

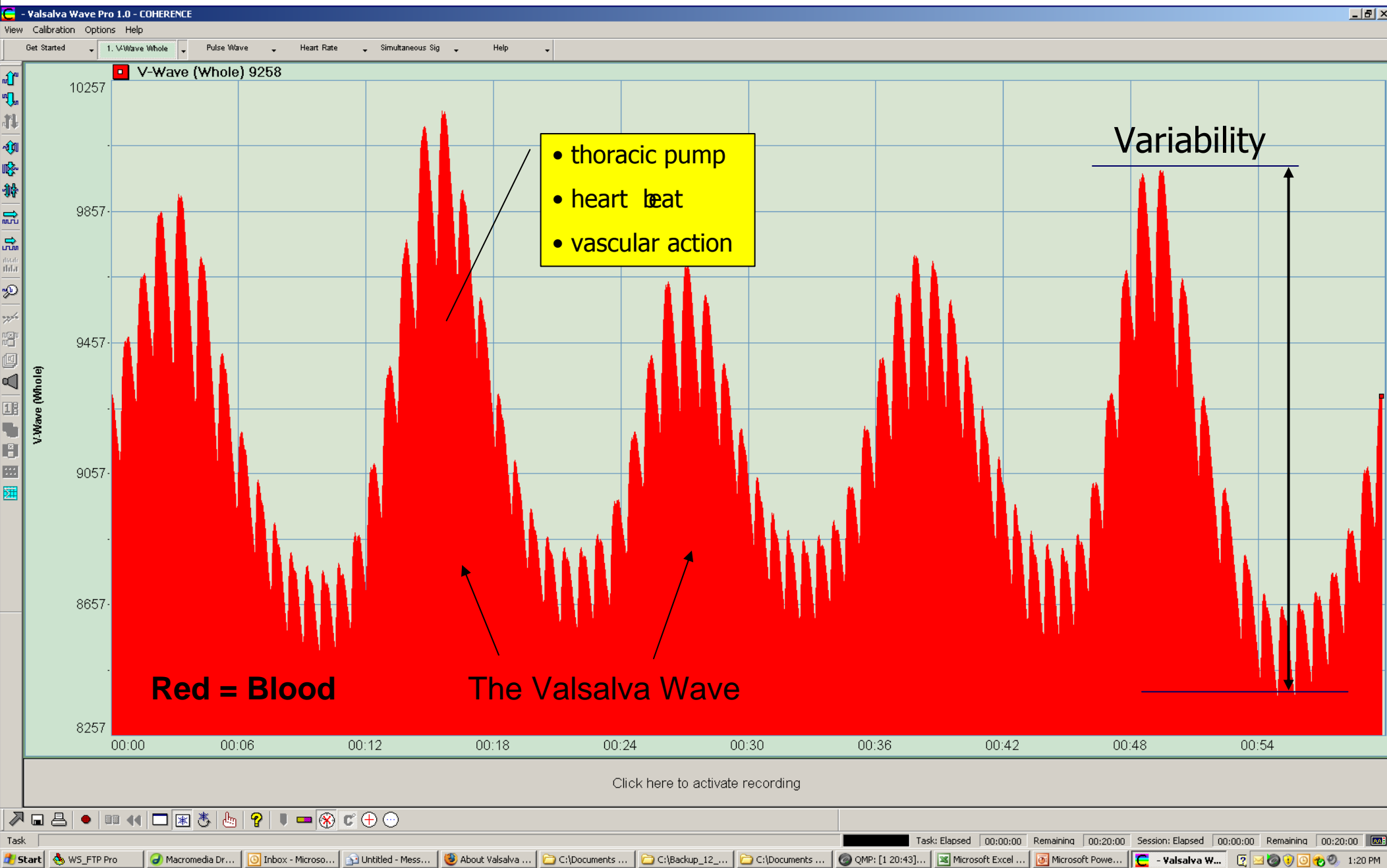
# ~The Valsalva Wave~

## The Changing Landscape of Heart Rate Variability Biofeedback

Stephen Elliott – President & Life Scientist, COHERENCE

Dee Edmonson, RN, BCIAC-EEG, Neurologics

# What Is The “Valsalva Wave”?



The Valsalva Wave is the “breathing induced” component of circulation.

**The question behind the effort (circa 2004):**

*What is heart rate variability and how does it relate to blood flow and pressure?*

# Introduction

- There is an arterial phenomenon known as the “respiratory arterial pressure wave” which rises with exhalation and falls with inhalation.
- There is also a recognized but little understood venous phenomenon known as the “venous wave”.
- In biofeedback circles, there is also a nascent discussion of “blood volume”.
- However, these phenomena have not been seen as being “connected”.
- “Valsalva Wave” is a name I’ve proposed for the wholistic arterial and venous phenomena that occurs as a function of respiration.

## About Stephen:

Stephen Elliott is the founder and president of COHERENCE LLC, Allen, TX. He is a long-term student/teacher of Eastern yogic and martial arts and an avid life sciences researcher. Stephen is an avid inventor with ~40 patents issued or pending in life sciences and telecommunications systems. Stephen is the developer of Coherent Breathing<sup>®</sup> and the theorist and proponent of the “respiratory arterial pressure wave” theory of heart rate variability and cardiopulmonary resonance.

## About Dee:

Integrative neurotherapist Dee Edmonson, RN, BCIAC-EEG, is the founder and director of Neurologics, Plano, Texas, specializing in the treatment of traumatic brain injury, attentional disorders, addiction, and stress/anxiety, with special emphasis on restoration of autonomic balance via breathing. Dee has pioneered the clinical application of Coherent Breathing<sup>®</sup>.

Dee also directs neurotherapy services Plano Neurotherapy, Plano, Texas.

Stephen and Dee are the authors of *The New Science of Breath* (2005) and *Coherent Breathing – The Definitive Method* (2008).

# A Work In Progress

Please note that the information presented here is correct to the best of our knowledge and consistent with the “state of this art”.

Please consider it a work in progress.

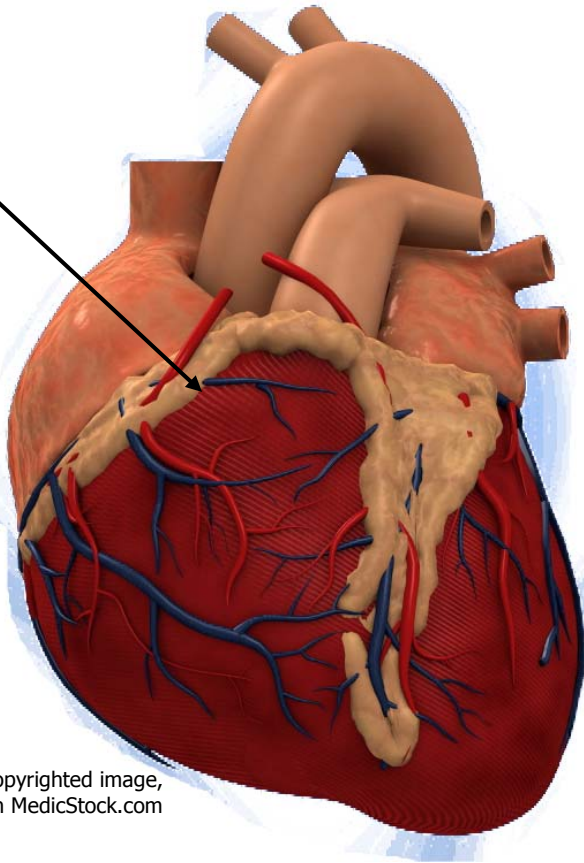
- The heart beat & heart rate variability (HRV)
- The Thoracic Pump
- Autonomic nervous system governance of blood flow and pressure
- Valsalva Wave – The Biometric
- Clinical experience and client observations
- Study: HRV Amplitude vs. blood pressure (if we have time)

