CVS
PHYSIOLOGY

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Cardiovascular Physiology

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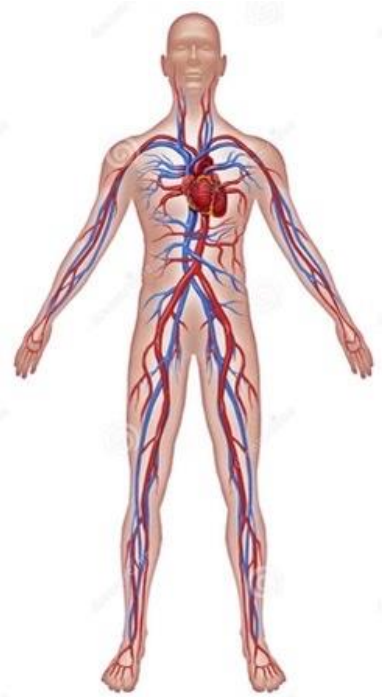

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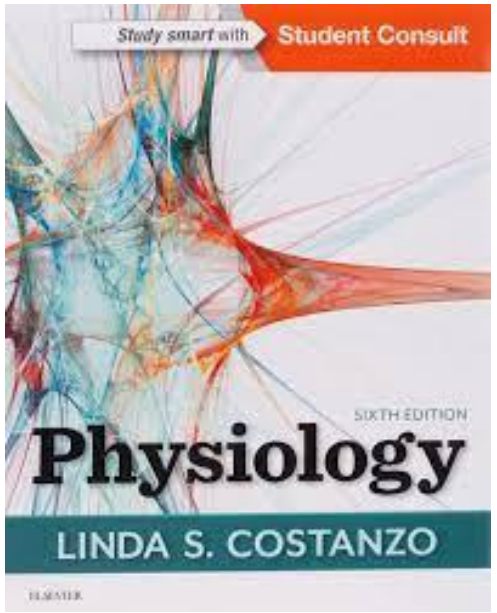
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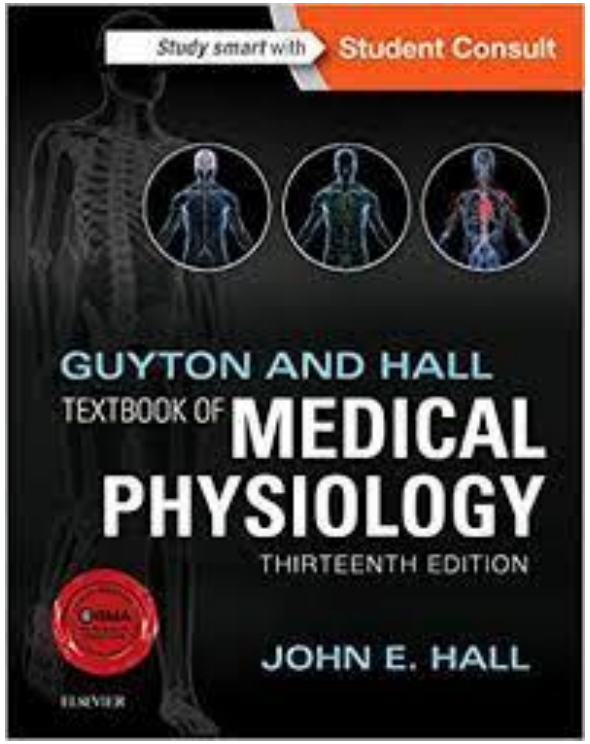
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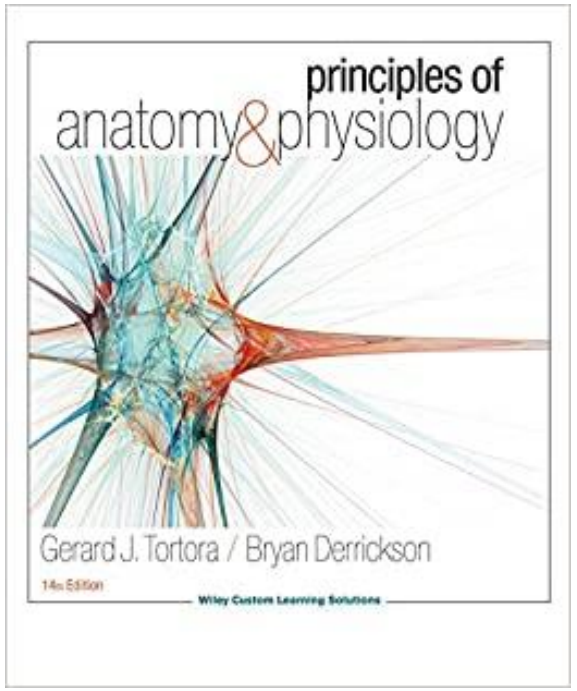
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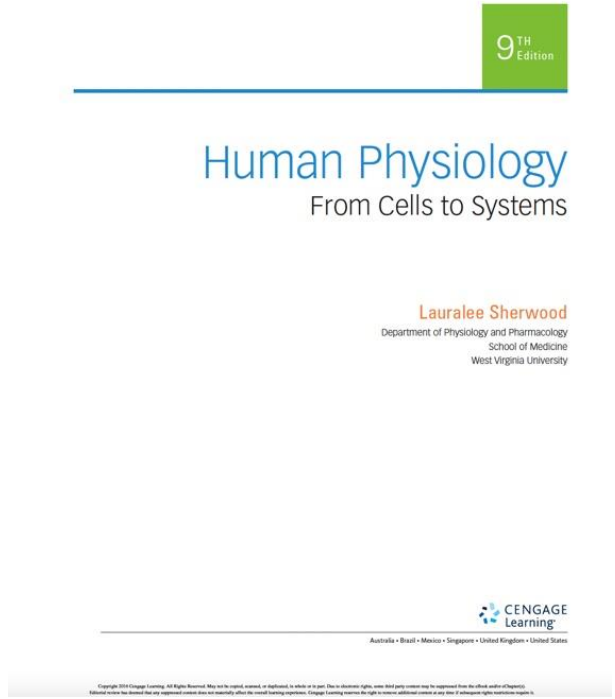
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ABP Regulation

- When we say blood pressure (BP), we are primarily talking about arterial blood pressure. And, when addressing the regulation of blood pressure, we are specifically referring to the regulation of mean arterial blood pressure (MABP).

Why ABP need to be regulated

- Mean arterial pressure is the main driving force for propelling blood to the tissues. This pressure must be closely regulated (in a certain range not lower or higher) for two reasons:

- First, it must be high enough to ensure sufficient driving pressure; without this pressure, the brain and other organs do not receive adequate flow, no matter what local adjustments are made in the resistance of the arterioles supplying them.

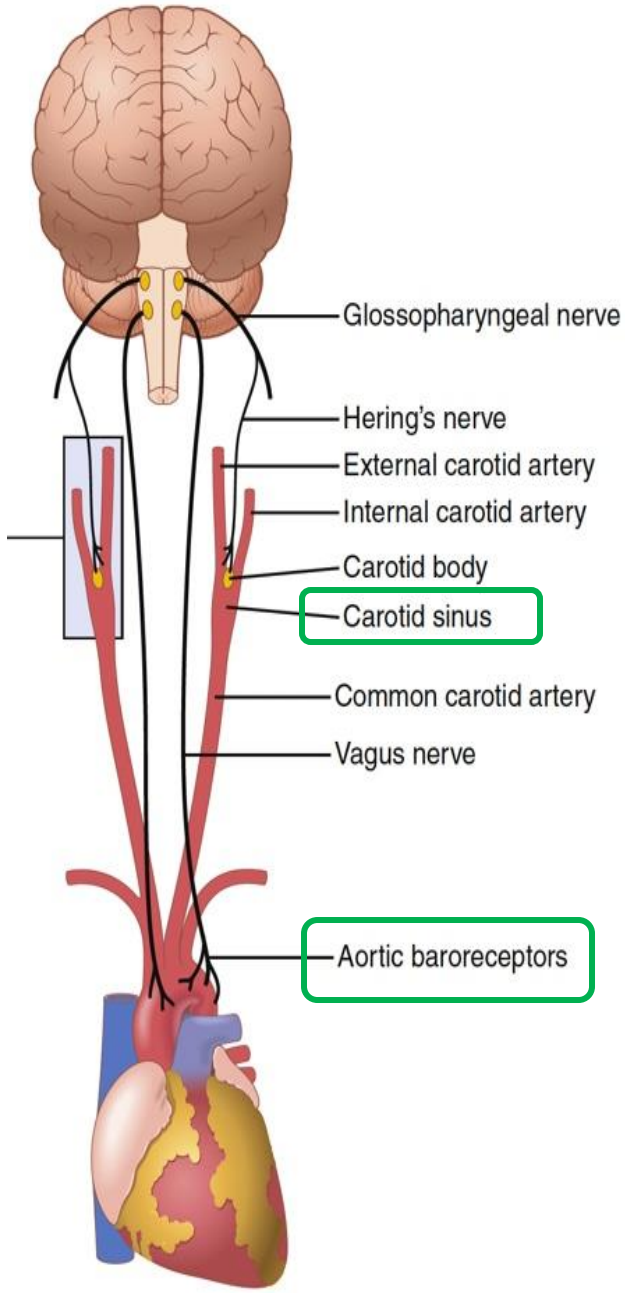
- Second, the pressure must not be so high that it creates extra work for the heart and increases the risk of vascular damage and possible rupture of small blood vessels (Certain hemorrhagic strokes occur as a result of extremely high blood pressure).

