Veterinary Bioscience: Cells to Systems

VETS30029 / VETS90121

THE UNIVERSITY OF MELBOURNE

Introduction to the peripheral nervous system – autonomic and somatic nervous systems

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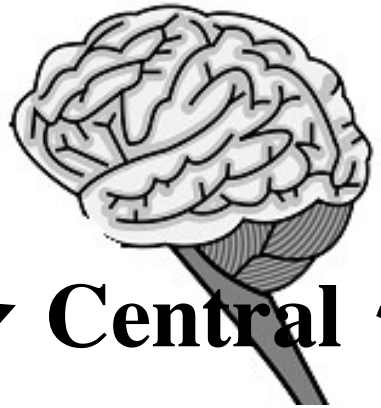
At the end of this lecture, you should be able to:

- **Describe the basic anatomy of the Peripheral NS (efferent), the Autonomic nervous System (ANS) and its Parasympathetic and Sympathetic divisions**

- Describe the major neurotransmitters and receptors involved in chemical transmission within the ANS and somatic NS

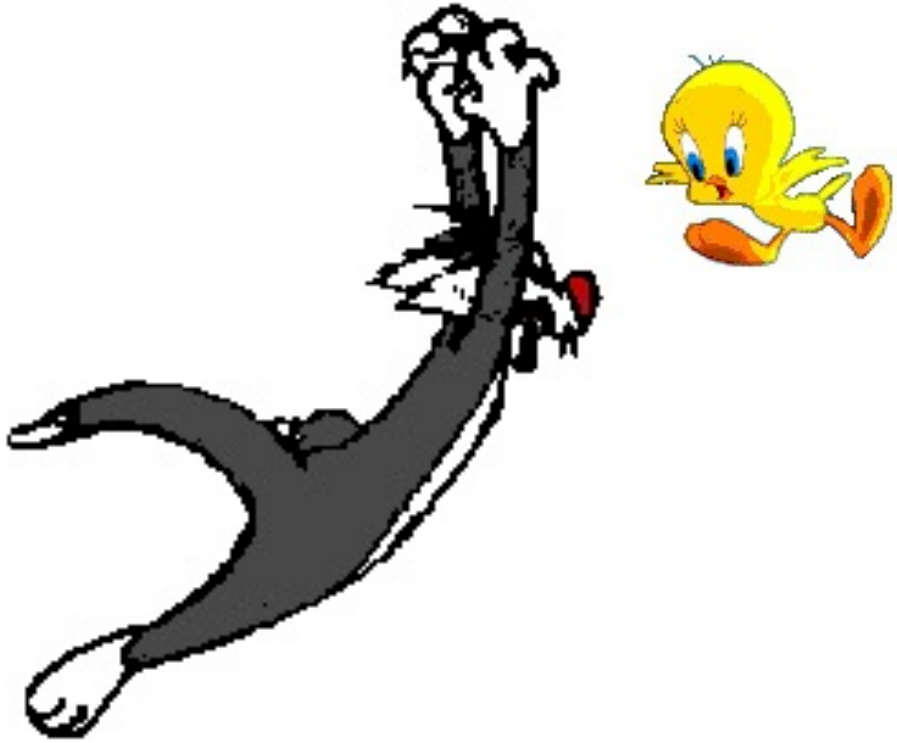
- List examples of agonists and antagonists that have selective activity at adrenoceptors

Nervous system organisation



Afferent → **Central** → *Efferent*

Sensory → **Peripheral**



Somatic/Motor

(Voluntary)

Autonomic

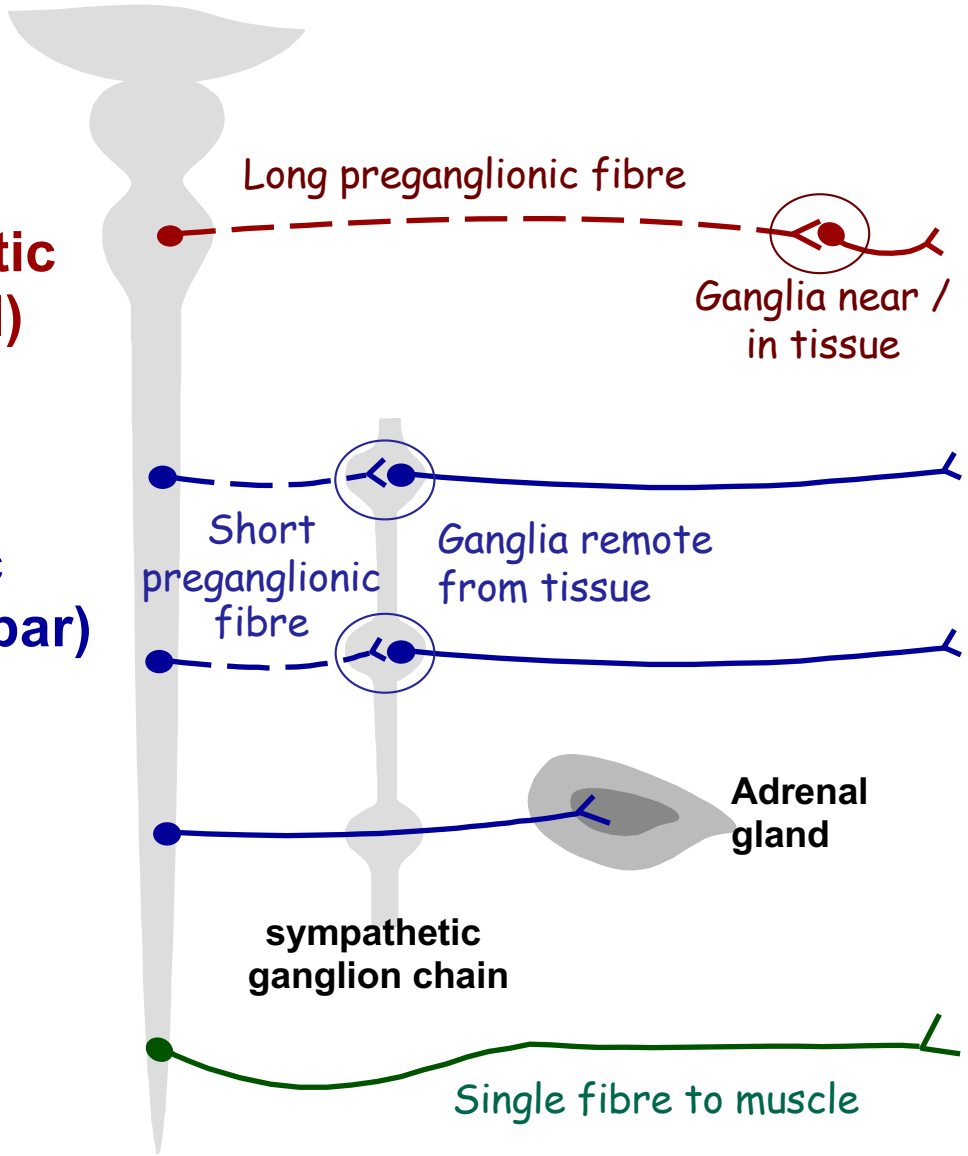
(sympathetic & parasympathetic)

