

## \* 類交感神經效益藥物 \*

血管加壓藥物  
或  
強心劑

| Medication            | Usual Infusion Dose   | Receptor Binding |           |           |          | Hemodynamic Effects |
|-----------------------|---|------------------|-----------|-----------|----------|---------------------|
|                       |   | $\alpha_1$       | $\beta_1$ | $\beta_2$ | Dopamine |                     |
| Vasopressor/inotropes |   |                  |           |           |          |                     |
| Dopamine              | 0.5–2 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$    | –                | +         | –         | +++      | ↑CO                 |
|                       | 5–10 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$     | +                | +++       | +         | ++       | ↑↑CO, ↑SVR          |
|                       | 10–20 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$    | +++              | ++        | –         | ++       | ↑↑SVR, ↑CO          |
| Norepinephrine        | 0.05–0.4 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ | ++++             | ++        | +         | –        | ↑↑SVR, ↑CO          |
| Epinephrine           | 0.01–0.5 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ | ++++             | ++++      | +++       | –        | ↑↑CO, ↑↑SVR         |
| Phenylephrine         | 0.1–10 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$   | +++              | –         | –         | –        | ↑↑SVR               |

同時具增加心收縮力  
與  
血管擴張功能藥物

| Medication    | Usual Infusion Dose   | Receptor Binding |           |           |          | Hemodynamic Effects |
|---------------|---|------------------|-----------|-----------|----------|---------------------|
|               |   | $\alpha_1$       | $\beta_1$ | $\beta_2$ | Dopamine |                     |
| Dobutamine    | 2.5–20 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ | +                | ++++      | ++        | –        | ↑↑CO, ↓SVR, ↓PVR    |
| Isoproterenol | 2.0–20 $\mu\text{g}/\text{min}$                             | –                | ++++      | +++       | –        | ↑↑CO, ↓SVR, ↓PVR    |



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自律神經平衡圖



交感神經

警戒、戰鬥  
心跳加快、肌肉緊張、  
精神緊張、荷適自覺收縮



副交感神經

休息、促進血管擴張、  
放鬆、肌肉鬆弛、  
促進精神放鬆

# 神經系統

## 中樞神經系統 (CNS)

- 腦及脊髓組成
- 整合及控制中心

## 周邊神經系統 (PNS)

- 腦神經及脊神經組成
- 中樞神經系統及身體其餘各部分的橋梁

## 輸入神經系統

- 感覺神經元組成
- 把感受器接收到的訊息傳至中樞神經系統

## 輸出神經系統

- 運動神經元組成
- 把訊息從中樞神經系統傳至反應器(肌肉及腺體)

## 軀體神經系統

- 從中樞神經系統傳達訊息至骨骼肌的運動神經元組成
- 使骨骼肌產生動作(隨意支配)

## 自主神經系統

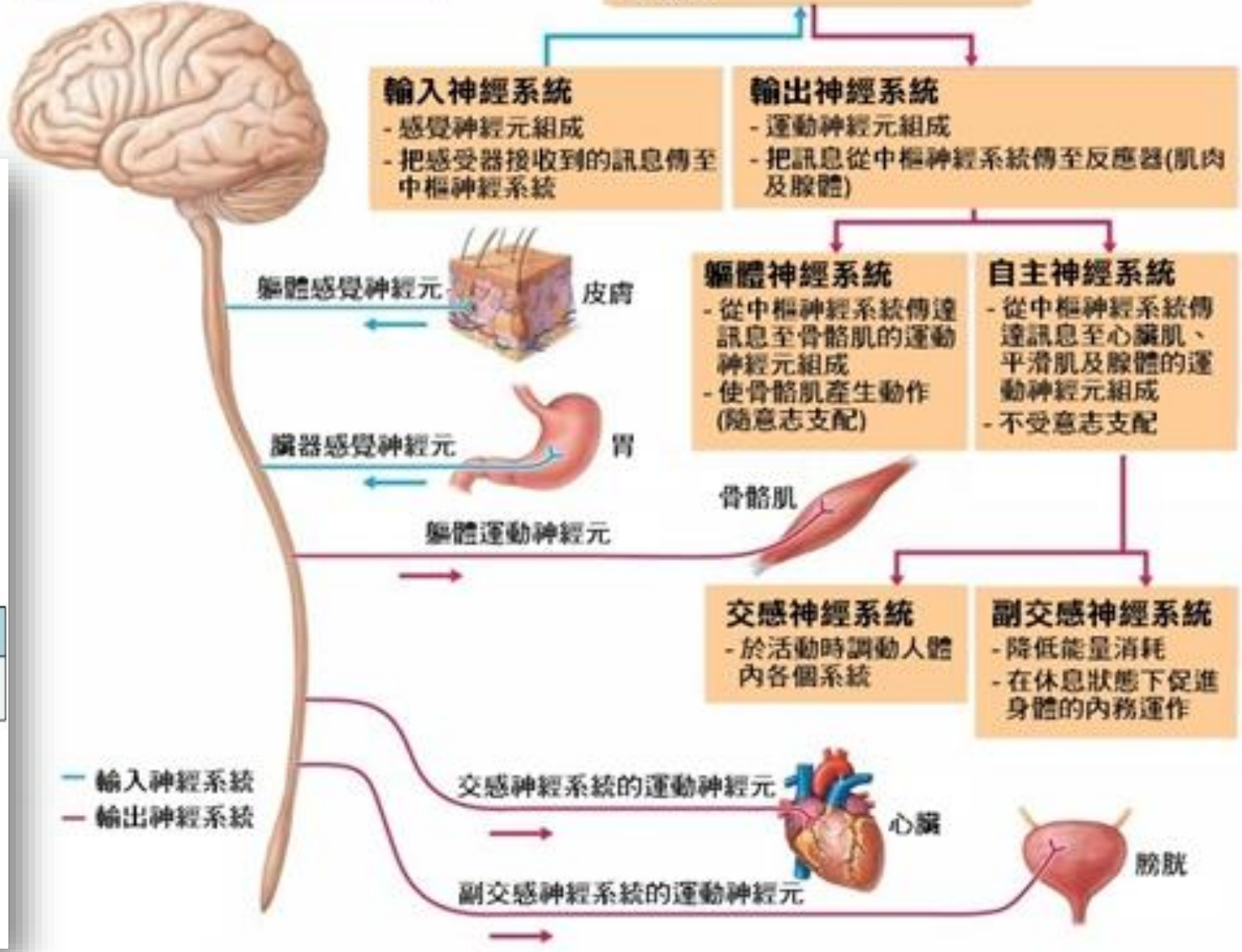
- 從中樞神經系統傳達訊息至心臟肌、平滑肌及腺體的運動神經元組成
- 不受意志支配

## 交感神經系統

- 於活動時調動人體內各個系統

## 副交感神經系統

- 降低能量消耗
- 在休息狀態下促進身體的內務運作



## Central Nervous System

- Brain and spinal cord
- Integrative control centre

## Peripheral Nervous System

- Peripheral nerves (cranial and spinal)
- Communication between CNS and body

## Sensory (Afferent) Division

- Composed of sensory neurons
- Conducts signals from receptors to CNS

## Motor (Efferent) Division

- Composed of motor neurons
- Conducts signals from CNS to effectors

## Autonomic Nervous System

- Controls involuntary responses

## Somatic Nervous System

- Controls voluntary movement

## Sympathetic Division

- Mobilises body systems
- 'Flight or fight' responses

## Parasympathetic Division

- Conserves energy
- 'Rest and digest' responses

# Anatomical Differences in Sympathetic and Parasympathetic Divisions

Come from different regions of the CNS

- **Sympathetic**—from the **thoracolumbar** region
- **Parasympathetic**—from the **craniosacral** region

Differing locations of ganglia

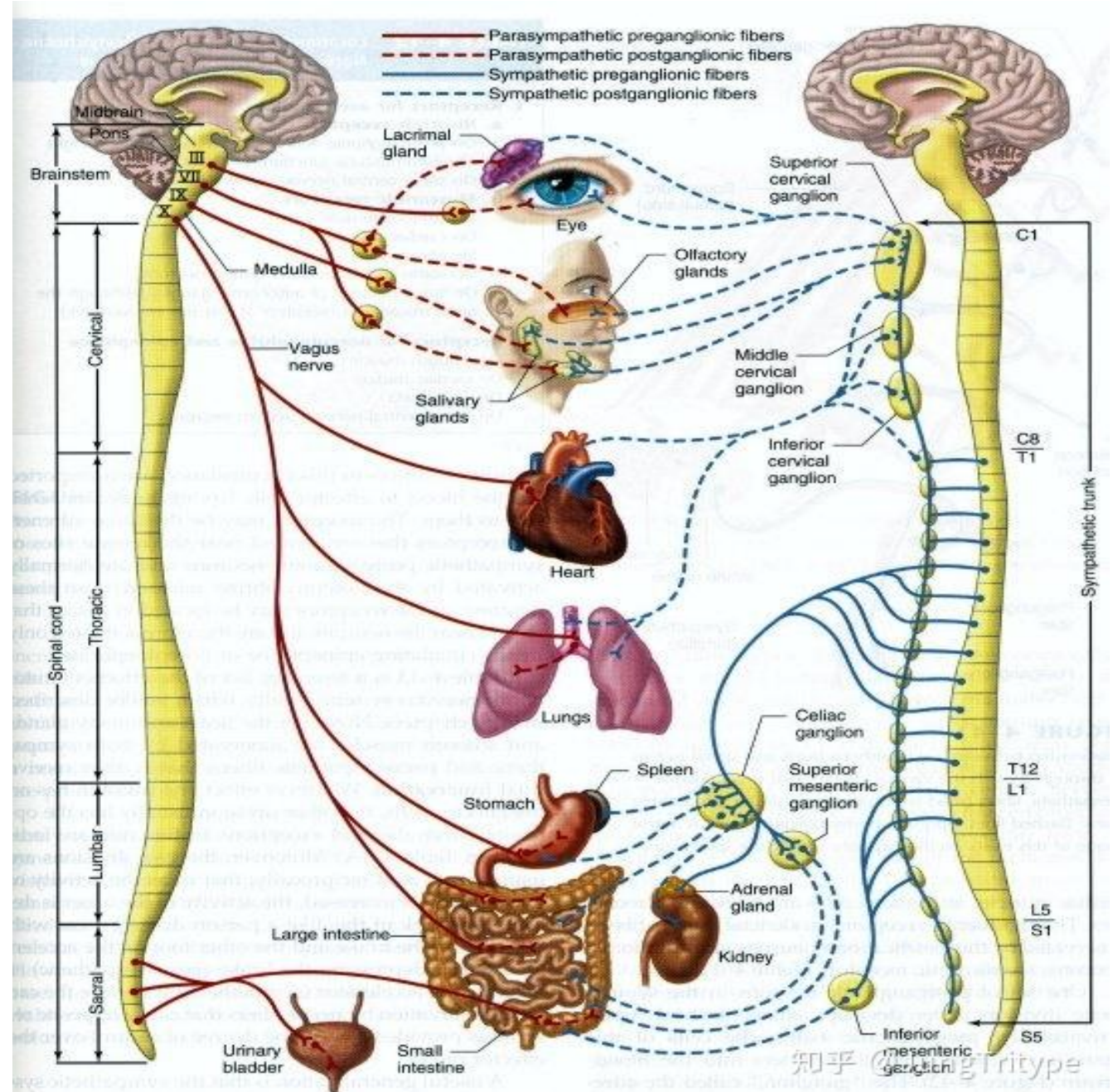
- Sympathetic – close to spinal cord in a chain
- Parasympathetic – close to target organs

