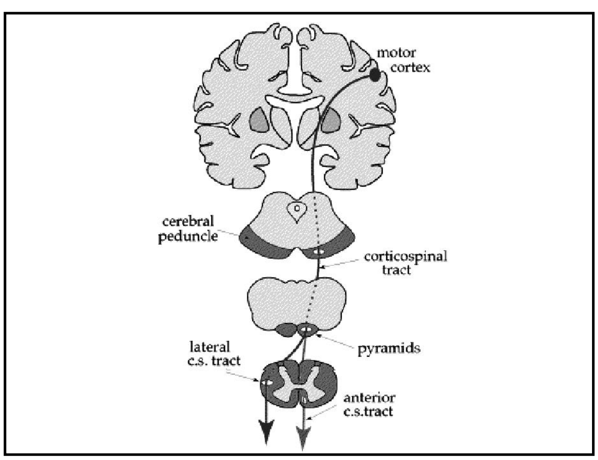

corticospinal tract
(pyramidal tract)
Precentral gyrus
Betz cells or pyramidal cells area 4 (some from 312)
Internal capsule
major fiber bundle between thalamus and putamen or globus pallidus
Crus cerebri
Pyramid
Lateral corticospinal tract
Anterior corticospinal tract
Motor decussation
C8
Primarily to cervical levels
To all levels

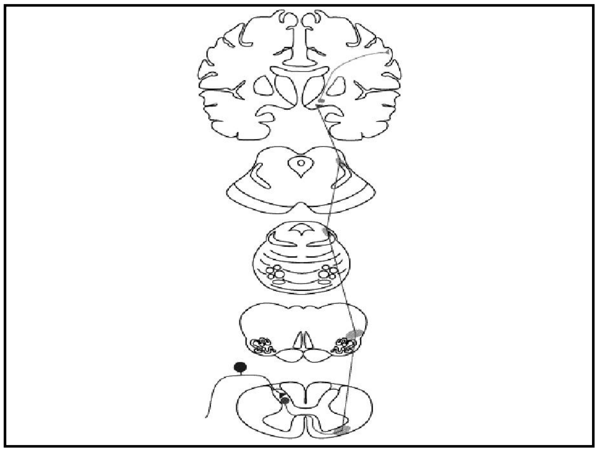

corticospinal tract
(pyramidal tract)
Precentral gyrus
Betz cells or pyramidal cells area 4 (some from 312)
Internal capsule
major fiber bundle between thalamus and putamen or globus pallidus
Crus cerebri
(cerebral peducle)
foot of the cerebrum
Pyramid
Lateral corticospinal tract
Anterior corticospinal tract
Motor decussation
C8
Primarily to cervical levels
To all levels

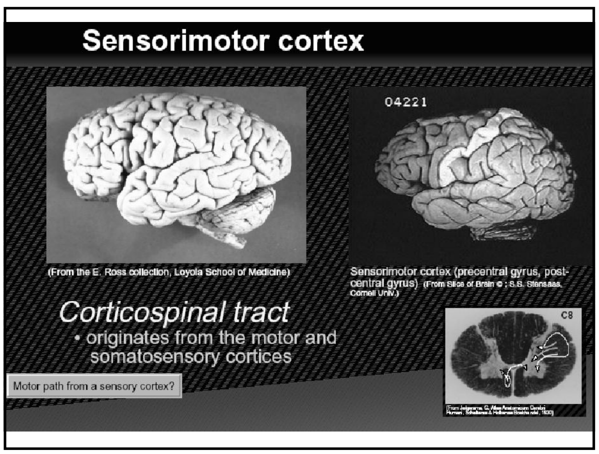

corticospinal tract
(pyramidal tract)
Precentral gyrus
Betz cells or pyramidal cells area 4 (some from 312)
Internal capsule
major fiber bundle between thalamus and putamen or globus pallidus
tectum
substantia nigra
"black substance"
red nucleus
Crus cerebri
(cerebral peducle)
foot of the cerebrum
Pyramid
Lateral corticospinal tract
Anterior corticospinal tract
Motor decussation
C8
Primarily to cervical levels
To all levels

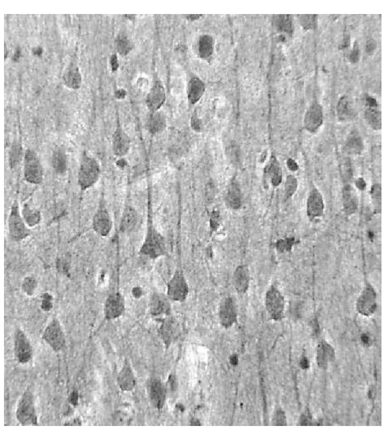

corticospinal tract
(pyramidal tract)
Precentral gyrus
Betz cells or pyramidal cells area 4 (some from 312)
Internal capsule major fiber bundle between thalamus and putamen or globus pallidus
tectum
substantia nigra "black substance"
red nucleus
Crus cerebri (cerebral peducle) foot of the cerebrum
4th ventricle
pons
medulla
synapses in dorsal horn, IG and ventral horn
Pyramid
Lateral corticospinal tract
Motor decussation
Anterior corticospinal tract 10% uncrossed
controls piano playing
C8
Primarily to cervical levels
To all levels

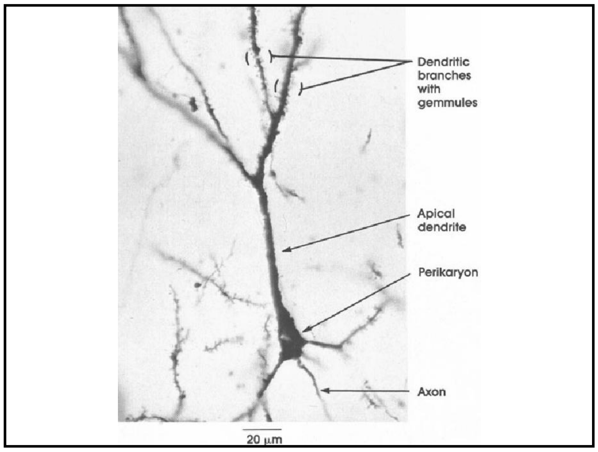

corticospinal tract
(pyramidal tract)
Precentral gyrus
Betz cells or pyramidal cells area 4 (some from 312)
Internal capsule major fiber bundle between thalamus and putamen or globus pallidus
tectum
substantia nigra "black substance"
red nucleus
Crus cerebri (cerebral peducle) foot of the cerebrum
4th ventricle
lesion causes spasticity and some hemiplegia
pons
UPPER MOTOR NEURON PATHWAY
medulla
synapses in dorsal horn, IG and ventral horn
Pyramid
Lateral corticospinal tract
Motor decussation
Anterior corticospinal tract 10% uncrossed
controls piano playing
C8
Primarily to cervical levels
To all levels

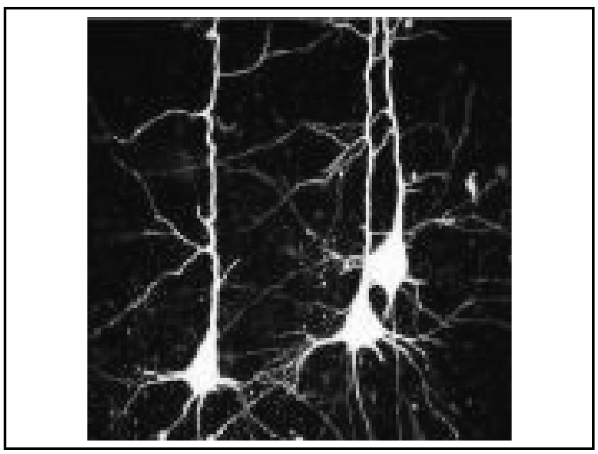

motor cortex
cerebral peduncle
corticospinal tract
pyramids
lateral c.s. tract
anterior c.s.tract

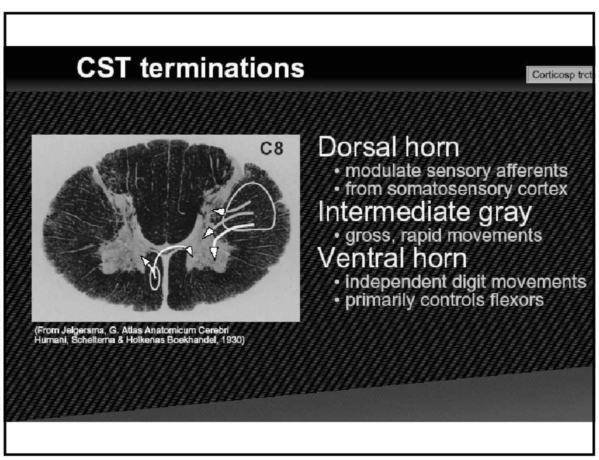


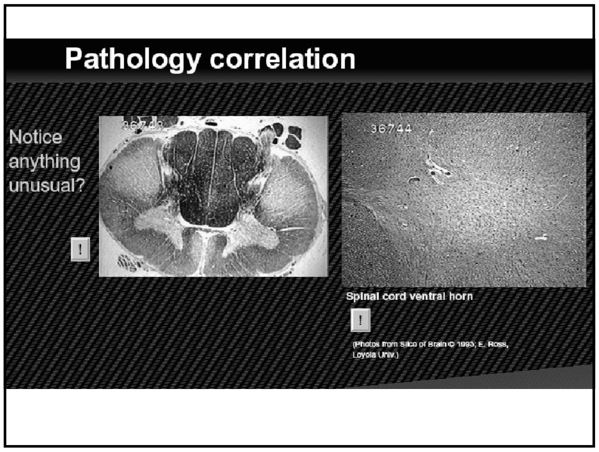

Sensorimotor cortex
04221
(From the E. Ross collection, Loyola School of Medicine)
Sensorimotor cortex (precentral gyrus, post-central gyrus) (From Slice of Brain © ; S.S. Stensaas, Cornell Univ.)
Corticospinal tract
• originates from the motor and somatosensory cortices
Motor path from a sensory cortex?
C8