# Part I

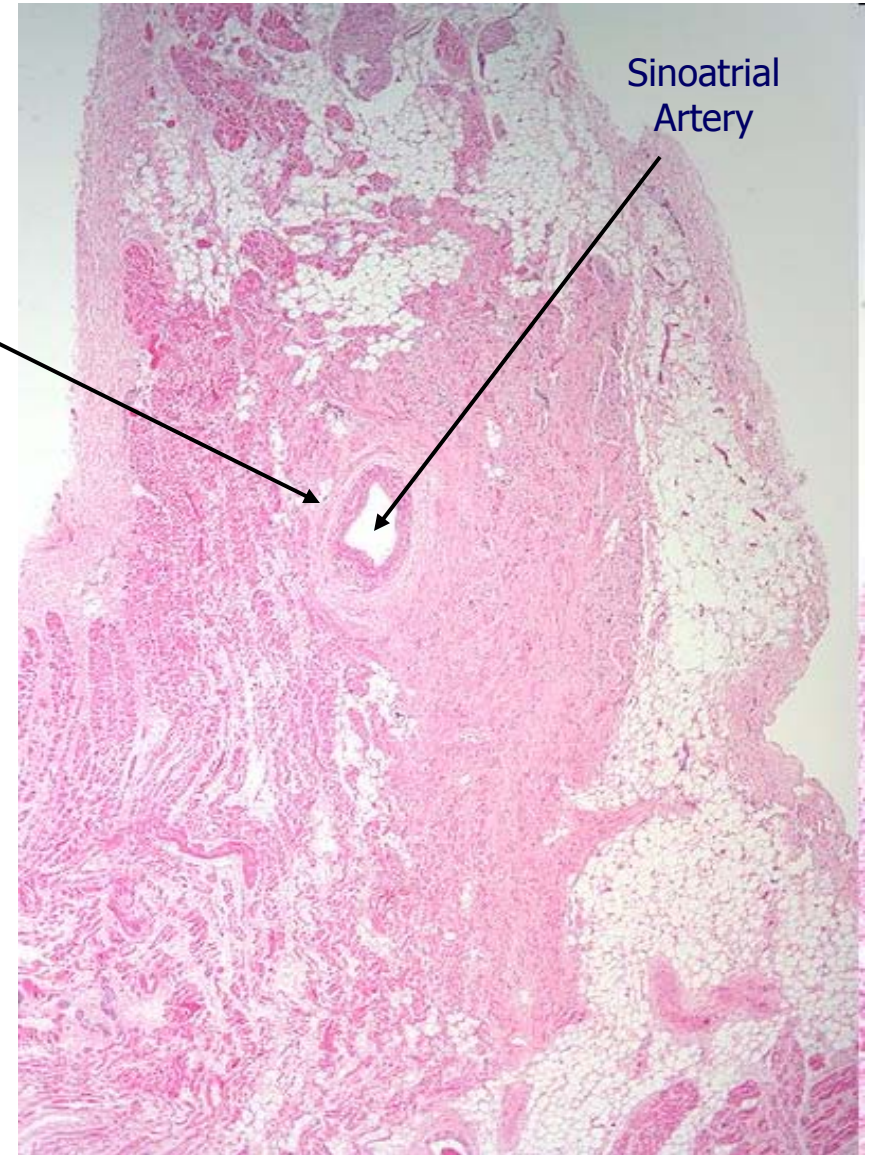
~ The Heart Beat ~

# The Heart Beat

Sinoatrial Node (upper  
inside wall of right atrium)



Heart is copyrighted image,  
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Micrograph of Sinoatrial Node *Source: Wikipedia*

The "beat" itself is generated by the Sinoatrial Node.

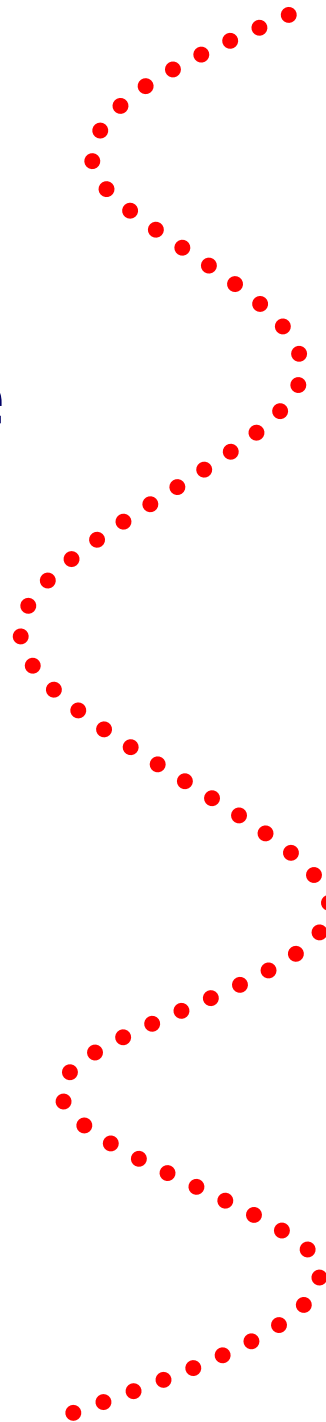
# Heart Rate Variability

Heart Rate Variability:  
“Variation in heart rate  
for any reason.”

*Breathing Induced* Heart  
Rate Variability:

“Variation in heart rate as  
a consequence of  
respiration.”

We also know it as  
“Respiratory Sinus  
Arrhythmia”.



# Heart Rate Variability

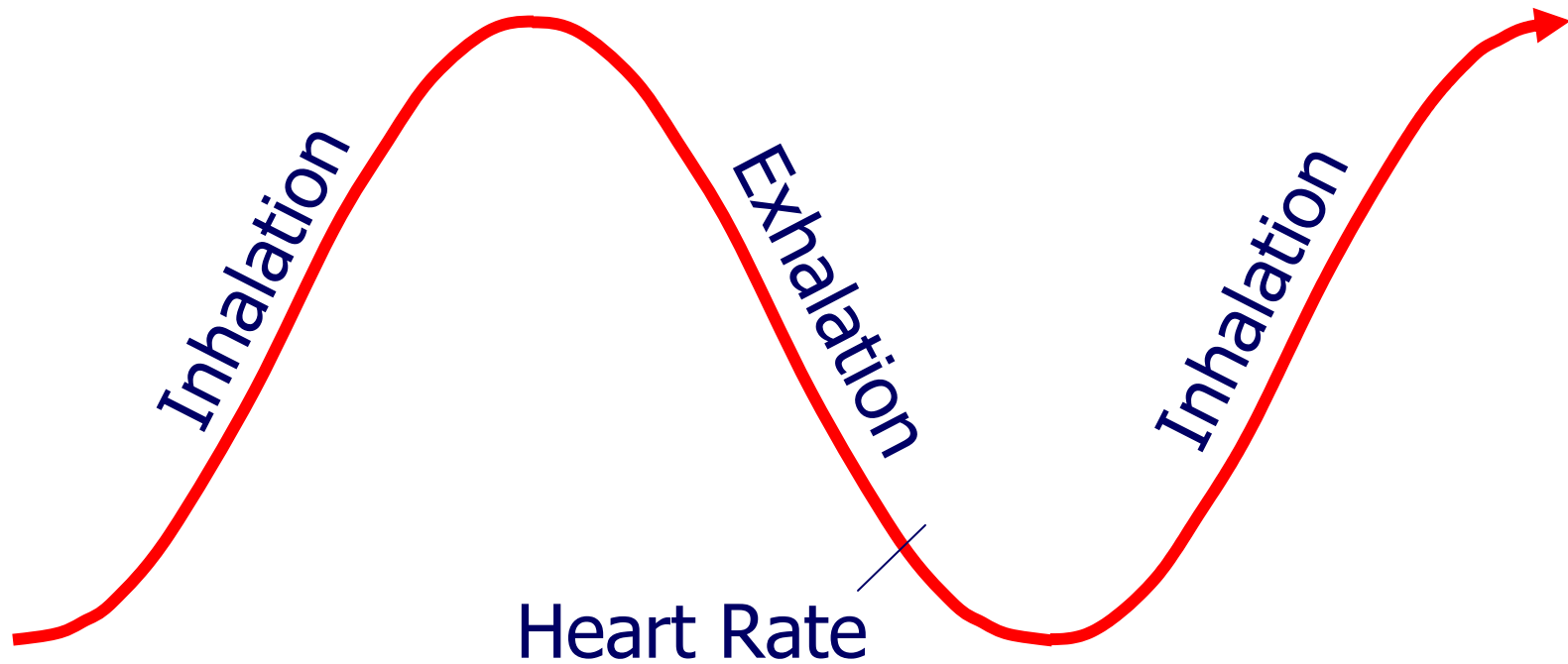
*Heart Rate Variability* : “Variation in heart rate for any reason”.

What are some of the reasons that the heart rate varies?

# Heart Rate Variability

- “*Breathing induced heart rate variability*” is variation in heart rate as a consequence of respiration.
- It is the same as the phenomenon that goes by the name “Respiratory Sinus Arrhythmia” or “RSA”.
- RSA refers to the “sinusoidal” variation in heart rate that tends to occur with breathing.

