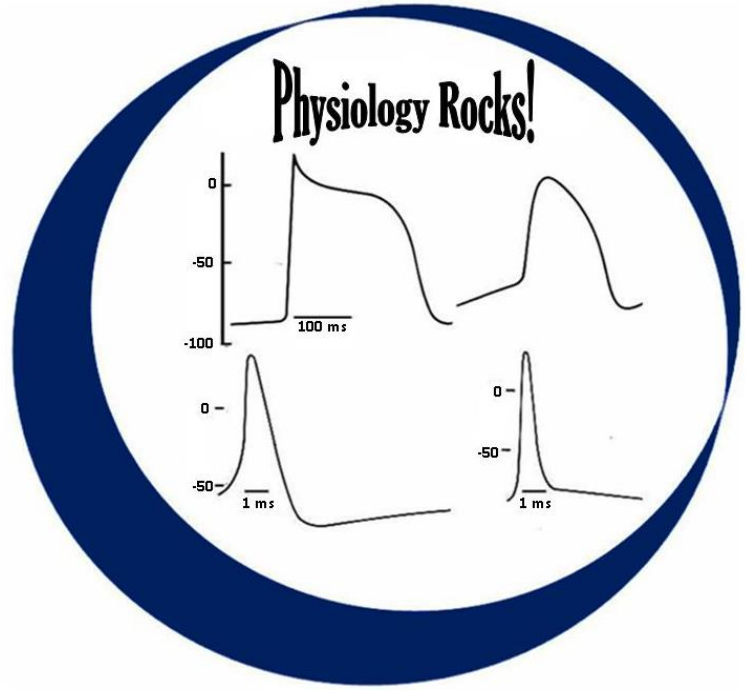
Lecture 13
Peripheral Vascular Control



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Topics

"Part 1"

- **Receptor Review for Vasodilation and Vasoconstriction**
- **Important Role of Calcium**
- **Important Role of Potassium**
- **Endothelial-Vascular Smooth Muscle Interaction**
- **Endothelial Vasoactive Substances → NO and Endothelin**

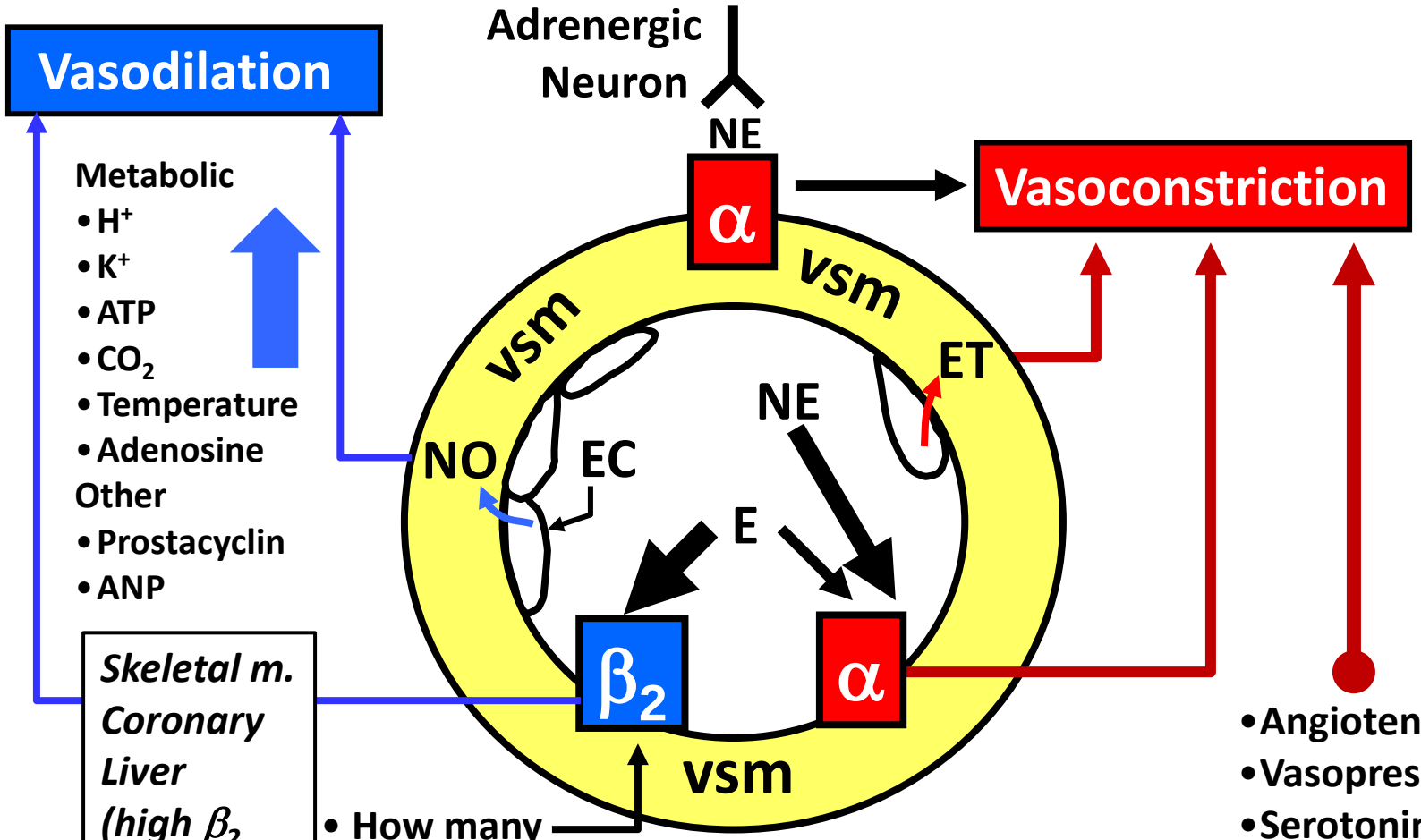
"Part 2" → Local Controls

- **Myogenic Response**
- **Autoregulation**
- **Metabolic Control**
- **Reactive Hyperemia**

"Part 3" → Selected circulations

- **Muscle**
- **Skin**
- **Cerebral**
- **Splanchnic**

Vascular Control: Neural-Humoral-Local



At high concentrations β_2 saturate effect shifts to vasoconstriction

NO=Nitric Oxide
ET=Endothelin
VSM=Vascular Smooth Muscle
EC=Endothelial Cell
E=Epinephrine
NE=Norepinephrine
ANP=Atrial Natriuretic Protein

VSM Ion Mechanisms: Overview

VSM tone and contractile state depends on Ion movements through

- **Voltage Operated Channels (VOC)**
- **Receptor Operated Channels (ROC)**

VOC → Voltage- Gated (Electromechanical Coupling)