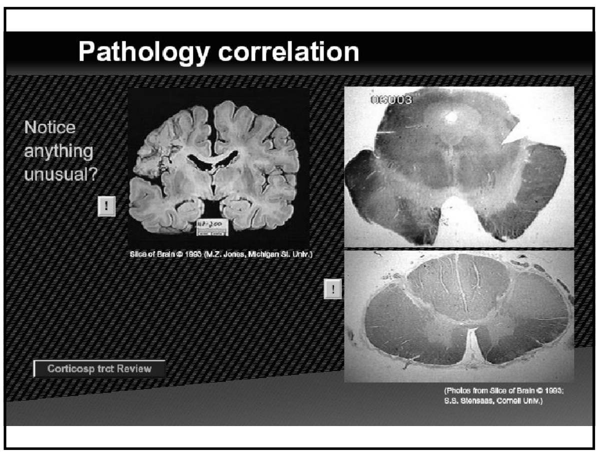


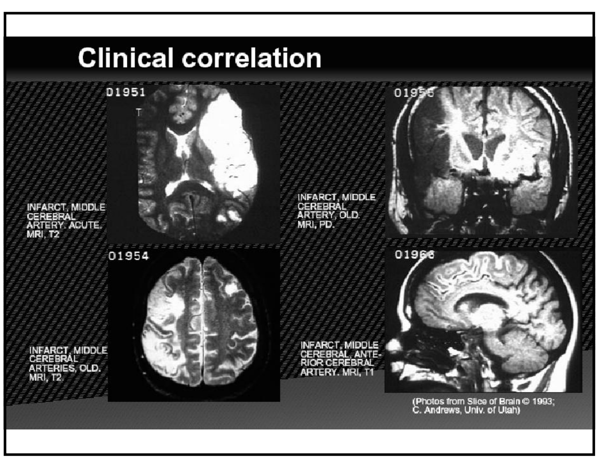

Dendritic branches with gemmules
Apical dendrite
Perikaryon
Axon
20 µm

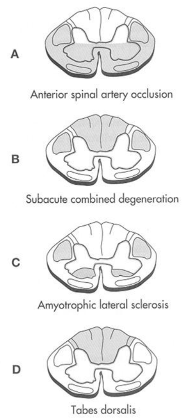


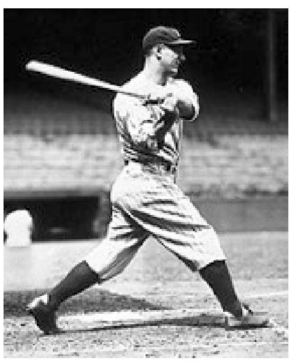

CST terminations
Corticosp trct
C8
Dorsal horn
• modulate sensory afferents
• from somatosensory cortex
Intermediate gray
• gross, rapid movements
Ventral horn
• independent digit movements
• primarily controls flexors
(From Jelgersma, G. Atlas Anatomicum Cerebri Humani, Scheltema & Holkemas Boekhandel, 1930)


Pathology correlation
Notice anything unusual?
36744
Spinal cord ventral horn
(Photos from Slice of Brain © 1993; E. Ross, Loyola Univ.)


Pathology correlation
Notice anything unusual?
Slice of Brain © 1993 (M.Z. Jones, Michigan St. Univ.)
Corticosp trct Review
(Photos from Slice of Brain © 1993; S.S. Stensaas, Cornell Univ.)

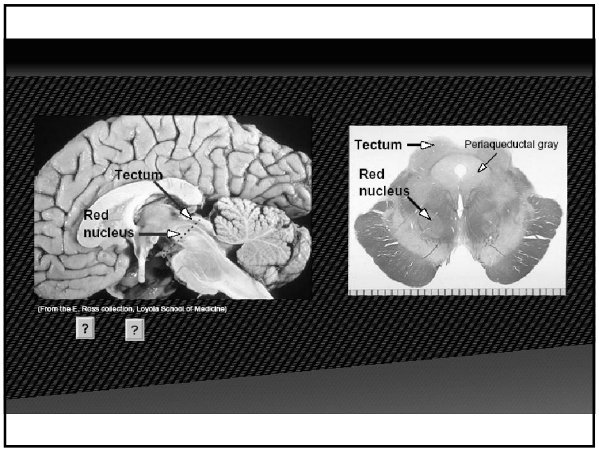

Clinical correlation
01951
INFARCT, MIDDLE CEREBRAL ARTERY. ACUTE. MRI, T2
INFARCT, MIDDLE CEREBRAL ARTERY, OLD. MRI, PD.
01954
INFARCT, MIDDLE CEREBRAL ARTERIES, OLD. MRI, T2.
INFARCT, MIDDLE CEREBRAL, ANTERIOR CEREBRAL ARTERY. MRI, T1
(Photos from Slice of Brain © 1993; C. Andrews, Univ. of Utah)

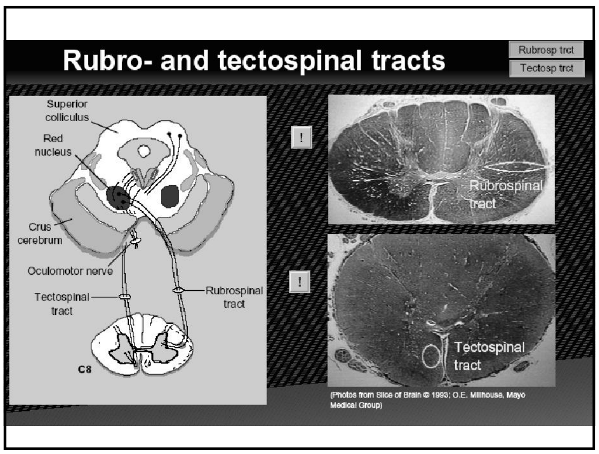


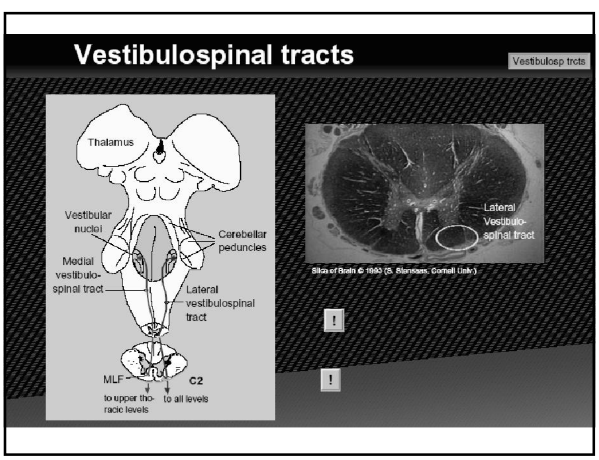


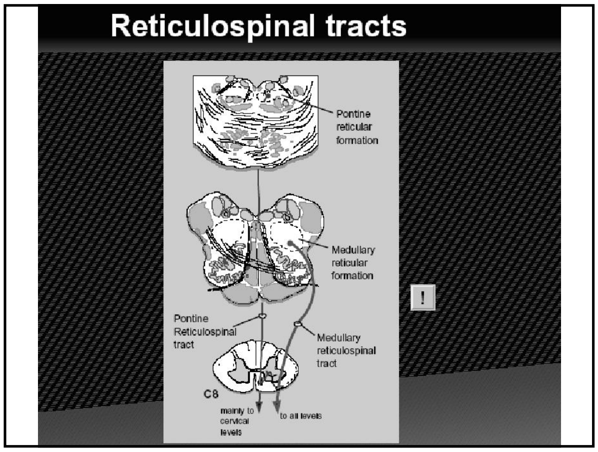
LOU GEHRIG (1903-1941)

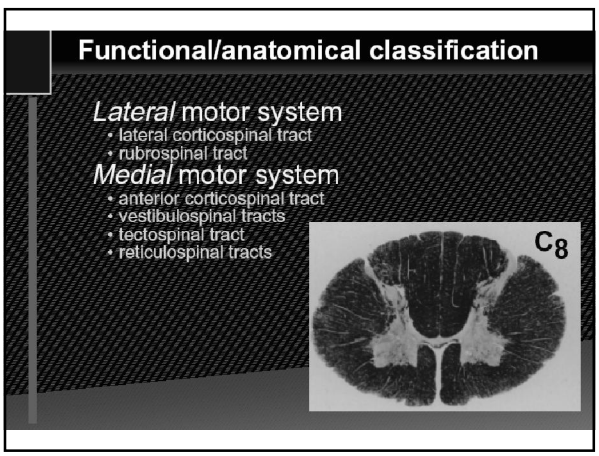
STEPHEN HAWKING (1942-)

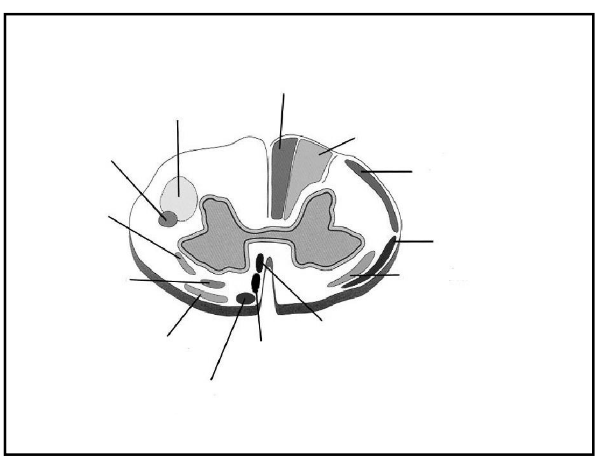

Tectum
Red nucleus
Tectum
Periaqueductal gray
Red nucleus
(From the E. Ross collection, Loyola School of Medicine)
?
?

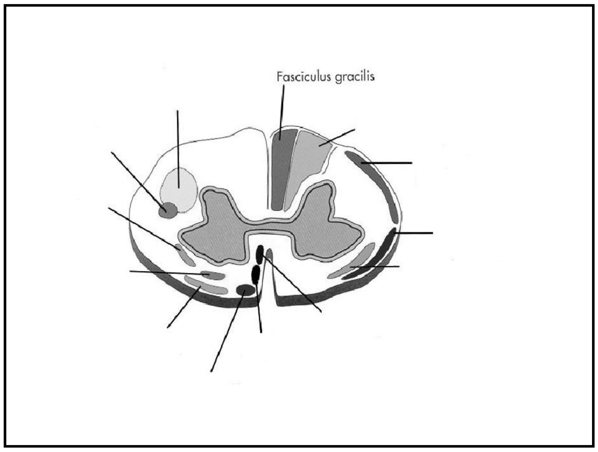

Rubro- and tectospinal tracts
Rubrosp trct
Tectosp trct
Superior colliculus
Red nucleus
Crus cerebrum
Oculomotor nerve
Tectospinal tract
Rubrospinal tract
C8
Rubrospinal tract
Tectospinal tract
(Photos from Slice of Brain © 1993; O.E. Millhouse, Mayo Medical Group)
!
!