(Involuntary)

Peripheral Nervous System - Anatomy

Autonomic

Parasympathetic (Cranio/Sacral)



heart, glands, eye, smooth muscle: gut, airway

Sympathetic (Thoracic/Lumbar)

sweat glands

heart, eye, smooth muscle: gut, vascular

Somatic

Motor

skeletal muscle

Peripheral Nervous System - Physiology

Somatic - skeletal muscle ⟶ posture & movement

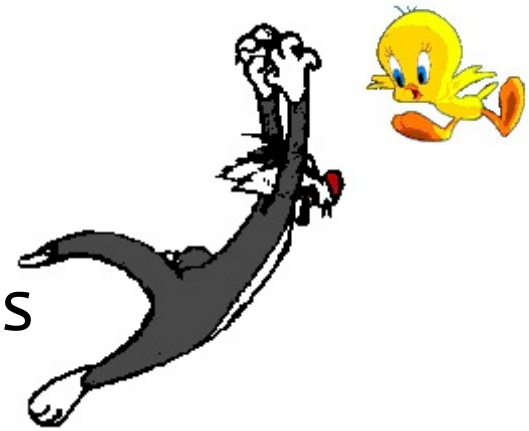
Autonomic - ALL other tissues ⟶ homeostasis
(housekeeping)

Parasympathetic

- anabolic, rest and repose

Sympathetic

- catabolic, fight or flight
  - neural & humoral elements



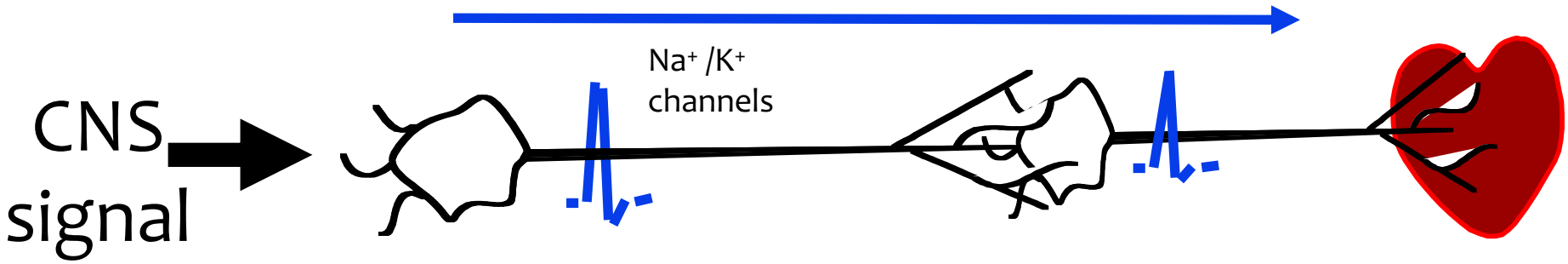
Nerves have specific actions at target tissues

Postganglionic Tissue Responses in the Autonomic Nervous System

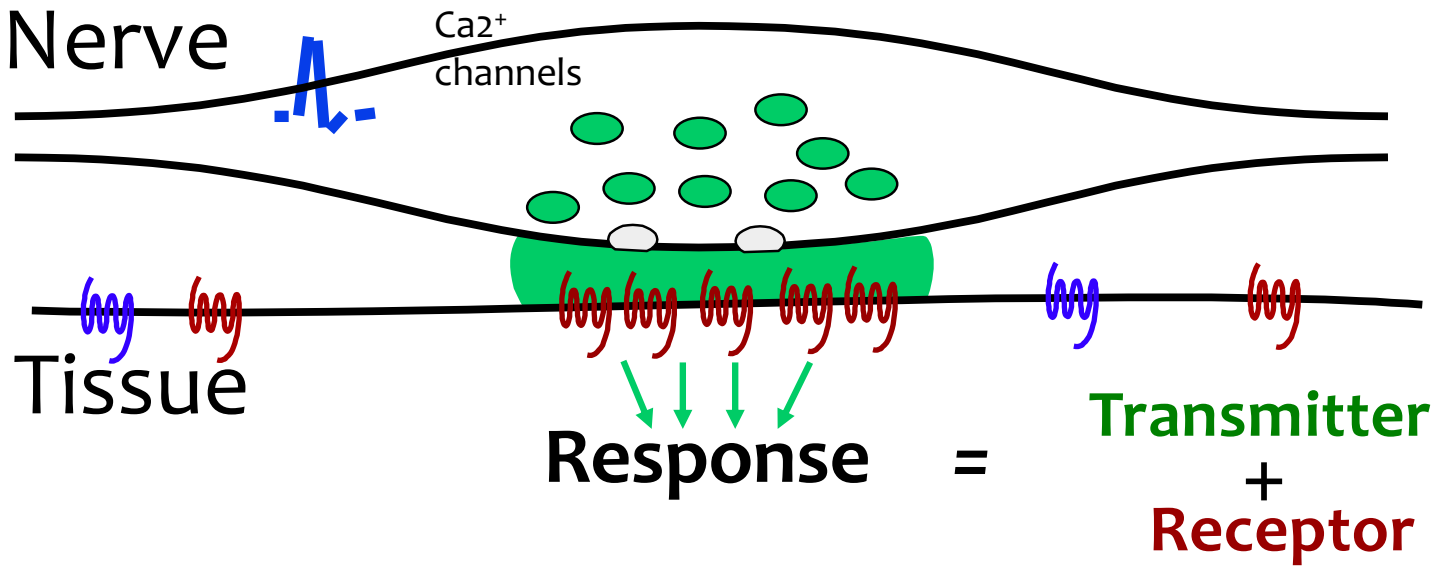
	Parasympathetic (catabolic actions)	Sympathetic (anabolic actions)
Heart	↓ rate	↑ rate
Arteries		constriction *dilation*
Bronchi	constriction	*dilation*
GIT	↑ activity	↓ activity
Pupil	constriction	dilation