Differing lengths of *postganglionic* fibers

- Sympathetic – Long
- Parasympathetic – Short

*Postganglionic* branching

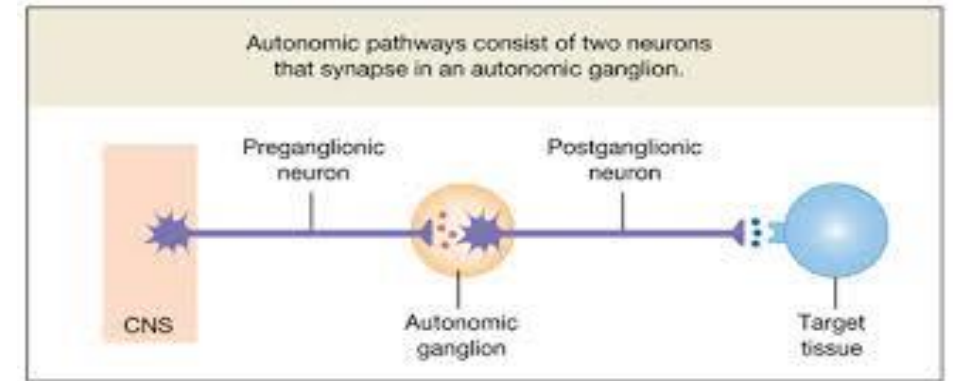
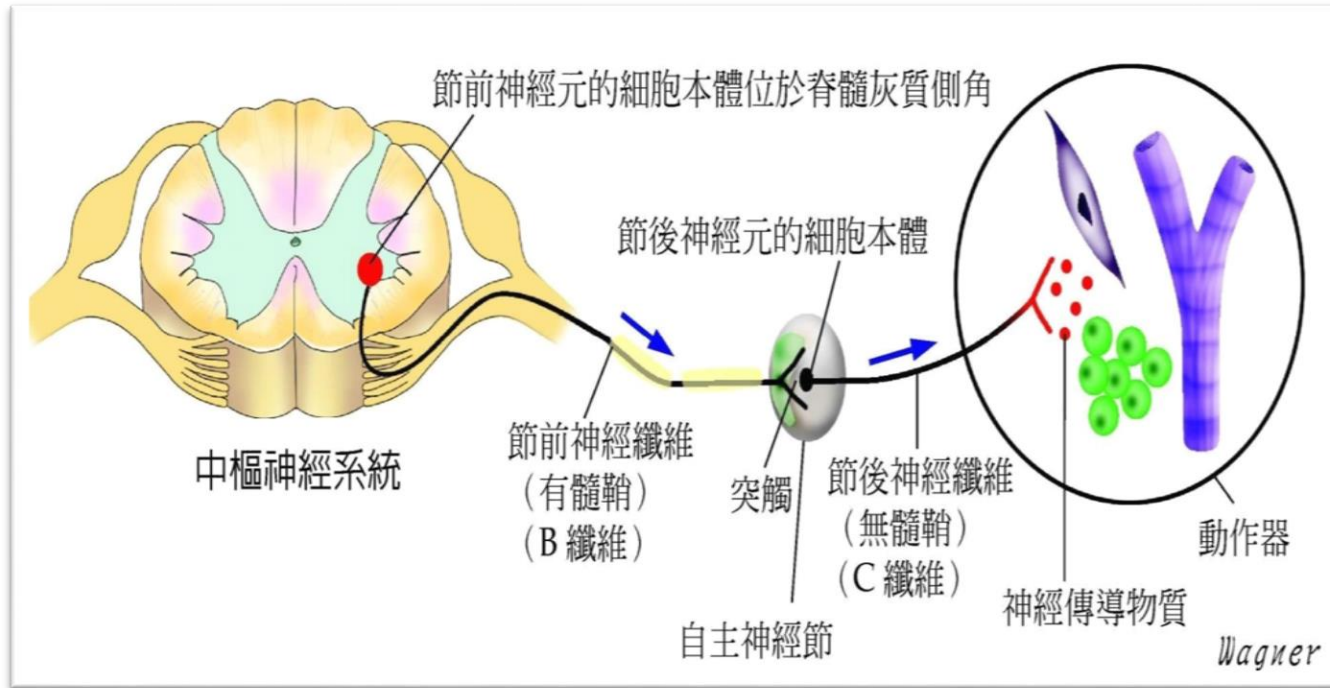
- Sympathetic – lots, so that multiple organs can be mobilized at once
- Parasympathetic – very little branching