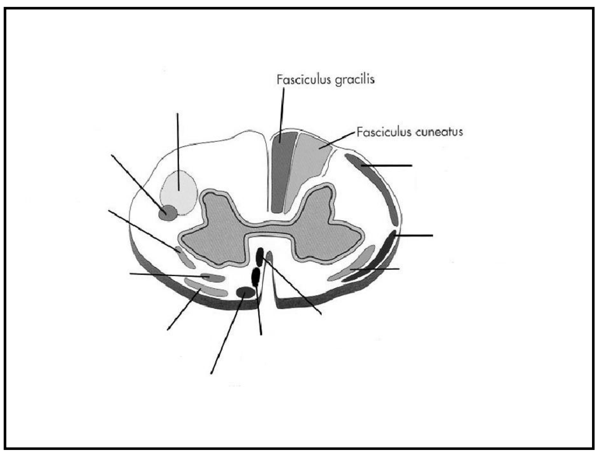

Vestibulospinal tracts
Vestibulosp trcts
Thalamus
Vestibular nuclei
Cerebellar peduncles
Medial vestibulo-spinal tract
Lateral vestibulospinal tract
MLF
C2
to upper tho-racic levels
to all levels
Lateral Vestibulo-spinal tract
Slice of Brain © 1993 (S. Stensaas, Cornell Univ.)
!
!

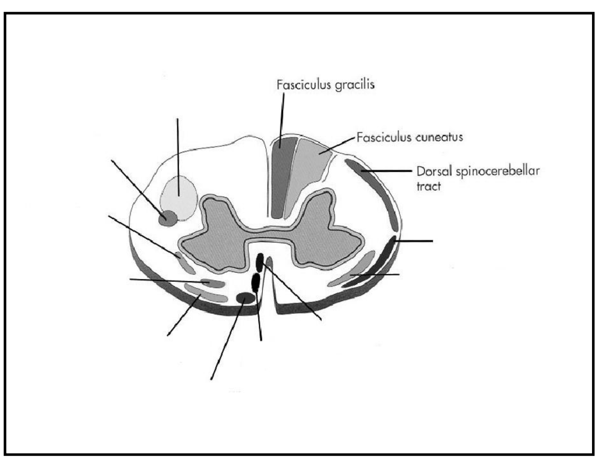

Reticulospinal tracts
Pontine reticular formation
Medullary reticular formation
Pontine Reticulospinal tract
Medullary reticulospinal tract
C8
mainly to cervical levels
to all levels

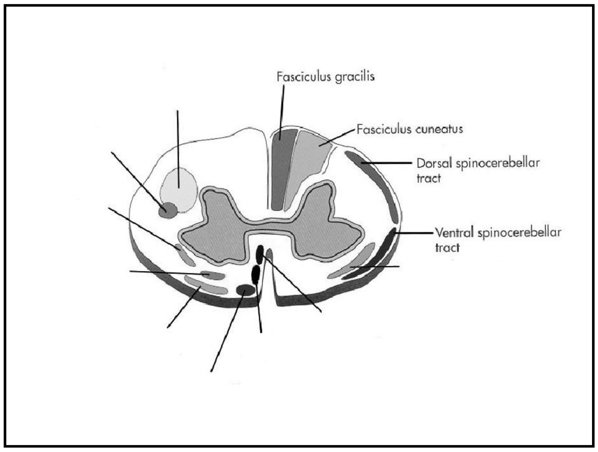

Functional/anatomical classification
Lateral motor system
• lateral corticospinal tract
• rubrospinal tract
Medial motor system
• anterior corticospinal tract
• vestibulospinal tracts
• tectospinal tract
• reticulospinal tracts
C8

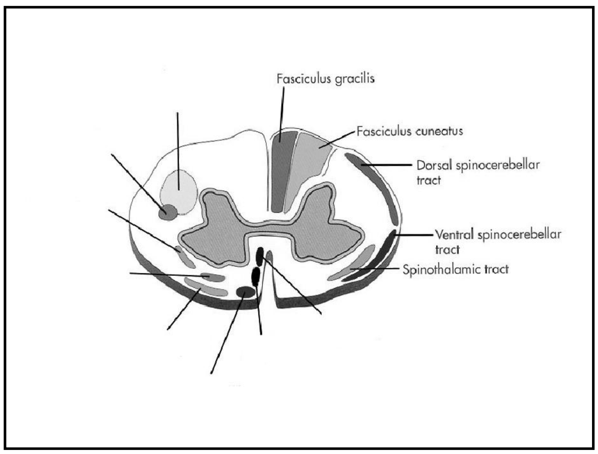


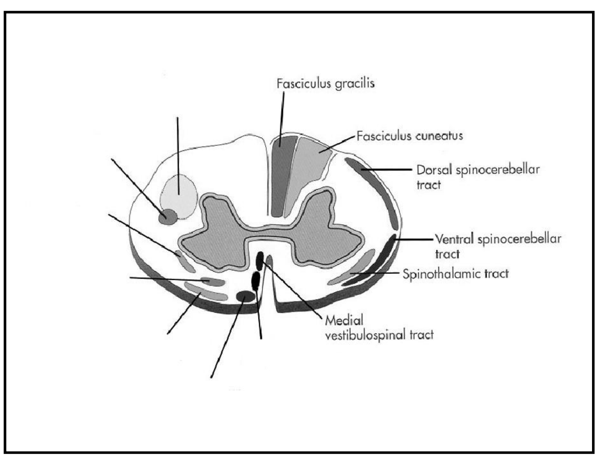

Fasciculus gracilis

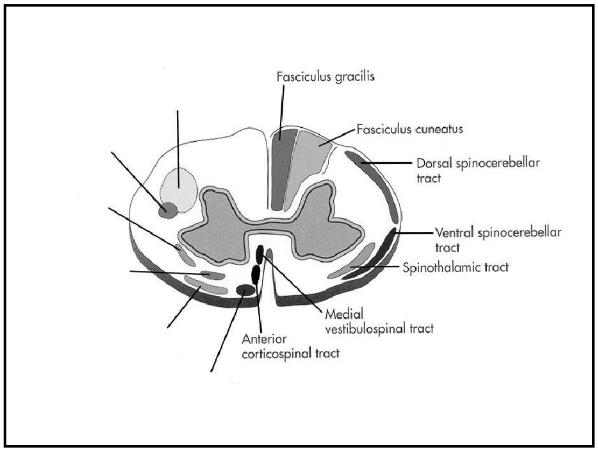

Fasciculus gracilis
Fasciculus cuneatus

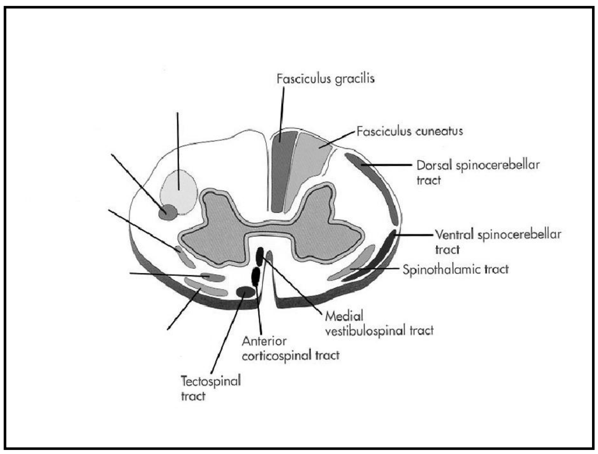

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract

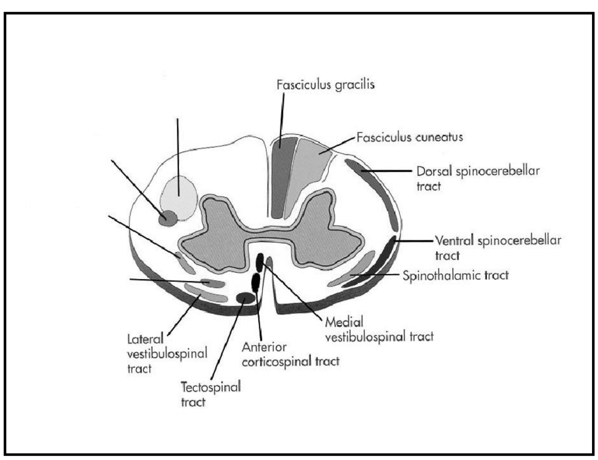

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Ventral spinocerebellar tract

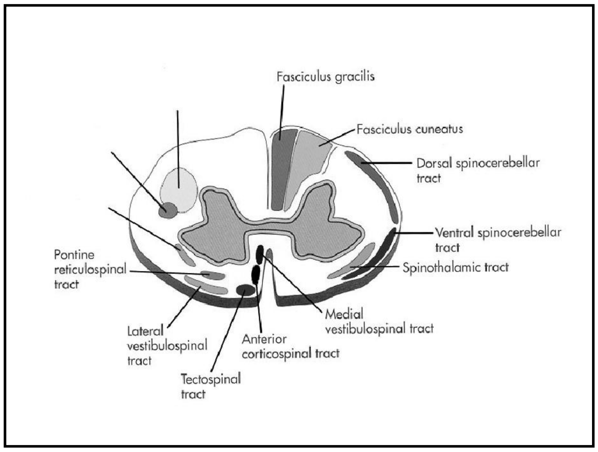

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Ventral spinocerebellar tract
Spinothalamic tract

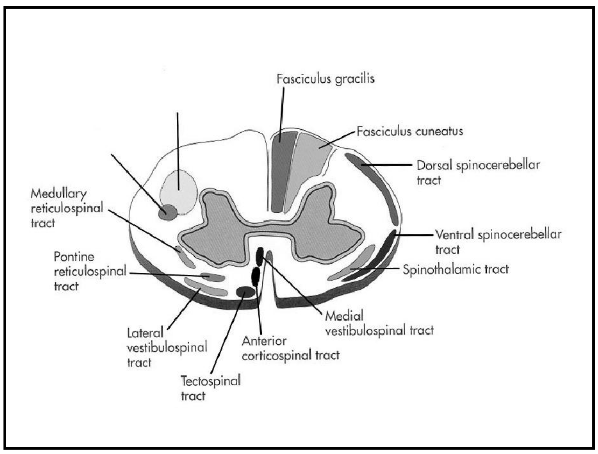

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Ventral spinocerebellar tract
Spinothalamic tract
Medial vestibulospinal tract

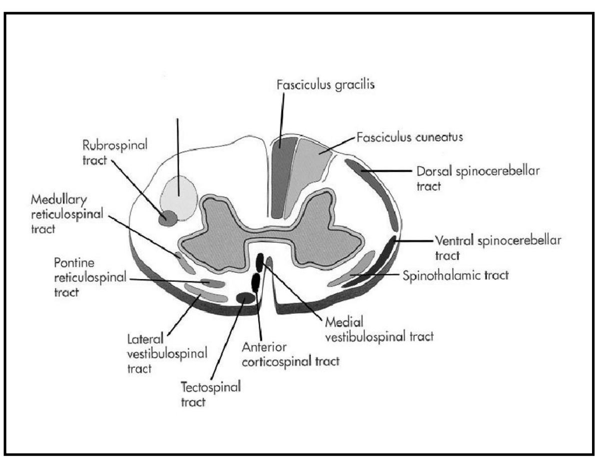

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Ventral spinocerebellar tract
Spinothalamic tract
Medial vestibulospinal tract
Anterior corticospinal tract