Electrical and Chemical signalling in nerves

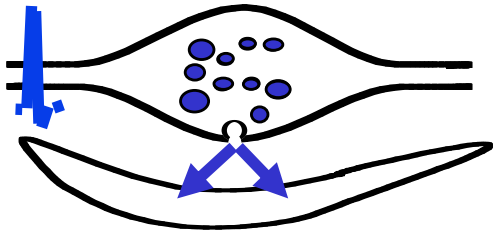
Action Potential - electrical along nerve



Neurotransmitter - chemical at nerve ending



Chemical transmission in peripheral nerves



Target cell

- Neurotransmitters must bind
  - receptors on target

Learn
- Muscarinic, nicotinic
- α- & β- adrenoceptors

Signalling cell (nerve)

- Neurotransmitters need to be:
  - present
    - Synthesised / stored
  - released
  - inactivated

Learn
- Acetylcholine
- Noradrenaline
- *Adrenaline*

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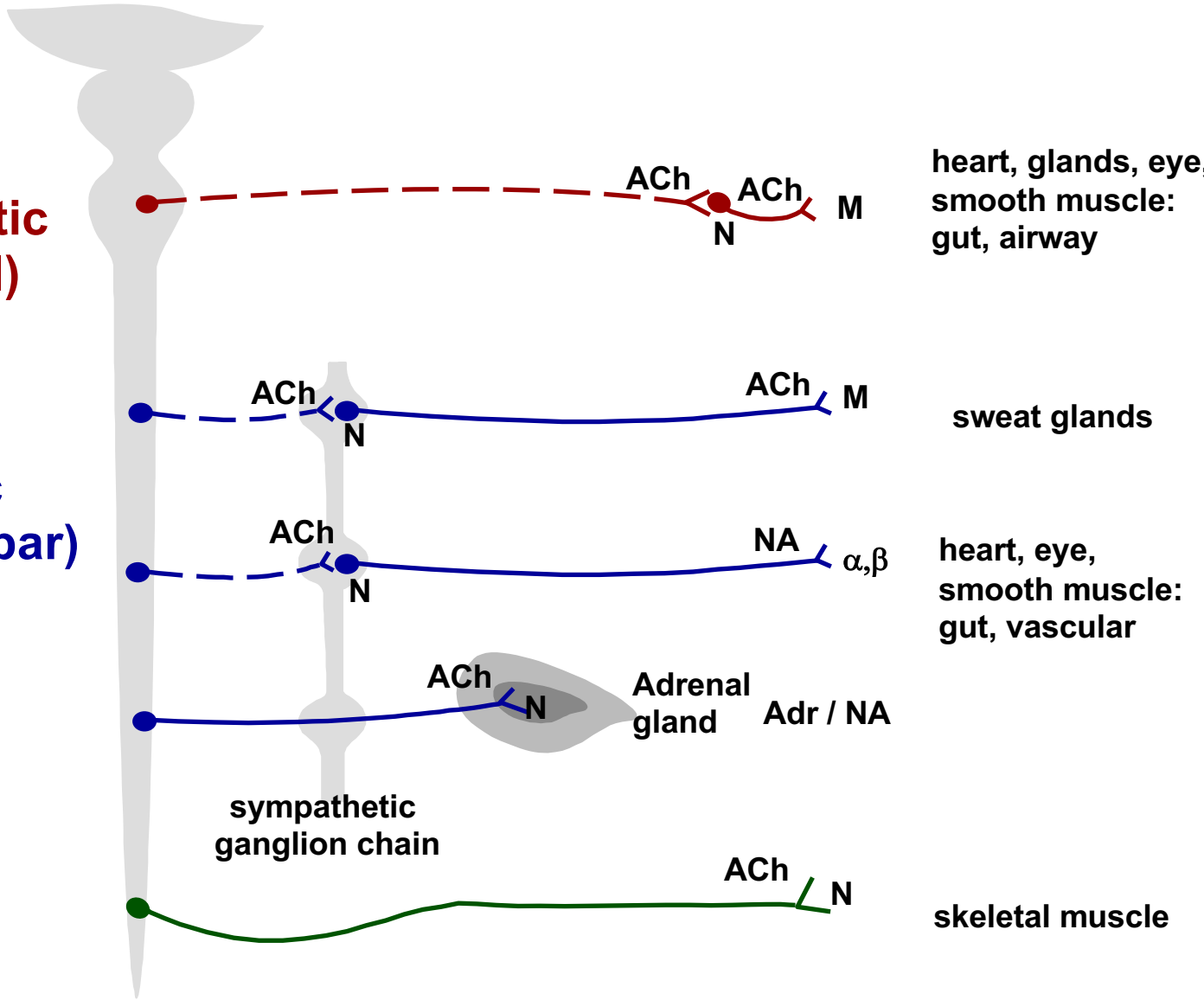
Peripheral Nervous System – Anatomy, Physiology & Pharmacology