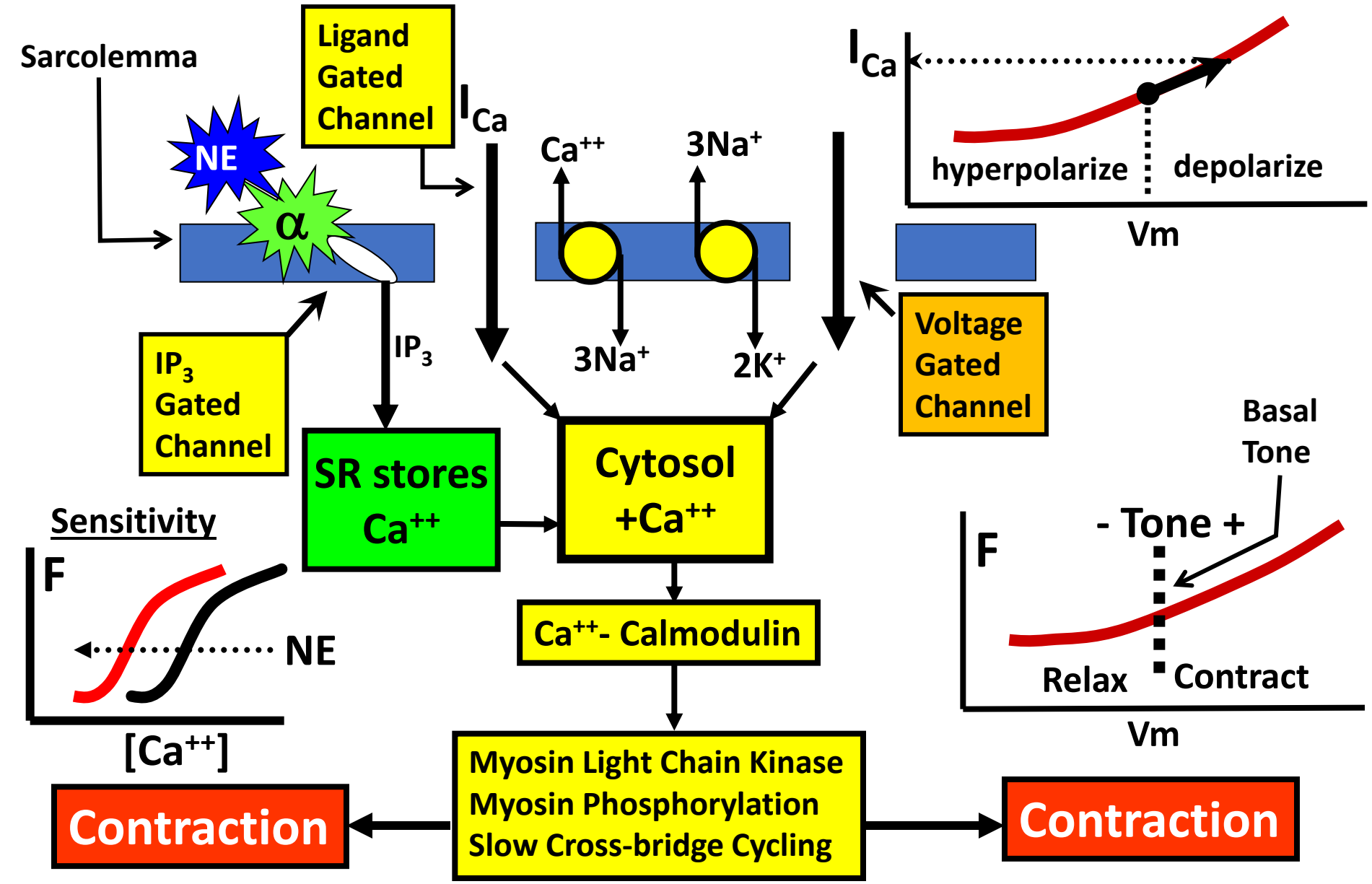
- **Hyperpolarization → Vasodilation**
- **Depolarization → Vasoconstriction**

ROC → Ligand-Gated (Pharmaco-mechanical Coupling)

Ca^{++} is a major player in VSM Contraction with increased contraction dependent on increased availability and less contraction (dilatation) the opposite.

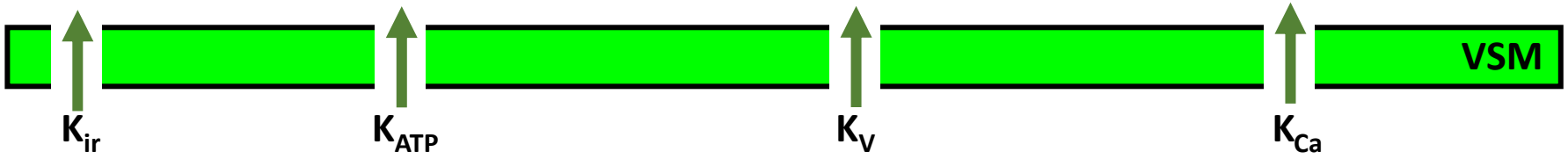
- **Ca^{++} entry via ROC's and VOC's**
- **Ca^{++} release from SR stores**
- **Ca^{++} removal via SR & membrane "pumps"**
- **Ca^{++} sensitivity of VSM**

Vascular Smooth Muscle: Dominant Role of Ca^{++}



IP_3=inositol triphosphate
SR=sarcoplasmic reticulum

Potassium Ion Channels in Vascular Smooth Muscle

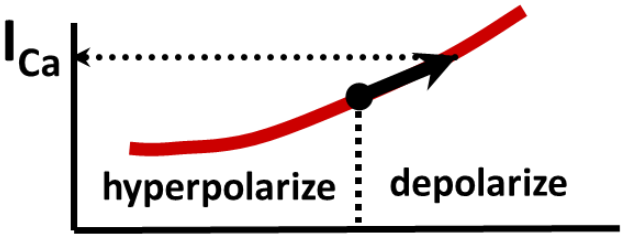


- Inward Rectifying (K_{ir})
- *Open state probability (OP) increases if +$[K]_o$*
- Causes hyperpolarization
- Less Ca^{++} entry
- Vasodilation
- $[K]_o$ is increased with metabolic activity
- Basis of metabolic hyperemia

- ATP-Dependent (K_{ATP})
- OP increases if intracellular ATP decreases (++Ischemia)
- OP increases if +ADP, +$[H^+]$ Adenosine or Mild Hypoxia
- Vasodilation

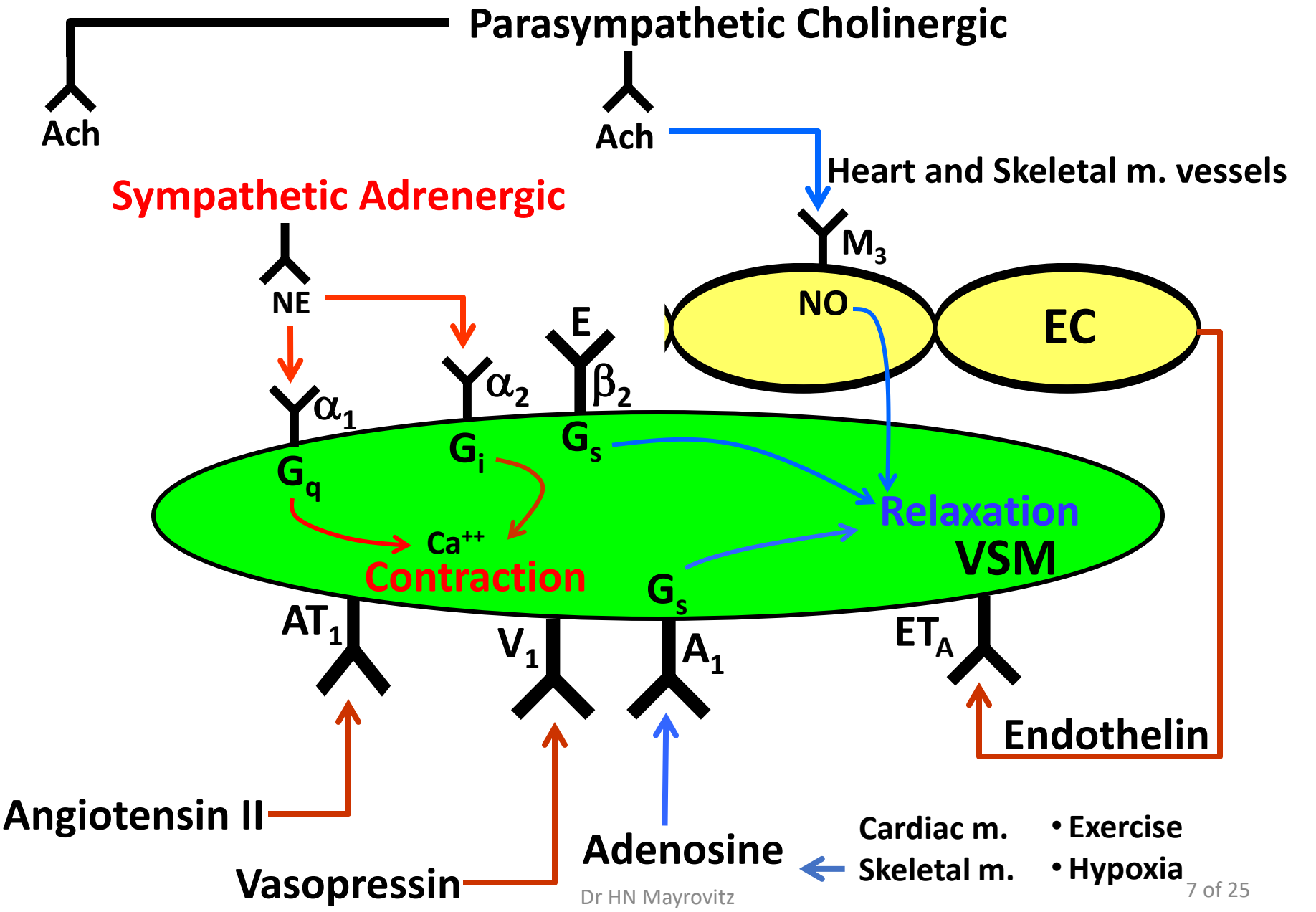
- Voltage-gated (K_V)
- Mainly in arterioles
- +OP with depolarization
- Vasodilation