# Respiratory Sinus Arrhythmia

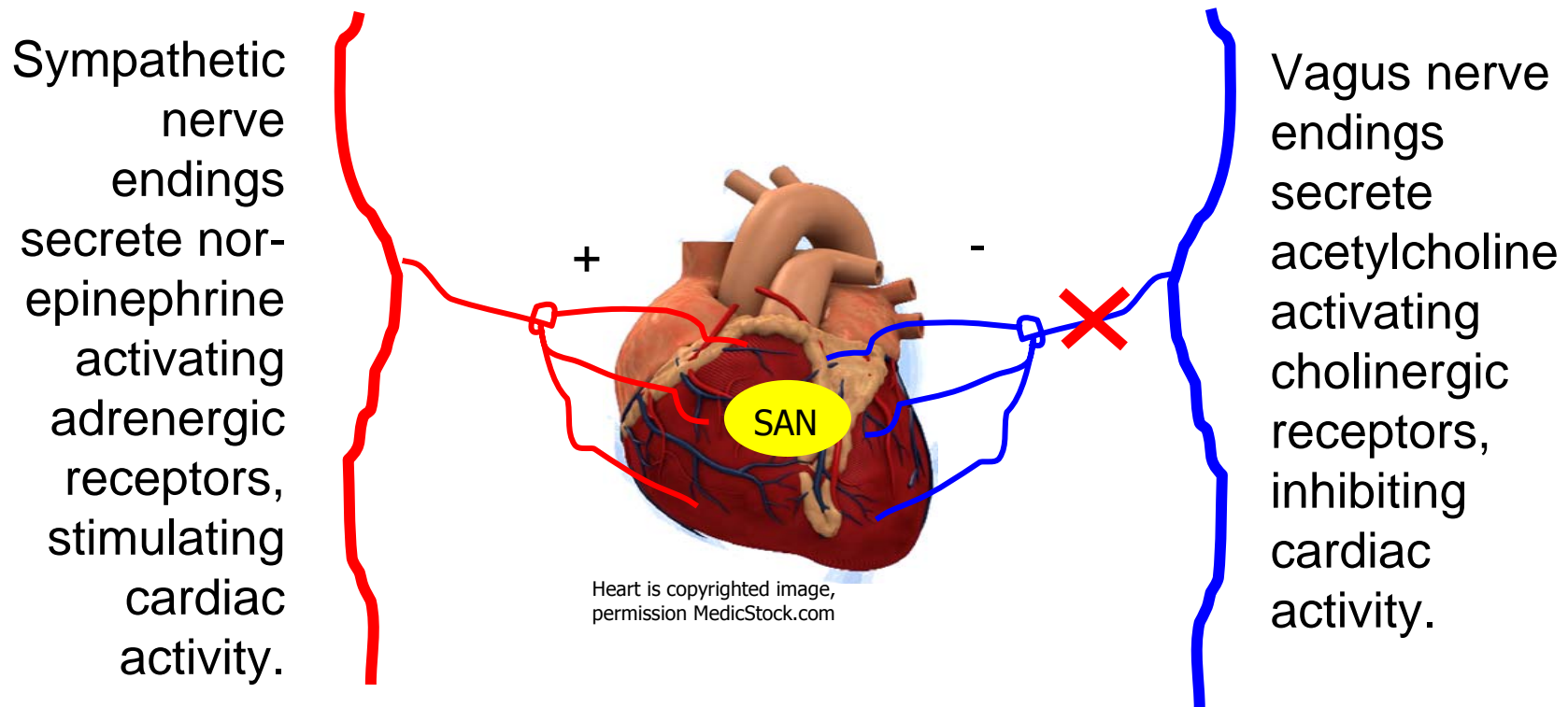


Heart rate *tends* to increase during inhalation and decrease during exhalation.

- The contemporary understanding is that the heart, as well as other body functions are managed via the complex interplay between sympathetic and parasympathetic systems.
- Sympathetic action causes the heart beat rate to increase.
- Parasympathetic action (“vagal braking”) causes the heart beat rate to decrease.

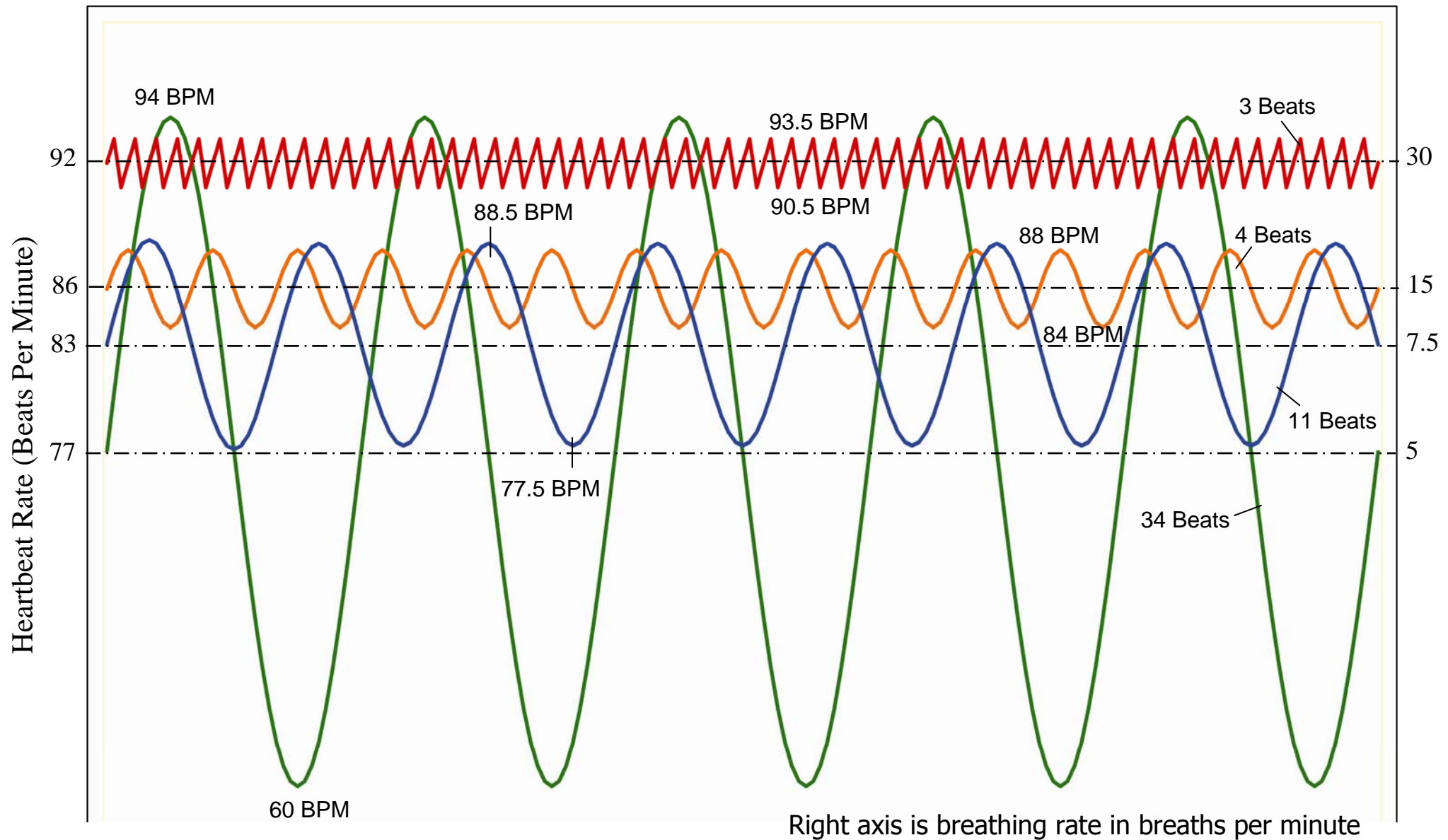
# HRV Is An Outcome Of ANS Modulation of HR

In the absence of ANS interaction, the heart rate is constant.



- It is the interplay between sympathetic and parasympathetic systems that results in breathing induced HRV (RSA).
- If the vagus nerve is sectioned, breathing induced HRV stops and the heart beats at a constant rate only moderated by sympathetic action.

# Synchronous RSA



When we breathe synchronously, RSA becomes synchronous, heart rate phase locking with respiration.