Adapted from Golan et al (3rd Ed); Ch 8

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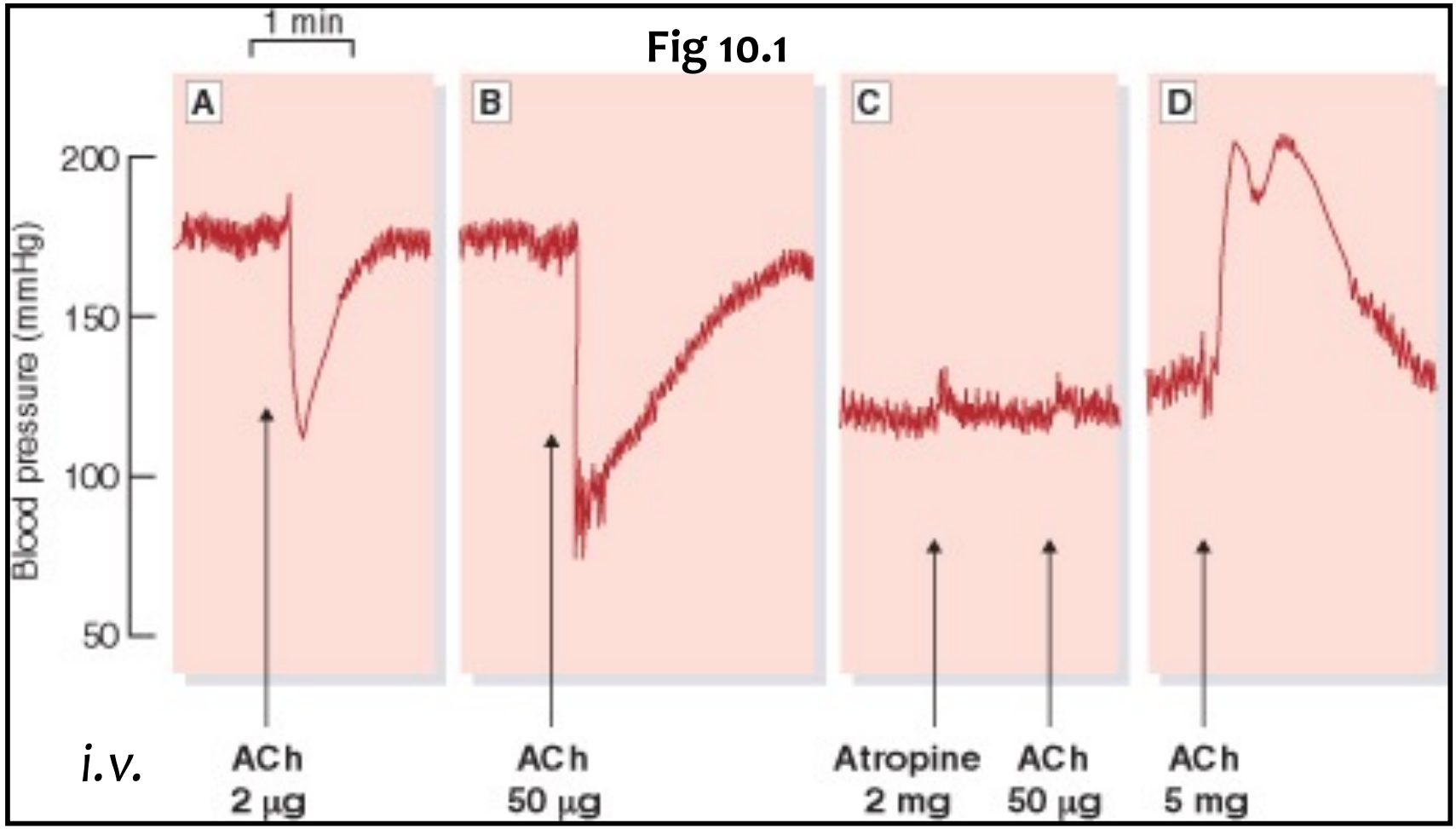
Heart	↓ rate	↑ rate
Arteries		constriction *dilation (Adr)*
Bronchi	constriction	*dilation (Adr)*
GIT	↑ activity	↓ activity
Pupil	constriction	dilation
Transmitter	acetylcholine	noradrenaline
Receptor	muscarinic	α or β

Effects of Ach On Cat Blood Pressure

A & B Dose-response

C & D Antagonist selectivity



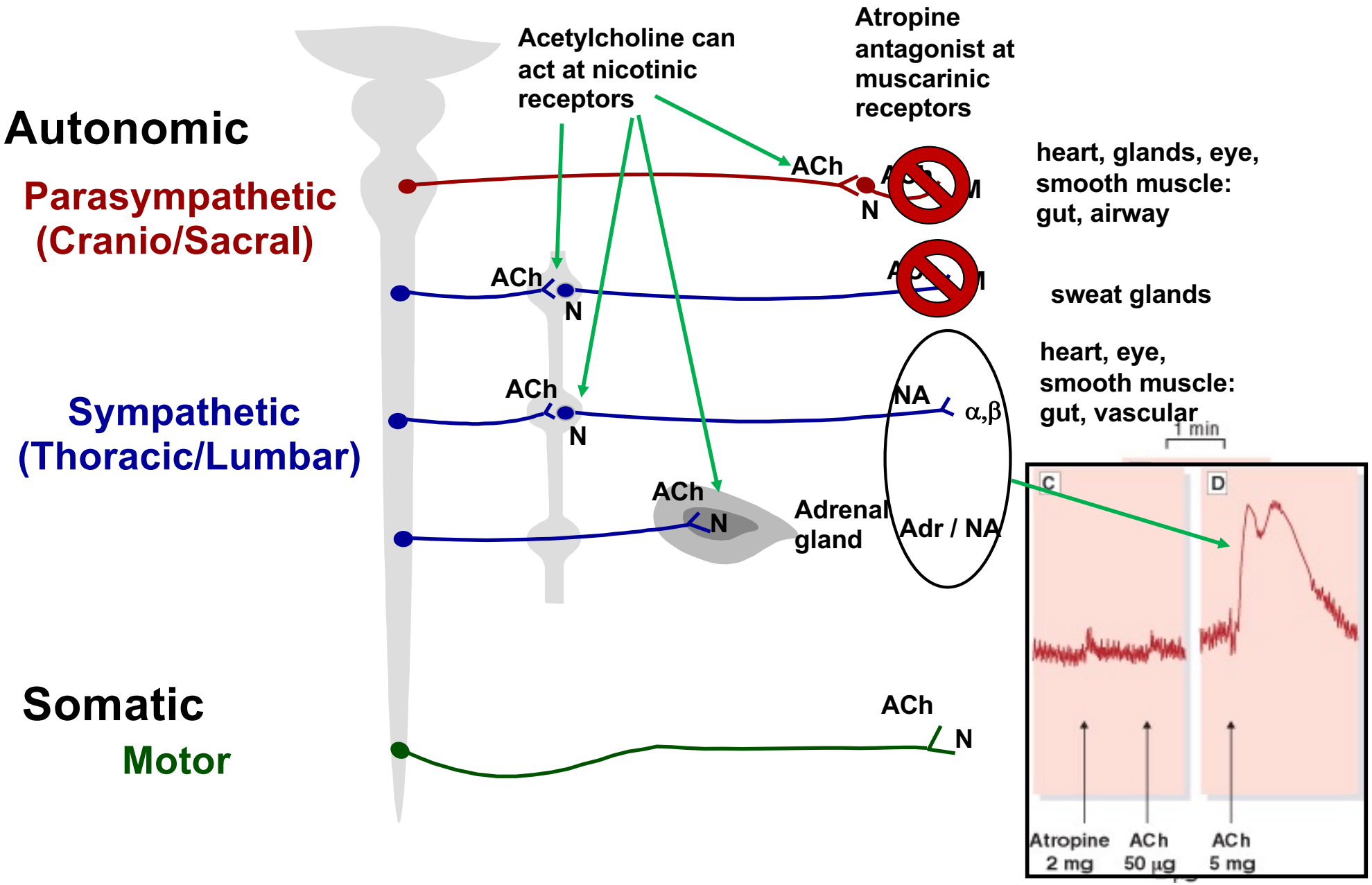
Rang et al; Pharmacology 6h Edition; Churchill Livingstone, 2007