- Calcium-activated (K_{Ca})
- Activated by increased intracellular Ca^{++} and membrane depolarization
- Vasodilation



- Increased I_k (K^+ outward flux) of any of these channels causes hyperpolarization
- Hyperpolarization reduces open-state probability of voltage-gated Ca^{++} channels
- As a result, inward I_{Ca} decreases causing $[Ca^{++}]$ to decrease
- Result is vasodilation directly or counteracting depolarization-induced vasoconstriction

Summary of Some Major CV-Related Receptors



Local Control Processes

- **Myogenic Response**
- **Autoregulation**
- **Metabolic → Active or Functional Hyperemia**
- **Reactive Hyperemia**

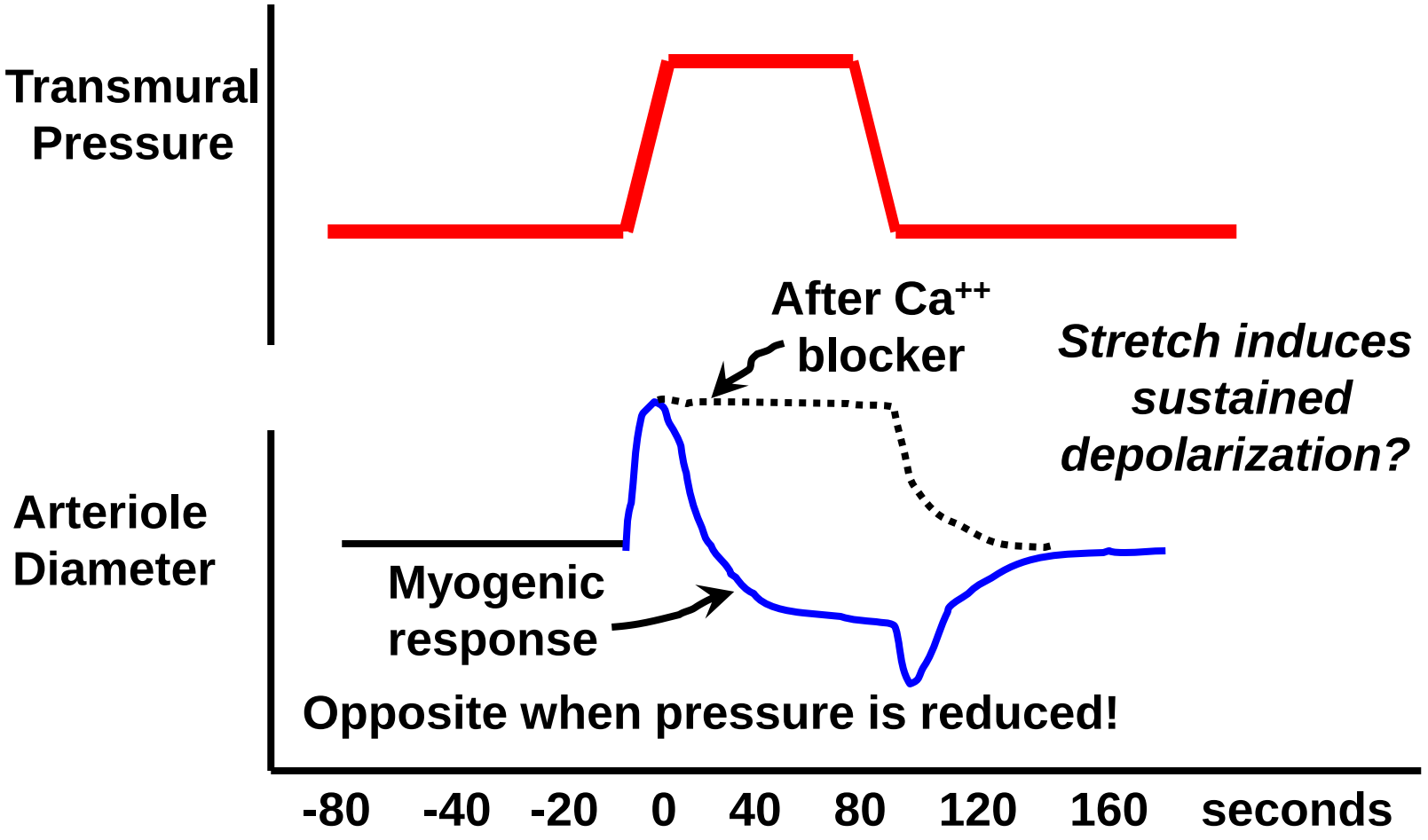
Myogenic Response: Defined

- Active vascular smooth muscle change in response to a change in transmural pressure (TMP)
- Direction of active change opposes stretch caused by the initiating pressure change