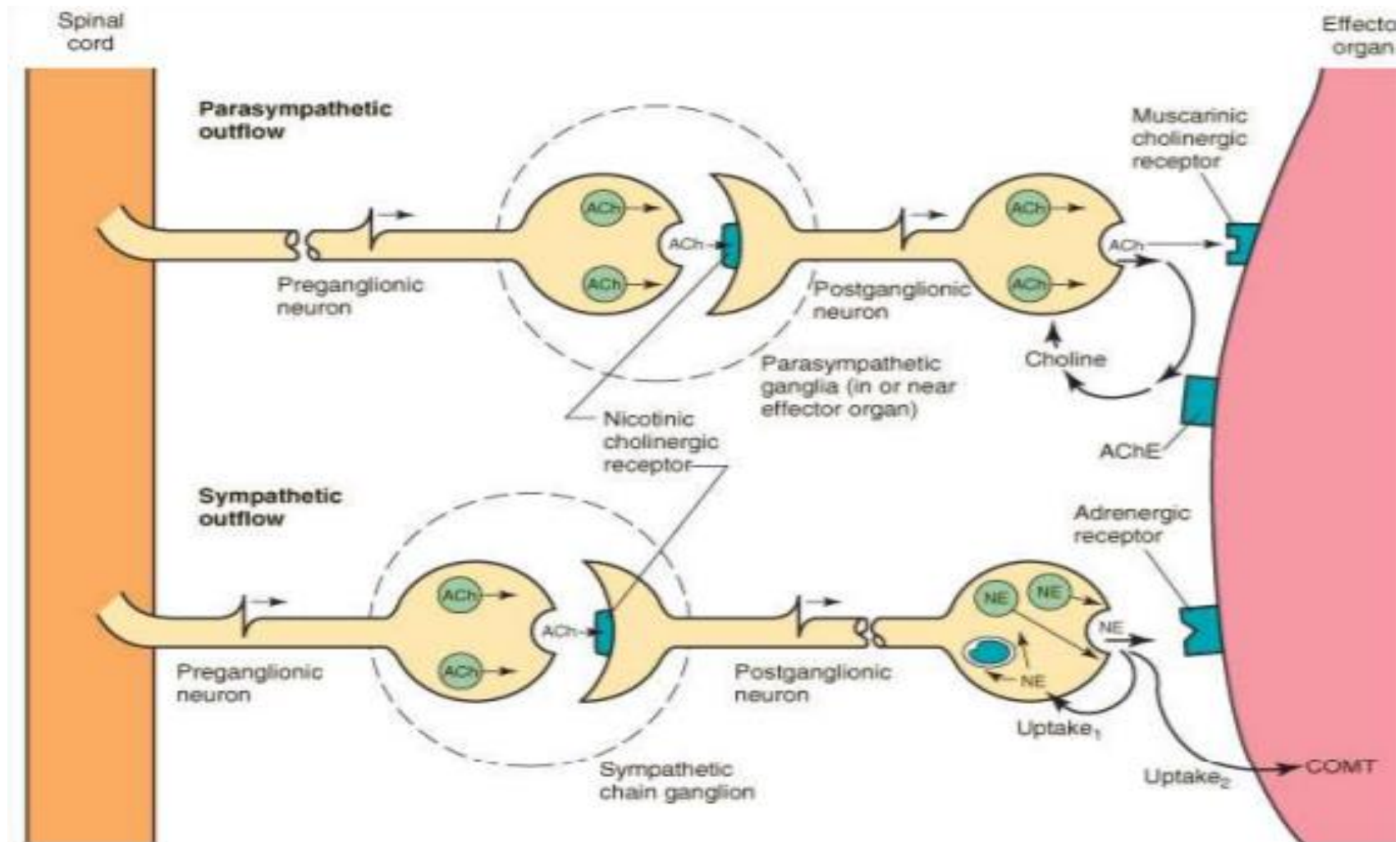


# 輸出神經系統(自主神經系統)

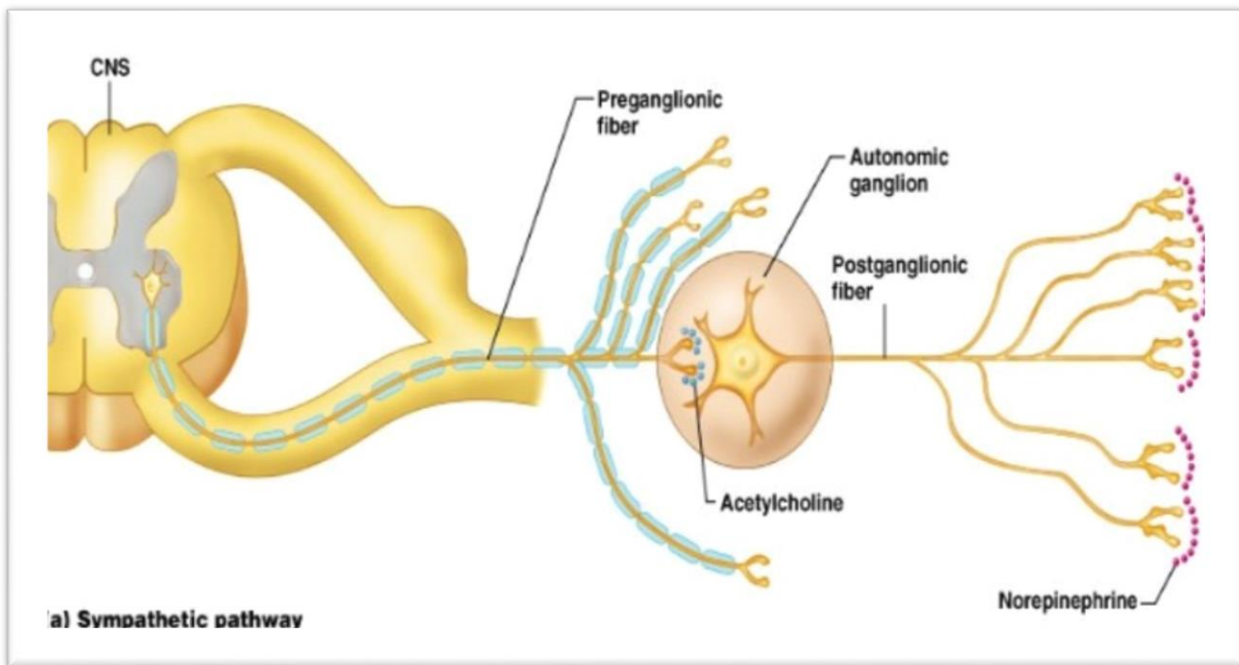
訊息離開脊髓(中樞)

訊息抵達動作器

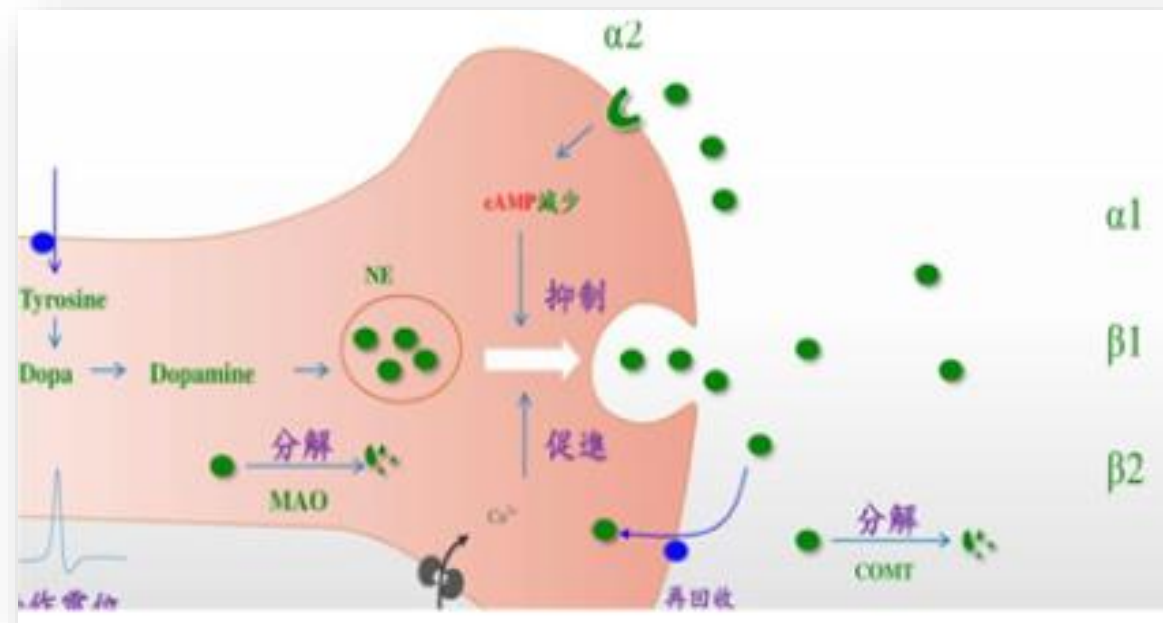




不同的動作器(心臟、血管...)有各種不同的交感神經接受體 (adrenergic receptor), 各產生不同的作用



| ANS                        | Receptor              | Receptor Sub-type |
|----------------------------|-----------------------|-------------------|
| Sympathetic nervous system | α adrenergic receptor | α1, α2            |
|                            | β adrenergic receptor | β1, β2, β3        |



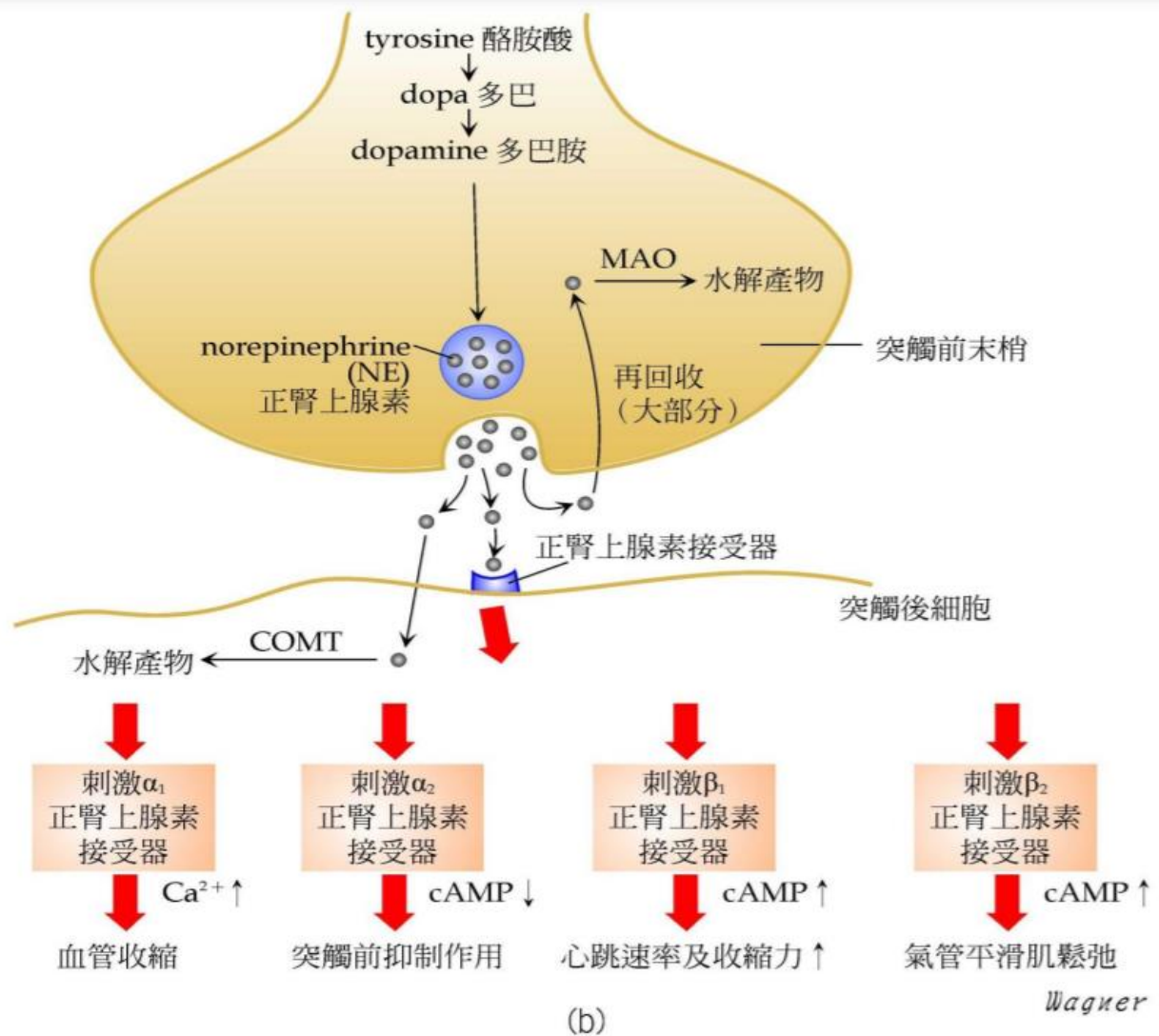
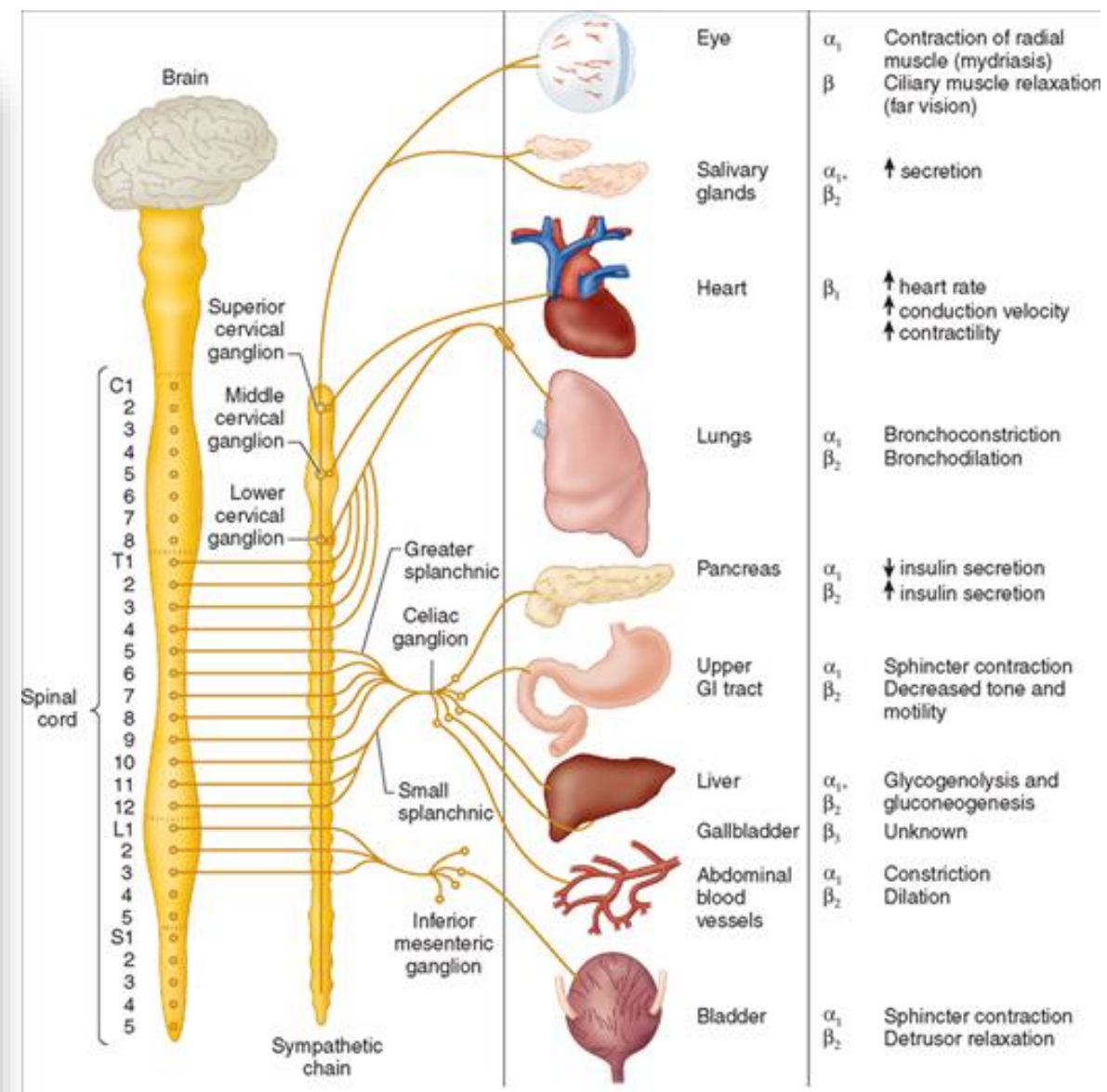