- As we know, the regulation of blood pressure (BP) can be either **neural or hormonal**. **Neural regulation** is characterized by its rapid, moment-to-moment action, allowing for quick control of BP. In contrast, **hormonal regulation** provides longer-term control, the renin-angiotensin-aldosterone system (RAAS) is the main hormonal regulator of BP (من التوجيهي و احنا نوخده زهقناه, ما رح نفصل فيه هون).

• If we want to talk about **rapid control**, we are referring to **neural reflexes**, which provide the fastest mechanism for regulating physiological changes. **A reflex always consists of five components:**

1. Sensory receptors: These are specialized receptors that detect specific changes. In the case of blood pressure, these are baroreceptors.
2. Afferent neurons: These neurons transmit information to the central nervous system (CNS) via action potentials, delivering the signal to the integrative centre.
3. Integrative centre: This is the part of the CNS responsible for processing the information and deciding how to respond to the change. Once a decision is made, it sends commands to the effectors.
4. Effector cells: These are the cells or organs where the changes occur. In the case of blood pressure regulation, the effectors are the heart and blood vessels.
5. Efferent neurons: These neurons carry the commands from the integrative centre to the effector cells.

- When discussing reflexes, always keep these components in mind.

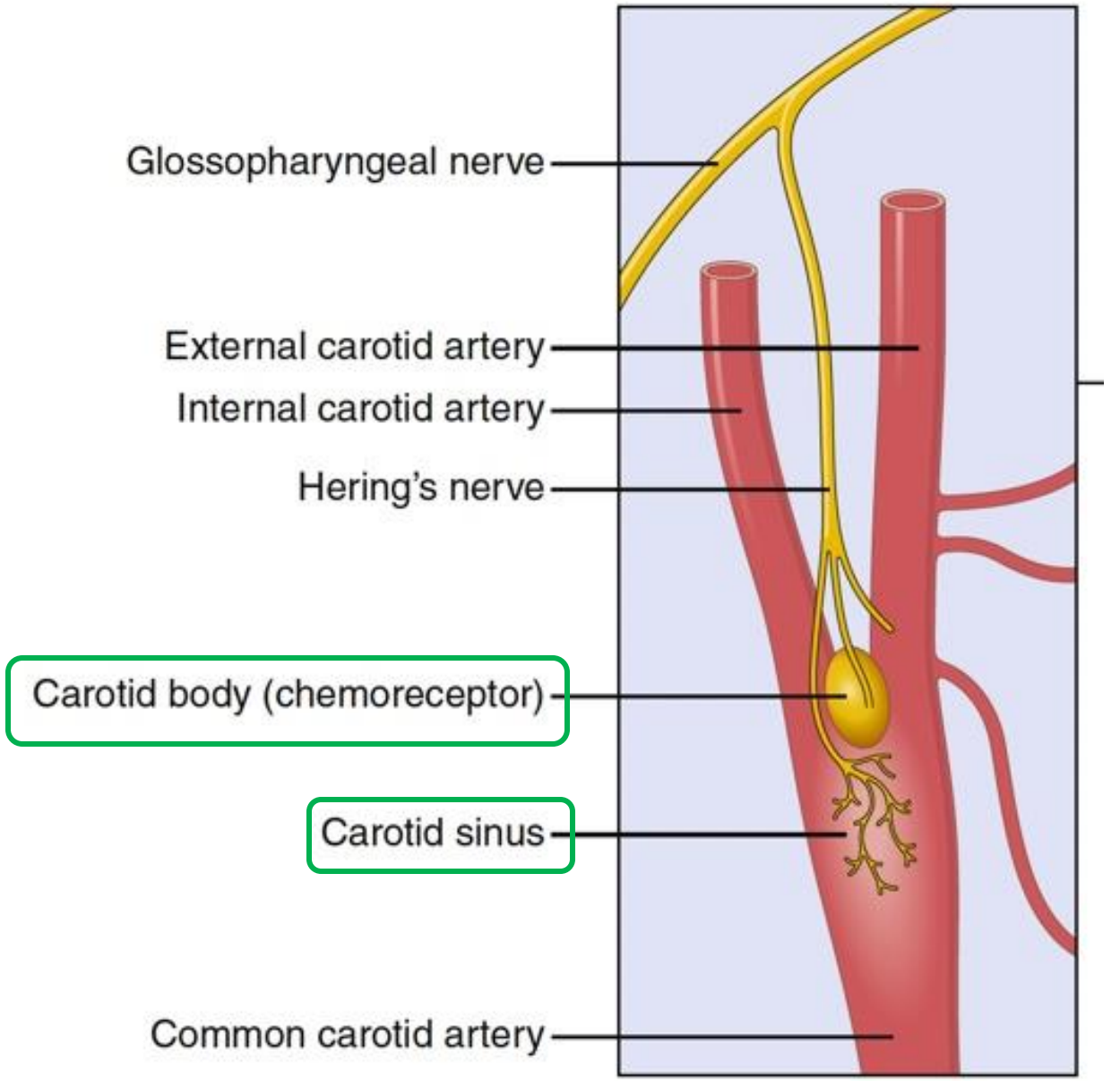


- When discussing the baroreflex, we are referring to the sensing of arterial blood pressure (ABP). Now, think about this: where is the best location for sensors to provide accurate information about blood pressure? The first location is the **aortic arch**.

- To understand why, recall the equation $F=\Delta P/R$

- In systemic circulation F represents cardiac output, R is the total peripheral resistance (TPR), and ΔP is the pressure difference between the aorta and the right atrium. If we assume that the pressure in the right atrium is approximately zero , then ΔP is the aortic pressure, okey, which pressure do we consider here? Mean arterial blood pressure (MABP). Thus, the aortic arch is the ideal location for the first sensory receptors (baroreceptors) to monitor changes in blood pressure (as it reflects the overall driving pressure in the body).

- The second location of sensory receptors (baroreceptors) is in the **carotid sinus.** It's important to note that the carotid sinus is a baroreceptor, while the carotid body is a chemoreceptor.