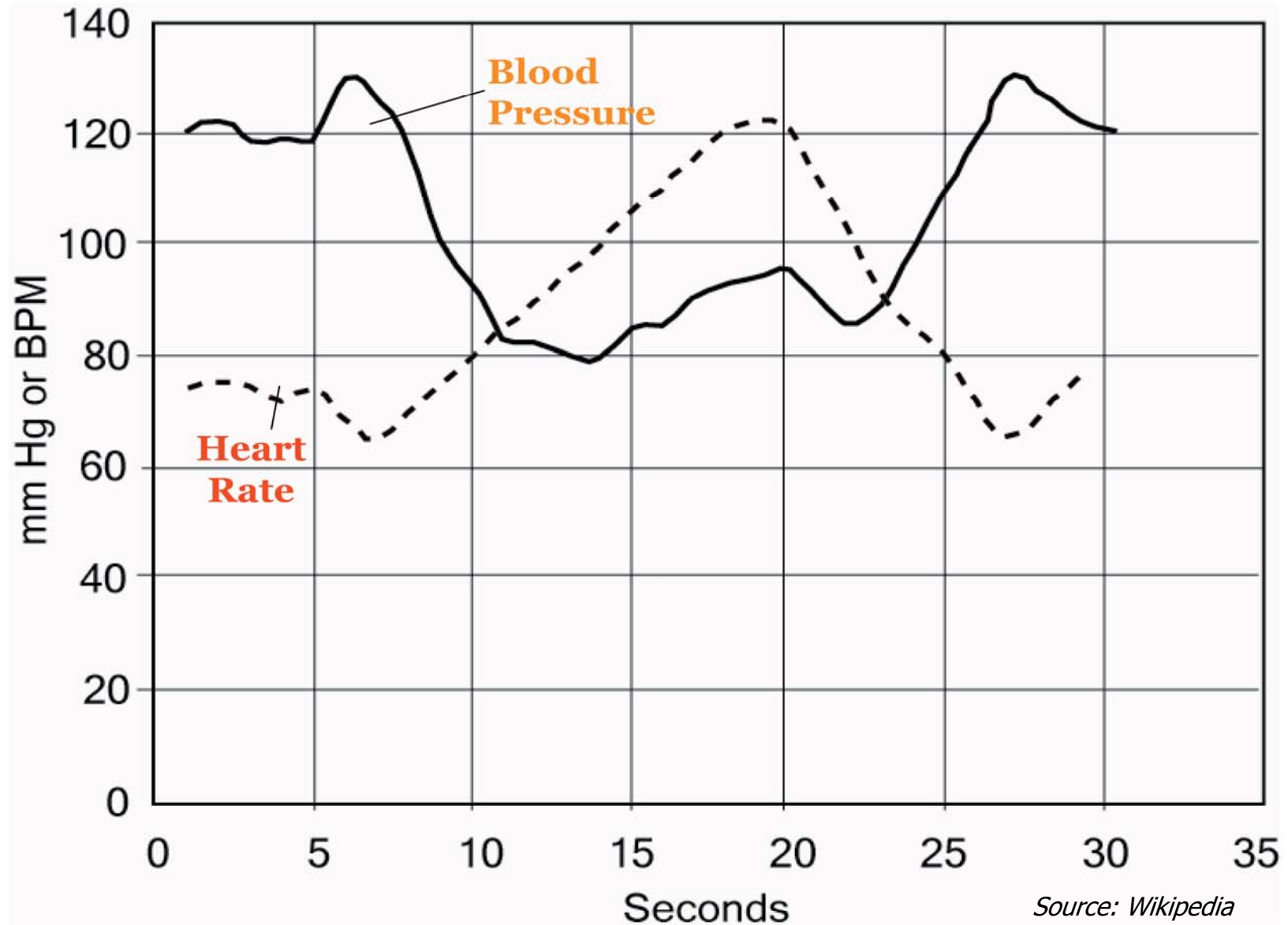
# Respiratory Sinus Arrhythmia

- The contemporary understanding is that “RSA” is the autonomic response to:
  - Baroreceptor action in response to changes in blood flow and pressure
  - Mechanoreceptors of the chest (Brown, Gerbarg, Muskin, 2009)
- Whatever the stimulus, RSA ends if the vagus nerve is sectioned.

# Respiratory Sinus Arrhythmia

- If the ANS is responding to changes in blood flow and pressure, then, flow and pressure must be changing with respiration...
- And there is some understanding that it does, but it's sketchy.

# A Valsalva Maneuver

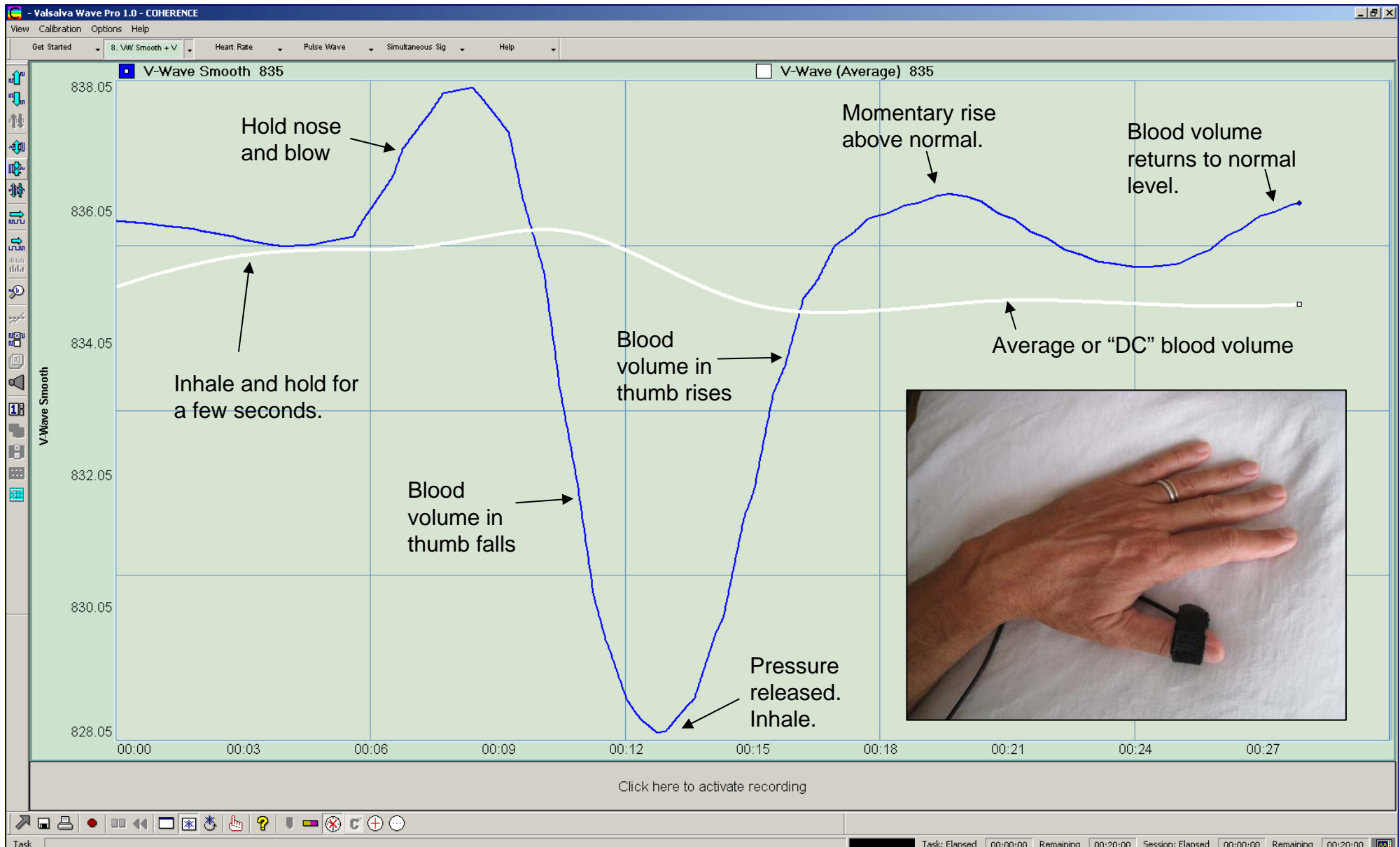


Source: Wikipedia

Blood pressure (systolic and diastolic) and pulse rate during a normal response to Valsalva's maneuver. Forty millimeter mercury pressure is applied at 5 seconds and relieved at 20 seconds.

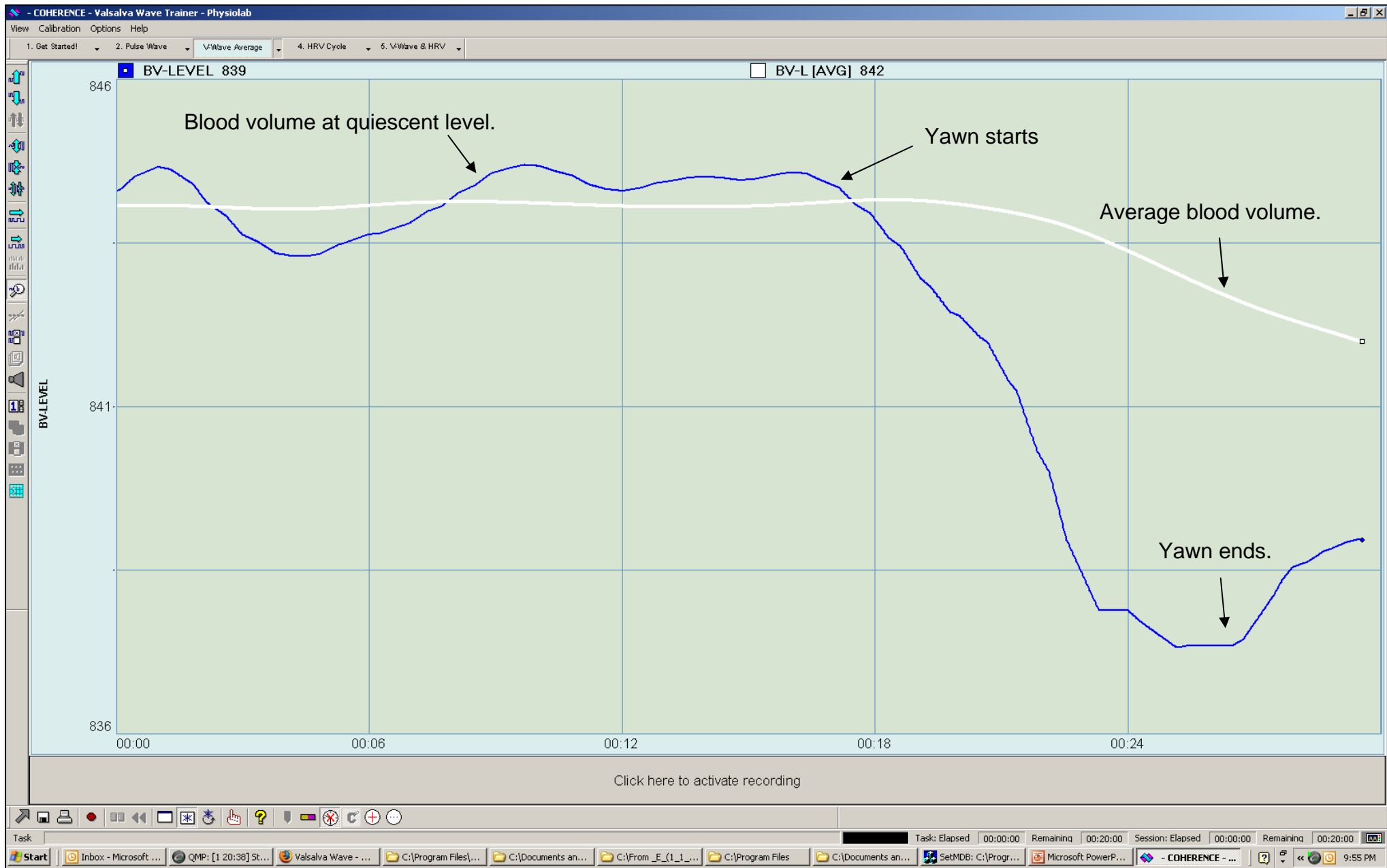
Heart rate responding to changes in blood pressure during a Valsalva maneuver. Baroreceptor action is thought to be primary mechanism behind the response.