圖 6-5 正腎上腺素在交感神經末梢之合成、釋放、分解與作用



Source: Butterworth JF, Mackey DC, Wasnick JD: Morgan & Mikhail's Clinical Anesthesiology, 5th Edition: www.accessmedicine.com  
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## ADRENOCEPTORS

$\alpha_1$

- Vasoconstriction
- Increased peripheral resistance
- Increased blood pressure
- Mydriasis
- Increased closure of internal sphincter of the bladder

$\alpha_2$

- Inhibition of norepinephrine release
- Inhibition of acetylcholine release
- Inhibition of insulin release

$\beta_1$

- Tachycardia
- Increased lipolysis
- Increased myocardial contractility
- Increased release of renin

$\beta_2$

- Vasodilation
- Decreased peripheral resistance
- Bronchodilation
- Increased muscle and liver glycogenolysis
- Increased release of glucagon
- Relaxed uterine smooth muscle

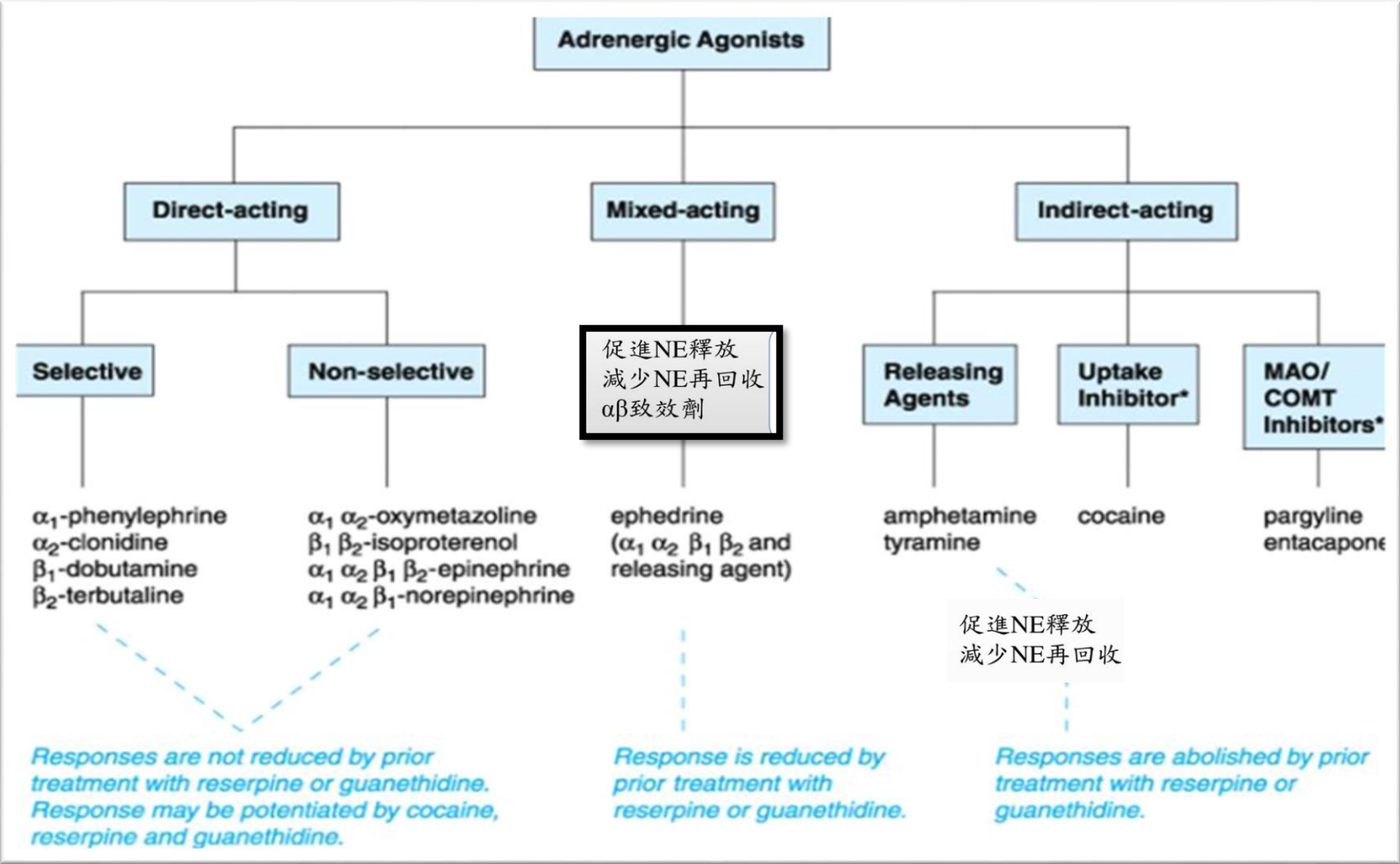
# \* 類交感神經效應藥物 \*

## adrenergic drugs classification

➤ 交感興奮藥物(擬交感神經藥物)  
 直接:  $\alpha_1$ 、 $\beta_1$ 、 $\beta_2$  致效劑 ( $\alpha_1$ 、 $\beta_1$ 、 $\beta_2$  agonists)  
 間接: 促進NE釋放或抑制再回收

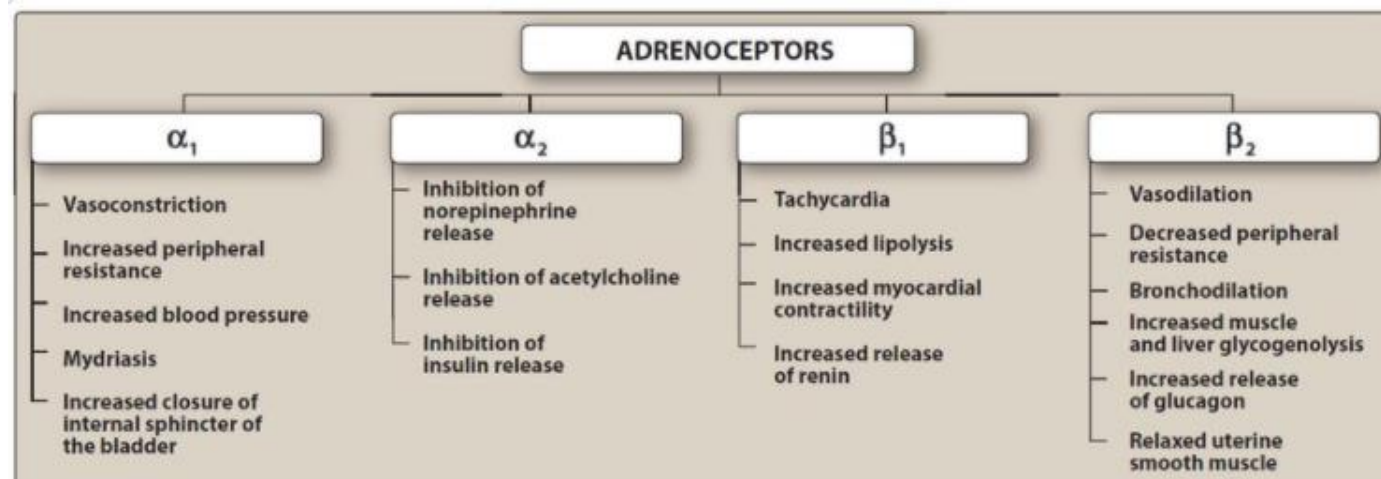
$\alpha_1$  致效劑-交感興奮藥物  
 $\beta_1$  致效劑-交感興奮藥物  
 $\beta_2$  致效劑-交感興奮藥物  
 $\alpha_2$  致效劑-交感抑制藥物

➤ 交感抑制藥物  
 $\alpha_2$  致效劑 ( $\alpha_2$  agonists)  
 $\alpha_1$ 、 $\beta_1$ 、 $\beta_2$  拮抗劑 ( $\alpha_1$ 、 $\beta_1$ 、 $\beta_2$  antagonists)