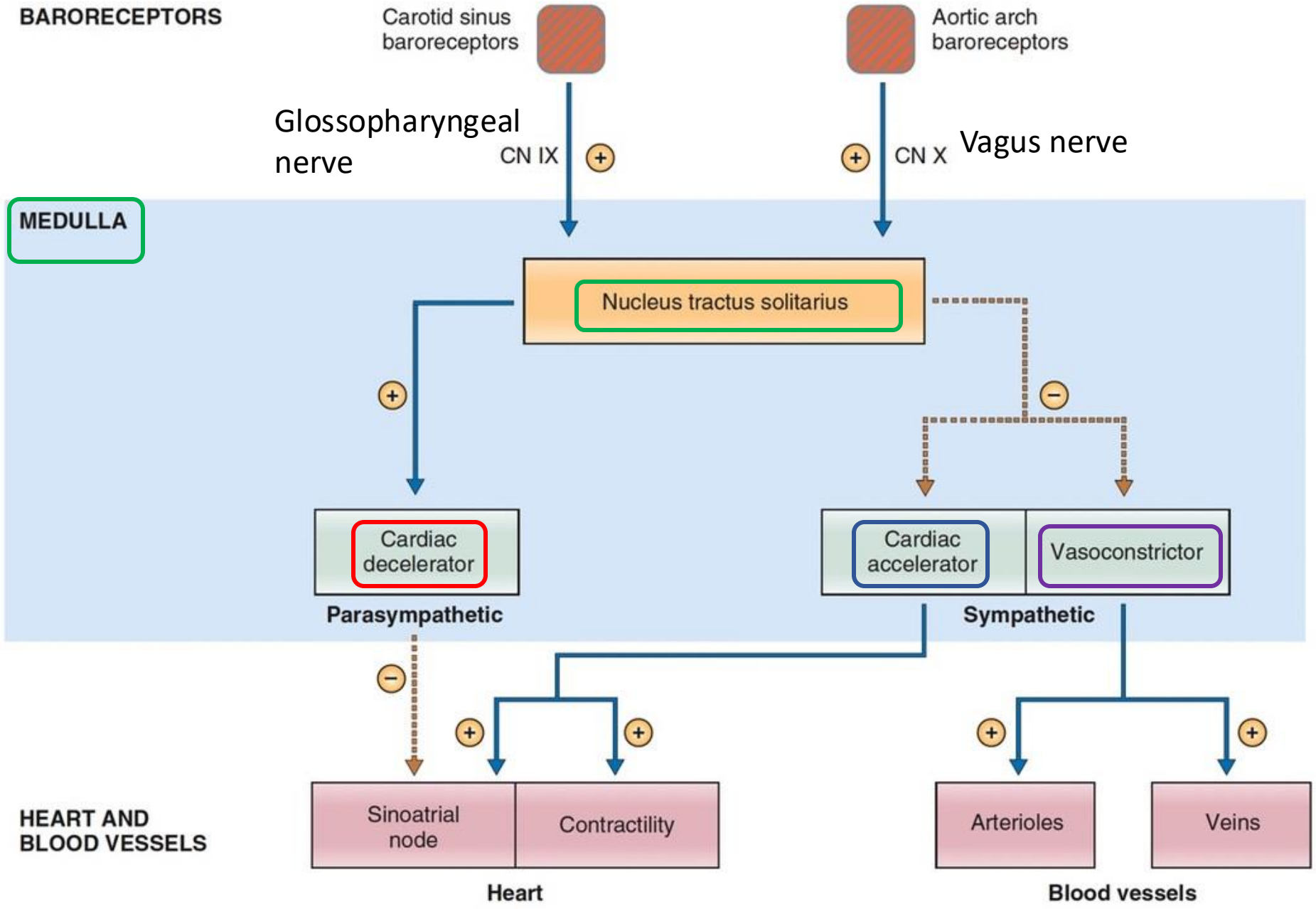

Glossopharyngeal nerve
External carotid artery
Internal carotid artery
Hering's nerve
Carotid body (chemoreceptor)
Carotid sinus
Common carotid artery

- The components of baroreceptors reflex:

1. Baroreceptor Sensory receptor: aortic arch and carotid sinus.
2. Afferent neurons: Glossopharyngeal (from carotid sinus) and Vagus (from aortic arch) nerves.
3. Integrative centre: In the brainstem specifically in the medulla (This is why it is very important to note that an injury to the brainstem is considered life-threatening, as it houses both the cardiovascular centre and the respiratory centre).
4. Efferent neurons: sympathetic and parasympathetic nervous systems.
5. Effector organs: Heart or blood vessels.

Baroreceptor reflex

- Blood pressure is sensed by baroreceptors in the carotid sinus and aortic arch (the best locations)
- Afferent information about blood pressure is then sent to the medulla via the glossopharyngeal (CN IX) and vagus (CN X) nerves.
- This information is integrated in the nucleus tractus solitarius, which then directs changes in the activity of several cardiovascular centers.
- These cardiovascular centers are tonically active, and the nucleus tractus solitarius simply directs, via the centers, increases or decreases in outflow from the sympathetic and parasympathetic nervous systems.


BARORECEPTORS
Carotid sinus baroreceptors
Aortic arch baroreceptors
Glossopharyngeal nerve
CN IX
CN X
Vagus nerve
MEDULLA
Nucleus tractus solitarius
Cardiac decelerator
Parasympathetic
Cardiac accelerator
Vasoconstrictor
Sympathetic
HEART AND BLOOD VESSELS
Sinoatrial node
Contractility
Heart
Arterioles
Veins
Blood vessels

➢ We mentioned that the afferent neurons transmit signals to the cardiovascular centre in the medulla. This information is processed in the nucleus tractus solitarius (NTS) , which receives input from the sensory receptors via the afferent neurons. The NTS analyses this information to determine whether blood pressure has increased or decreased.

➢ Then, NTS will affect different centres (see the previous slide):

1. Cardiac decelerator center: This is the parasympathetic center, which will decrease heart rate (HR).
2. Cardiac accelerator center: This is the sympathetic center, which will increase heart rate and contractility (thereby increasing stroke volume) because it works at the SA node .
3. Vasoconstrictor center (vasomotor): This center is responsible for vasoconstriction. The afferent input here is sympathetic, and as we know the sympathetic effect on the vasculature is vasoconstriction.

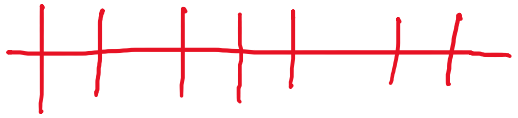
➢ It's important to note that sympathetic nerves innervate all blood vessels except the capillaries. However, when discussing blood pressure regulation, the focus is mainly on the arterioles and veins, as these are the primary vessels affecting blood pressure.

Q: how does the nucleus tractus solitarius know or differentiate if the blood pressure increased or decreased ?

The afferent neurons are tonically active, meaning that in resting state, the NTS receive a certain rate of action potential

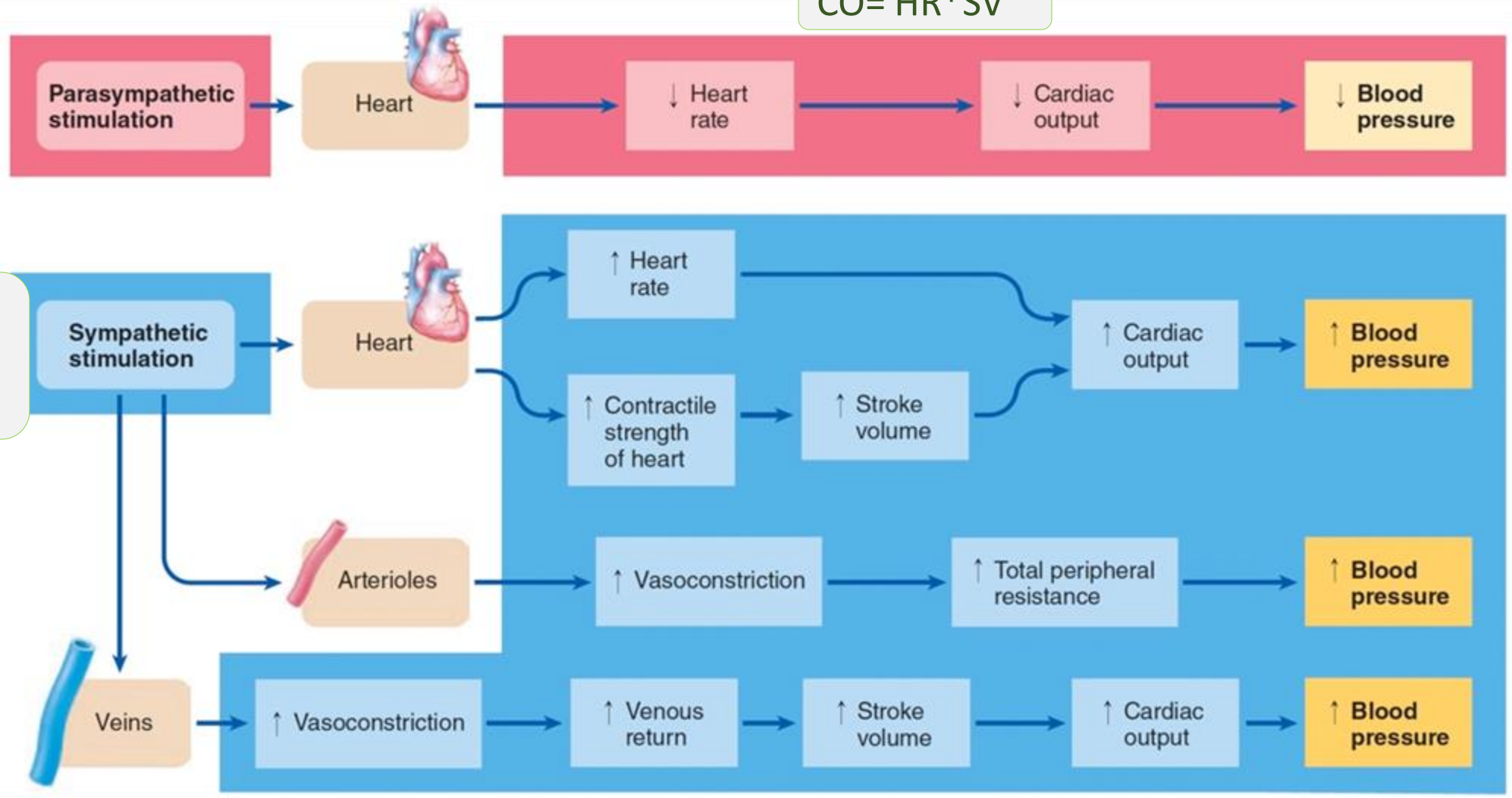
When blood pressure increases (e.g. when stretch of aortic arch cause baroreceptors stimulation), the firing rate increases, so more frequent action potential reaching the NTS. In this context the NTS will activate the parasympathetic side and inhibit the sympathetic to decrease Blood Pressure

On the other hand, When blood pressure decreases (e.g. hemorrhage, heart failure), less firing frequency so less action potentials, and the NTS will react to increase the Blood Pressure by stimulating sympathetic and decreasing parasympathetic



Focus on the diagram and read everything

CO= HR*SV



Sympathetic will affect the heart and the vessels

- One of the key effects of sympathetic stimulation on the vasculature is generalized vasoconstriction.