If TMP increases → Vasoconstriction

If TMP decreases → Vasodilation

Myogenic Response: Illustrated



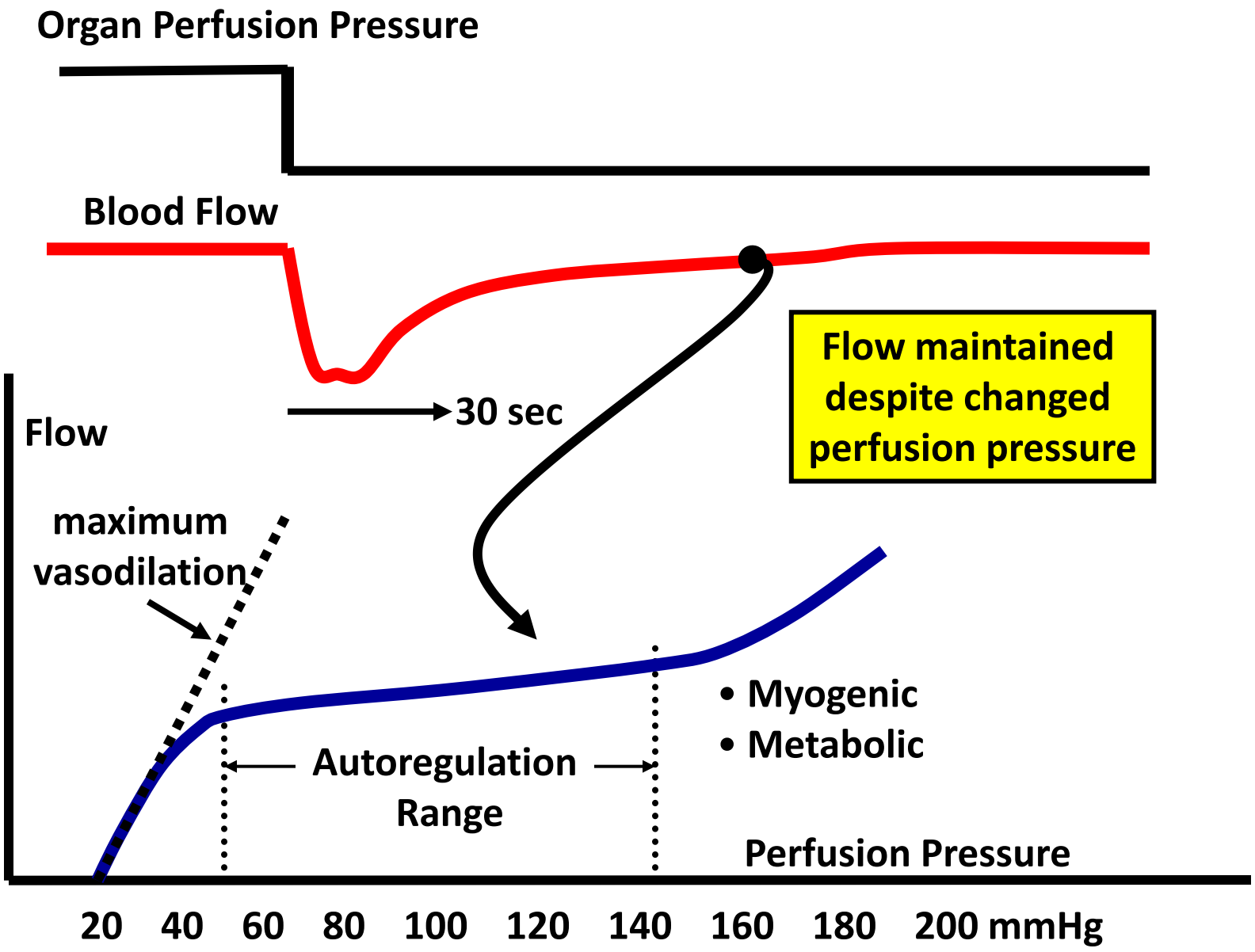
Autoregulation of Blood Flow: Defined

- Tendency to maintain blood flow
  despite changes in perfusion pressure

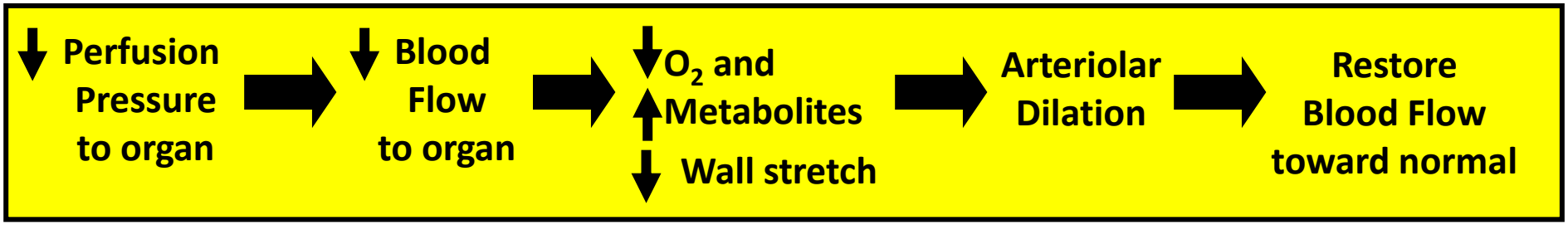
- Change is produced by increases or decreases
  in vascular resistance of the organ

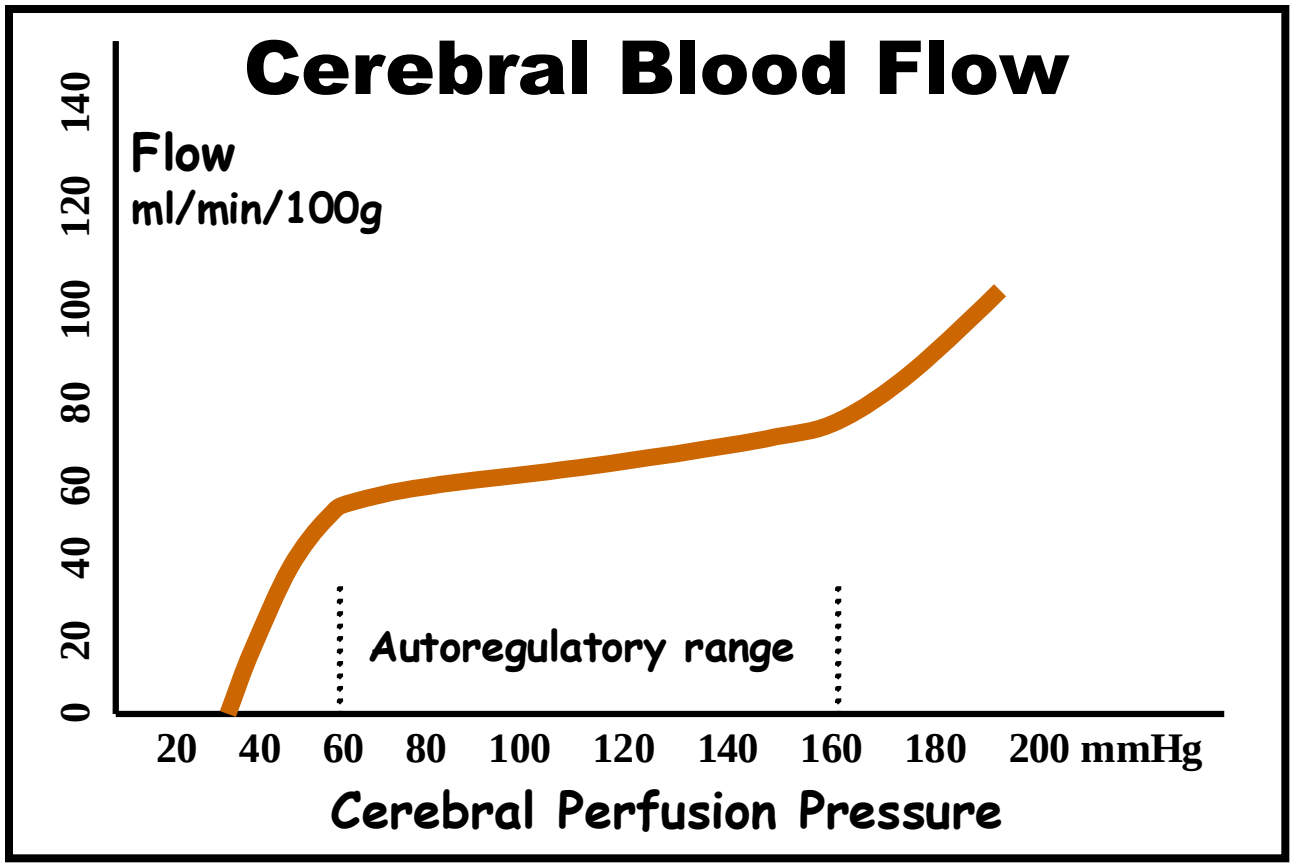
- If perfusion pressure decreases so does resistance
- If perfusion pressure increases so does resistance