# Valsalva Wave of the Valsalva Maneuver



Blood volume measured at the tip of the thumb during a Valsalva maneuver.  
This demonstrates volume as opposed to pressure.

# Blood Volume of A Yawn



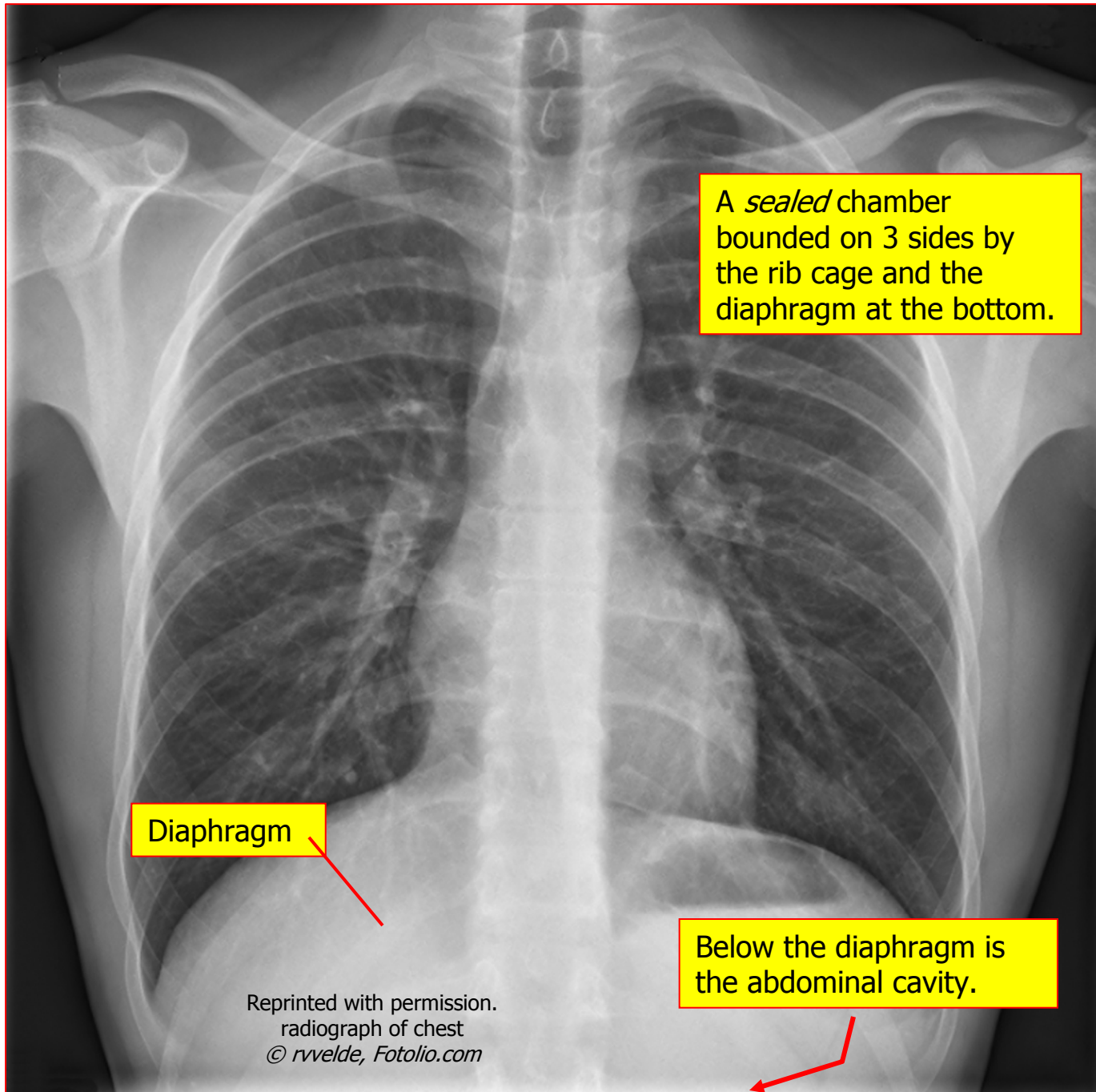
# The Valsalva Maneuver

- Today, the Valsalva Maneuver is frequently used in cardiology to assess autonomic and cardiac responsiveness.
- It is a means of “forcing” blood pressure to both increase and decrease such that the response can be observed.
- The general response that is anticipated is that heart beat increases as blood pressure falls and heart beat decreases as blood pressure rises....consistent with RSA.

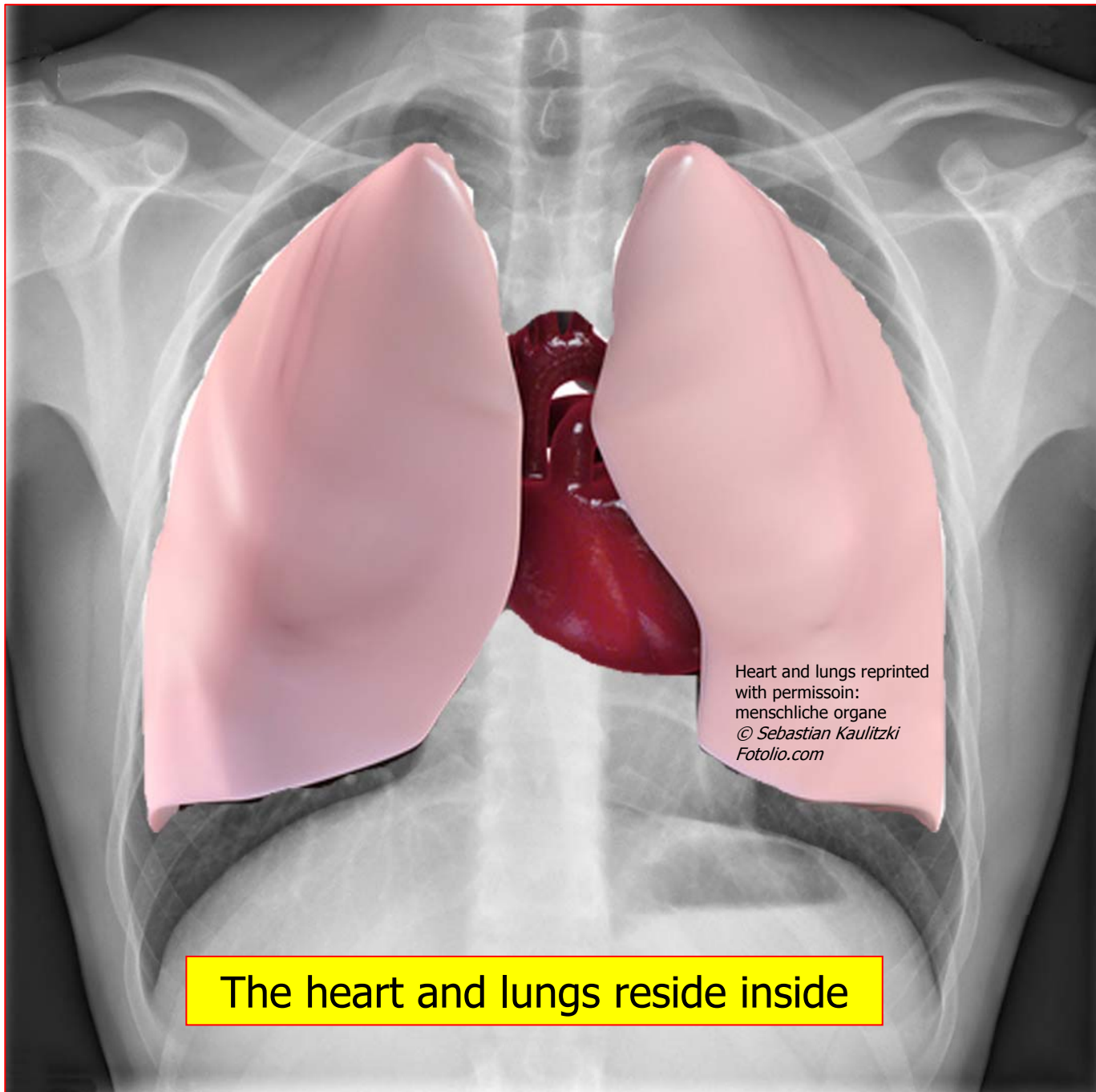
Let's explore *why* heart beat rate changes with respiration....