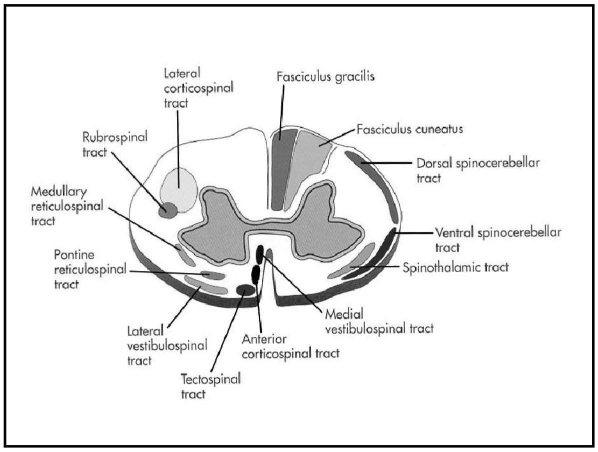

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Ventral spinocerebellar tract
Spinothalamic tract
Medial vestibulospinal tract
Anterior corticospinal tract
Tectospinal tract

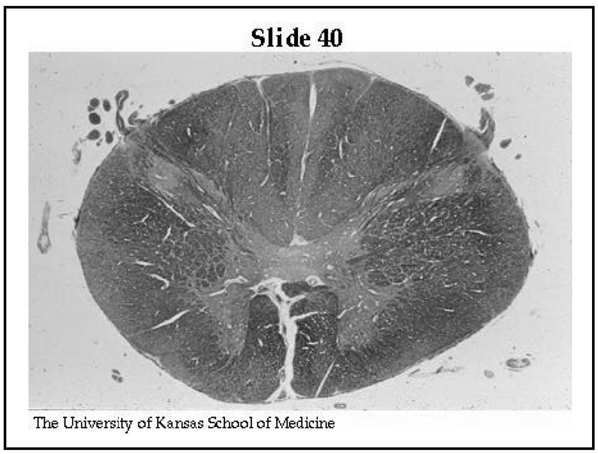

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Ventral spinocerebellar tract
Spinothalamic tract
Medial vestibulospinal tract
Lateral vestibulospinal tract
Anterior corticospinal tract
Tectospinal tract

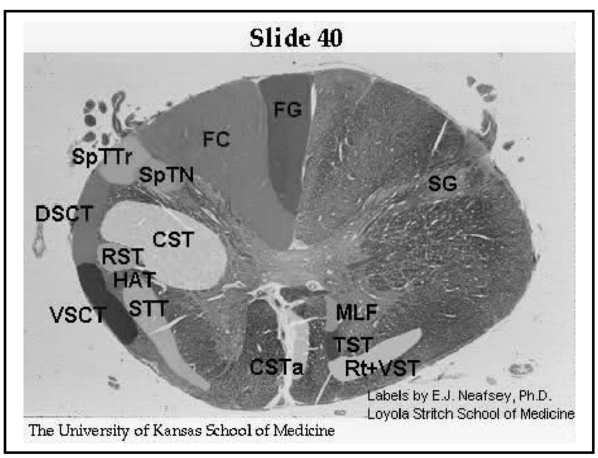

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Ventral spinocerebellar tract
Spinothalamic tract
Pontine reticulospinal tract
Medial vestibulospinal tract
Lateral vestibulospinal tract
Anterior corticospinal tract
Tectospinal tract

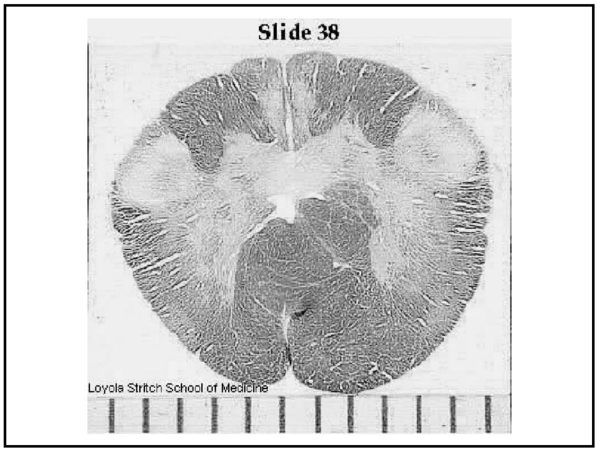

Fasciculus gracilis
Fasciculus cuneatus
Dorsal spinocerebellar tract
Medullary reticulospinal tract
Ventral spinocerebellar tract
Spinothalamic tract
Pontine reticulospinal tract
Medial vestibulospinal tract
Lateral vestibulospinal tract
Anterior corticospinal tract
Tectospinal tract

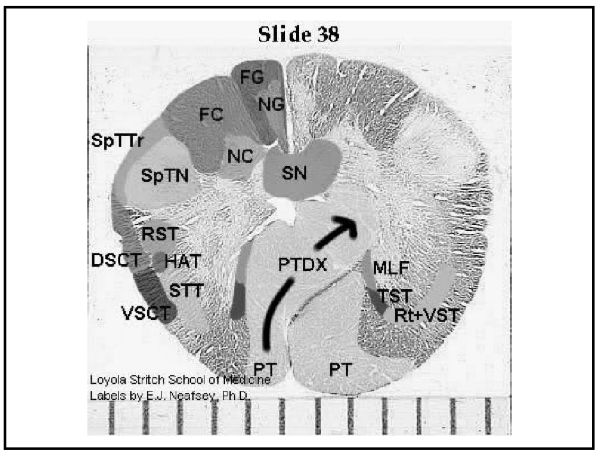

Fasciculus gracilis
Rubrospinal tract
Fasciculus cuneatus
Dorsal spinocerebellar tract
Medullary reticulospinal tract
Ventral spinocerebellar tract
Spinothalamic tract
Pontine reticulospinal tract
Medial vestibulospinal tract
Lateral vestibulospinal tract
Anterior corticospinal tract
Tectospinal tract

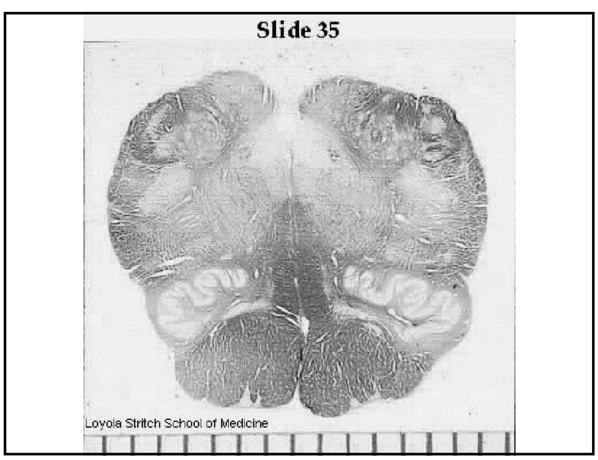

Lateral corticospinal tract
Fasciculus gracilis
Fasciculus cuneatus
Rubrospinal tract
Dorsal spinocerebellar tract
Medullary reticulospinal tract
Ventral spinocerebellar tract
Pontine reticulospinal tract
Spinothalamic tract
Medial vestibulospinal tract
Lateral vestibulospinal tract
Anterior corticospinal tract
Tectospinal tract

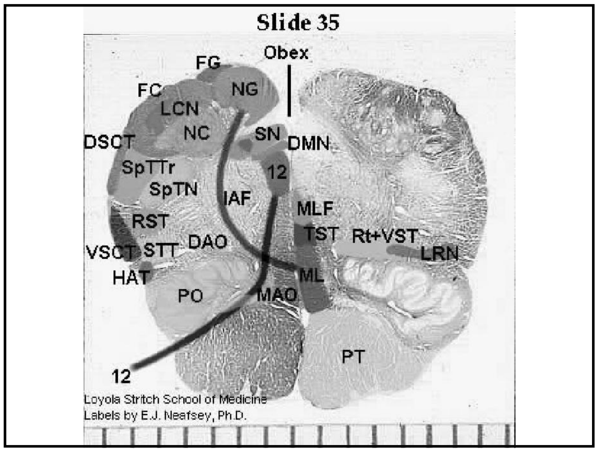

Slide 40
The University of Kansas School of Medicine

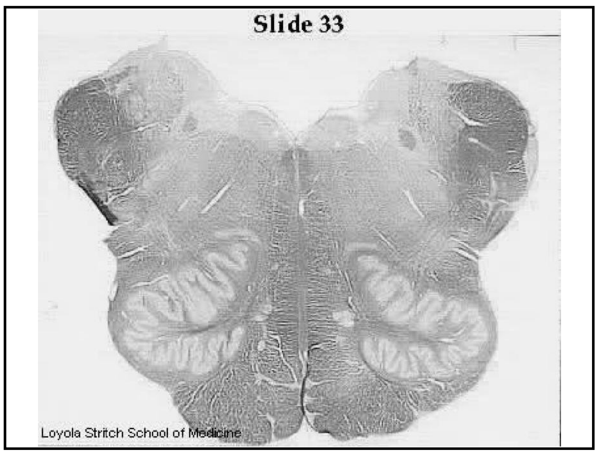

Slide 40
FG
FC
SpTTr
SpTN
SG
DSCT
CST
RST
HAT
VSCT
STT
MLF
TST
CSTa
Rt+VST
Labels by E.J. Neafsey, Ph.D.
Loyola Stritch School of Medicine
The University of Kansas School of Medicine

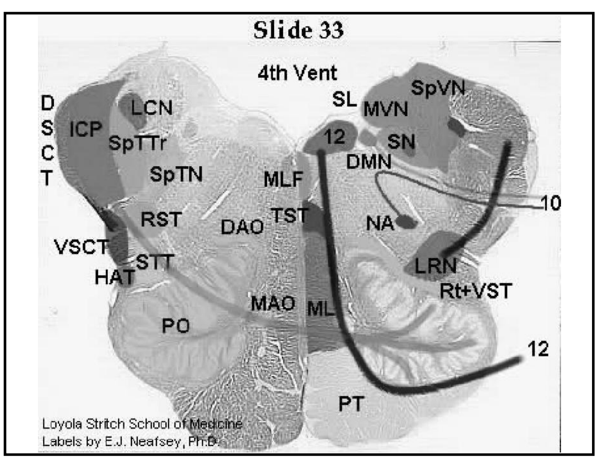

Slide 38
Loyola Stritch School of Medicine

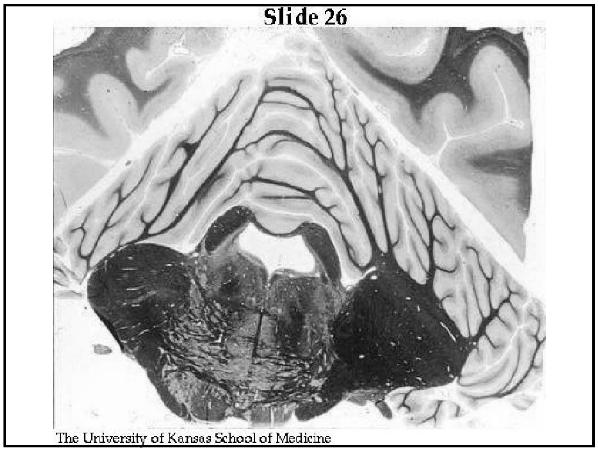

Slide 38
FG
NG
FC
SpTTr
NC
SN
SpTN
RST
DSCT
HAT
PTDX
MLF
STT
TST
VSCT
Rt+VST
PT
PT
Loyola Stritch School of Medicine
Labels by E.J. Neafsey, Ph.D.

