Physiology A

Autonomic Nervous System

Autonomic Organisation

ANS is part of the **efferent nervous system** which is the division carrying impulses from CNS to muscles and glands

- Innervates cardiac and smooth muscle, glands, adipose tissue
  - Organs involved in four Fs

Enteric: autonomous neurons controlling gut motility and secretion

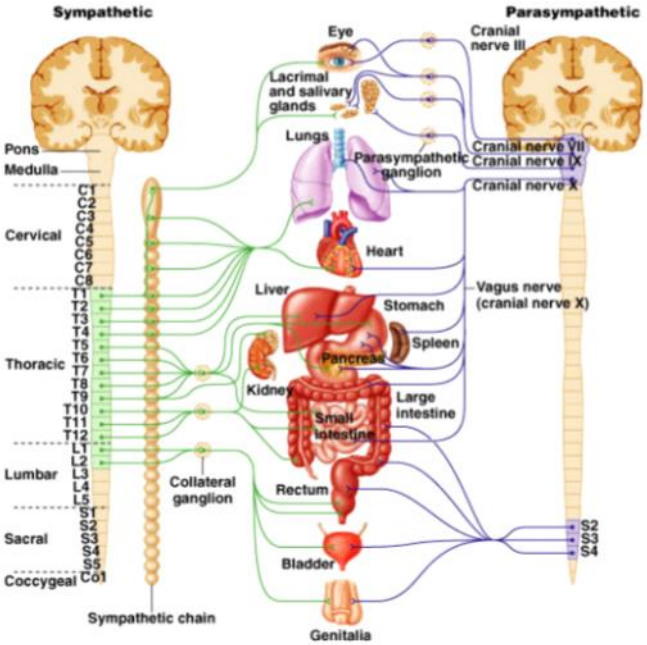
Parasympathetic: at rest - produces responses that maintain body under normal conditions

Sympathetic: fight or flight - produces responses that prepare body for strenuous physical activity or in situations involving fear, anger, stress, danger, competition which provoke fight/flight responses

- Brake vs accelerator; working in opposition. Dual innervation.
- Also carry sensory information: pain (sympathetic) and visceral senses such as distention / blood chemistry (parasympathetic)
- Afferent neurons = ascending = sensory neurons
- Efferent neurons = descending = motor neurons

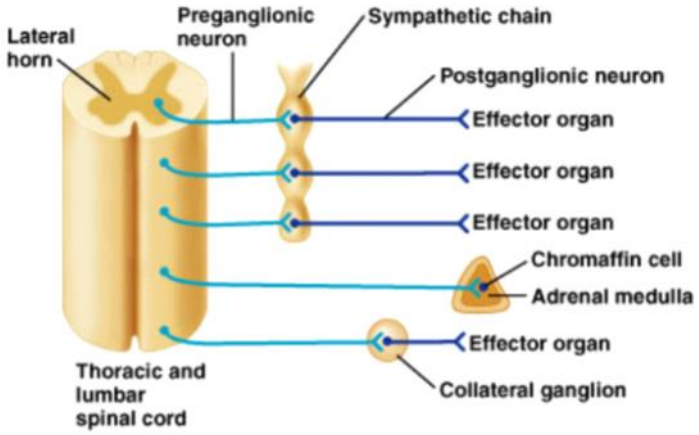
Basic plan of efferent ANS: CNS (preganglionic) -> PNS (postganglionic) -> target cell

- Series of pathways of two types of neurons which communicate through synapses in peripheral ganglia
- Single preganglionic neuron synapses with several postganglionic neurons
  - To spread response across many neurons / large area of body



Anatomy of sympathetic system

1. Sympathetic chains with pre and postganglionic neurons
   - Whole body control
   - Short preganglionic synapse with long postganglionic
2. Chromaffin cell acts as modified sympathetic postganglionic cell, adrenal medulla releases adrenaline, noradrenaline
   - General effects
   - Long preganglionic innervate adrenal gland
3. Collateral ganglia to effector organ
   - Specific effects