Receptors: Tissue distribution and innervation

Muscarinic receptors on endothelial cells release NO

Drugs: Action & selectivity

Peripheral Nervous System
Anatomy, Physiology, Pharmacology



Cholinergic receptor localisation and action

Autonomic Nervous System

Muscarinic receptors

- Parasympathetic neuroeffector junction
  - Slow responses – G protein-coupled, second messengers
    Salivation, **L**acrimation, **U**rination, Daefaction
- Also endothelial cells
  - Not innervated, can release NO

Nicotinic receptors

- Autonomic ganglia (Sympathetic & parasympathetic)
  - Fast responses – Ligand-gated ion channel
    Action potential initiation

Skeletal neuromuscular junction

Nicotinic receptors

- Fast responses – Ligand-gated ion channel
  Skeletal muscle contraction

Adrenoceptor localisation & action

Golan et al (Ed); Ch 10, p132

α-adrenoceptors

Blood vessels	- constrict
Pupil (dilates)	- constrict radial muscle
GIT	- constrict sphincters

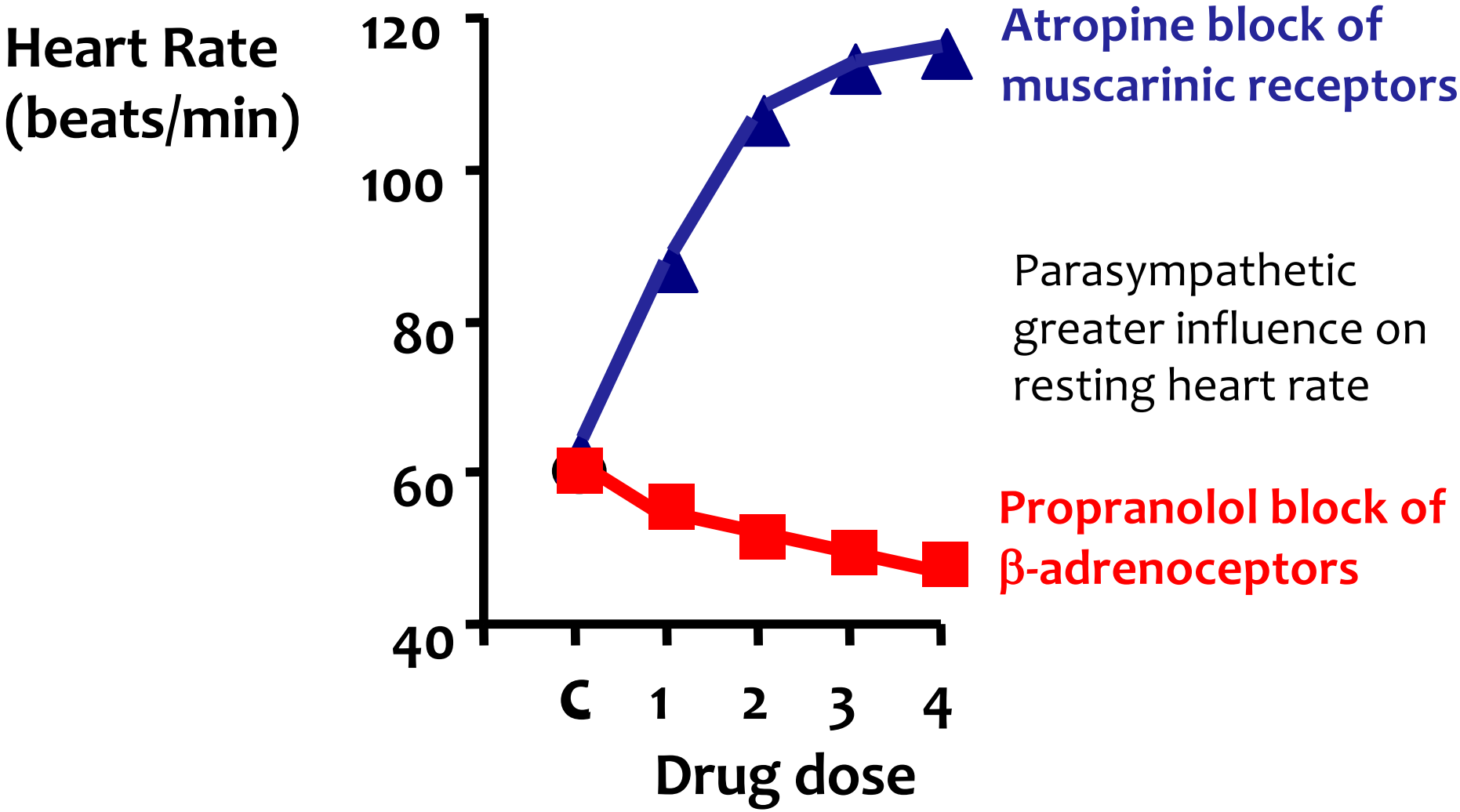
β-adrenoceptors

Heart	- increase rate & force
Kidney	- renin secretion
Skeletal BV's	- dilate } (circulating Adr)
Bronchi	- dilate } (circulating Adr)