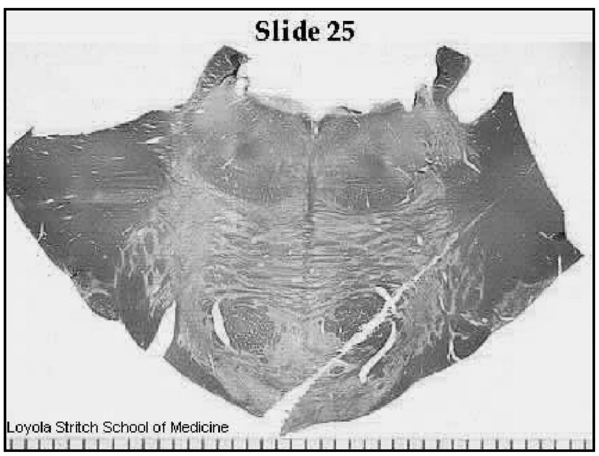

Slide 35
Loyola Stritch School of Medicine

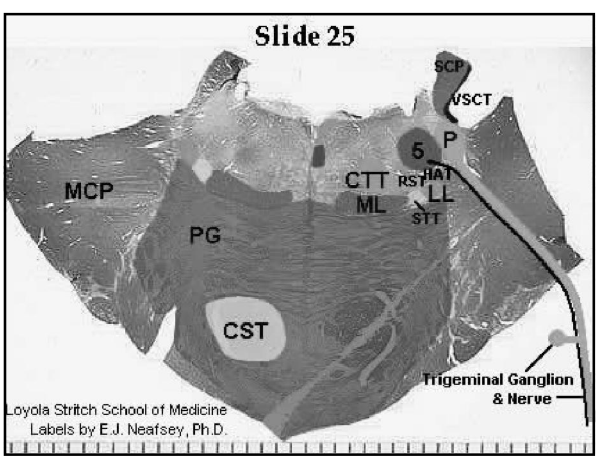

Slide 35
Obex
FG
FC
NG
LCN
NC
SN
DMN
DSCT
SpTTr
12
SpTN
IAF
MLF
RST
TST
Rt+VST
LRN
VSCT
STT
DAO
HAT
ML
PO
MAO
PT
12
Loyola Stritch School of Medicine
Labels by E.J. Neafsey, Ph.D.


Slide 33
Loyola Stritch School of Medicine

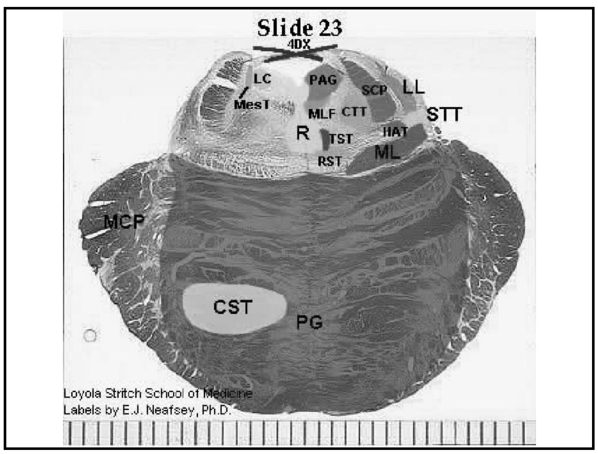

Slide 33
4th Vent
SpVN
D
S
C
T
LCN
SL
MVN
ICP
12
SN
SpTTr
DMN
SpTN
MLF
10
RST
DAO
TST
NA
VSCT
LRN
STT
HAT
Rt+VST
MAO
ML
PO
12
PT
Loyola Stritch School of Medicine
Labels by E.J. Neafsey, Ph.D.

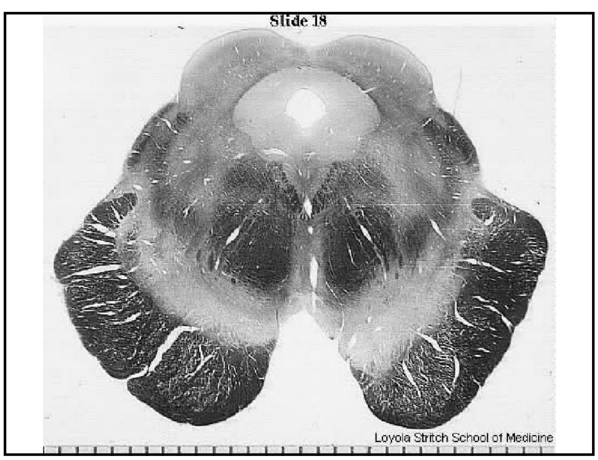

Slide 26
The University of Kansas School of Medicine

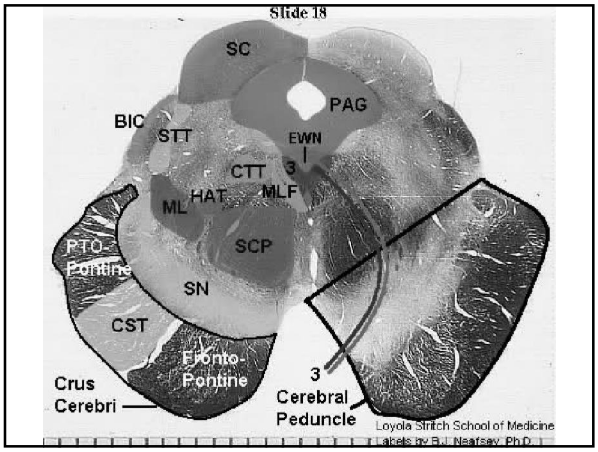

Slide 25
Loyola Stritch School of Medicine

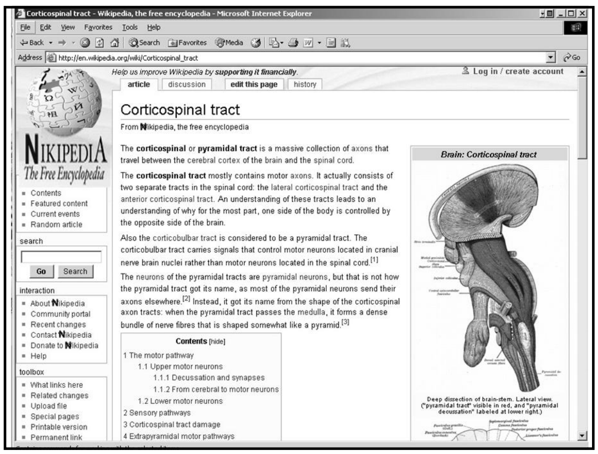

Slide 25
SCP
VSCT
P
5
MCP
CTT
RST
HAT
LL
ML
STT
PG
CST
Trigeminal Ganglion
& Nerve
Loyola Stritch School of Medicine
Labels by E.J. Neafsey, Ph.D.


Slide 23
Loyola Stritch School of Medicine


Slide 23
4DX
LC
MesT
PAG
SCP
LL
STT
MLF
CTT
R
TST
HAT
RST
ML
MCP
CST
PG
Loyola Stritch School of Medicine
Labels by E.J. Neafsey, Ph.D.


Slide 18
Loyola Stritch School of Medicine




Corticospinal tract - Wikipedia, the free encyclopedia - Microsoft Internet Explorer

http://en.wikipedia.org/wiki/Corticospinal_tract

Help us improve Wikipedia by **supporting it financially**.

Corticospinal tract

From Wikipedia, the free encyclopedia

The **corticospinal** or **pyramidal tract** is a massive collection of axons that travel between the cerebral cortex of the brain and the spinal cord.

The **corticospinal tract** mostly contains motor axons. It actually consists of two separate tracts in the spinal cord: the lateral corticospinal tract and the anterior corticospinal tract. An understanding of these tracts leads to an understanding of why for the most part, one side of the body is controlled by the opposite side of the brain.

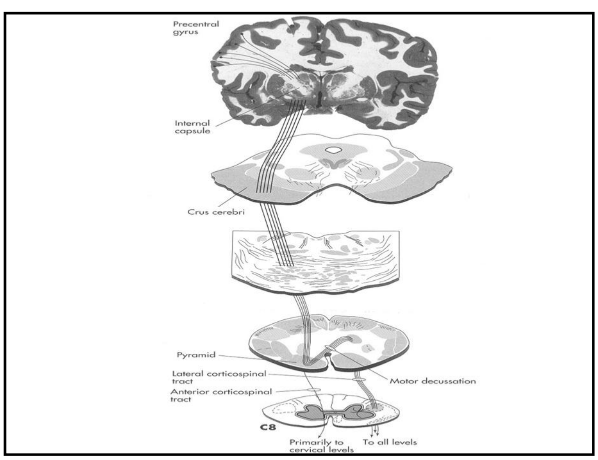
Also the corticobulbar tract is considered to be a pyramidal tract. The corticobulbar tract carries signals that control motor neurons located in cranial nerve brain nuclei rather than motor neurons located in the spinal cord.[1]

The neurons of the pyramidal tracts are pyramidal neurons, but that is not how the pyramidal tract got its name, as most of the pyramidal neurons send their axons elsewhere.[2] Instead, it got its name from the shape of the corticospinal axon tracts: when the pyramidal tract passes the medulla, it forms a dense bundle of nerve fibres that is shaped somewhat like a pyramid.[3]

Contents [hide]

Brain: Corticospinal tract

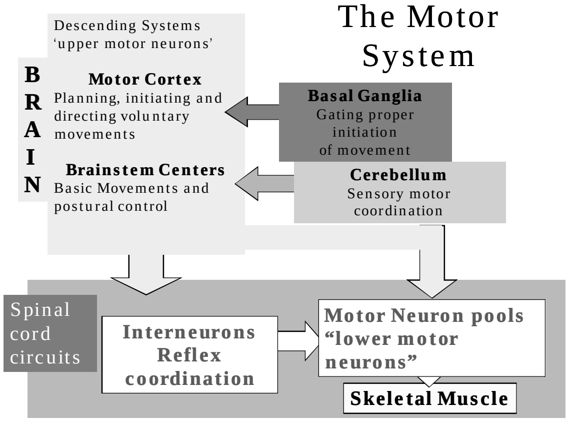
Deep dissection of brain-stem. Lateral view. ("pyramidal tract" visible in red, and "pyramidal decussation" labeled at lower right.)