- The importance of increasing total peripheral resistance (TPR) through sympathetic stimulation lies in its ability to raise blood pressure (BP), which enhances the driving force for blood flow to organs. However, sympathetic stimulation also causes vasoconstriction in the arterioles, reducing local blood flow to these organs. This raises a valid question: **What is the benefit if local blood flow decreases?**
- To address this, consider the following:

1. Local control mechanisms override sympathetic stimulation: If an organ requires more blood supply and nutrients, its local control mechanisms (such as metabolic vasodilation) can override the vasoconstriction caused by sympathetic stimulation. This ensures that the organ receives adequate blood flow despite systemic sympathetic activity.

2. Variable sensitivity of different vascular beds to sympathetic stimulation:

- The strength of vasoconstriction induced by sympathetic stimulation varies across organs:

Most responsive: Gastrointestinal tract, kidneys , and skin.

Less responsive: Skeletal muscles and the heart.

No response: The brain, which lacks alpha receptors for sympathetic stimulation. This is crucial because maintaining constant blood flow to the brain is essential for its function and survival.

By prioritizing blood flow where it is most needed and adjusting the responsiveness of different organs, the body effectively balances systemic and local demands during sympathetic activation.

Nervous regulation of the circulation

- In most tissues, all the vessels except the capillaries are innervated.
- The innervation of the small arteries and arterioles allows sympathetic stimulation to increase resistance to blood flow and thereby decrease the rate of blood flow through the tissues.
- The innervation of the large vessels, particularly of the veins, makes it possible for sympathetic stimulation to decrease the volume of these vessels. This decrease in volume can push blood into the heart and thereby plays a major role in regulation of heart pumping

Nervous regulation of the circulation

- Sympathetic stimulation markedly increases the activity of the heart, both increasing the heart rate and enhancing its strength and volume of pumping.

- Parasympathetic stimulation causes a marked decrease in heart rate and a slight decrease in heart muscle contractility.

- This sympathetic vasoconstrictor effect is especially powerful in the kidneys, intestines, spleen, and skin but is much less potent in skeletal muscle, heart, and the brain.

Rapid control of arterial pressure by nervous system

- Three major changes occur due to sympatsimultaneously, each of which helps increase arterial pressure:

1. Most arterioles of the systemic circulation are constricted, which greatly increases the total peripheral resistance, thereby increasing the arterial pressure.

2. The veins especially (but the other large vessels of the circulation as well) are strongly constricted. This constriction displaces blood out of the large peripheral blood vessels toward the heart (increase the venous return), thus increasing the volume of blood in the heart chambers.

3. The stretch of the heart then causes the heart to beat with greater force and therefore to pump increased quantities of blood. This also increases the arterial pressure.

Rapid control of arterial pressure by nervous system

- Finally, the heart is directly stimulated by the autonomic nervous system, further enhancing cardiac pumping.
- Much of this enhanced cardiac pumping is caused by an increase in the heart rate, which sometimes increases to as much as three times normal.
- In addition, sympathetic nervous signals directly increase the contractile force of the heart muscle, increasing the capability of the heart to pump larger volumes of blood.
- During strong sympathetic stimulation, the heart can pump about two times as much blood as under normal conditions, which contributes still more to the acute rise in arterial pressure.

Baroreceptor reflex

- A rise in arterial pressure stretches the baroreceptors and causes them to transmit signals into the CNS.

- Feedback signals are then sent back through the autonomic nervous system to the circulation to reduce arterial pressure down toward the normal level.

- In the normal operating range of arterial pressure, around 100 mm Hg, even a slight change in pressure causes a strong change in the baroreflex signal to readjust arterial pressure back toward normal. Thus, the baroreceptor feedback mechanism functions most effectively in the pressure range where it is most needed

Baroreceptor reflex

- Although the baroreceptors are sensitive to the absolute level of pressure, they are even more sensitive to changes in pressure and the rate of change of pressure.

- The strongest stimulus for the baroreceptors is a rapid change in arterial pressure.

- That is, if the mean arterial pressure is 150 mm Hg but at that moment is rising rapidly, the rate of impulse transmission may be as much as twice that when the pressure is stationary at 150 mm Hg.

Baroreceptor reflex

- Pressure buffer system:
- A primary purpose of the arterial baroreceptor system is therefore to reduce the minute-by-minute variation in arterial pressure to about one-third that which would occur if the baroreceptor system were not present.

- The extreme variability of pressure caused by simple events of the day, such as lying down, standing, excitement, eating, defecation, and noises is minimized.

- When the baroreceptors were functioning normally, the mean arterial pressure remained within a narrow range of between 85 and 115 mm Hg throughout the day and, for most of the day, it remained at about 100 mm Hg.

During normal activities in the day, BP changes are high, the fluctuations in BP is high, and this is not healthy to our bodies. To solve this issue, the baroreceptor buffer reflex will narrow the fluctuations in BP

If the nerves were denervated, the buffer system of baroreceptors wouldn't work, so that will cause highly fluctuating BP.

This system is highly organized, it can detect rapid changes in BP and correct it by returning it back to normal narrow range.

Orthostatic hypotension

- One of the applications of baroreceptor reflex

- The ability of the baroreceptors to maintain relatively constant arterial pressure in the upper body is important when a person stands up after lying down.

- Immediately on standing, the arterial pressure in the head and upper part of the body tends to fall, and marked reduction of this pressure could cause loss of consciousness.

- However, the falling pressure at the baroreceptors elicits an immediate reflex, resulting in strong sympathetic discharge throughout the body that minimizes the decrease in pressure in the head and upper body.

Orthostatic hypotension is the decrease of BP in the head and upper body due to pooling down of the blood to lower extremities.
So, if the person have functioned baroreceptor reflex, orthostatic hypotension and the fainting (due to decreased blood flow to the brain) shouldn't happen.
Certain pathologies (e.g. autonomic dysfunction and diabetes) cause orthostatic hypotension due to baroreceptors reflex dysfunction