Autoregulation of Blood Flow: Illustrated



Autoregulation of Blood Flow: Reviewed

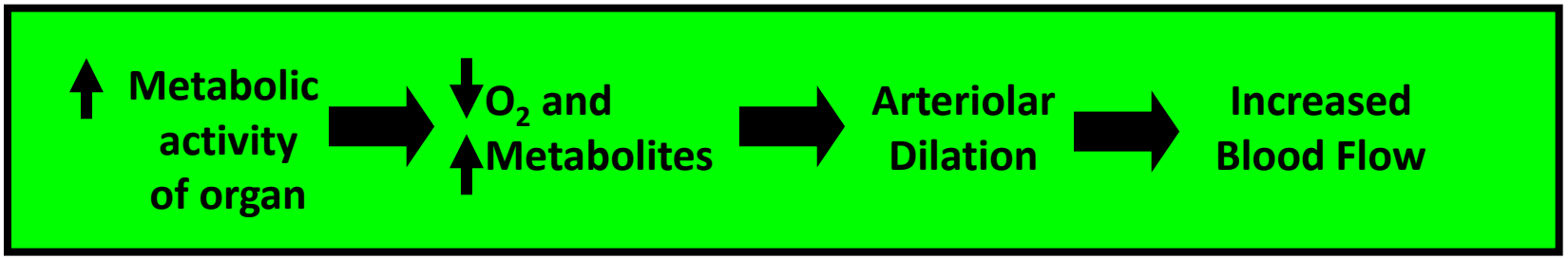




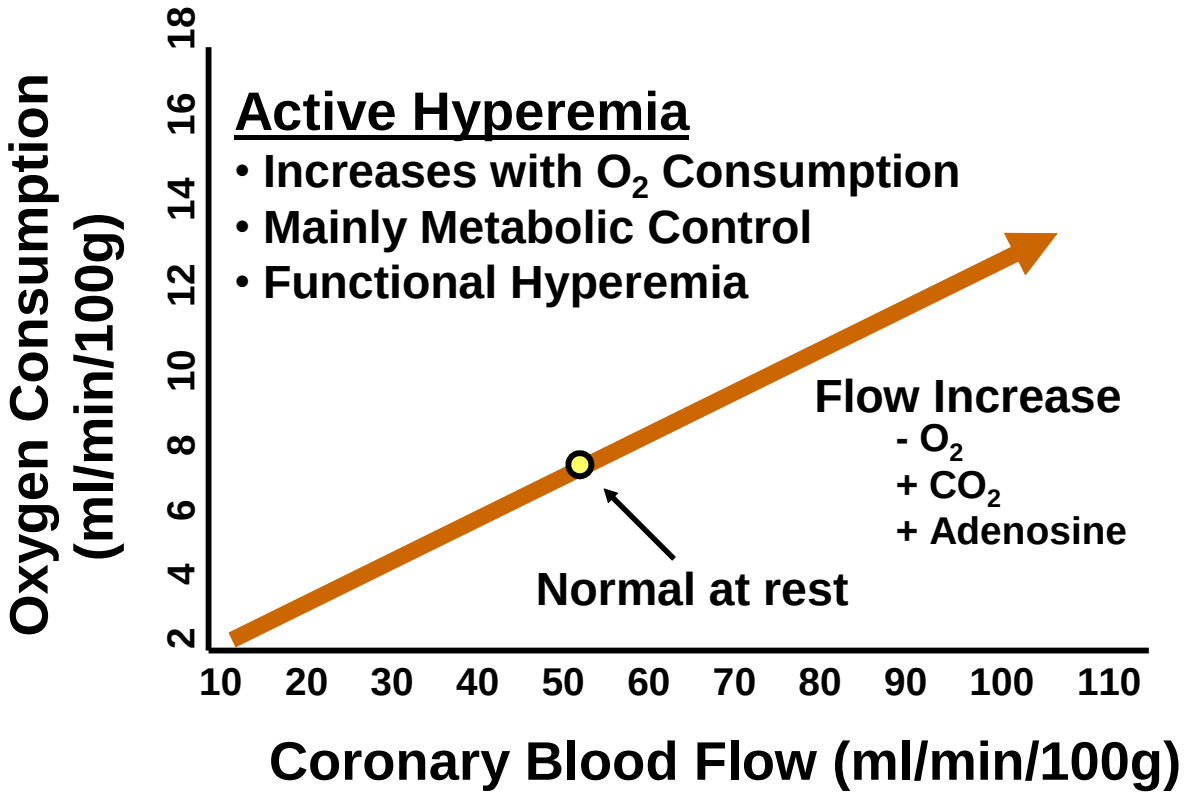
Metabolic Control: Defined

- Local blood flow change to match metabolic demand
- Referred to as Active or Functional Hyperemia

- Increased metabolic demand → increased flow
- Decreased metabolic demand → decreased flow

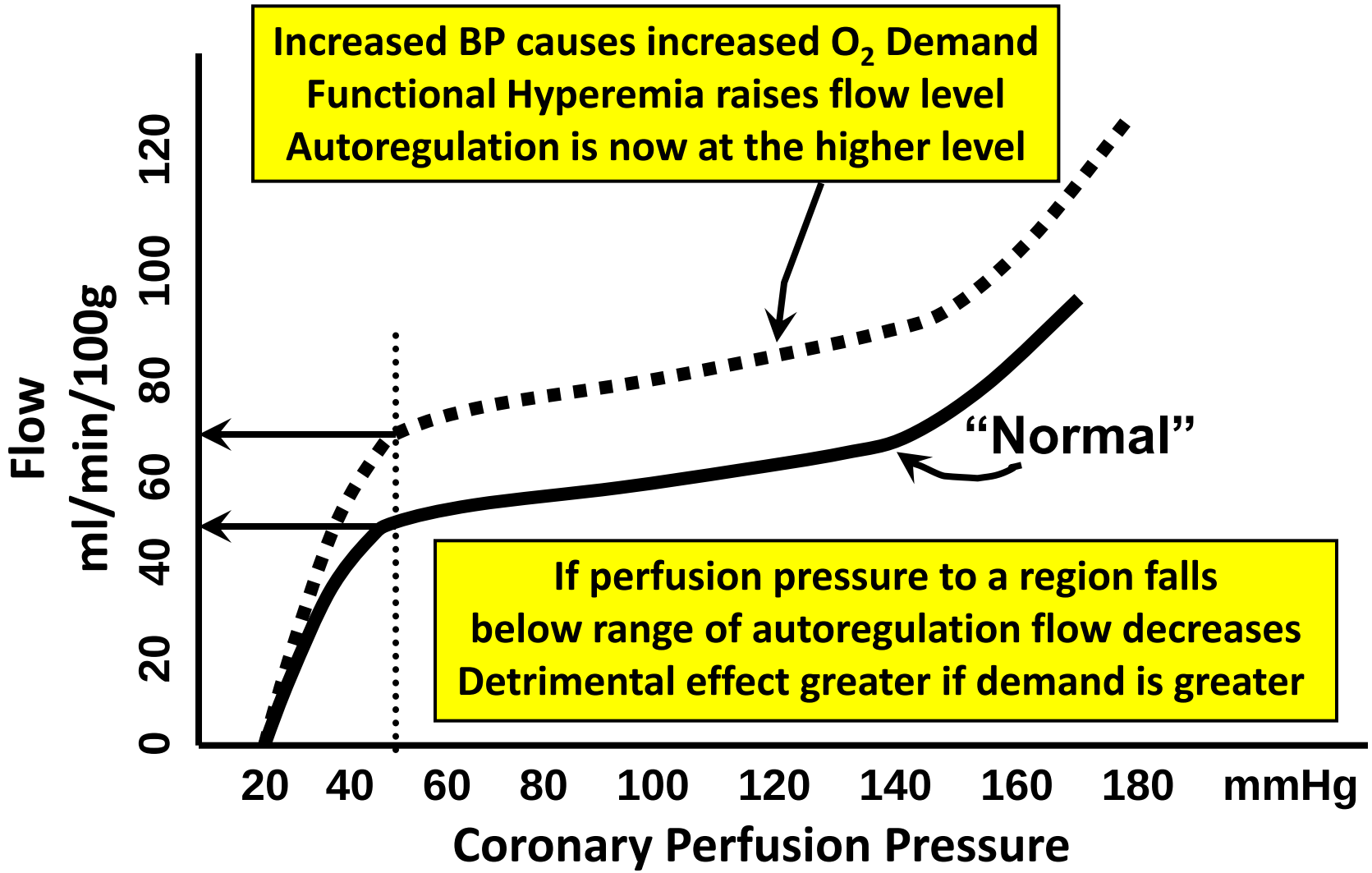


Metabolic Control: Illustrated



- Local Hypoxia
- Adenosine
- Local Acidosis
- CO_2
- Histamine
- Bradykinin
- Prostaglandins

Functional and Autoregulation Combined



Reactive Hyperemia: Defined

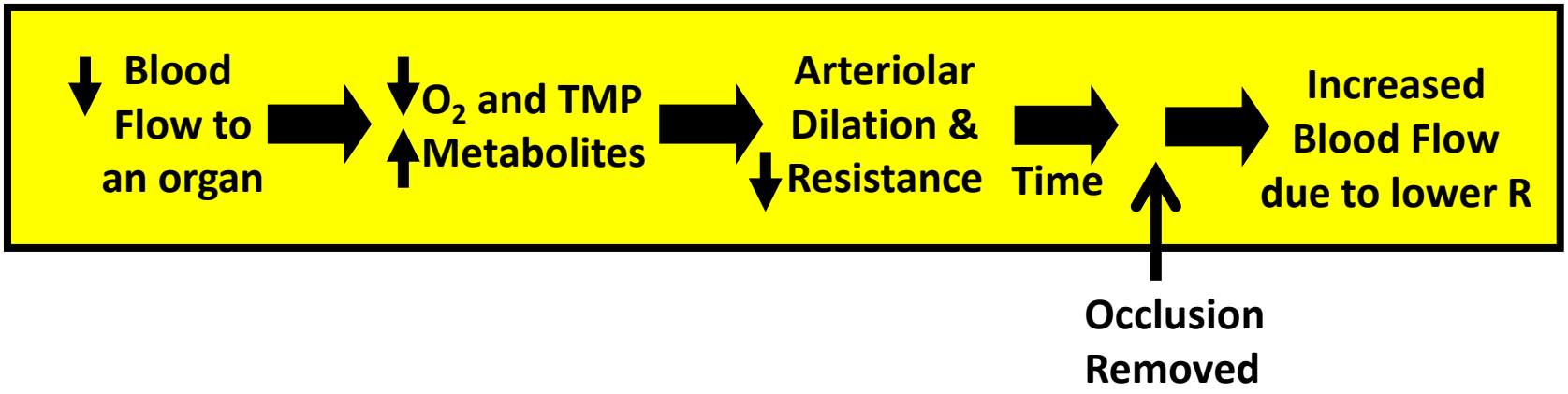
- Excess blood flow increase in response to prior deprivation
- Prior blood flow deficit usually transient then restored