Skeletal Muscle & Spinal Cord Control I

Leonardo DaVinci

The Motor System



- Session I

  - Concept review: NMJ, motor unit, motor pool advantages for control of muscles, Henneman's principle

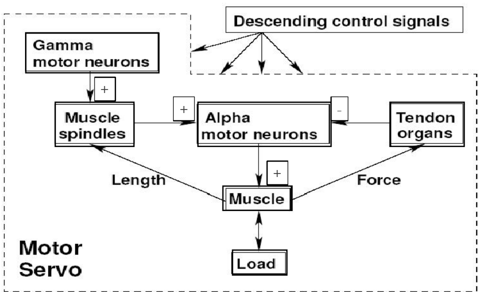
  - Nerve-Muscle interaction & effects: denervation, neurogenic disease

  - Muscle receptors and their function: spindle, golgi

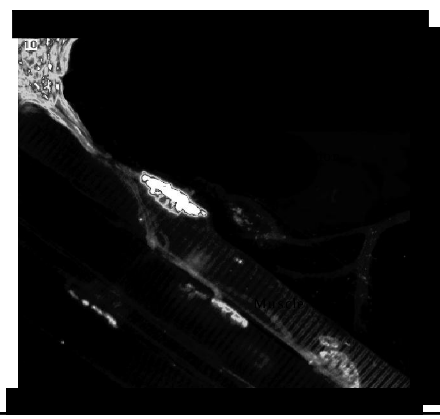
  - Afferent information, pathways

  - Efferent information

B R E A K



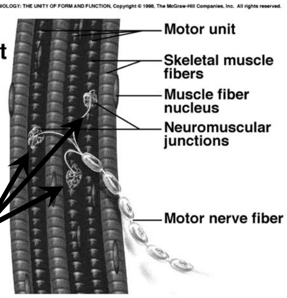
(Houk, JC and Rymer, WZ 1981. Neural control of muscle length and tension. Handbook of Physiology. Section 1. The Nervous System, Vol. II, Motor Control, Part 1. Am Physiol Soc, Bethesda, pp 257–323)



mprises
alpha
otor
uron and
e muscle
ers it
nervates

Motor Unit Size & Strength

Motor Nerve Unit



Size:
number of fibers innervated by the motor neuron (3)

Strength:
is proportional to its size

is inversely related to the fineness of the movement.

In the Clinic

- Myasthenia Gravis
- LEMS Lambert-Eaton Myasthenic Syndrome

Table 1. Ion Channel and Related Targets in Antibody-Mediated Diseases

Ion Channel or Related Protein	Associated Autoimmune Disease(s)	Main Clinical Features	Location	Genetic Defects also Found?
α1 nicotinic acetylcholine receptor (AChR)	myasthenia gravis	muscle weakness and fatigue	neuromuscular junction	congenital myasthenic syndromes
Muscle-specific kinase (MuSK)	myasthenia gravis without AChR antibodies	muscle weakness and fatigue	neuromuscular junction	one case of congenital myasthenic syndrome
P/Q-type (α1A) voltage-gated calcium channel (VGCC)	Lambert Eaton myasthenic syndrome	muscle weakness	presynaptic nerve terminal at neuromuscular junction	congenital myasthenic syndrome not yet identified, but subtle defects in transmitter release in spontaneous mouse mutants and α1A knockouts

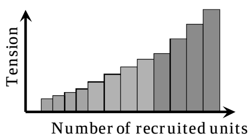
Neuron 52, 123-138, October 5, 2006 ©2006 Elsevier Inc. DOI 10.1016/j.neuron.2006.09.024

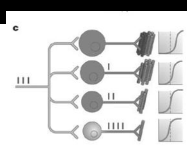
Autoimmune Channelopathies and Related Neurological Disorders

Angela Vincent,[1,*] Bethan Lang,[1] and Kleopas A. Kleopa[2]

Henneman's size principle

- Ordered recruitment of motor neurons
- Small, slow units are active during low force contractions = *Smooth control*
- Large, fast units are active during high force contractions = *Poor control*

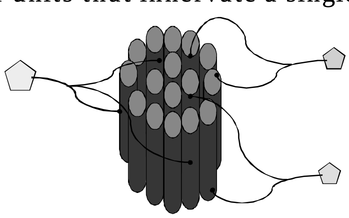




Modified from .Stein, RB, Gossen, ER & K E Jones. Nature Reviews Neuroscience 6, 389-397 (May 2005) | doi:10.1038/nrn1668

Motor Pool:

Motor units that innervate a single muscle



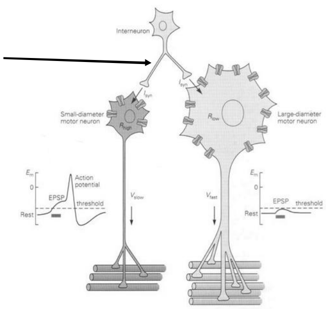
The nervous system controls the motor pool rather than motor units; neuronal inputs are usually distributed to most of the motor units in a motor pool.

Advantages of the Size principle strategy for muscle control

It simplifies motor control

- Increased excitation to the motor pool increases the muscle force produced.

- Requires only a limited number of axons to control motor pool (e.g. corticospinal tract).



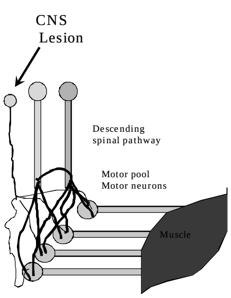
Modified from Principles of Neural science, Kandel et al., 4th ed, 2000

Advantages of the Size principle strategy for muscle control

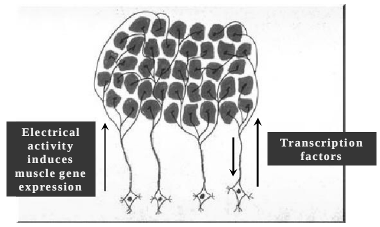
- Compensation

- Allows continued function even with partial loss of a motor pathway by increasing the discharge frequency of remaining neurons.

- The loss may not be noticeable to the patient until >50% of neuronal loss is reached.

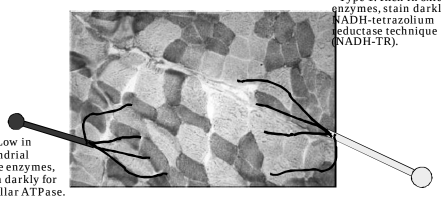


The functional and structural integrity of skeletal muscle depends on its nerve supply. Motor neurons in the spinal cord or brain stem innervate many muscle fibers (hundreds in large muscles)



Modified from www.pathology.vcu.edu/.../imageindex.html

Histochemical staining techniques reveal two basic types of fibers



• Type 1. Rich in oxidative enzymes, stain darkly by NADH-tetrazolium reductase technique (NADH-TR).

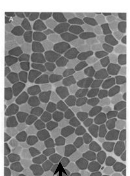
Type 2. Low in mitochondrial oxidative enzymes, but stain darkly for myofibrillar ATPase.

Modified from www.pathology.vcu.edu/.../image/05.jpg

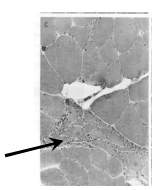
All of the muscle fibers in a given motor unit are of the **same** histochemical types (1 or 2); **the innervating neuron determines the type of muscle fiber.**

The diagnostic investigation of a muscle biopsy specimen includes evaluation of the size, distribution and the relative number of the two major fiber types.

Normal Muscle "checkerboard pattern"



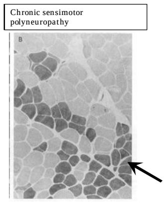
Atrophied fibers & Hypertrophied fibers



group atrophy

Fiber-type grouping after fiber re-innervation

Chronic sensimotor polyneuropathy



Axon sprouting from surviving MNs confer histological type

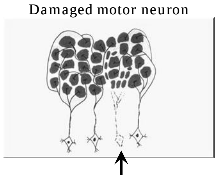
Modified from Principles of Neural science, Kandel et al., 4th ed, 2000

In the Clinic

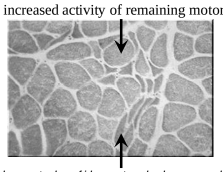
Neurogenic disease

Neurogenic or denervation atrophy. The primary lesion is in the nervous system, either in the cell body, ventral root damage, spinal or peripheral nerve damage of lower motor neuron.

Damaged motor neuron



the unaffected muscle hypertrophies due to increased activity of remaining motor units



denervated myofibers atrophy become smaller and more angular cross striation usually persists until very late in the process

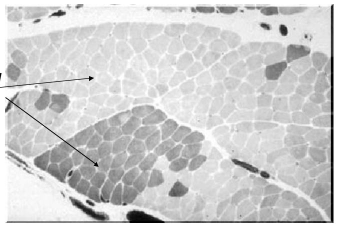
Images Modified from www.pathology.vcu.edu/.../imageindex.html

If the denervated muscle fibers are in the vicinity of intact axons, they may become re-innervated by collateral sprouting.

Since the motor neuron determines the muscle fiber type, all of the re-innervated fibers are converted to a single histochemical fiber type, with loss of the normal checkerboard pattern.

Type grouping

ATPase stain

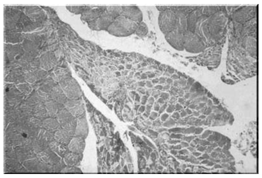


Modified from www.pathology.vcu.edu/.../imageindex.html

NEUROGENIC DISEASES EXAMPLES

* Amyotrophic lateral sclerosis (adults)
* Spinal muscular atrophy (usually in children)
* Poliomyelitis – (viral, now rare)
* Peripheral neuropathy of various types
* Histologic Changes

GROUPED
Atrophic muscle fibers caused by involvement of an isolated motor unit.