# ~The Thoracic Pump~

# The Thoracic Cavity



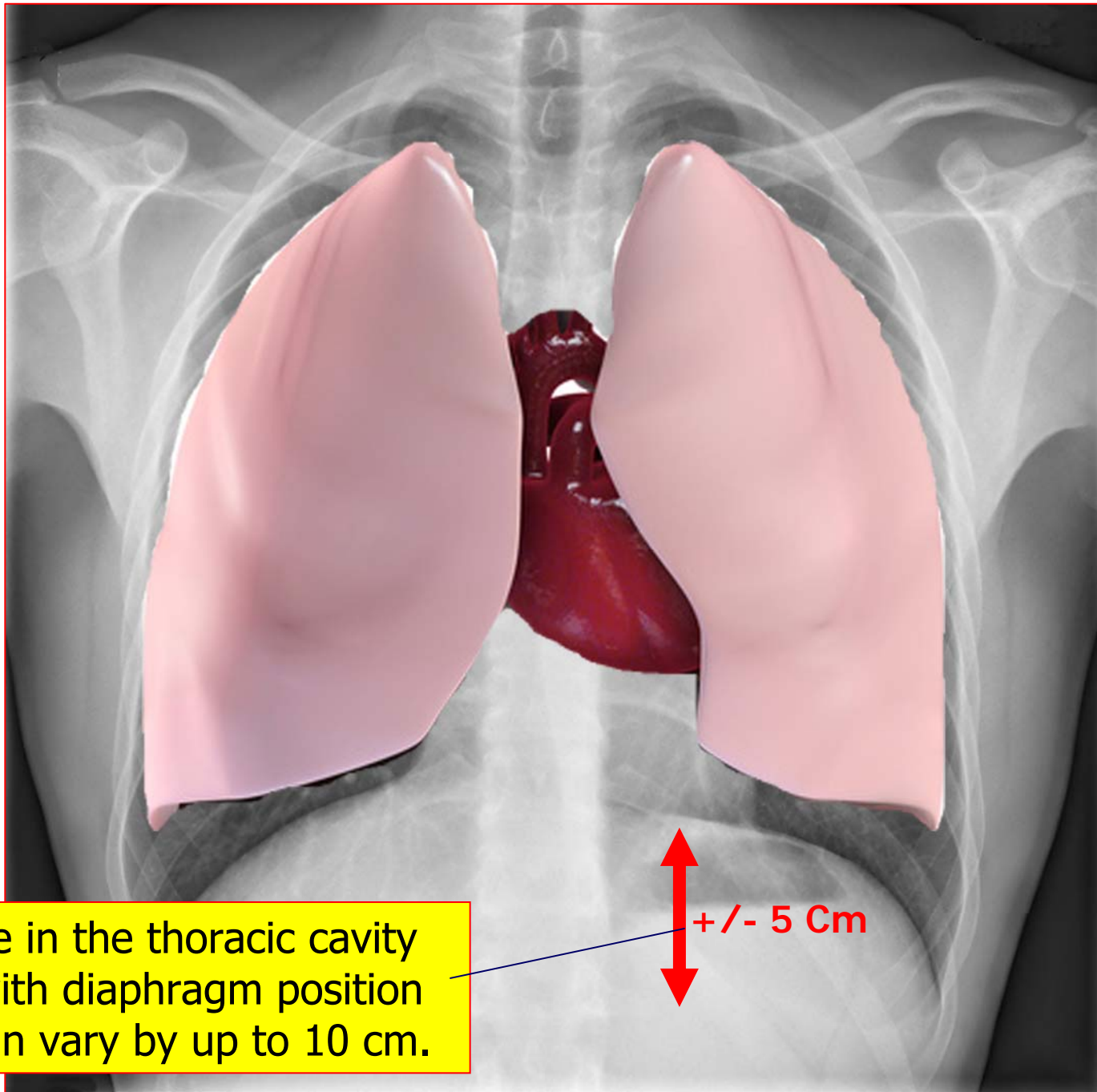
# The Thoracic Cavity



Heart and lungs reprinted  
with permission:  
menschliche organe  
© Sebastian Kaulitzki  
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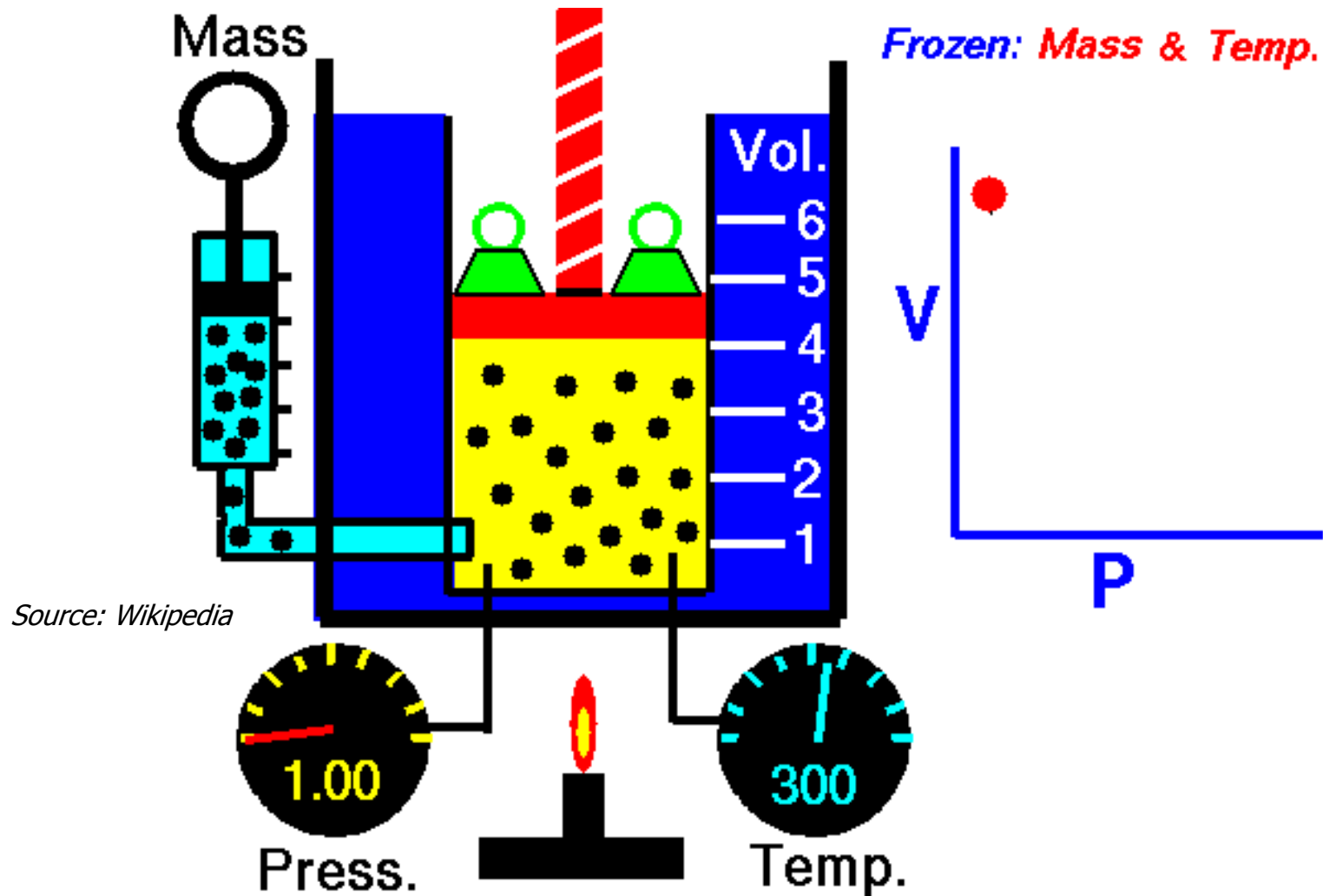
The heart and lungs reside inside

# The Thoracic Cavity



Pressure in the thoracic cavity varies with diaphragm position which can vary by up to 10 cm.