Autonomic Nervous System: Summary

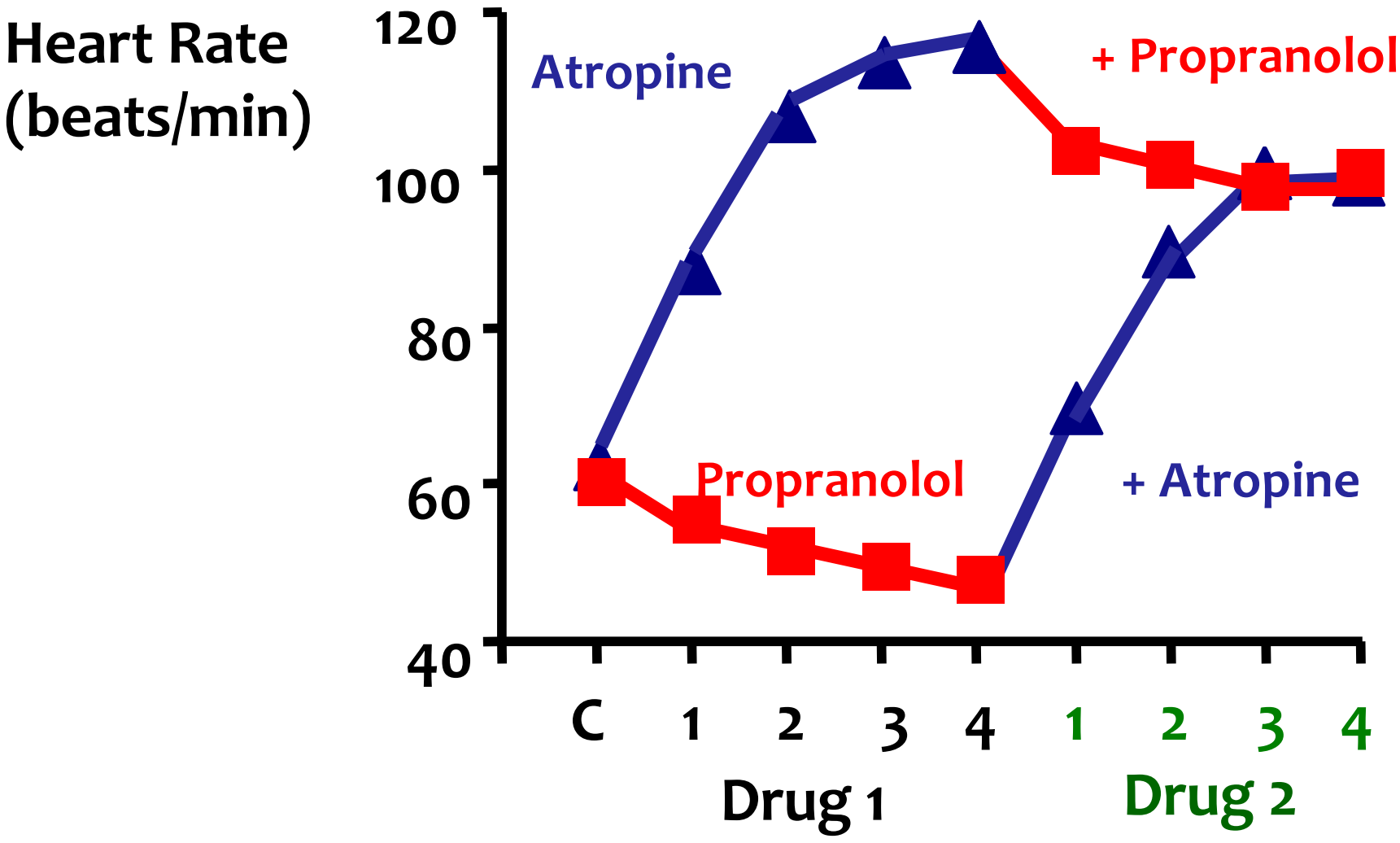
- Contrasting effects of sympathetic and parasympathetic nerves in tissues due to different transmitters
- Discrete responses for each division
  - Parasympathetic: acetylcholine, rest & repose responses
  - Sympathetic: noradrenaline, fight or flight responses
    - » *(also involving circulating Adr release)*
  - Receptors may be present in tissues that are not directly innervated
    - Muscarinic receptors on endothelium
    - β–adrenoceptors in airways
- In tissues receiving dual innervation
  - relative activity depends on needs of organ/tissue
- Nerves modulate activity
  - Pacemaker activity in heart, GIT motility