Images Modified from www.pathology.vcu.edu/.../imageindex.html

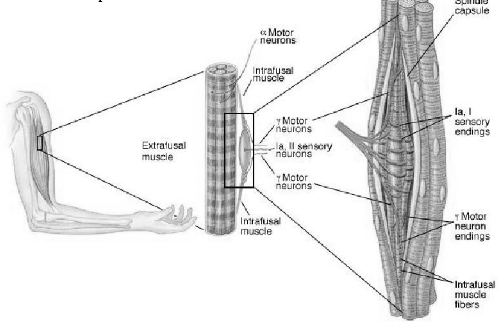
2) Afferent Innervation: fiber classification

Table 36-1 Classification of Sensory Fibers from Muscle

Type	Receptor	Axon	Sensitive to
Ia	Primary spindle endings	12–20 μm myelinated	Muscle length and rate of change of length
Ib	Golgi tendon organs	12–20 μm myelinated	Muscle tension
II	Secondary spindle endings	6–12 μm myelinated	Muscle length (little rate sensitivity)
II	Nonspindle endings	6–12 μm myelinated	Deep pressure
III	Free nerve endings	2–6 μm myelinated	Pain, chemical stimuli, and temperature (important for physiological response to exercise)
	Abundant: twice as many as any other receptors		
IV	Free nerve endings	0.5–2 μm nonmyelinated	Pain, chemical stimuli, and temperature

From Castro et al.

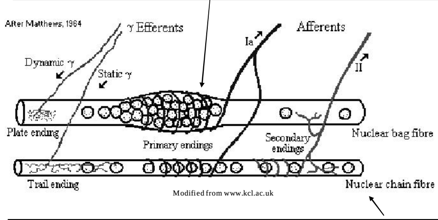
Muscle Spindle



Modified from www.abcbodybuilding.com/psycho_files/13.jpg

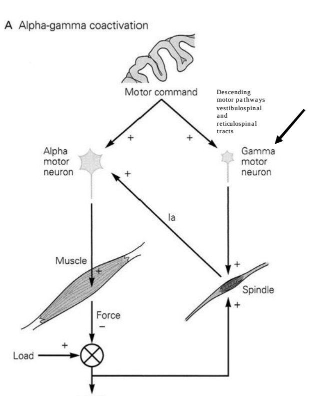
Muscle spindle organ: sensing ΔLENGTH

Regulate afferent responses to rapid length changes (transient or dynamic)



Modified from www.kcl.ac.uk

Regulate spindle responses to slow length changes (static)

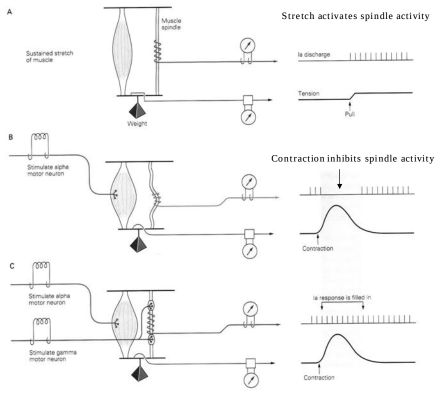


Small size motorneurons or fusimotor or γ-efferent fibers

provide a mechanism to adjust the sensitivity of the muscle spindle.

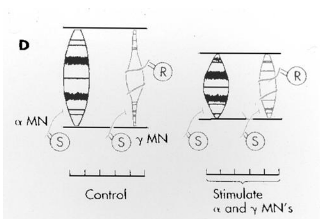
Extend the spindle's dynamic range to the full extent of the range of motion of the extrinsic muscle

Modified from Principles of Neural Science, Kandel



Modified from Principles of Neural Science, Kandel

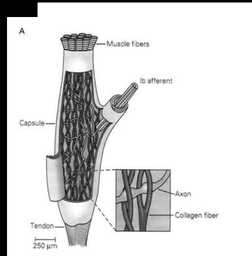
Normal movement



From Castro et al. Neuroscience textbook

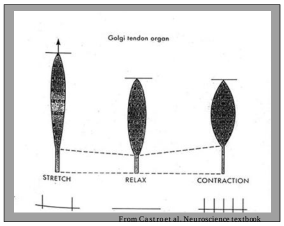
Co-activation of α and γ motor neurons causes no net discharge rate change

Golgi Tendon Organ: sensing Δ FORCE



- Long shaped capsule, enclosing several small tree-shaped nervous endings: found around the musculotendinous junction
- Golgi Tendon organs are muscle tension receptors
- High threshold, sensitive when muscle is contracted
- Signal variations in contractile force

Modified from Principles of Neural Science, Kandel

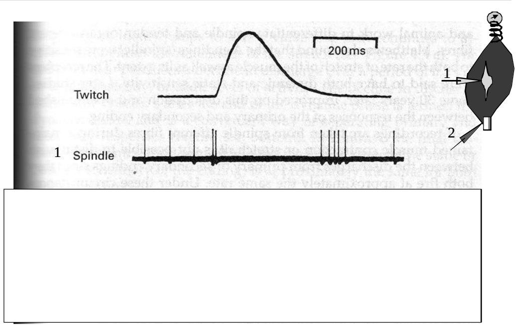


From Castro et al. Neuroscience textbook

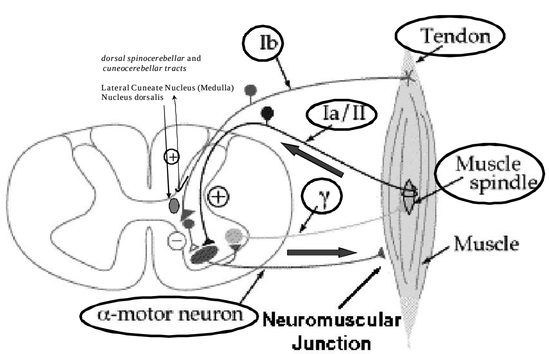
TABLE 11-2 Factors Affecting Tendon Organ Discharge

Condition	Tendon organ response
Resting muscle	No activity
Passive stretch of resting muscle	Little or no response
Moderate to severe stretch of resting muscle	Small increased discharge frequency
Muscle activation and contraction	Moderate increased discharge frequency
Muscle activation plus moderate stretch	Large increased discharge frequency

Responses of a spindle ending and a Golgi tendon organ during a muscle twitch



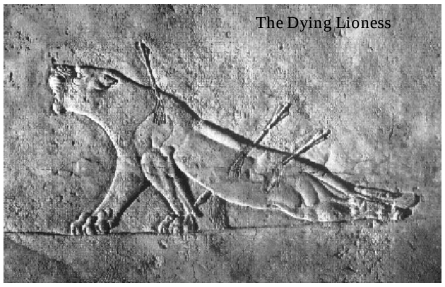
From Control of Human Voluntary Movement, Rothwell 1994



Modified from thalamus.wustl.edu/course/spinal.html

"The most remarkable thing about moving is how easy it is. Only when we watch someone whose movements continually go wrong we are reminded of the problems with movement control with which our nervous system copes so uncomplainingly." J. Rothwell

Skeletal Muscle & Spinal Cord Control II



This Assyrian relief from ~ 650 B.C. is an excellent depiction of the nervous system control of skeletal muscle. Injury to the spinal cord results in paralysis of the otherwise undamaged hind legs.

(modified from users.rcn.com / ... / BiologyPages / ; courtesy of The Trustees of the British Museum)

- Session II

-Spinal reflexes: simple, complex. Stretch, GTO, recurrent inhibition

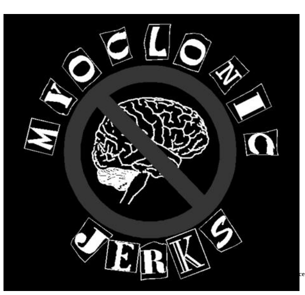
-Other reflexes: withdrawal, cross-extensor, multi-segmental

- Reflexes & clinical implications of testing

- Pathophysiology: hyperreflexia, clonus & clasp-knife; hyporeflexia

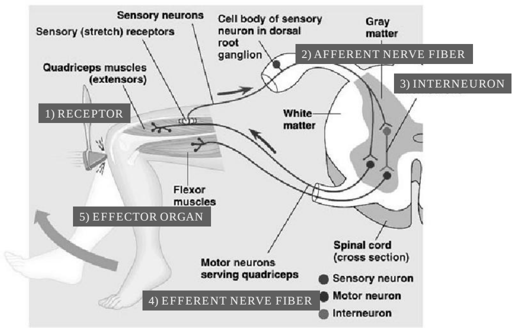
Reflexes

Neural, involuntary response of an effector organ induced by an applied stimulus



...ce Softball Team

Reflexes



Reflexes

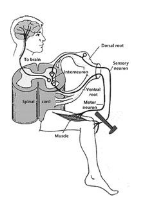
Monosynaptic.-

- Local, direct response
- No interneurons

Polysynaptic.-

- One or more interneurons
- Slower than monosynaptic
- Decrease with time
- May require several stimuli to elicit a response
- May involve more muscle groups

Reflexes

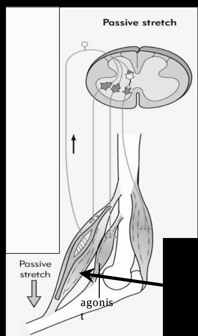


Modified from www.dushkin.com/connectext/psy/ch02/spinal.mhtml

- Myotatic or Stretch Reflex
- Golgi Tendon organ reflex
- Withdrawal Reflex (flexor)
- Cross extensor reflex
- Recurrent inhibition
- Multisegmental Reflexes: Moro, Tonic neck
- Abnormal reflexes: hyperreflexia → clasp-knife, clonus; hyporeflexia

[redacted] Reflex

[redacted]



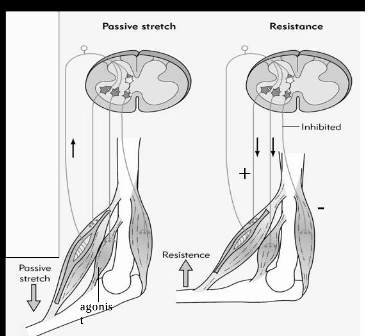
[redacted] of the spindle

[redacted] n of skeletal muscle
[redacted] ponse to stretching

Antagonist muscle

From Hopkins, Voluntary Motor Systems -skeletal muscle, reflexes and control of movement

[redacted]



Reciprocal Innervation: activation of MN to homonymous muscle, with concomitant inhibition of the *antagonistic* muscle *via* interneurons (1a inhibitory neurons).

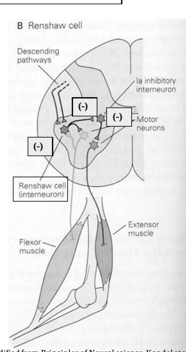
Antagonist muscle

From Hopkins, Voluntary Motor Systems -skeletal muscle, reflexes and control of movement

Recurrent Inhibition

- *Renshaw cells (RC)* are small MNs in the ventral horn
- Ach release by axon colaterals of α-MNs excites RC
- RC axons release glycine (inhibitory)

[redacted]



Modified from Principles of Neural science, Kandel et al., 4th ed, 2000

Recurrent Inhibition Function

- Adjusts the sensitivity of α- motor neurons to descending or afferent outputs.