# 交感效應的藥物討論





血管加壓藥物  
或  
強心劑

| Medication            | Usual Infusion Dose   | Receptor Binding  |           |           |          | Hemodynamic Effects   |
|-----------------------|---|---|-----------|-----------|----------|---|
|                       |   | $\alpha_1$  | $\beta_1$ | $\beta_2$ | Dopamine |   |
| Vasopressor/inotropes |   |   |           |           |          |   |
| Dopamine              | 0.5–2 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$      | –   | +         | –         | +++      | $\uparrow\text{CO}$   |
|                       | 5–10 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$       | +   | +++       | +         | ++       | $\uparrow\uparrow\text{CO}$ , $\uparrow\text{SVR}$                            |
|                       | 10–20 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$      | +++   | ++        | –         | ++       | $\uparrow\uparrow\text{SVR}$ , $\uparrow\text{CO}$                            |
| Norepinephrine        | 0.05–0.4 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$   | ++++  | ++        | +         | –        | $\uparrow\uparrow\text{SVR}$ , $\uparrow\text{CO}$                            |
| Epinephrine           | 0.01–0.5 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$   | ++++  | ++++      | +++       | –        | $\uparrow\uparrow\text{CO}$ , $\uparrow\uparrow\text{SVR}$                    |
| Phenylephrine         | 0.1–10 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$     | +++   | –         | –         | –        | $\uparrow\uparrow\text{SVR}$  |
| Vasopressin           | 0.02–0.04 U/min   | Stimulates $V_1$ receptors in vascular smooth muscle    |           |           |          | $\uparrow\uparrow\text{SVR}$ , $\leftrightarrow\text{PVR}$                    |
| Inodilators           |   |   |           |           |          |   |
| Dobutamine            | 2.5–20 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$     | +   | ++++      | ++        | –        | $\uparrow\uparrow\text{CO}$ , $\downarrow\text{SVR}$ , $\downarrow\text{PVR}$ |
| Isoproterenol         | 2.0–20 $\mu\text{g}/\text{min}$                                 | –   | ++++      | +++       | –        | $\uparrow\uparrow\text{CO}$ , $\downarrow\text{SVR}$ , $\downarrow\text{PVR}$ |
| Milrinone             | 0.125–0.75 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ | PD-3 inhibitor  |           |           |          | $\uparrow\text{CO}$ , $\downarrow\text{SVR}$ , $\downarrow\text{PVR}$         |
| Enoximone             | 2–10 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$       | PD-3 inhibitor  |           |           |          | $\uparrow\text{CO}$ , $\downarrow\text{SVR}$ , $\downarrow\text{PVR}$         |
| Levosimendan          | 0.05–0.2 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$   | Myofilament $\text{Ca}^{2+}$ sensitizer, PD-3 inhibitor |           |           |          | $\uparrow\text{CO}$ , $\downarrow\text{SVR}$ , $\downarrow\text{PVR}$         |

同時具增加心收縮力  
與  
血管擴張功能藥物

Q1: 75y/o CADxIII CABG LVP: borderline EF: 48%

Postop: HR:52 BP:78/40 CI:1.5

A: Dopamine? Dobutamine? Isoproterenol

Postop: HR:70 BP: 65/38 CI:1.5

A: Dopamine? Dobutamine? Isoproterenol

Postop: HR:40 BP: 90/43 CI:1.5

A: Dopamine? Dobutamine? Isoproterenol

Q2: 75Y/o abdominal pain x 4day R/O ischemic bowel

Perioperative vital sign: HR:80 BP:65/40

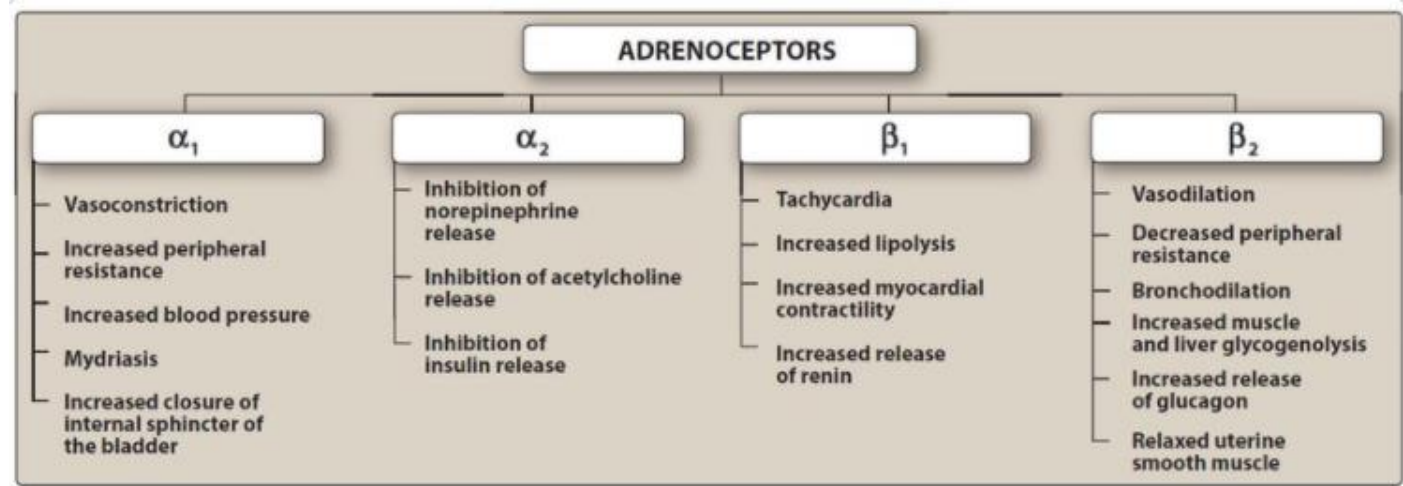
SVV:10% CI:2.2 SVRI:1200

A: Ephedrine? Phenylephrine? Norepinephrine?

Q3: 35Y/o TA radial fracture ORIF ASA I

Post-induction/before operation : HR:98 BP:78/58

A: Ephedrine? Phenylephrine? Norepinephrine?



| Medication    | Usual Infusion Dose   | Receptor Binding |           |           |
|---------------|---|------------------|-----------|-----------|
|               |   | $\alpha_1$       | $\beta_1$ | $\beta_2$ |
| Dopamine      | 0.5–2 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  | –                | +         | –         |
|               | 5–10 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$   | +                | +++       | +         |
|               | 10–20 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  | +++              | ++        | –         |
| Dobutamine    | 2.5–20 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ | +                | ++++      | ++        |
| Isoproterenol | 2.0–20 $\mu\text{g}/\text{min}$                             | –                | ++++      | +++       |

| Medication     | Usual Infusion Dose   | Receptor Binding |           |           |
|----------------|---|------------------|-----------|-----------|
|                |   | $\alpha_1$       | $\beta_1$ | $\beta_2$ |
| Phenylephrine  | 0.1–10 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$   | +++              | –         | –         |
| Norepinephrine | 0.05–0.4 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ | ++++             | ++        | +         |