Examples include

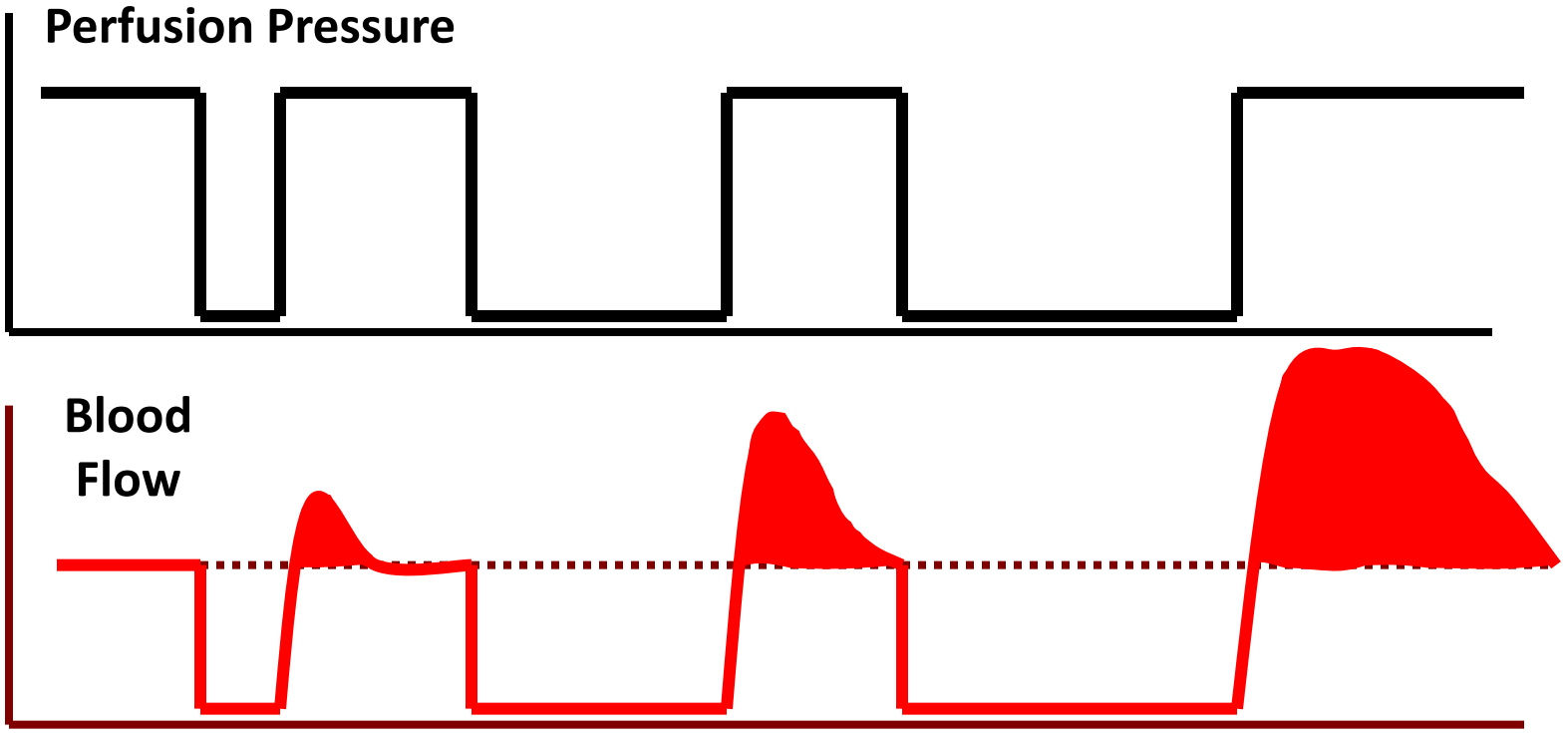
→ Clearing of a clot or embolus

→ Opening a blocked artery

→ Release of a clamp in surgery



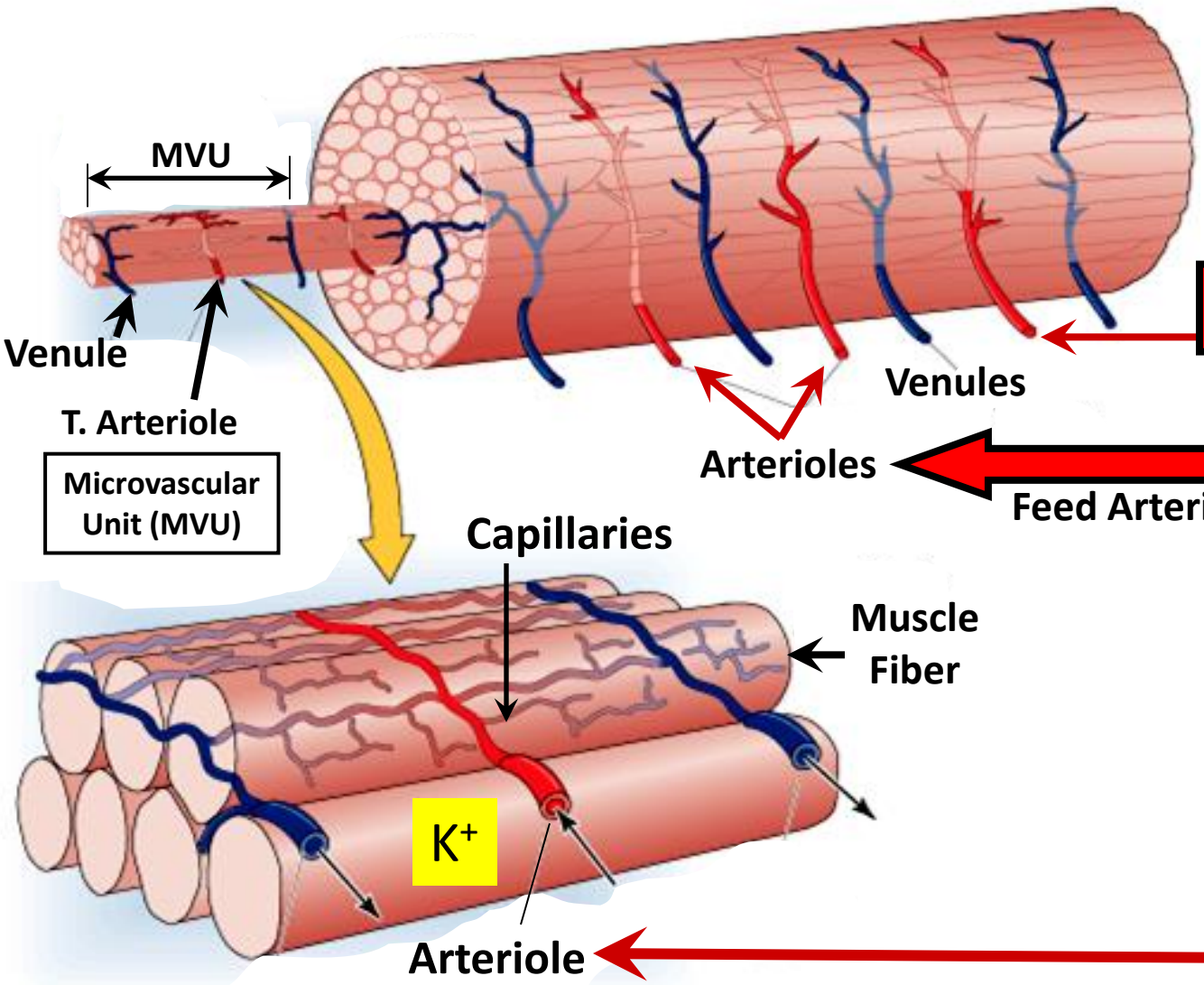
Reactive Hyperemia: Illustrated



Myogenic → Vasodilator Metabolites

Skeletal Muscle Control
Neurogenic
Metabolic

Skeletal Muscle



Muscle
~40% body mass
~ 20% of CO
~ 3 ml/min/100g