# Boyle's Law



**Boyle's Law: Absolute pressure and volume of a gas are inversely proportional:**

- As volume increases, pressure decreases
- As volume decreases, pressure increases

# A 10X Relationship?

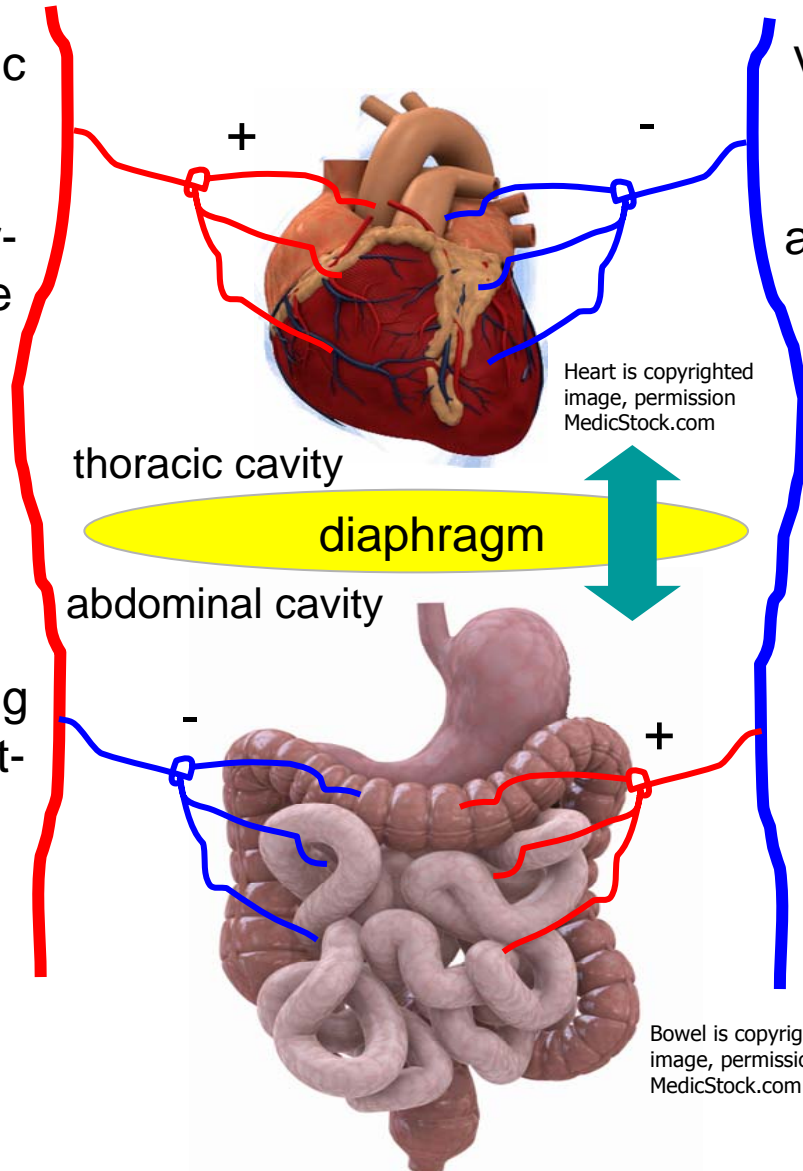
	A	B	C	D
1	<b>Physiologic Phenomenon</b>	<b>Typical "Shallow" Breathing (10% of VC)</b>	<b>Deep Synchronous Breathing (75% of VC)</b>	<b>Vital Capacity (4.5L) (75% of total lung capacity)</b>
2	<b>Diaphragmatic Movement (Range)</b>	<b>1 cm (10%)</b> Source: Source:Pulmonary Physiology, p.15	<b>7.5 cm (75%)</b> Estimated	<b>10 cm (100%)</b> Source:Pulmonary Physiology, p. 15
3	<b>Intrapleural Pressure (Range)</b>	<b>2.5 cmH<sub>2</sub>O (8%)</b> (-5 to -7.5 mmH <sub>2</sub> O) Source: Medical Physiology, p. 433	<b>25 cmH<sub>2</sub>O (75%)</b> Estimated	<b>33 cmH<sub>2</sub>O (100%)</b> Estimated (Can be much higher during forced inspiration)
4	<b>Inspiratory/Expiratory Volume</b>	<b>.5 L (Tidal volume of typical adult -11% of VC) Source: Pulmonary Physiology, p. 55</b>	<b>3.4 L (75% of VC)</b>	<b>4.5 L (Vital Capacity) Source: Pulmonary Physiology, p. 55</b>
5	<b>Respiratory Arterial Pressure Wave Magnitude</b>	<b>2 mmHg (8%)</b> Source: Medical Physiology, p. 193	<b>20 mmHg (75%)</b> Source: Medical Physiology, p. 193; Measured by Elliott	<b>~27 mmHg (100%) Estimated</b>
6	<b>Heart Rate Variability Amplitude</b>	<b>5.3 beats (10%)</b> (Source: Measured by Elliott)	<b>40 beats (75%)</b> Source: Measured by Elliott	<b>~53 beats (100%)</b> Measured by Elliott (60 beat HRVs have been witnessed by others)

Reprinted from *Coherent Breathing – The Definitive Method*, Elliott & Edmonson, 2008.

# The Diaphragm – The Bigger Picture

Upward movement of the diaphragm emphasizes sympathetic function.


Sympathetic nerve endings secrete nor-epinephrine activating adrenergic receptors, stimulating cardiac activity; yet inhibiting gastrointestinal activity.



Vagus nerve endings secrete acetylcholine activating cholinergic receptors, inhibiting cardiac activity yet stimulating gastrointestinal activity.

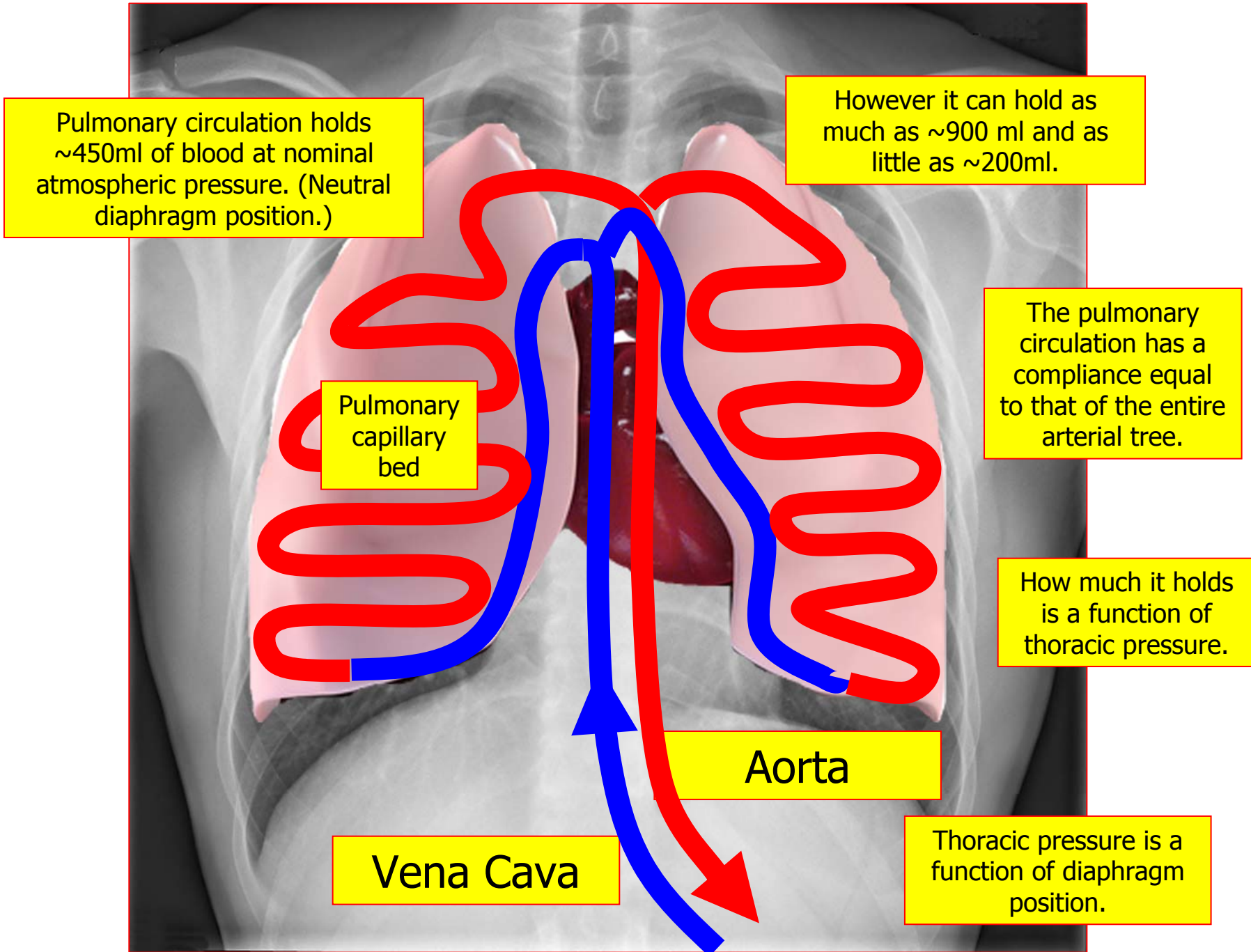
Downward movement of the diaphragm emphasizes parasympathetic function.