The parasympathetic system works on a collateral ganglion model

- Preganglionic neurons from brain stem or sacral spinal cord

Levels of reflex control

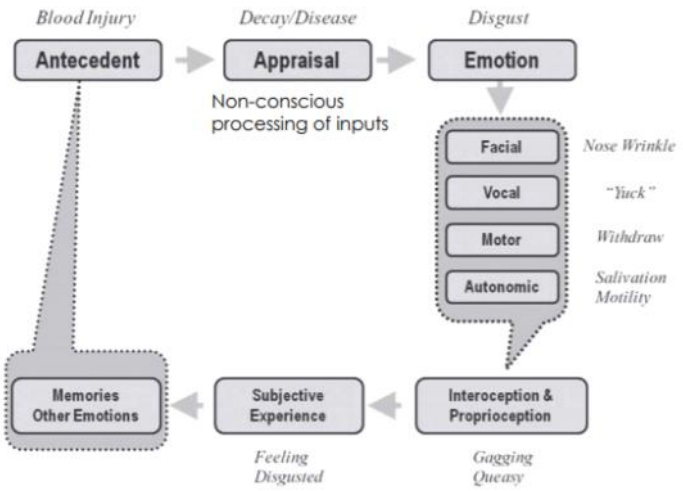
Sensory input leads to autonomic effects at local and higher / more integrated levels.

1. Enteric NS or effector such as heart, blood vessels, eye
2. Ganglion: integration of sensory, preganglionic and interneurons
3. Spinal cord: integration across spinal levels
4. Brain stem: integration across organs, contains medulla which regulates respiratory, vasomotor (blood vessel) and CV functions
5. Higher CNS centres such as hypothalamus: integration with motivation and desires

Sensory Input

- Brain regions involved in ANS integrate sensory inputs
  - Usually these regions influence parasympathetic and sympathetic in tandem
- Sources of sensory input: autonomic / visceral afferents integrated to produce coordinated output
  - Reflex loops depend upon this sensory input
  - Mainly located in innervated tissue and travel in same nerve as efferent impulses
  - Higher centres integrate inputs from a broader region
  - Somatic inputs are integrated to provide fast or predictive response

