Peripheral Nervous System

Nervous system consists of

CNS = **brain** and **spinal cord**

~90% of all neurons in body are in CNS

PNS = **cranial** & **spinal nerves**, **ganglia** & **nerve plexuses**

~10% of all neurons in body are in PNS

PNS is our link to the outside world

without it CNS us useless

sensory deprivation → hallucinations

some terminology:

	CNS	PNS
bundles of axons	tract	nerve
cell bodies, dendrites, synapses	nuclei	ganglia

Nerves

each nerve is an organ composed mainly of nervous tissue (neurons and neuroglia) and fibrous connective tissue with rich supply of blood vessels

arranged in pattern similar to that of muscle organs:

endoneurium →around each individual neuron

perineurium →around bundles of neurons (=fascicles)

epineurium →around entire nerve

2 kinds of neurons can be found in nerves:

sensory (afferent) neurons
6-8x's more sensory than motor fibers

motor (efferent) neurons

Nerves can be classified according to the kinds of neurons they contain:

a. **sensory nerves** – contain mainly sensory neurons

b. **motor nerves** – contain mainly motor neurons

c. **mixed nerves** – contain a combination of both

Ganglia

= groups of cell bodies and sometimes dendrites and synapses associated with nerves of PNS

examples of PNS ganglia:

dorsal root ganglia = cell bodies of **sensory** neurons

autonomic chain ganglia = cell bodies, dendrites & synapses of autonomic **motor** neurons

Nerve Plexuses

weblike interconnected fibers from many different nerves

eg. spinal nerve plexuses

→ fibers from several spinal nerves come together

eg. autonomic plexuses

Cranial Nerves

PNS consists of 43 pairs of nerves branching from the CNS including **12 pairs of cranial nerves**

most cranial nerves arise from the brain stem

functional classification of cranial nerves:

a. **sensory** cranial nerves

(no more than a few motor fibers)

I. **Olfactory** [sense of smell]
II. **Optic** [sense of sight]
VIII. **Vestibulocochlear** [senses of hearing and balance]
has a few motor fibers
-injury causes deafness

b. **motor** cranial nerves

(no more than a few sensory fibers)

III. **Oculomotor**
IV. **Trochlear**
VI. **Abducens**
} [eye movements]

-injury to VI causes eye to turn inward

c. **mixed** cranial nerves

–contain a large number of both sensory and motor neurons

IX. **Glossopharyngeal** [sense of taste, swallowing]
XII. **Hypoglossal** [tongue]
V. **Trigeminal** [cutaneous senses of head and face, chewing muscles]
VII. **Facial** [sense of taste, facial expression]
X. **Vagus** [sensory and motor to larynx, heart, lungs, digestive system]
XI. **Accessory** [shoulder and head]

severe head injury often damages one or more cranial nerves

Spinal Nerves

31 pairs

all are mixed nerves

they are named and numbered according to the level of the vertebral column from which they arise:
8 cervical
12 thoracic
5 lumbar
5 sacral
1 coccygeal

each spinal nerve is attached to spinal cord by two **roots**:

dorsal (posterior) **root** → sensory neurons and a **ganglion**

ventral (anterior) **root** → motor neurons

the two roots joint to form a mixed, spinal nerve

Dermatomes

sensory neurons of each spinal nerve innervate the skin and skeletal muscles in the roughly same order in which they emerge from the spinal cord

→ **segmental arrangement** of spinal nerves

this is clinically useful since physicians can determine the site of spinal damage by simple pin prick exam

Spinal Nerve Plexuses

after the spinal nerves exit the intervertebral foramina they branch and interconnect to form **nerve plexuses**

from these plexuses new nerves emerge that contain a mixture of fibers from various spinal nerves