- For this reason, we advise inpatients to stand up slowly and not suddenly

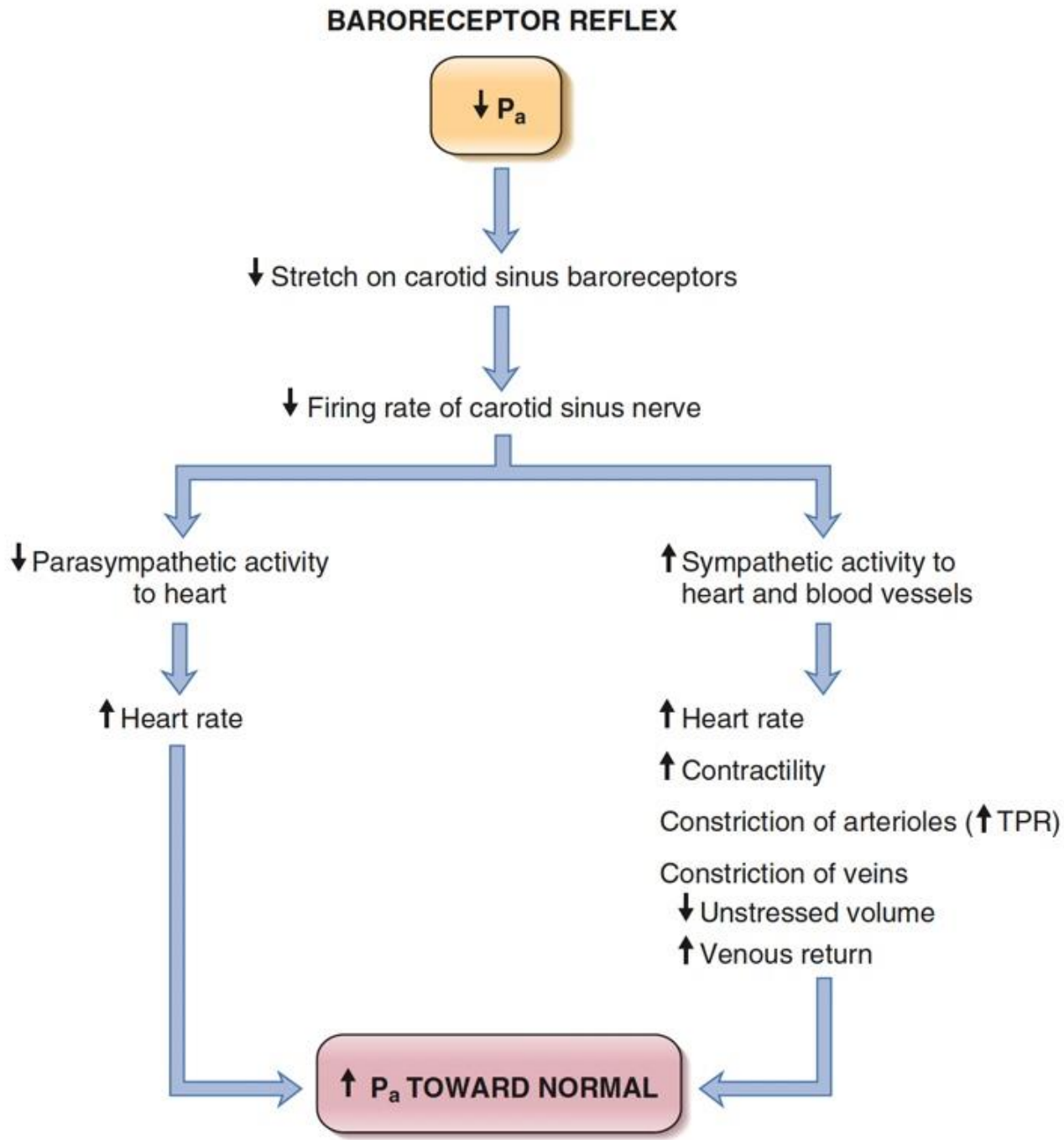
Baroreceptor reflex

- Relatively unimportant in chronic regulation of arterial pressure is that they tend to reset in 1 to 2 days to the pressure level to which they are exposed. That is, if the arterial pressure rises from the normal value of 100 to 160 mm Hg, a very high rate of baroreceptor impulses is at first transmitted. During the next few minutes, the rate of firing diminishes considerably. Then, it diminishes much more slowly during the next 1 to 2 days, at the end of which time the rate of firing will have returned to nearly normal, despite the fact that the mean arterial pressure still remains at 160 mm Hg. Conversely, when the arterial pressure falls to a very low level, the baroreceptors at first transmit no impulses but gradually, over 1 to 2 days, the rate of baroreceptor firing returns toward the control level.

The baroreceptor reflex works best for a rapid (acute) change in BP rather than the absolute number of BP.

If the BP was 100, and after minutes it changed to 160 mmHg, this will activate the baroreceptor reflex. The baroreceptor reflex respond to changes in BP within seconds, minutes, during a day or two, but after that do you think, the reflex will continue responding? No, there will be neural reflex instead, and generally speaking, if the changes in BP remained continuous, this will cause adaptation.

What do we mean by adaptation? Means that the BP will reset to a new reset point, 160 mmHg in our example, and this will be the normal point that the baroreceptor reflex will work around (This happens in chronic hypertension patients). Why does that happened? Because we have been there for a long time, and the baroreceptor reflex doesn't really work in chronic changes.

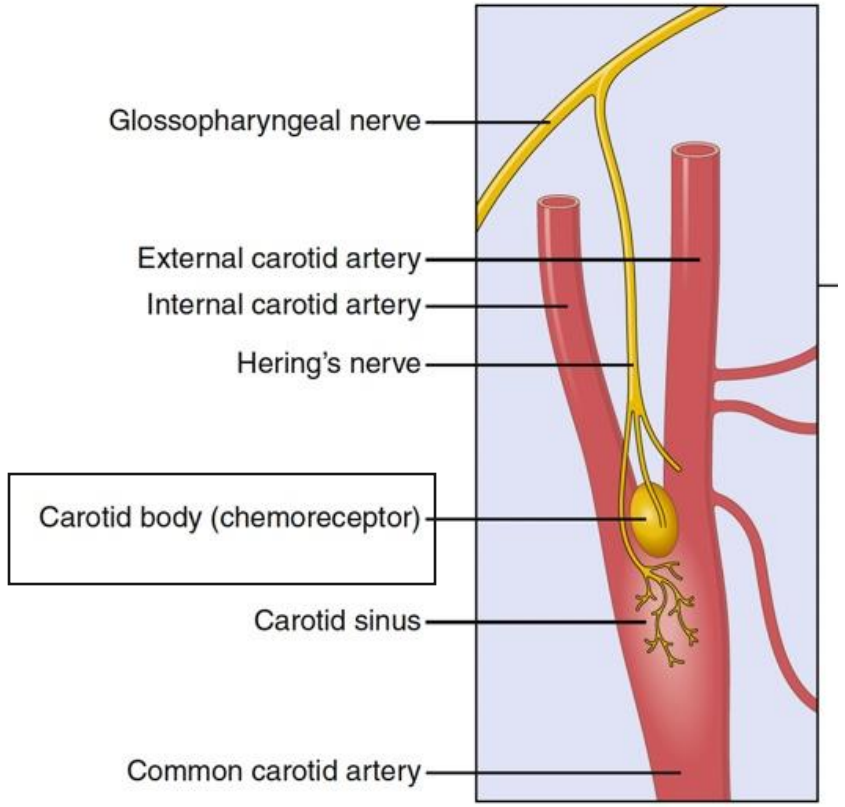

BARORECEPTOR REFLEX
↓ P_a
↓ Stretch on carotid sinus baroreceptors
↓ Firing rate of carotid sinus nerve
↓ Parasympathetic activity to heart
↑ Sympathetic activity to heart and blood vessels
↑ Heart rate
↑ Heart rate
↑ Contractility
Constriction of arterioles (↑ TPR)
Constriction of veins
↓ Unstressed volume
↑ Venous return
↑ P_a TOWARD NORMAL

Chemoreceptor reflex

- Chemoreceptor organs: carotid bodies and aortic bodies.

There's another reflex mechanism, **the chemoreceptor reflex.** As we said about local blood flow, there are chemicals that will change in concentration, this changes will be detected by chemoreceptors, like changes in O2, CO2 and H+.
There are **central** chemoreceptors & **peripheral** chemoreceptors, these are the peripheral ones

Important note: peripheral chemoreceptors are more sensitive to (low) O2 concentration rather than CO2 or H+ concentrations.



Aortic body doesn't appear in this image

- Sensitive to lowO2 or elevated CO2 and H+.

- The signals transmitted from the chemoreceptors excite the cardiovascular center, and this response elevates the arterial pressure back toward normal.

When chemoreceptors detect low O2 in local area, it will stimulate the sympathetic side in order to increase the BP and return O2 concentration into normal. (And this is the reflex..)

- However, this chemoreceptor reflex is not a powerful arterial pressure controller until the arterial pressure falls below 80 mmHg. Therefore, it is at the lower pressures that this reflex becomes important to help prevent further decreases in arterial pressure

Central chemoreceptors

- Central chemoreceptors are located in the medulla. They are most sensitive to CO_2 and pH and less sensitive to O_2.

  - They're more sensitive to **high CO_2** and **high H^+ (low pH)**, why is that? One of the reasons is that these chemicals can **change the excitability of neuronal cells**, so it's important to **detect** the **change** in their concentrations **early**.

• If the brain becomes ischemic (i.e., there is decreased cerebral blood flow), cerebral PCO2 immediately increases and pH decreases. The medullary chemoreceptors detect these changes and direct an increase in sympathetic outflow that causes intense arteriolar vasoconstriction in many vascular beds and an increase in TPR. Blood flow is thereby redirected to the brain to maintain its perfusion. As a result of this vasoconstriction, BP increases dramatically, even to life-threatening levels.

If CO2 concentration increased in the brain, central chemoreceptors will detect this, and it will stimulate the sympathetic to increase the BP. What is the mechanism? It will cause vasoconstriction →increase TPR →increase BP. Wait a minute, if I caused vasoconstriction in the arteriole in the brain, I am worsening the condition, is that right? Good thinking, but you forget something important, that is the brain arterioles don't have alpha1 receptors, so they don't respond to the sympathetic vasoconstriction =D, so I'm here somehow redirecting the blood flow toward the brain, because the brain is more important than other tissues, even if the flow redirection is at the expense of other tissues and organs.

Additional from the writer: Notice that both peripheral and central chemoreceptors stimulate the sympathetic in their reflexes in order to solve their issue

These chemoreceptors reflexes (whether central or peripheral) are not robust like baroreceptor reflex in controlling BP. They're more related to respiratory reflexes (O2 level, CO2 level, more to come in RS). Also they work more and better at low BP as mentioned in the slides

Atrial and pulmonary artery reflexes

- Another type of reflex in CNS

- The atria and pulmonary arteries have stretch receptors in their walls called low-pressure receptors. Because the pressure in them is low
- Low-pressure receptors are similar to the baroreceptor stretch receptors of the large systemic arteries.
- These low-pressure receptors play an important role, especially in minimizing arterial pressure changes in response to changes in blood volume.