Sympathetic

Feed Arteries

Predominates at rest
1-2 Hz "Moderate" resistance
big range to Increase/decrease

~1/3 capillaries perfused

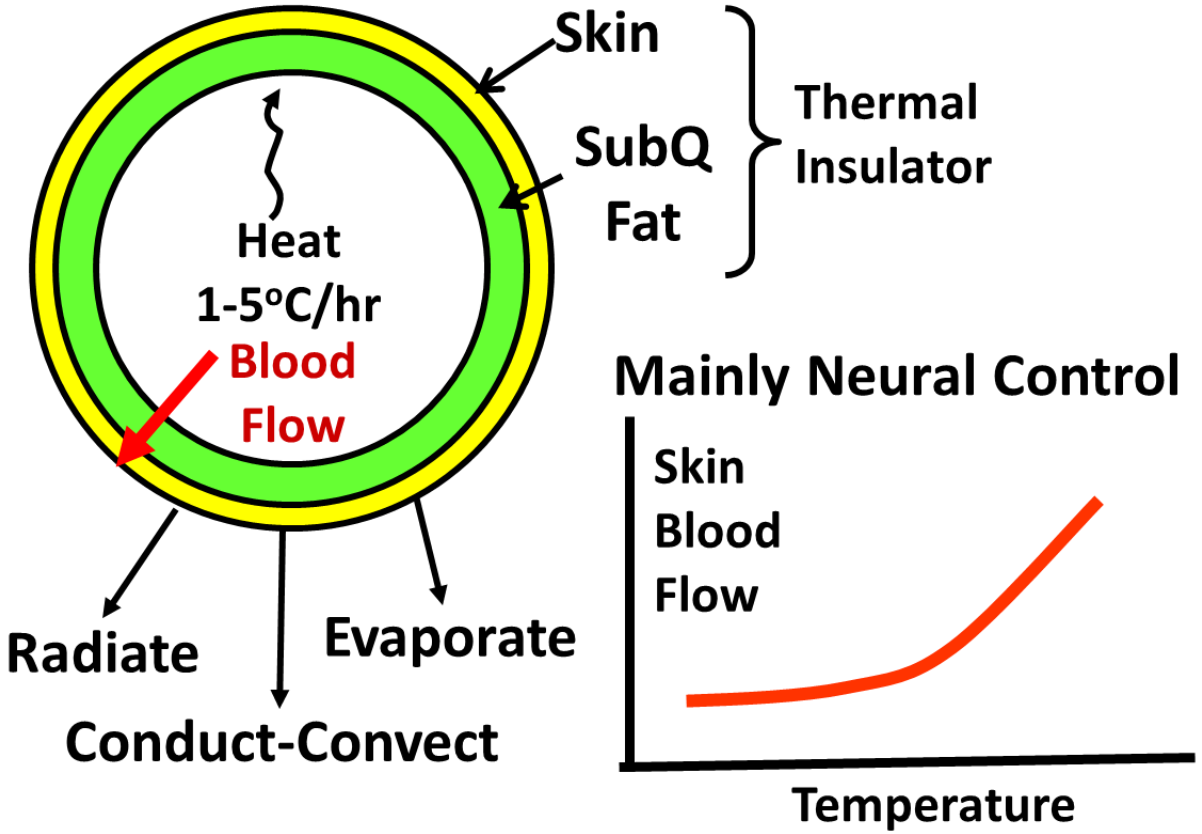
If BP fall baroreceptor control with Increased sympathetic 8-16 Hz --> +R

Exercise induced Metabolic vasodilation

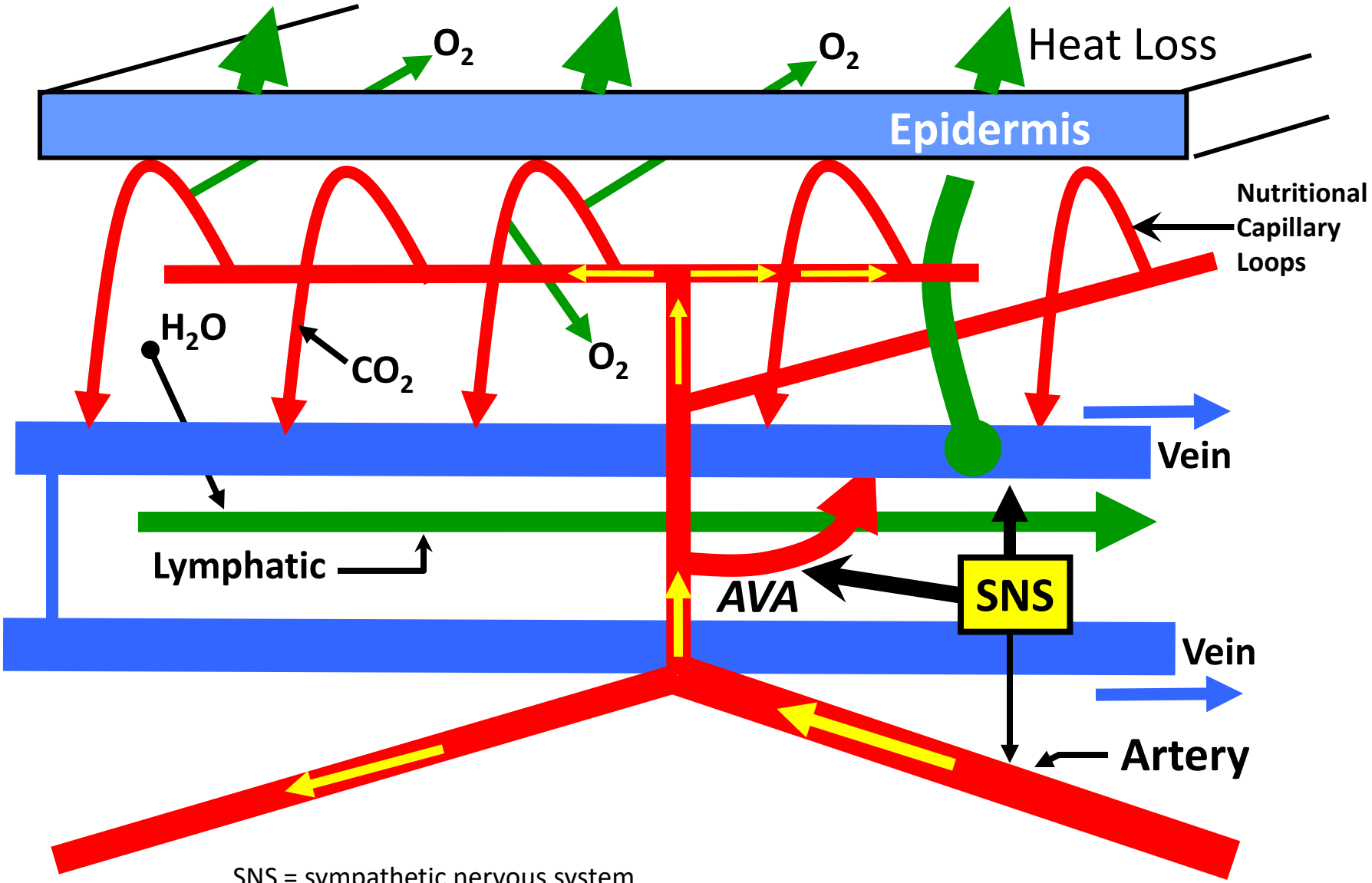
+K^+→ hyperpolarization related vasodilation