Cervical Plexus
formed from C1 – C4,5

supplies sensory and motor neurons to head, neck and upper shoulders

emerging nerves include:

phrenic nerve (C3-C5) → diaphragm

Brachial Plexus
formed from fibers in C5 to C8, & T1

innervates shoulders and upper limbs

emerging nerves include:

axillary (C5,C6)	→	to deltoid
radial (C5-C8,T1)	→	triceps and forearm extensors
median (C5-C8,T1)	→	flexor muscles of forearm and hand
ulnar (C8,T1)	→	wrist and hand muscles

this plexus is sometimes stretched or torn at birth leading to paralysis and numbness of baby's arm if untreated may produce "withered arm"

prolonged use of crutch may injure this plexus = **crutch palsy**

[most thoracic spinal nerves (2-12) do not form a plexus]

Lumbar Plexus
formed from fibers in L1 to L4

innervates abdominal wall, genitals, parts of leg

emerging nerves include:

femoral nerve (L2-L4) → thigh and leg muscles

Sacral Plexus
formed from fibers in L4 & 5, S1 to S4

supplies nerves to buttocks, perineum, leg

emerging nerves include:

sciatic nerve (L4,L5, S1-S3) → leg muscles; largest nerve in body

Autonomic Nervous System

2 major subdivisions of the **motor neurons** of the PNS

somatic - innervate skeletal (voluntary) muscles

autonomic – innervate smooth and cardiac (involuntary) muscles and glands

autonomic = "self governed"

Differences Between Somatic and Autonomic Motor Neurons

Somatic	**Autonomic**
voluntary effectors: striated muscles	**involuntary effectors: smooth & cardiac muscles, glands**
single motor neuron from spinal cord to target organ	**usually 2 neurons with synapse (ganglion) between from spinal cord to target organ** presynaptic vs postsynaptic
NT always stimulatory	**NT stimulatory or inhibitory**
ACh released at synapse	**ACh and NE released at synapses**
No firing at rest	**Baseline firing – speeds up when stimulated**

The Autonomic Nervous System is divided into 2 branches:

sympathetic
parasympathetic

Structure of the Sympathetic Branch

formed by neurons from **spinal nerves T1 to L2**

sympathetic neurons branch from spinal nerves as they exit intervertebral foramina and form interconnected ganglia (= **chain ganglia**) in ventral body cavity on each side of vertebral column

Structure of the Parasympathetic Branch

formed by neurons in cranial nerves:
III (oculomotor)
VII (facial)
IX (glossopharyngeal)
X (vagus)
and fibers in some sacral (S_2-S_4) spinal nerves

no chain ganglia, fibers not interconnected

ganglia are usually near organs they innervate

Function of the Sympathetic Branch

adapts body for intense physical activities:

increases alertness, blood pressure, air flow, blood sugar concentrations, blood flow to heart and skeletal muscles

acts as an **emergency system**
emergency or stress that threatens homeostasis

"fight or flight"

maximum energy expenditure

acts as a unit = **mass activation**

more diffuse, body-wide response involving hormones

→effects are longer lasting

Studies show that animals cannot live in nature without a functioning sympathetic NS but only if they are kept warm and under no stress and protected from normal stressors

Function of the Parasympathetic Branch

most active in non-stressful, non-emergency situations

"resting and digesting"

tends to have a calming effect on body:
reduced energy expenditure and

normal body maintenance

organs are individually activated
no mass activation

ACh is quickly produced and quickly destroyed
→ short lived, localized effects

promotes normal daily activities:
GI tract works to process food
> glandular secretions
> peristalsis

blood pressure, heart rate, respiratory rates maintained at low levels

Interactions between two branches of ANS

the body doesn't alternate between only sympathetic or parasympathetic activity

normally, both systems are active
both always exhibit at least a baseline level of "**autonomic tone**"

eg. parasympathetic always maintains smooth muscle tone in intestine and keeps heart rate down to 70 bpm (vs intrinsic 100 bpm)

eg. sympathetic always maintains smooth muscle tone around most blood vessels to maintain blood pressure

most visceral organs receive dual innervation of both

branches of ANS

In some organs with dual innervation the branches work antagonistically:

eg. heart

> sym stimulation → faster
> parasym stimulation → slower

eg. digestive tract

> sym stimulaton → inhibits
> parasym stimulation → promotes

eg. respiratory system

> sym stimulation → dilation (inhibition) of air passages
> parasym stimulation → constriction