- So what is the main effects that will occur in response to change (increase) in volume ?

We are working on blood volume ; more effect on the kidney . Increasing the filtration and decreasing the absorption

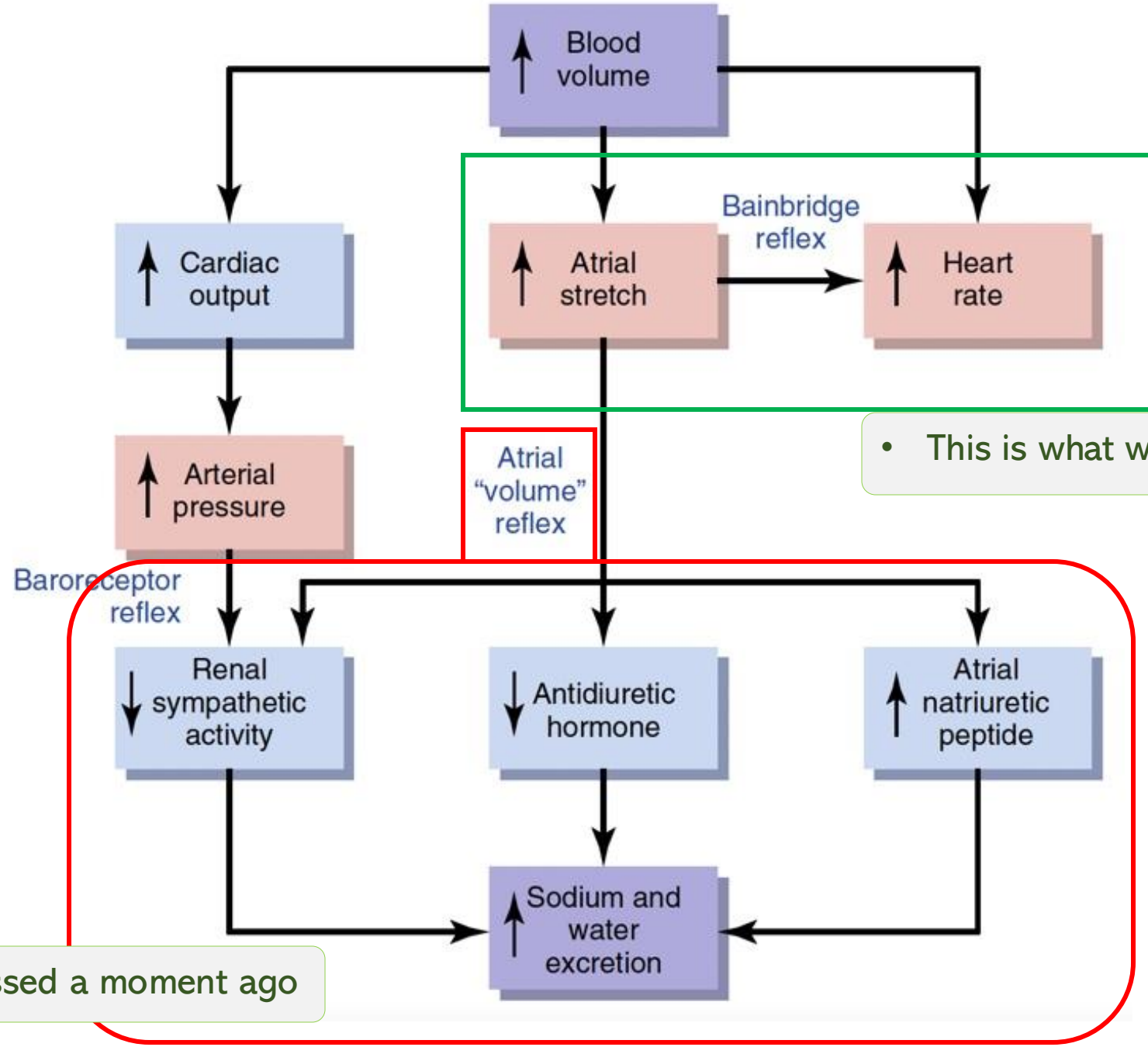
Atrial reflexes

1) Because the blood volume increased I want to decrease it. Thus , going to the kidneys causing renal sympathetic activity .

- 1Increase in volume will cause Stretch of the atrial wall and activation of low-pressure atrial receptors, this will cause reflex reductions in renal sympathetic nerve activity, decreased tubular reabsorption, and dilation of afferent arterioles in the kidneys. This will decrease the blood volume
- 2 Signals are also transmitted simultaneously from the atria to the hypothalamus to **decrease** secretion of antidiuretic hormone (**ADH**).
- The combination of these effects—an increase in glomerular filtration and a decrease in reabsorption of the fluid—increases fluid loss by the kidneys and attenuates the increased blood volume.
- 3 Atrial stretch caused by increased blood volume also elicits release of atrial natriuretic peptide (ANP), a hormone that adds further to the excretion of sodium and water in the urine and return of blood volume toward normal.

- From the name, **natri**: natrium (sodium, Na)
- **uretic**: excretion in urine.

Atrial reflexes mainly response to high blood volume by increasing the water and salt secretion , to decrease the blood volume



- This is what we will discuss next

- This is what we discussed a moment ago

Bainbridge reflex

- Increases in atrial pressure sometimes increase the heart rate as much as 75%, particularly when the prevailing heart rate is slow.
- When the heart rate is rapid, atrial stretch cause by infusion of fluids may reduce the heart rate due to activation of arterial baroreceptors. Thus, **the net effect** of increased blood volume and atrial stretch on heart rate **depends** on the relative contributions of the baroreceptor reflexes (which tends to slow the heart rate) and the Bainbridge reflex which tends to accelerate the heart rate,

- When blood volume and atrial stretching increase, that will increase the heart rate. Is this what we will expect? No. when blood pressure is increased, baroreceptor reflex will respond by decreasing the heart rate
- But in Bainbridge reflex, the result is increase in heart rate.
- So what will be the net effect? It's different in different situations, the one with higher effect than the other will affect the heart rate

CNS ischemic response

- One of the responses that the brain use to control its blood flow

- arterial pressure elevation in response to cerebral ischemia is known as the CNS ischemic response.
- The ischemic effect on vasomotor activity can elevate the mean arterial pressure dramatically, sometimes to as high as 250 mm Hg for as long as 10 minutes.
- The degree of sympathetic vasoconstriction caused by intense cerebral ischemia is often so great that some of the peripheral vessels become totally or almost totally occluded.
- The kidneys, for example, often cease their production of urine entirely because of renal arteriolar constriction in response to the sympathetic discharge. Therefore, the CNS ischemic response is one of the most powerful of all the activators of the sympathetic vasoconstrictor system.

- When blood supply is decreased to the brain, sort of ischemic changes will happen, CO2 & H+ will increase, chemoreceptors will detect that, causing sympathetic stimulation and redirecting the blood to the brain.
- What is special about **CNS ischemic response** is that it is very powerful, the sympathetic vasoconstriction is very strong to the arteriole that can block the blood supply to other organs, one of the most important organs are the kidneys , it may cause acute renal failure .
- **This response occurs during emergency, it's not a normal response.**

CNS ischemic response

- Despite the powerful nature of the CNS ischemic response, it does not become significant until the arterial pressure falls far below normal, down to 60 mm Hg and below, reaching its greatest degree of stimulation at a pressure of 15 to 20 mm Hg.
- Therefore, the CNS ischemic response is not one of the normal mechanisms for regulating arterial pressure.
- Instead, it operates principally as an emergency pressure control system that acts rapidly and powerfully to prevent further decrease in arterial pressure whenever blood flow to the brain decreases dangerously close to the lethal level.
- It is sometimes called the last-ditch stand pressure control mechanism.

- If the BP is very low and I want to increase sympathetic stimulation, This is my last mechanism in order to keep the function of the brain.