Autonomic control of heart rate at rest



Berne & Levy, Physiology 5th Ed. p323

Effect of combined autonomic blockade on resting heart rate



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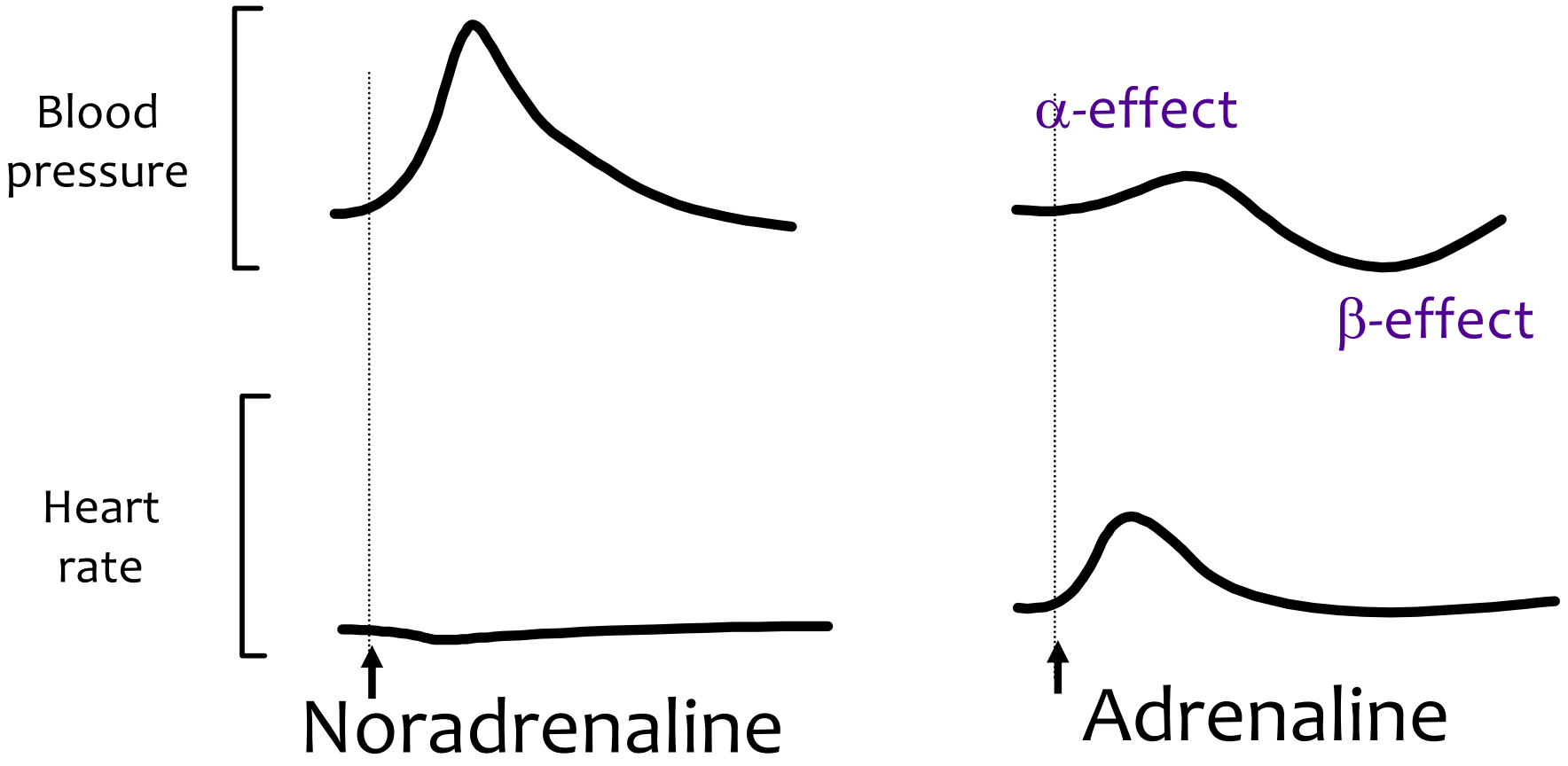
Cardiovascular adrenoceptor responses

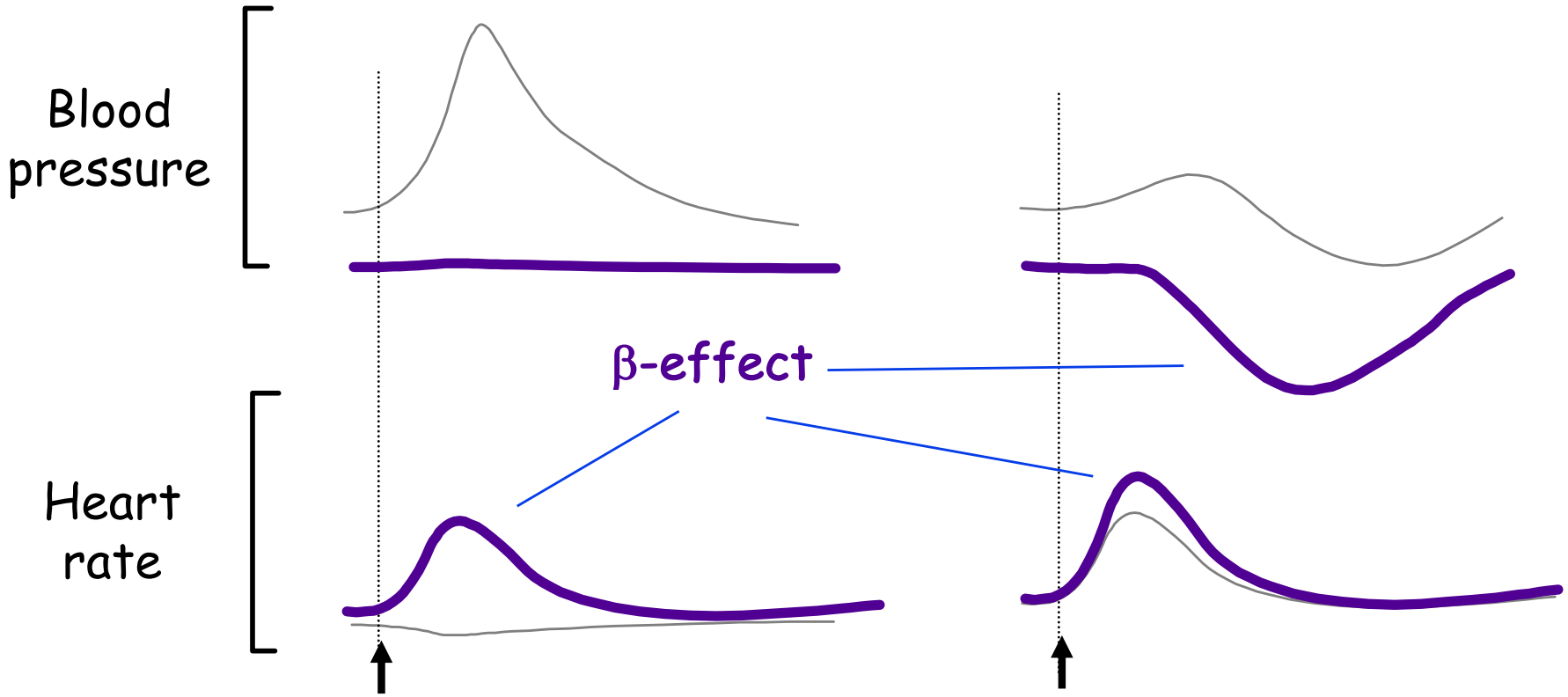
Comparison of i.v. noradrenaline & adrenaline