+Flow, +Cap recruitment, +O_2 extraction 30% →90%

Cutaneous Control
Nutritional
Thermal

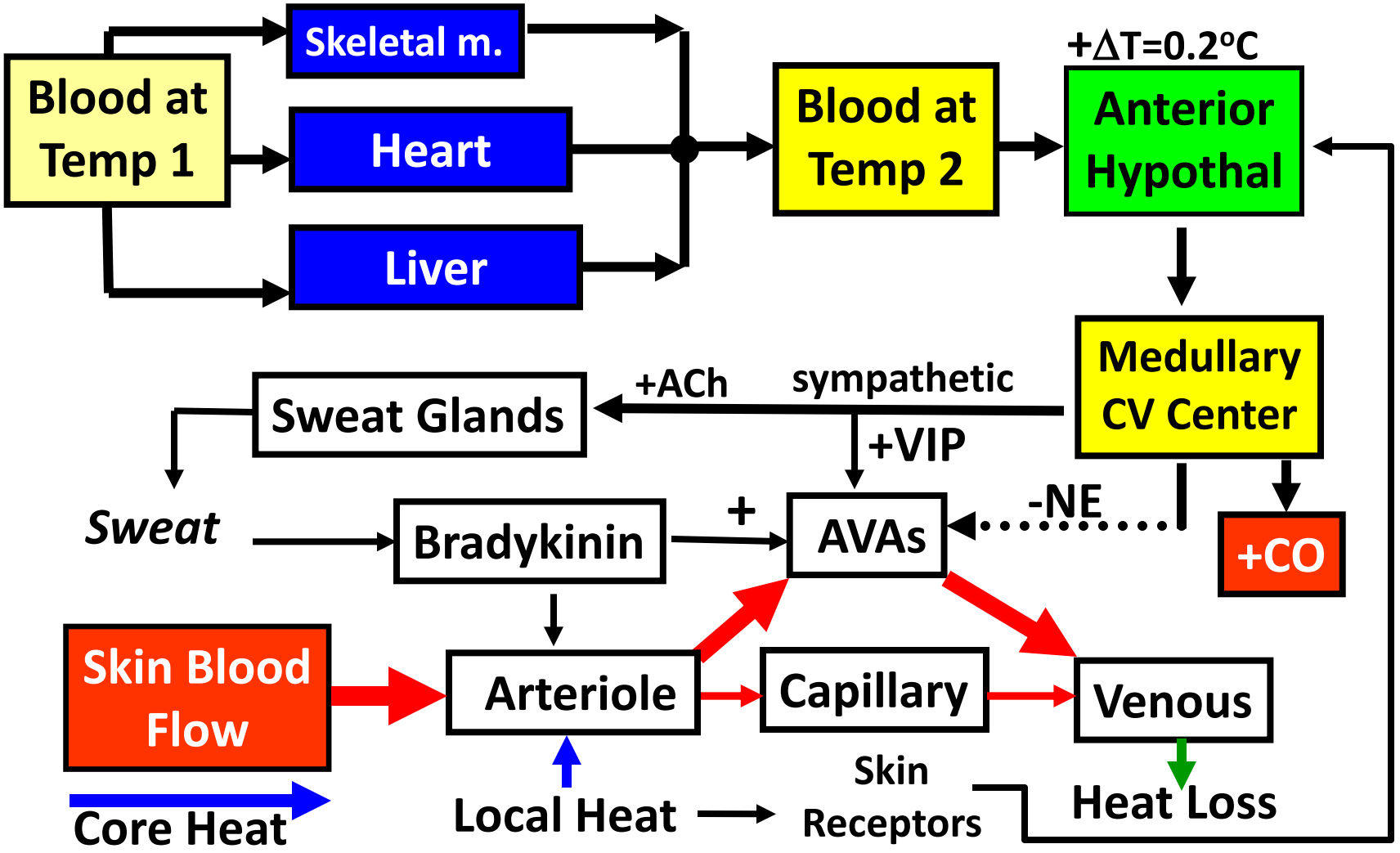


Skin



SNS = sympathetic nervous system
AVA = arterial venous anastomosis

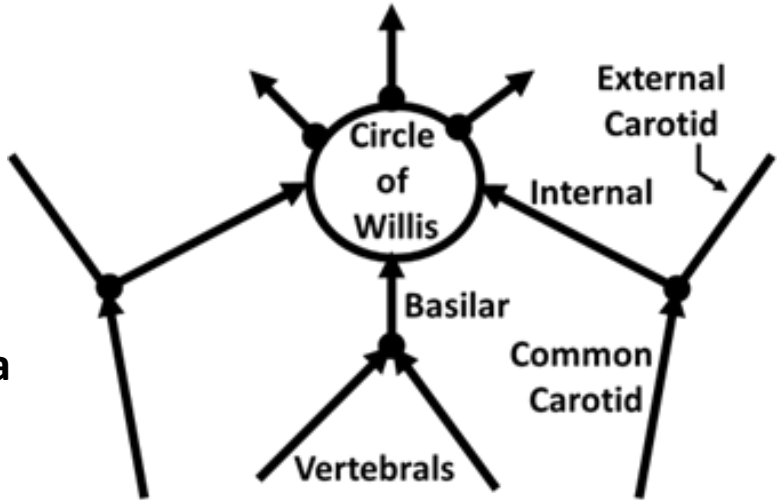
Skin Overall Control



Cerebral Circulation

Main Function

Maintain O_2 and glucose) to hypoxia-intolerant grey matter



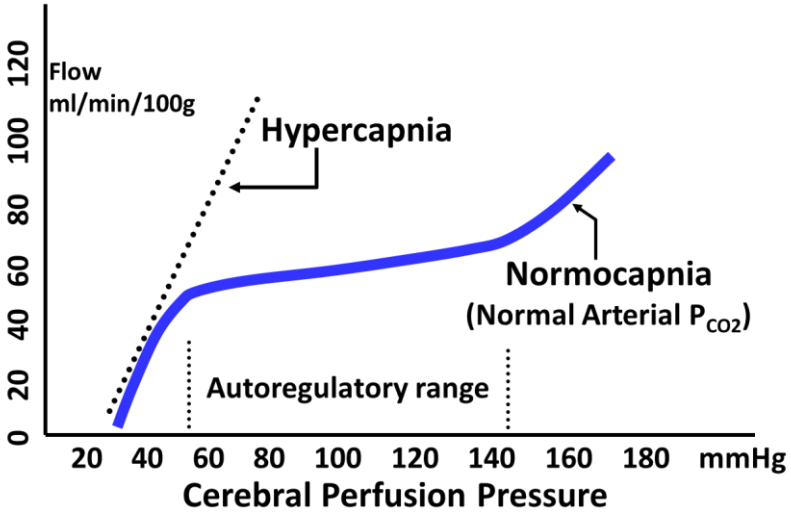
Main Features

- **Circle of Willis - Anatomical guard against ischemia**
- **High capillary density - Small O_2 diffusion distance**
- **Blood brain barrier - Stable neuronal environment**
- **High Basal Blood Flow ~ 50 ml/min/100g**
- **Brain can control own flow by changing BP**
- **Highly developed blood flow autoregulation**

Metabolic control with physiological vasodilators

- **Increased CO_2**
- **Decreased O_2 (P_{O2} < 50 mmHg)**
- **Increased K^+ or H^+**
- **Adenosine due to low O_2**

(Ischemia – Hypoxemia – Hypotension)



Splanchnic Circulation

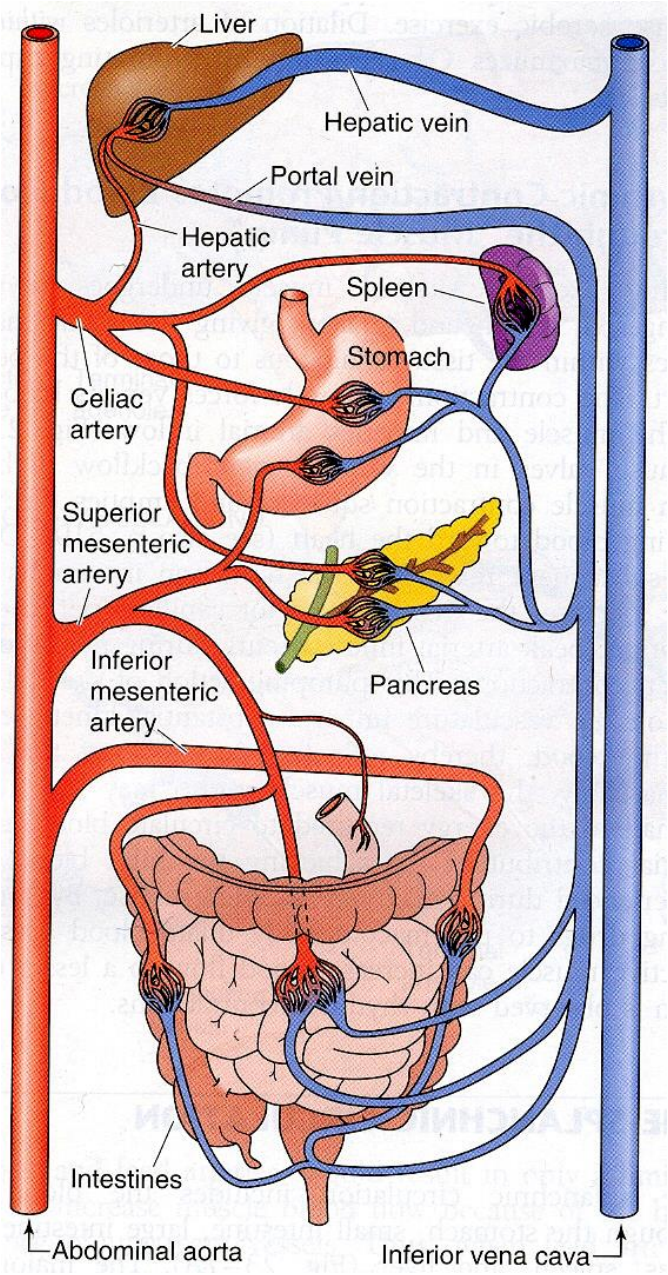
Blood flow through

- **Liver**
- **Spleen**
- **Stomach**
- **Pancreas**
- **Large Intestines**
- **Small Intestines**

Highly Interconnected Vascular Supply

In each gut region

- **Blood Flow ~ Metabolic Activity in that region ~ Digestive and Absorptive Activities in region**
- **Blood Flow increases sequentially from stomach to more distal segments in accordance with activity**



End CV Physiology Lecture 13

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