- Subtype/ another type of CNS ischemic response

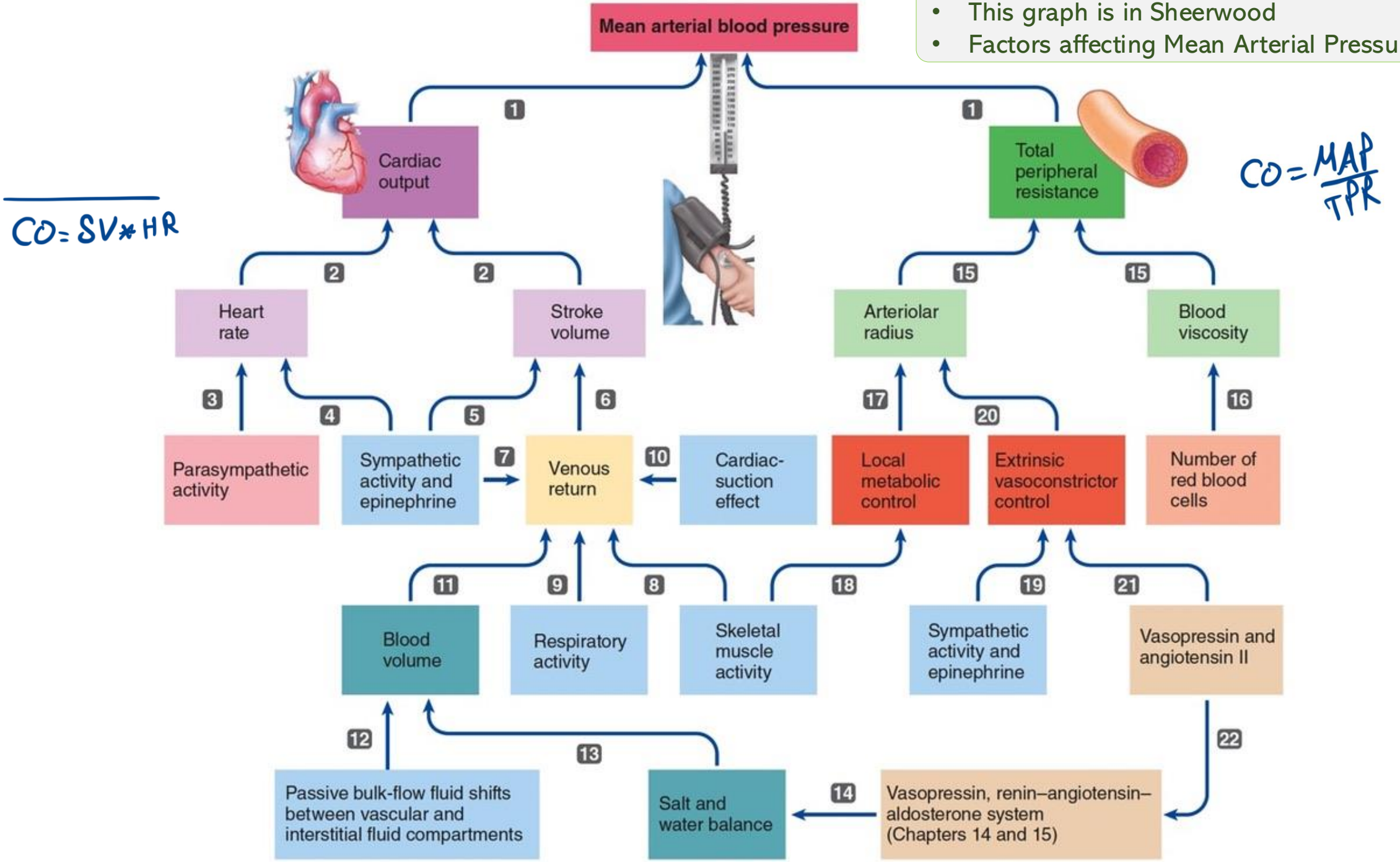
Cushing reaction

- The Cushing reaction illustrates the role of the cerebral chemoreceptors in maintaining cerebral blood flow. When intracranial pressure increases (e.g., tumors, head injury), there is compression of cerebral arteries, this will exceed arterial pressure which results in decreased perfusion of the brain and will conduct ischemic response. There is an immediate increase in PCO_2 and a decrease in pH because CO_2 generated from brain tissue is not adequately removed by blood flow. The medullary chemoreceptors respond to these changes in PCO_2 and pH by directing an increase in sympathetic outflow to the blood vessels. Again, the overall effect of these changes is to increase TPR and dramatically increase P.

- This graph is in Sheerwood
- Factors affecting Mean Arterial Pressure (MAP)

$CO = SV * HR$

$CO = \frac{MAP}{TPR}$



- MAP depends on CO and TPR (1 on Figure 10-29).
- CO depends on heart rate and stroke volume 2.
- Heart rate depends on the relative balance of parasympathetic activity 3, which decreases heart rate, and sympathetic activity 4 (including epinephrine throughout this discussion), which increases heart rate.
- Stroke volume increases in response to sympathetic activity 5 (extrinsic control of stroke volume).
- Stroke volume also increases as venous return increases 6 (intrinsic control of stroke volume according to the Frank–Starling law of the heart).
- Venous return is enhanced by sympathetically induced venous vasoconstriction 7, the skeletal muscle pump 8, the respiratory pump 9, and cardiac suction 10.
- The effective circulating blood volume also influences how much blood is returned to the heart 11 and therefore ultimately on how much blood is pumped out by the heart. Blood volume depends in the short term on the size of passive bulk-flow fluid shifts between the plasma and the interstitial fluid across the capillary walls 12. In the long term, blood volume depends on salt and water balance 13, which are hormonally controlled by the renin–angiotensin–aldosterone system and vasopressin, respectively 14.
- The other major determinant of mean arterial pressure, TPR, depends on the radius of all arterioles and on blood viscosity 15. The main factor determining blood viscosity is the number of red blood cells 16. However, arteriolar radius is the more important factor determining TPR.

Additional: This is the legend from sheerwood that you can follow

- Arteriolar radius is influenced by local (intrinsic) metabolic controls that match blood flow with metabolic needs 17. For example, local changes that take place in active skeletal muscles cause local arteriolar vasodilation and increased blood flow to these muscles 18.
- Arteriolar radius is also influenced by sympathetic activity 19, an extrinsic control mechanism that causes arteriolar vasoconstriction 20 to increase TPR and subsequently MAP.
- Arteriolar radius is also extrinsically controlled by the hormones vasopressin and angiotensin II, which are potent vasoconstrictors 21 as well as being important in salt and water balance 22.

Mean arterial pressure (MAP) is affected by 2 factors: Cardiac output (CO) & Total peripheral resistance (TPR)
Cardiac output is controlled by 2 factors: Heart Rate and Stroke Volume
What control HR ? Sympathetic or parasympathetic activities
What control SV ? Sympathetic activity (it also increase contractility) & venous return
What control Venous Return ? This is the topic of the veins lecture, many factors include: cardiac suction effect, skeletal muscle activity, respiratory activity and blood volume
What affects Blood Volume ? The bulk flow and the kidney activity, through salt and water balance.
How BV is increased? Increasing bulk flow from interstitial fluid, and increasing salt and water reabsorption
What affects TPR? Blood factor or blood vessel factor
Blood factor: viscosity, increase with increased RBCs
Blood vessel factor: arteriolar radius
What affects arteriolar radius? →**local effects** (metabolic effects, previous lecture)

→**extrinsic effect** (on diameter) –Neural (sympathetic)
-Humoral (vasopressin / Epinephrin / Norepinephrin /angiotensin II, RAAS plays a rule for sure)

TPR effect on MAP

- Thus, the extent of TPR offered collectively by all the systemic arterioles influences MAP immensely.
- generalized, sympathetically induced vasoconstriction reflexly reduces blood flow downstream to the organs while elevating the upstream mean arterial pressure, thereby increasing the main driving force for blood flow to all the organs.