加油，加油！



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自律神經平衡圖



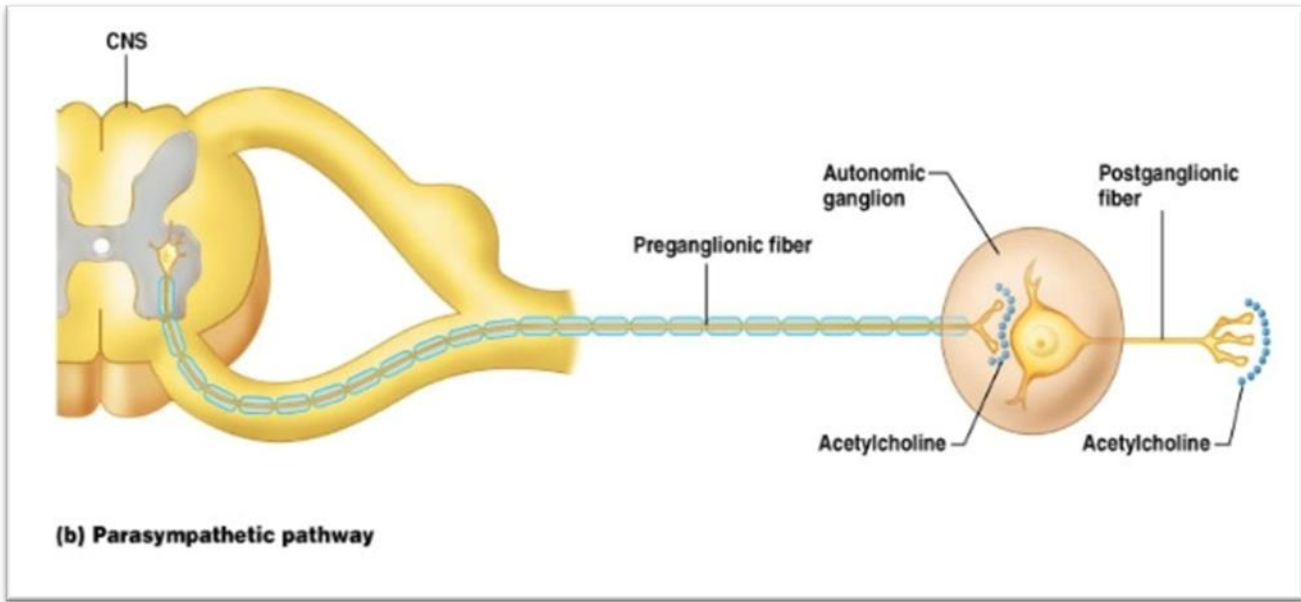
交感神經

警戒、戰鬥  
心跳加快、肌肉緊張、  
精神緊張、荷適自覺收縮

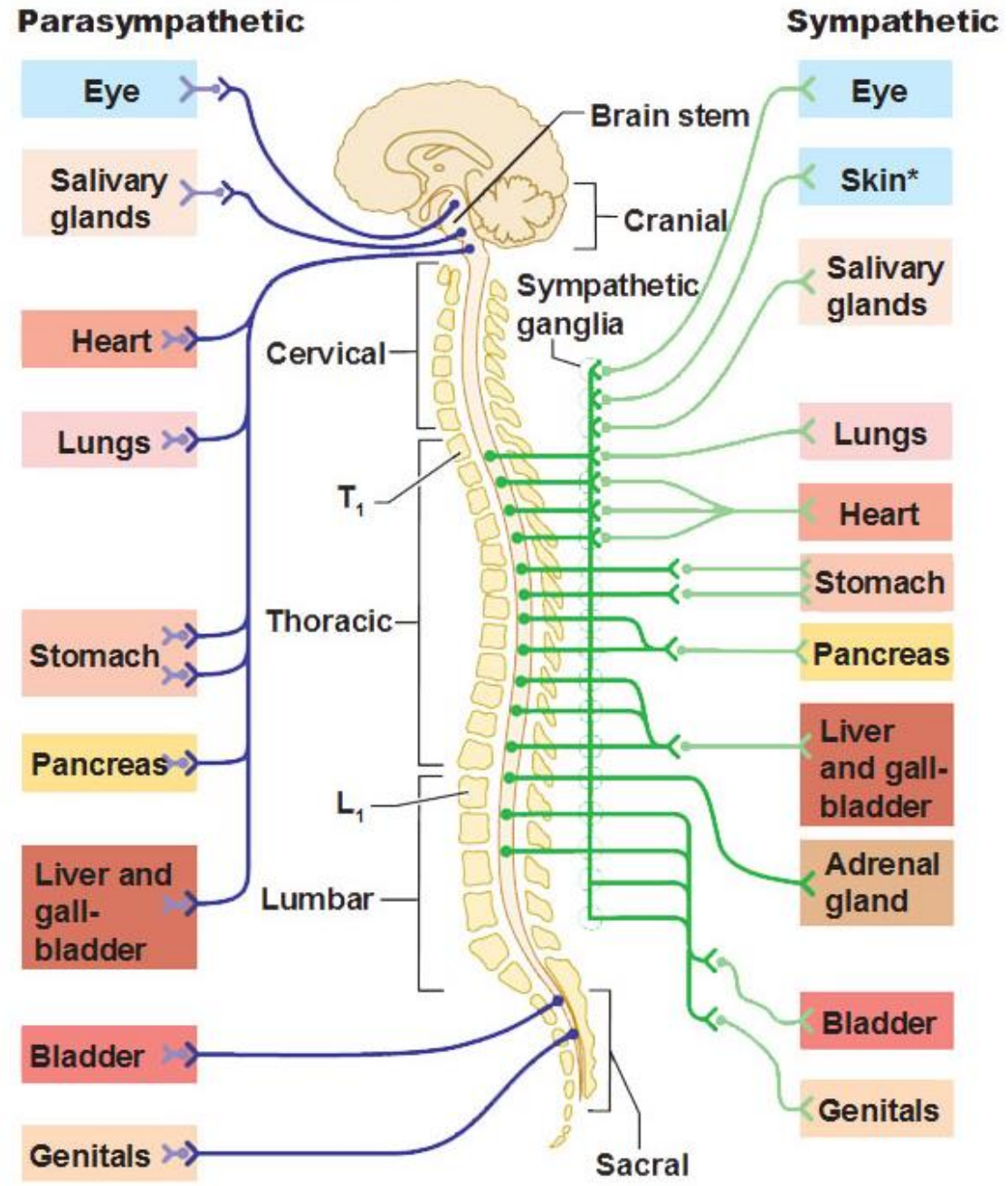


副交感神經

休息、促進血管擴張、  
飲食、肌肉鬆弛、  
獲取精神放鬆

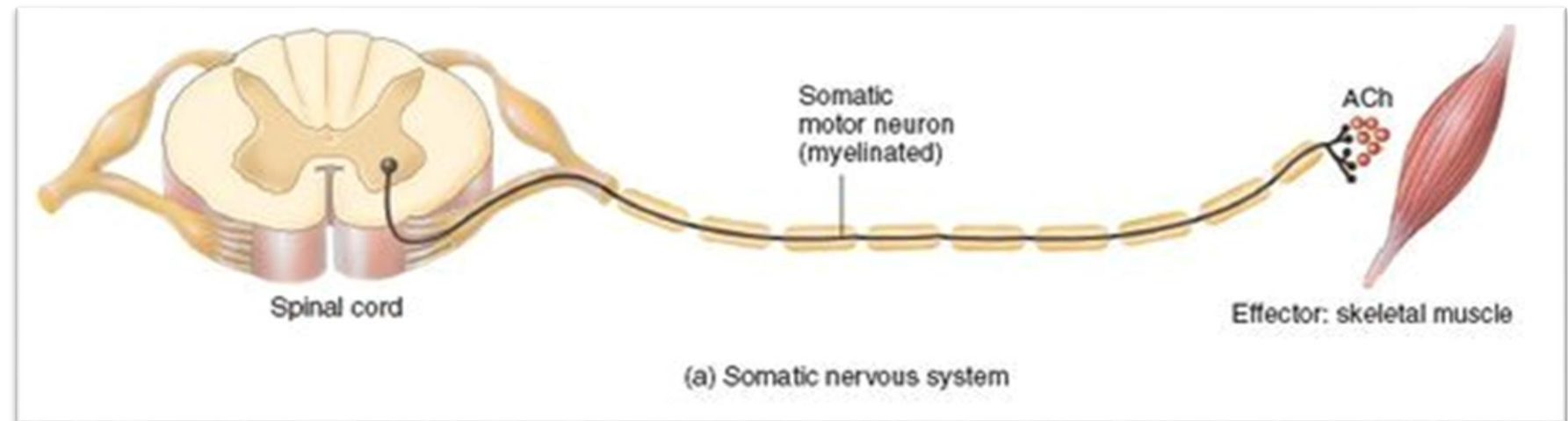
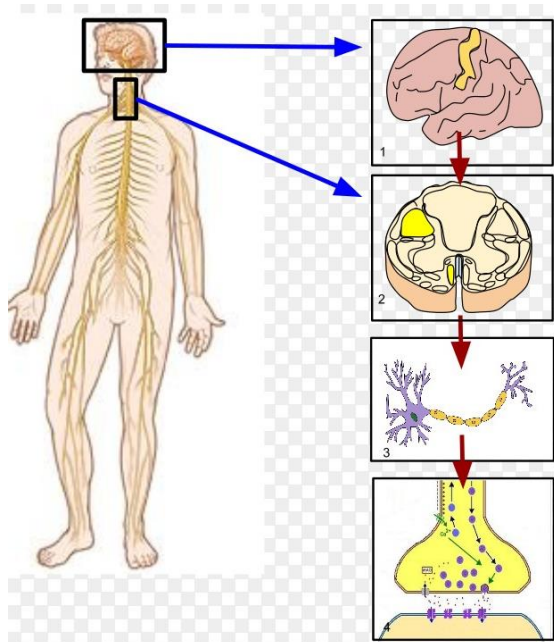


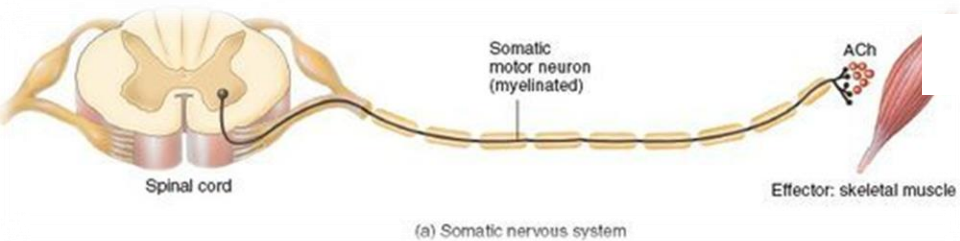
| ANS                            | Receptor                         | Receptor Sub-type  |
|--------------------------------|----------------------------------|--------------------|
| Parasympathetic nervous system | Nicotinic cholinergic receptors  | Nn, Nm             |
|                                | Muscarinic cholinergic receptors | M1, M2, M3, M4, M5 |



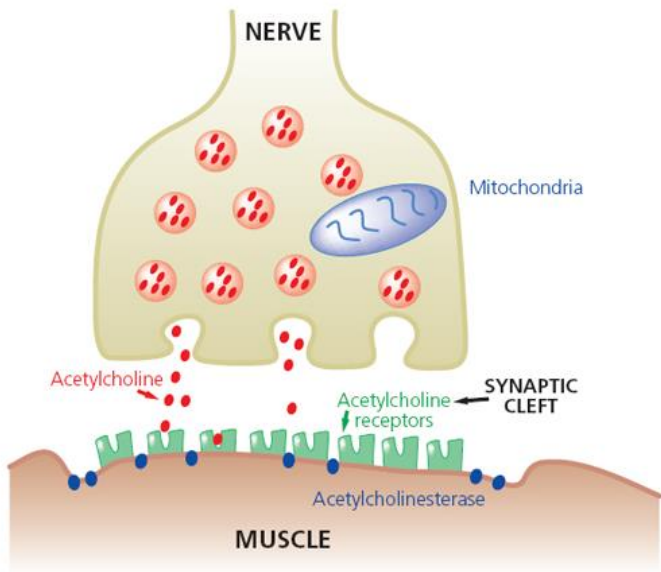
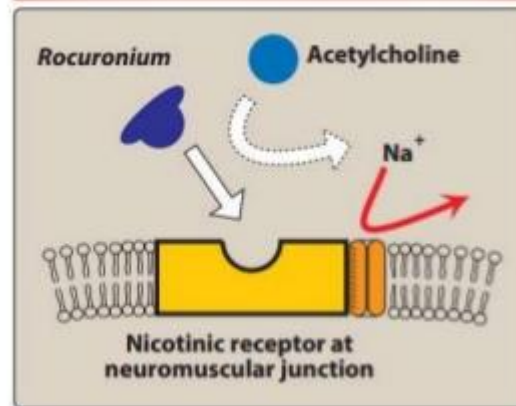
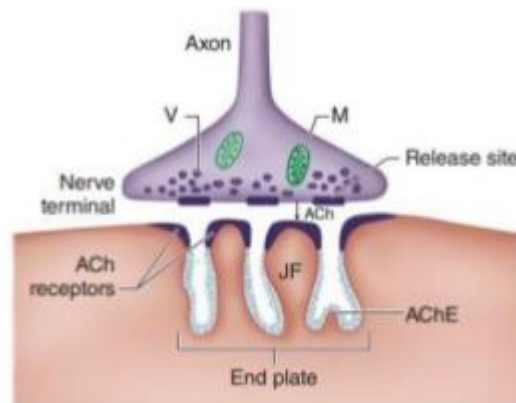