→ High excitability of RCs leads to reduced α MN output

- Causes rapid inhibition of α- motor neurons after excitation thus effecting brief muscle contractions

Hyperekplexia (startle disease)

In the clinic

Autosomal dominant, rare non-epileptic disorder

Exaggerated, persistent startle reaction to unexpected stimuli

Hyperexcitability due to impaired glycinergic inhibition (R [271] GlyR)

Generalised muscular rigidity, and nocturnal myoclonus. The tonic spasms may mimic generalized tonic seizures, leading to apnea and death.

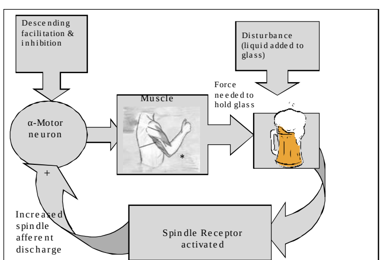
Characteristic almost permanent muscular activity with periods of electrical quietness.

Clonazepam, (GABA receptor agonist), is the treatment of choice.

Myotatic or Stretch Reflex

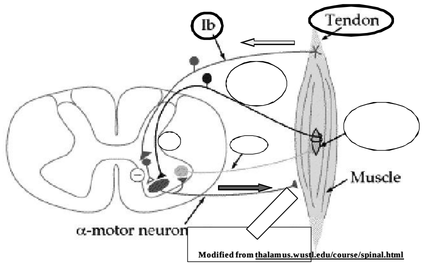
ü Compensates for load and fatigue, keeps muscle shortening

ü Reflex excitability depends on both α and γ MNs



*Modified from www.lieberson.com/.../neuro_exam.htm

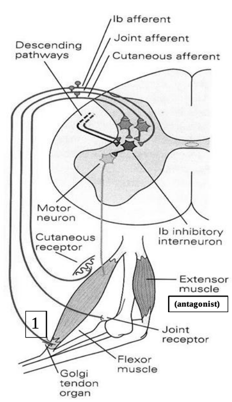
Golgi Tendon Organ Reflex (Type Ib afferent reflex)



Excite spinal interneurons, which inhibit the MNs innervating homonymous muscle → increased tendon organ activity inhibits muscle contraction

Tendon (GTO) reflex

1. Homonymous muscle contraction increases tension in tendon and Golgi tendon organ
2. 1b afferent excites both excitatory and inhibitory interneurons
3. Inhibition of homonymous MNs relaxes muscle. Reduced tension = ↓ GTO stimulation
4. α MNs from antagonist muscle are excited, antagonist muscle contracts

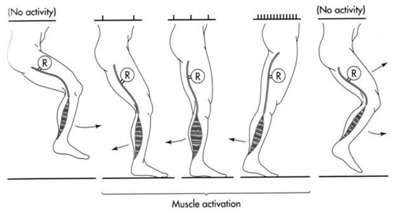


Modified from Principles of Neural science, Kandel et al., 4th ed, 2000

Myotatic vs. Tendon organ Reflex

- Myotatic or stretch reflex is a response in LENGTH changes
  Causes reflex excitation and contraction
- Tendon organ reflex responds to increased muscle TENSION
  Causes reflex inhibition of contraction
- Their reflex activities have antagonistic effects on the motor neuron

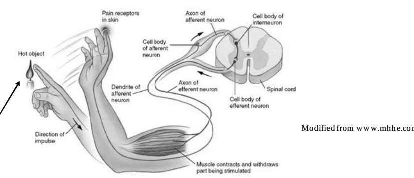
ü May play a role in the precise termination of particular phases of the step cycle by inhibiting homonymous MNs involved in the step cycle phase and initiating the next phase, specially when the activated muscle is stretched



From Castro et al textbook

ü May play a role in the CNS control of constant tension, detect muscle stiffness

Withdrawal Reflex (flexor)

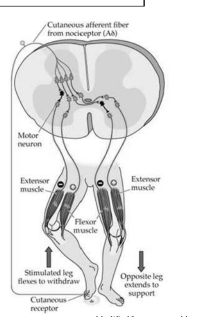


Modified from www.mhhe.com

- Withdrawal of an extremity from the source of afferent stimulus
- Mediated by flexor reflex afferent fibers (medium-small fibers) and small unmyelinated fibers from skin & muscle, sensory (including nociceptors)
- Excite α- MN of flexor muscles via one or more interneurons

Crossed extensor reflex

- Contralateral activation or inhibition of the muscle groups opposite those innervated in the ispilateral side of the spinal cord: Muscle groups excited on one side are inhibited on the opposite side
- Allows for body weight support on the opposite leg of an ipsilateral withdrawal reflex



Modified from www.mhhe.com

- Supports alternating leg muscle activation on the opposite side of the body during walking/running

Multisegmental Reflexes

- Involve reflexes from one segment level to another
- Postural responses, help coordinate muscle groups at different spinal cord levels
- Mediated by interneurons in the *fasiculus proprius*
- Some examples : Moro reflex, tonic neck reflex are normal in infants (< 6 mo)

Moro or Infantile Reflex

Modified from picasaweb.google.com

∨ Stimulated by a sudden movement of the head backwards (but it may also be activated through a sudden change of light or a loud noise).

∨ The response consists of an immediate wide abduction of the arms, and a rapid intake of breath. This is followed by flexion of the legs

∨ It initiates with the neck, it's coordinated by the *fasciculus proprius*

Modified from www.flickr.com

- Normal in infants
- Two-sided absence of the Moro reflex suggests damage to the central nervous system (brain or spinal cord).
- One-sided absence of the Moro reflex suggests the possibility of a fractured clavicle or injury to the brachial plexus (birth trauma). Conditions associated with brachial plexus injury include Erb's palsy or Erb-Duchenne paralysis.

Tonic Neck Reflex

Modified from www.winfssi.com

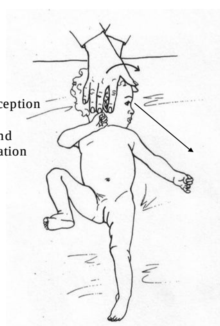
Rotation of the head to one side when the infant is laying on the back, elicits extension of the ipsilateral arm and flexion of the contralateral arm.

The infant tends to assume a "fencing" position-with his face toward the extended arm, while the other arm flexes at the elbow. The lower limbs respond in a similar manner

---

Sight
Proprioception

Eye-Hand coordination



From Technique of the neurologic examination. DeMyer

2-4 mo normal infants spend much time in the TNR position, but they can readily escape from it

Learn to fixate on and reach for objects

Learn to convert primitive grasp reflex into volitional grasping of objects

Disappear as cerebral pathways establish dominance

Persistence predicts poor motor development

Role of reflex testing in clinical evaluation

"Reflexes seem normal. You kept him waiting over two hours."

LMN injury => decreases the strength of the reflex
UMN injury=> increases the strength of the reflex

Myotatic Reflex Excitability

- Tested in the neurological exam by passively moving the extremity, or stretching the muscle by tapping the body of the muscle or its tendon
- Changes in the size of the reflex response suggest a change in the reflex excitability
- Reflex excitability depends upon the excitability of both the alpha and gamma motor neurons

Modified from DeJong's The Neurologic Examination

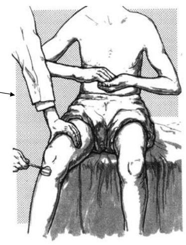
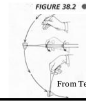


FIGURE 38.2 ● Method of reinforcing the patellar reflex.



From Technique of the neurologic examination. DeMye

Role of reflex testing in clinical evaluation

- Tendon reflexes provide an objective sign indicating an abnormality and some indication to the level of the abnormality
- The responsiveness of reflexes can be altered by trauma or disease
- Interruption of reflex arc by either peripheral sensory or lower motor neuron lesions à loss / reduction in reflex
  Muscle disease à reduced reflex (myasthenia gravis)
- UMN lessions. Lesions of inhibitory descending motor pathways, often result in increased excitability (hyperreflexia) of the myotatic reflex (clinical spasticity)

Pathophysiology of spinal Reflexes

- Hyperreflexia
  - Clonus Reflex
  - Spasticity: Clasp-knife reflex
- Hyporeflexia

Hyperreflexia: increased myotatic reflex or abnormally high reflex excitability

- Exaggerated stretch reflexes
- Sign of UMN lesion
- CNS Structural: malformation, palsy, vascular, traumatic, neoplasic, infectious, degenerative.
- Toxic / metabolic disorder; hypocalcemia, tetanus, strychnine.
- Spinal cord injury, cerebral palsy, MS, stroke, ALS.

Clonus reflex

3-7 Hz oscillatory motor response to muscle stretch

- Clonus occurs when there is a lack of normal cortical inhibition of a deep tendon reflex, resulting in rapid, strong, oscillating muscular contractions.
  - Occurs when sustained tension is placed on one of the muscles controlling a joint, such as the wrist or ankle.
  - Hyperactive myotatic reflex

To test for clonus, hold the relaxed lower leg in your hand, and sharply dorsiflex the foot and hold it dorsiflexed. Feel for oscillations between flexion and extension of the foot indicating clonus. Nothing is felt in healthy individuals.

Modified from dinfo.med.nyu.edu / ... / reflexes.html

Clonus reflex

Clasp-knife reflex

Gradual muscle stretch leads to reflex resistance followed by disappearance of the resistance and muscle extension at a critical length of the muscle.

Castro et al. textbook

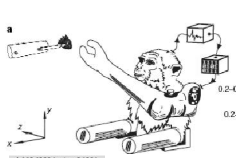
Brief excitation followed by a powerful, long-lasting inhibition in homonymous and synergistic muscles

---

- Caused by loss of inhibition of interneurons relaying groups II, III and IV afferent signals
- Also known as the inverse myotatic reflex
- Force-limiting reflex that protects the limb from bearing damaging loads

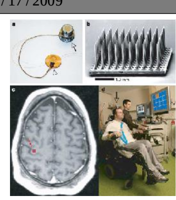
In the Clinic

Cortical control of a prosthetic arm for self-feeding



http://www.nature.com/nature/journal/v453/n7198/extref/nature06996-s3.mpg

Brain-Computer Interface, Developed at Brown, Begins New Clinical Trial
6/17/2009



Nature04970, Vol442, 2006 doi 10.1038

Hyporeflexia

- Abnormal decrease in myotatic reflex
- Lesion of sensory input from muscle spindles; α motor neuron lesion or lesion to the anterior horn of the spinal cord
- Peripheral neuropathy, Guillain-Barre, muscular dystrophy, and myasthenia gravis.