TPR effect on MAP

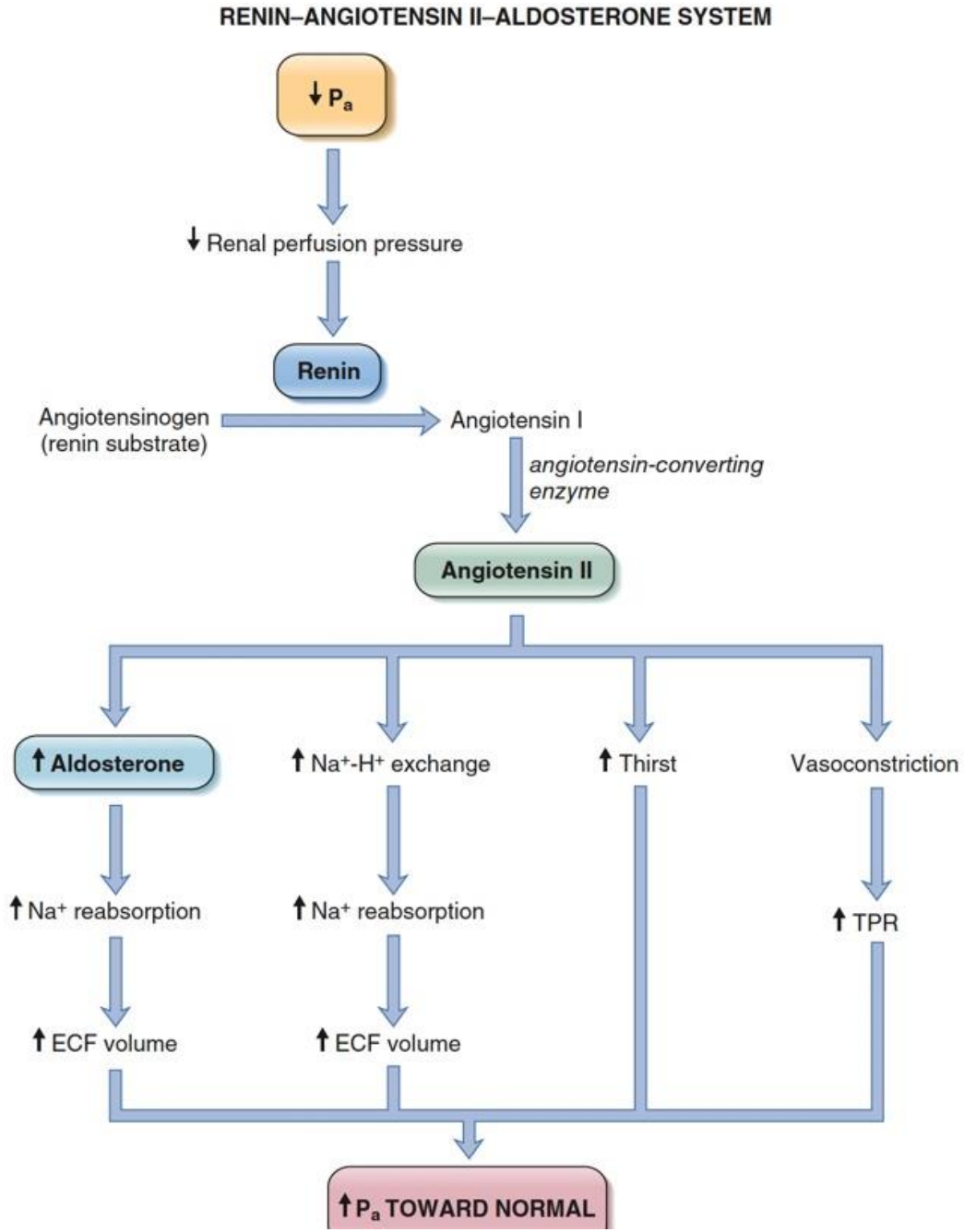
- Why increase the driving force for flow to the organs by increasing MAP while reducing flow to the organs by narrowing the vessels supplying them?
- In effect, the sympathetically induced arteriolar responses help maintain the appropriate driving pressure head (that is, the MAP) to all organs. The extent to which each organ actually receives blood flow is determined by local arteriolar adjustments that override the sympathetic constrictor effect. If all arterioles were dilated, blood pressure would fall substantially, so there would not be an adequate driving force for blood flow.
- Skeletal and cardiac muscles have the most powerful local control mechanisms with which to override generalized sympathetic vasoconstriction.

TPR effect on MAP

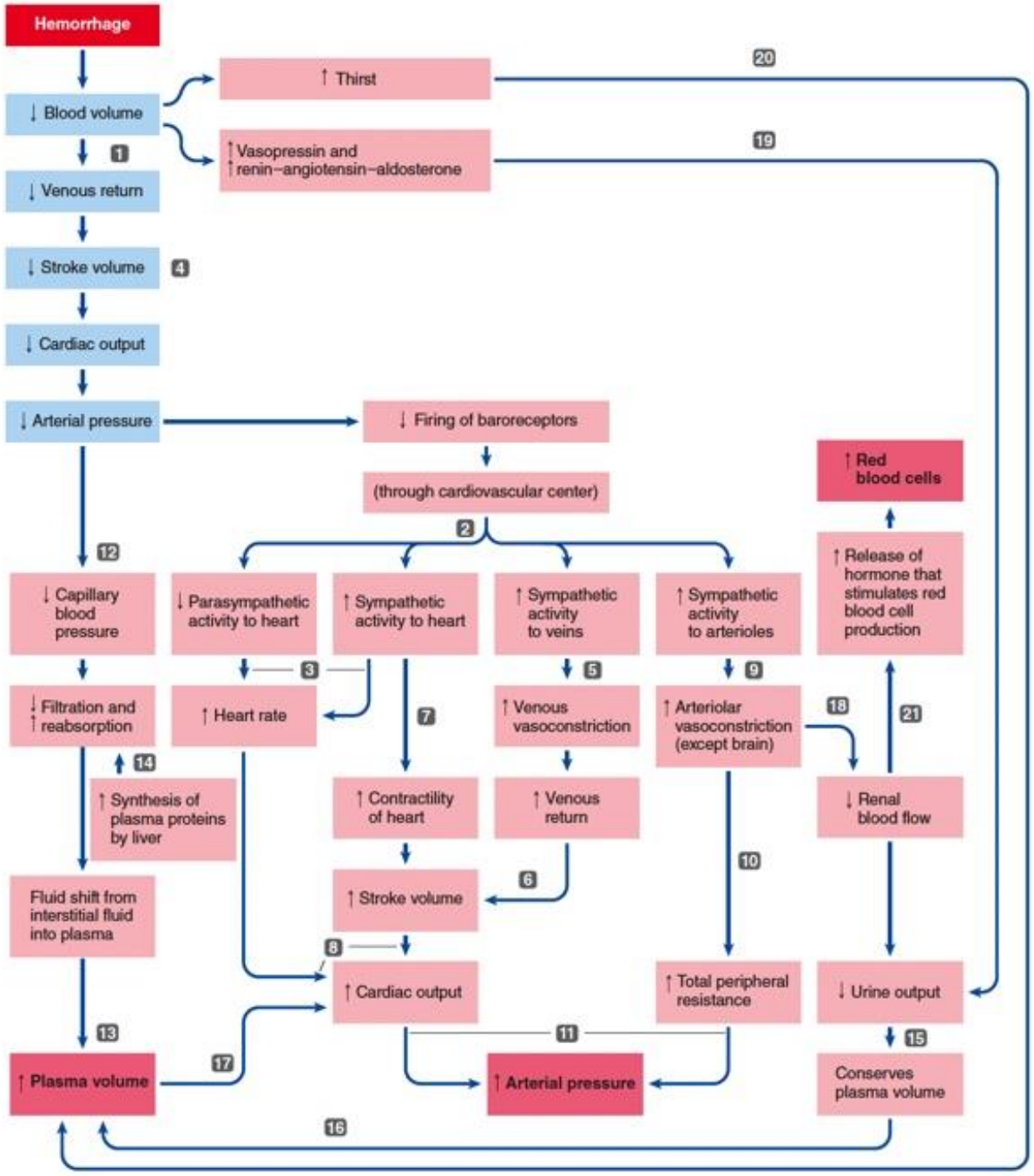
- The norepinephrine released from sympathetic nerve endings combines with a1-adrenergic receptors on arteriolar smooth muscle to bring about vasoconstriction.
- Cerebral arterioles are the only ones that do not have a1 receptors, so no vasoconstriction occurs in the brain. It is important that cerebral arterioles are not reflexly constricted by neural influences because brain blood flow must remain constant to meet the brain's continuous need for O2, no matter what is going on elsewhere in the body. Cerebral vessels are almost entirely controlled by local mechanisms that maintain a constant blood flow to support a constant level of brain metabolic activity. In fact, reflex vasoconstrictor activity in the remainder of the cardiovascular system is aimed at maintaining an adequate pressure head for blood flow to the vital brain.

Arteriolar Myogenic response to stretch

- Arteriolar smooth muscle responds to being passively stretched by myogenically increasing its tone via vasoconstriction, thereby acting to resist the initial passive stretch.
- Increased vessel stretching brings about opening of mechanically gated cation channels, which leads to a small depolarization that triggers opening of more surface-membrane voltage-gated Ca channels. The resultant Ca entry promotes increased smooth muscle contraction, boosting myogenic vessel tone and causing vasoconstriction. Conversely, a reduction in arteriolar stretching decreases myogenic vessel tone and promotes vasodilation.


RENIN–ANGIOTENSIN II–ALDOSTERONE SYSTEM
↓ P_a
↓ Renal perfusion pressure
Renin
Angiotensinogen (renin substrate)
Angiotensin I
angiotensin-converting enzyme
Angiotensin II
↑ Aldosterone
↑ Na^+-H^+ exchange
↑ Thirst
Vasoconstriction
↑ Na^+ reabsorption
↑ Na^+ reabsorption
↑ TPR
↑ ECF volume
↑ ECF volume
↑ P_a TOWARD NORMAL

This diagram shows hemorrhage and how the changes will be different, it's good to read it



Thank you

VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2			
V2→V3			

امسح الرمز و شاركنا بأفكارك لتحسين أدائنا!!