# 體神經系統(運動神經元:隨意)



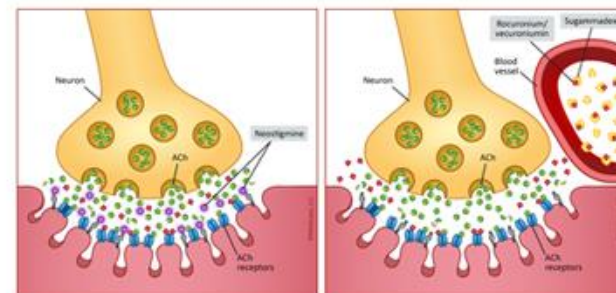


## Mechanism of Action



## Nondepolarizing NMBA Reversal

- Redistribution
- Administration of reversal agents



### Neostigmine

- Binds with any NMBA at the NMJ
- Has a ceiling effect and therefore cannot reverse deep NMB

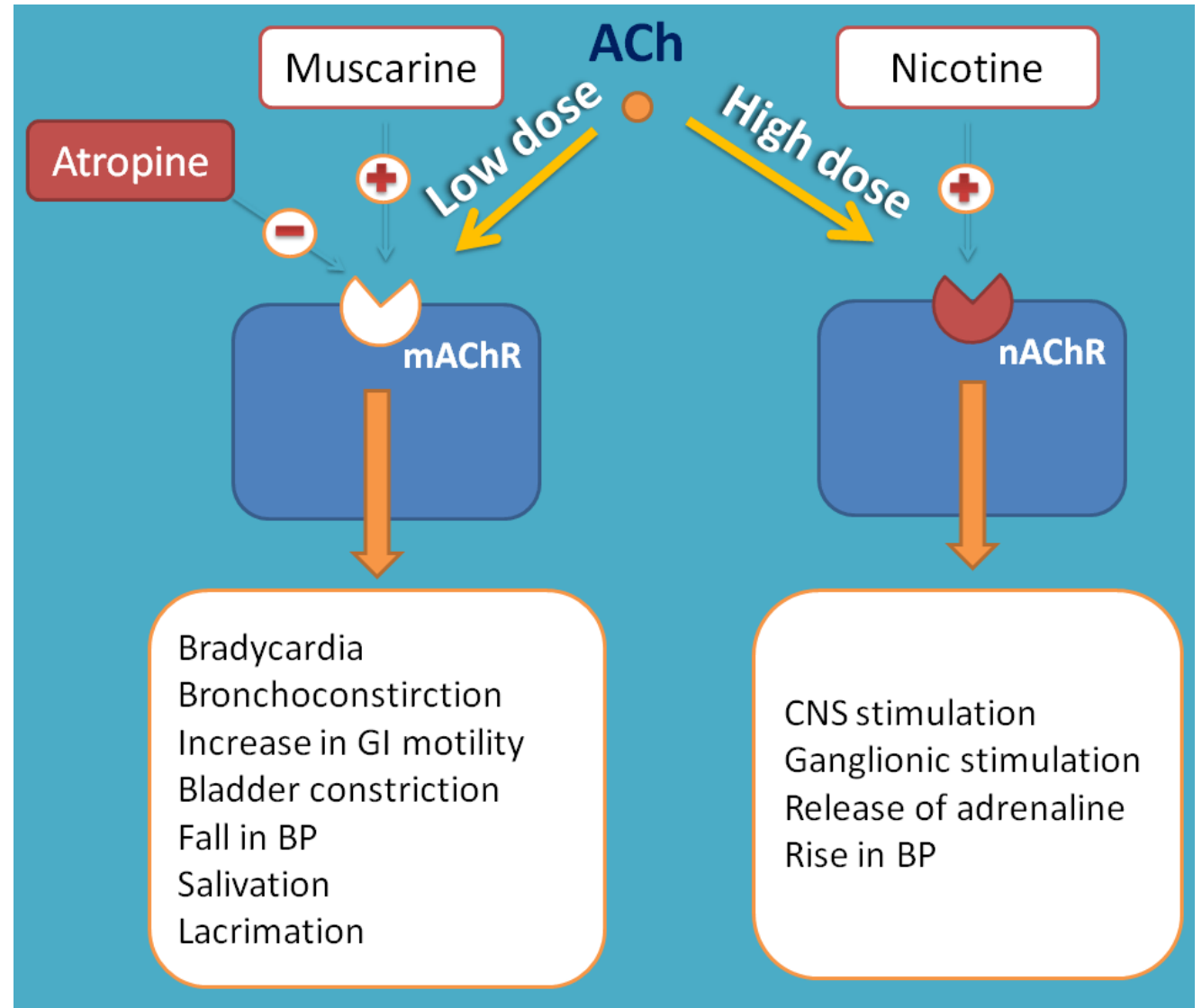
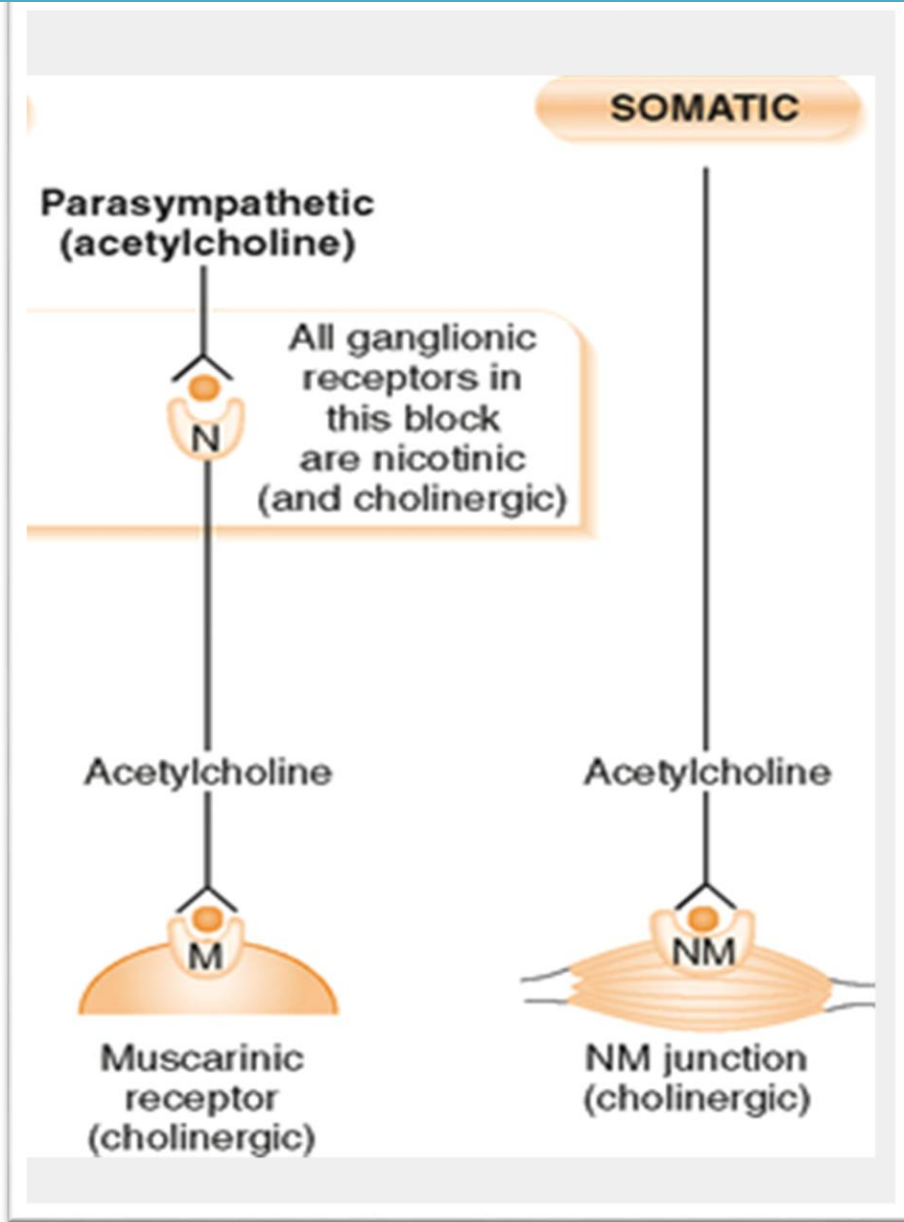
### Sugammadex

- Encapsulates rocuronium or vecuronium in the blood stream
- Rapidly reverses any level of NMB

Bloxiverz® PI 2015.

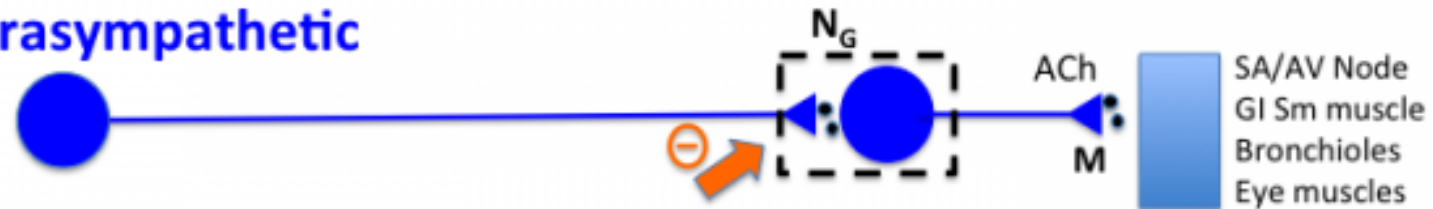
Bridion® PI 2015.