Reflexes and emotions

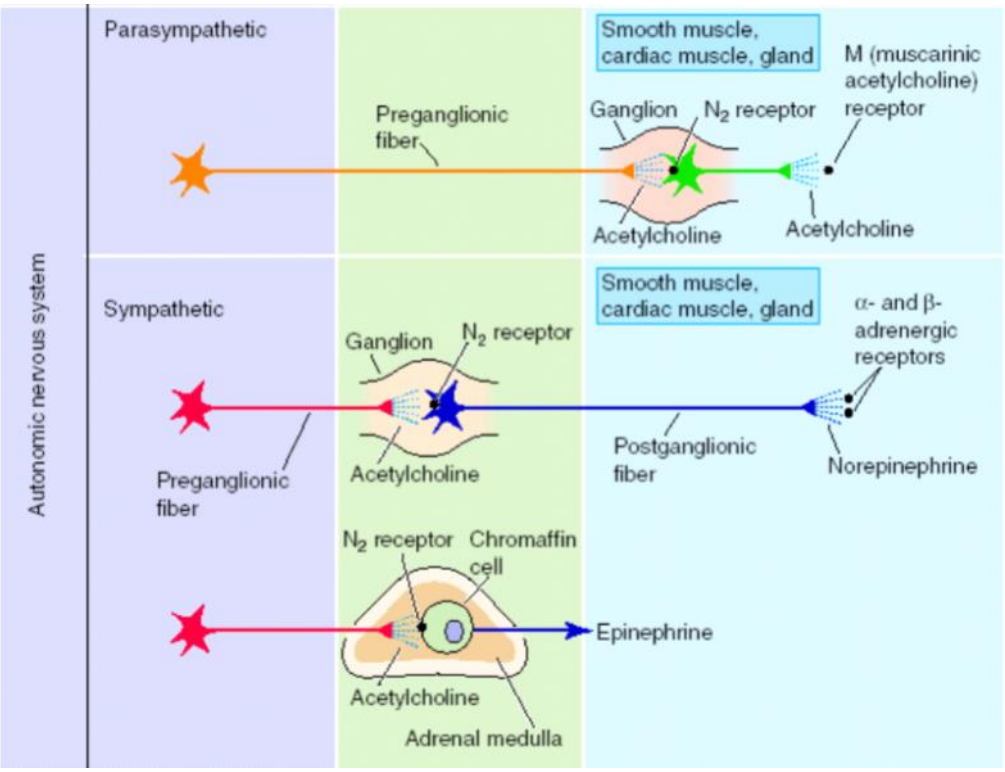


The ANS is intimately involved with our emotions: in their physical expression, and perhaps in their generation.
This also provides a path for conscious influence over the ANS.

Synapses

Autonomic synapses resemble neuromuscular junctions: each neuron has many synapses and has axons on target tissues where NTs are released. These axons produce strong effects due to lots of release sites

- Wider synaptic cleft than NMJ
- More spill over effect of NT as the space the neurotransmitter has to diffuse is greater



- Preganglionic and post parasympathetic use ACh
  - **Cholinergic** neurons release acetylcholine
    - Nicotinic receptors and muscarinic receptors
- Postganglionic sympathetic release noradrenaline or chromaffin cell releases adrenaline
  - **Adrenergic** neurons release noradrenaline - adrenergic receptors bind both adrenaline and noradrenaline
- ANS uses ionotropic receptors in ganglia, metabotropic at target organ

Receptor type	Signal mechanism	Target cell	Effect
ACh: nicotonic	Opens Na / K channels	Postganglionic cell body, chromaffin cells (stimulates adrenaline release), skeletal muscle cells (stimulates EPP)	excitatory
ACh: muscarinic	G-protein coupled to open/close ion channels	Parasympathetic effectors	Excitatory or inhibitory
Noradrenaline > adrenaline: α1	Activates IP_3	Vascular smooth muscle, pupils	Excitatory
Noradrenaline > adrenaline: α2	Inhibits cAMP	CNS, platelets, adrenergic nerve terminals, some smooth muscle, adipose tissue	Excitatory
Noradrenaline / adrenaline: β1	Activates cAMP	CNS, cardiac muscle, kidney	Excitatory
Adrenaline > noradrenaline: β2	Activates cAMP	Some blood vessels, respiratory tract, uterus	Inhibitory
Noradrenaline / adrenaline: β3	Activates cAMP	Adipose tissues	Excitatory

- Multiple NTs are released at synapses which produces different effects and may be selectable based on rate of axon activity
- Noradrenaline affects only SNS; ACh affects SNS and PSNS

Effects of Autonomic Organ Control

[only need to know three]

	Parasympathetic (only uses ACh ionotropic)	**Sympathetic**	
Organ system	Effect	Effect	Adrenergic receptor class
Heart			

SA node AV node Force of contraction	Decreases HR Decreases conduction velocity Decreases	Increases HR Increases… Increases	β1 β1 β1
Blood vessels Arterioles of body Arterioles of skeletal muscle Arterioles to brain Veins	Nil	Constrict Constrict or dilate (adrenaline) None Constrict or dilate (adrenaline)	α1 α1 / β2 α1 / β2
Lungs Bronchial muscle Bronchial glands	Contraction Secretion	Relaxation Inhibited secretion	β2 α
Digestive tract Motility Secretions Sphincters	Increased Stimulated Relaxation	Decreased Inhibited Contraction	α1, α2, β2 α2 α1
Bladder Bladder wall Sphincter	Contract Relax	Relax Contract	β2 α1
Male reproductive tract Blood vessels (erection) Vas deferens and seminal vesicles (ejaculation)	Dilation Nil	Nil Ejaculation	- α1
Female reproductive tract Uterus Uterus (pregnant)	Unknown Unknown	Relaxation Contraction	β2 α1
Skin Sweat glands Piloerector muscles	Secretion Nil	Secretion Contraction (hairs up)	α1 α1
Eye Iris muscles (controls pupil size) Ciliary muscles	Circular muscle contracts - pupils constrict Contraction - near vision	Radial muscle contracts - pupil dilates Relaxation - far vision	α1 β2