Noradrenaline blood pressure increase can trigger reflex slowing of heart
Direct β-effect can be offset by increased parasympathetic activity

Cardiovascular adrenoceptor responses

Selective inhibition of α-effect by phentolamine



Selective inhibition of β-effect by propranolol

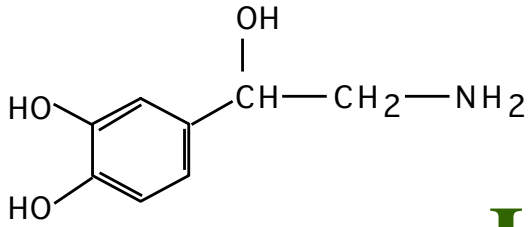
α- and β- adrenoceptors

- Subtle differences between Noradrenaline and Adrenaline
  - **Agonist receptor selectivity**
    - NA ≥ Adr at α-adrenoceptors
    - Adr ≥ NA at β-adrenoceptors

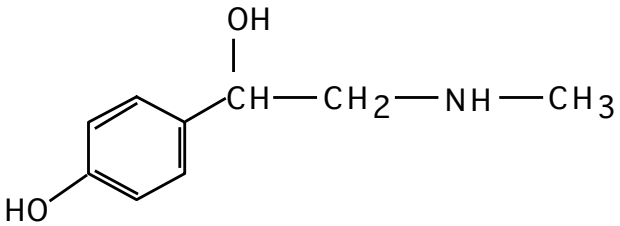
- Selective inhibition of
  - BP increase by phentolamine
  - BP decrease and HR increase by propranolol
    - **Antagonist receptor selectivity**
      - Phentolamine α- adrenoceptors
      - Propranolol β- adrenoceptors

Synthetic agonists with adrenoceptor selectivity

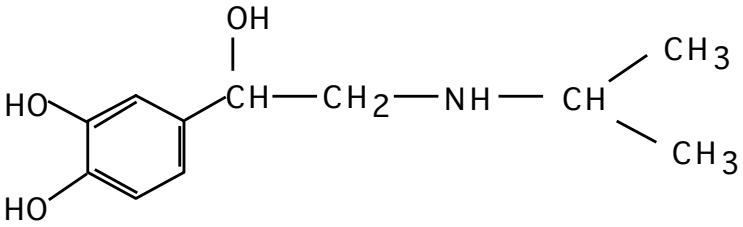
Noradrenaline

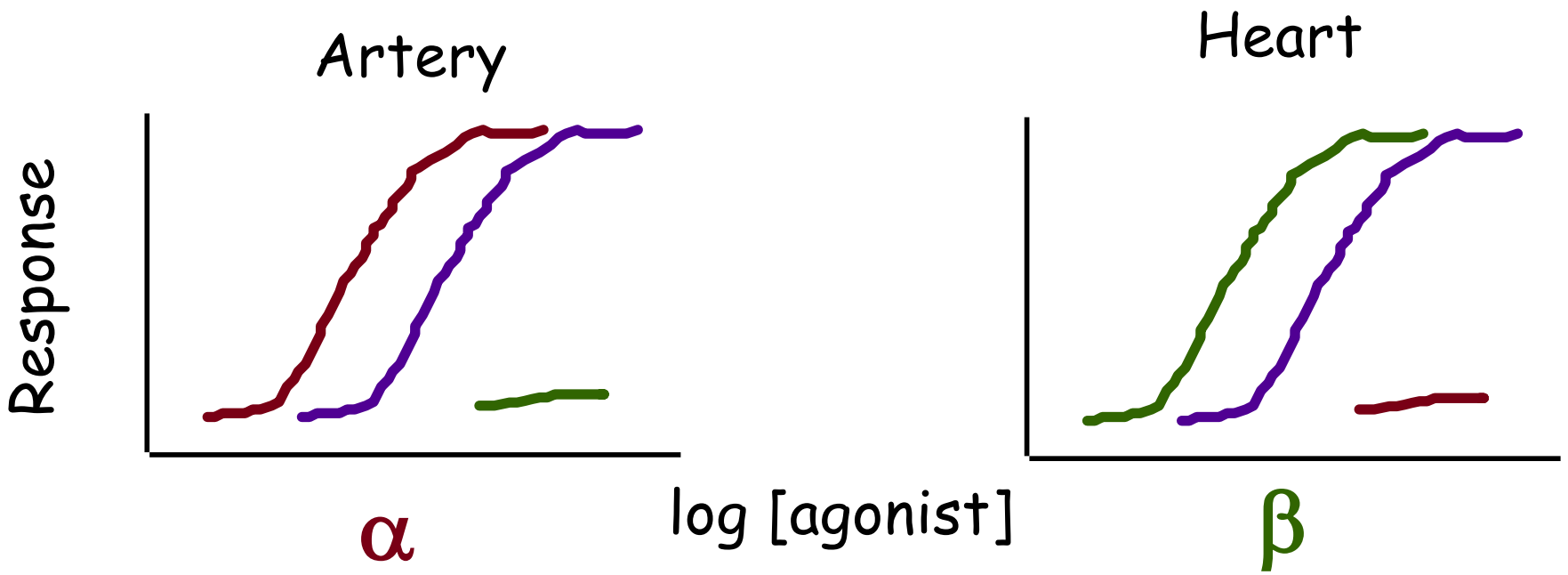


Phenylephrine



Isoprenaline





Therapeutic use of drugs with selectivity for β-adrenoceptors over α-adrenoceptors

Agonist: Isoprenaline

- Aerosol trialled in asthmatics
  - airway benefit offset by cardiac effects
    - » Cardiac palpitations
  - Salbutamol now used for bronchodilation
    - » **Selectivity for airways, partial agonist**

Antagonist: Propranolol

- Reduce cardiac output for hypertension
  - cardiac benefit offset by airway effect
- Still used clinically, but not if patient has asthma
  - » specific contraindications

(Laurence &Black, 1980)

"To get relief you must take some risk"