Acetylcholine acts on 2 receptors: muscarinic (mAChR) & nicotinic (nAChR)

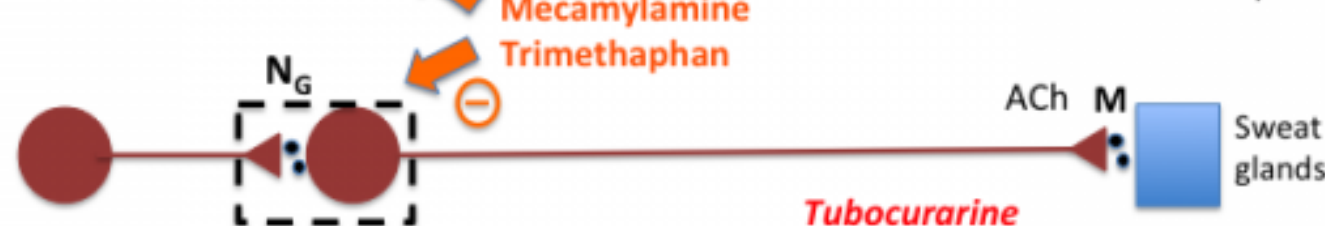
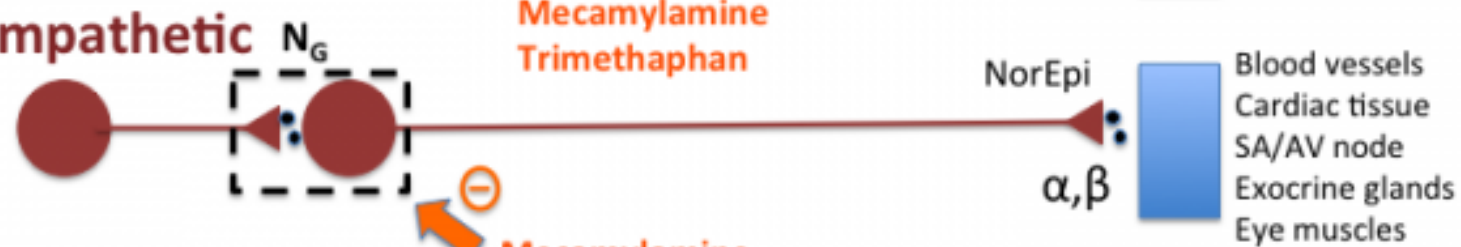


# Different Pathways & Receptors in the PNS

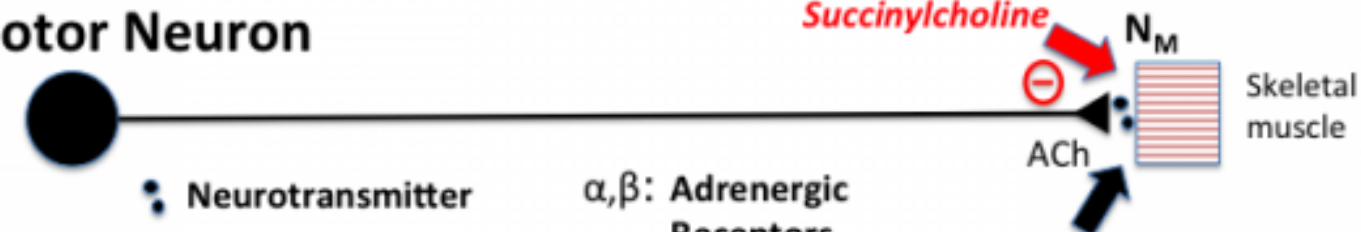
## Parasympathetic



## Sympathetic



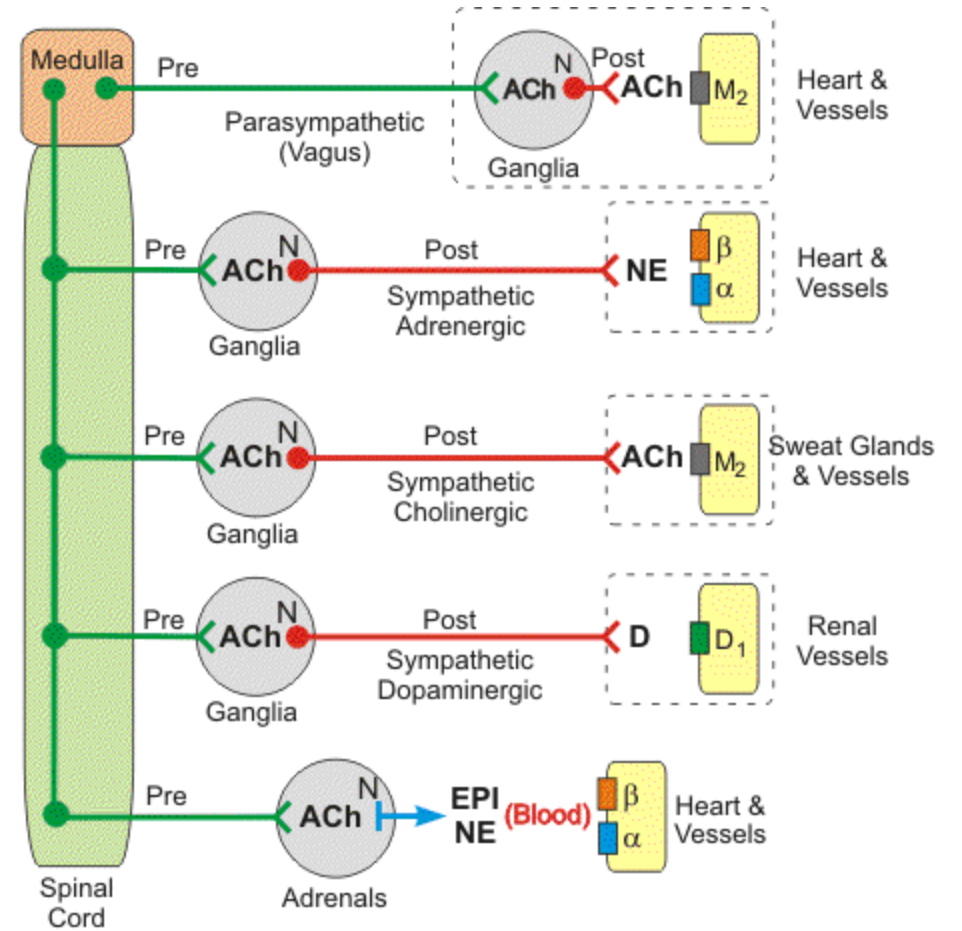
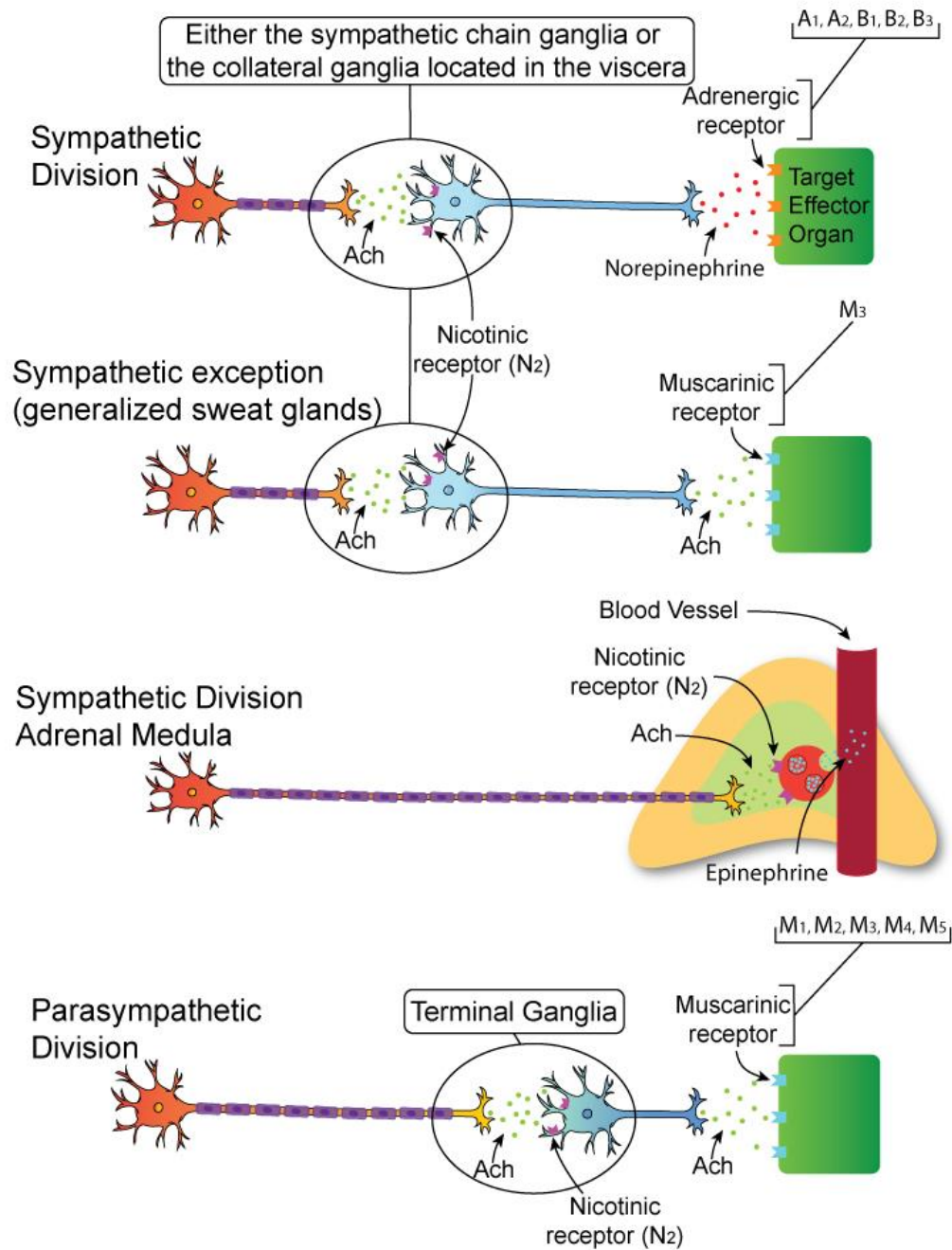
## Motor Neuron



• Neurotransmitter  
 [ ] Ganglionic Nicotinic Receptors (  $N_G$  )

$\alpha, \beta$ : Adrenergic Receptors  
 M: Muscarinic Receptors

Skeletal Muscle Nicotinic Receptors (  $N_M$  )



CNS = central nervous system; Pre = preganglionic; Post = postganglionic; ACh = acetylcholine; N = nicotinic receptor; NE = norepinephrine; EPI = epinephrine; D = dopamine; M<sub>2</sub> = muscarinic receptor; β = β-adrenoceptor; α = α-adrenoceptor; D<sub>1</sub> = dopaminergic receptor