# The Great Scheme of Things

Diaphragm Action	Autonomic Emphasis	Thoracic Pressure	Abdominal Pressure	Enteric Nervous System Activity	Heart Rate	Arterial Blood Flow	Venous Blood Flow	Circulatory Emphasis
Diaphragm Moves Up (Exhalation)	Parasympathetic	Increases	Decreases	Increases	Decreases	Increases	Decreases	Arterial
 <b>The Diaphragm</b>								
Diaphragm Moves Down (Inhalation)	Sympathetic	Decreases	Increases	Decreases	Increases	Decreases	Increases	Venous

The diaphragm is a key determinant of both thoracic and abdominal function and status.

# The Thoracic Cavity



anatomy is simplified for purposes of illustration

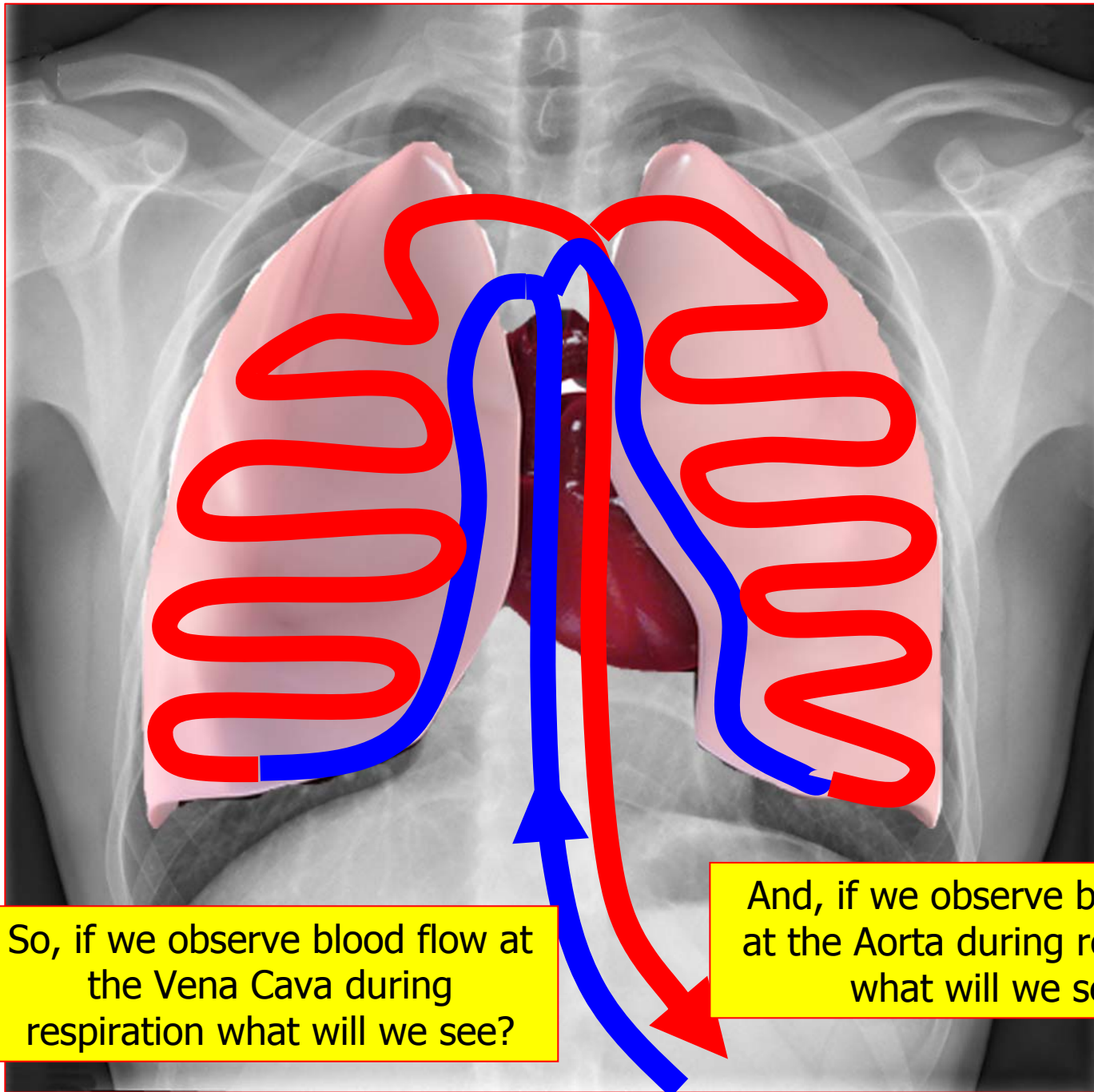
# Pulmonary Blood Volume



Very complete exhalation

Very complete inhalation

# Blood Flow

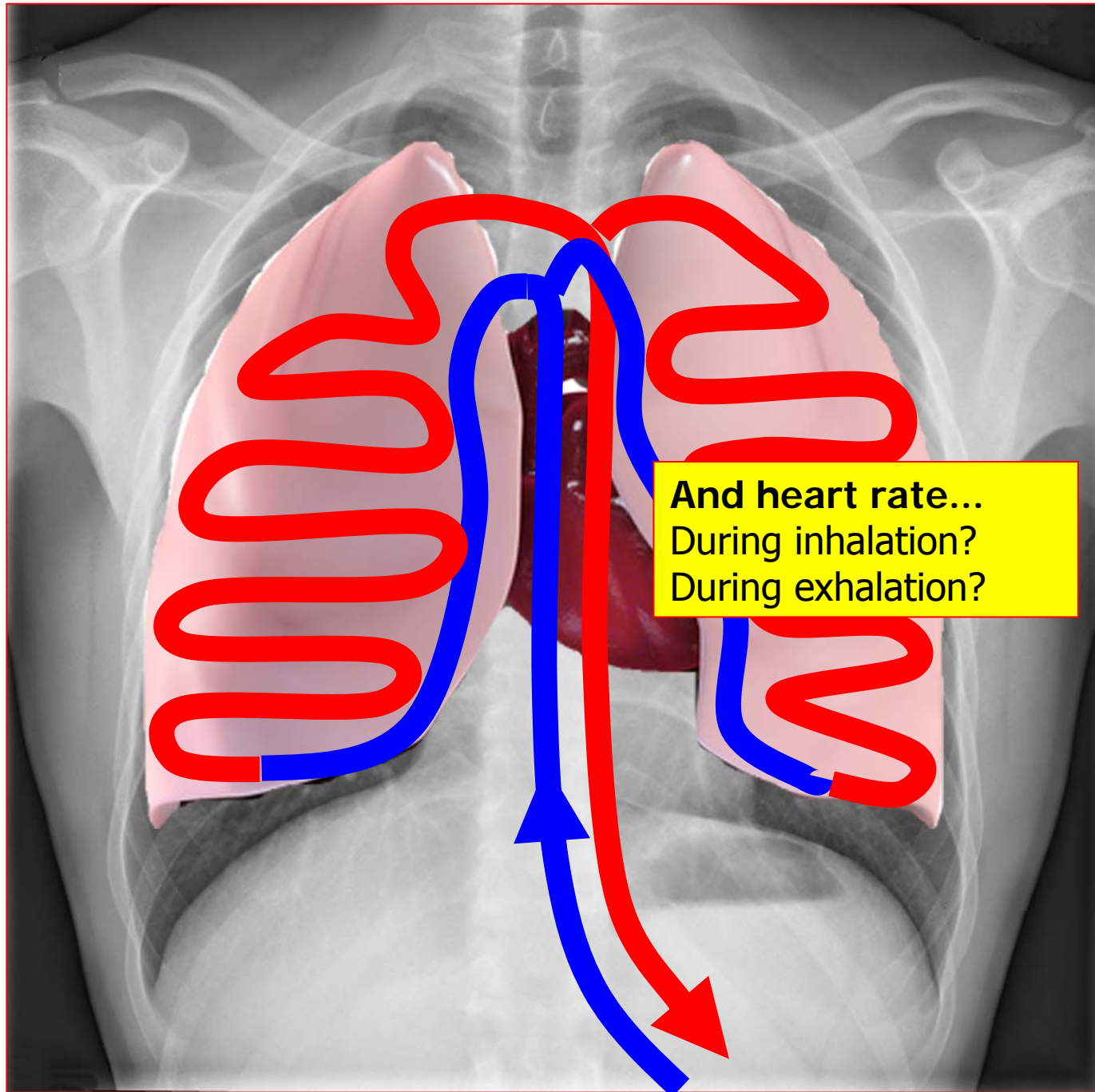


So, if we observe blood flow at the Vena Cava during respiration what will we see?

And, if we observe blood flow at the Aorta during respiration what will we see?

anatomy is simplified for purposes of illustration

# And Heart Rate?



anatomy is simplified for purposes of illustration

# Why Does Heart Rate Change?

Why does heart rate change during respiration?

➤ The simple answers....

1. When this much blood (the extreme case) flows into the aorta rapidly, if heart rate did not decrease, blood pressure would rise too much.
2. When the lungs are storing this much blood, heart rate did not increase, blood pressure would decrease too much.



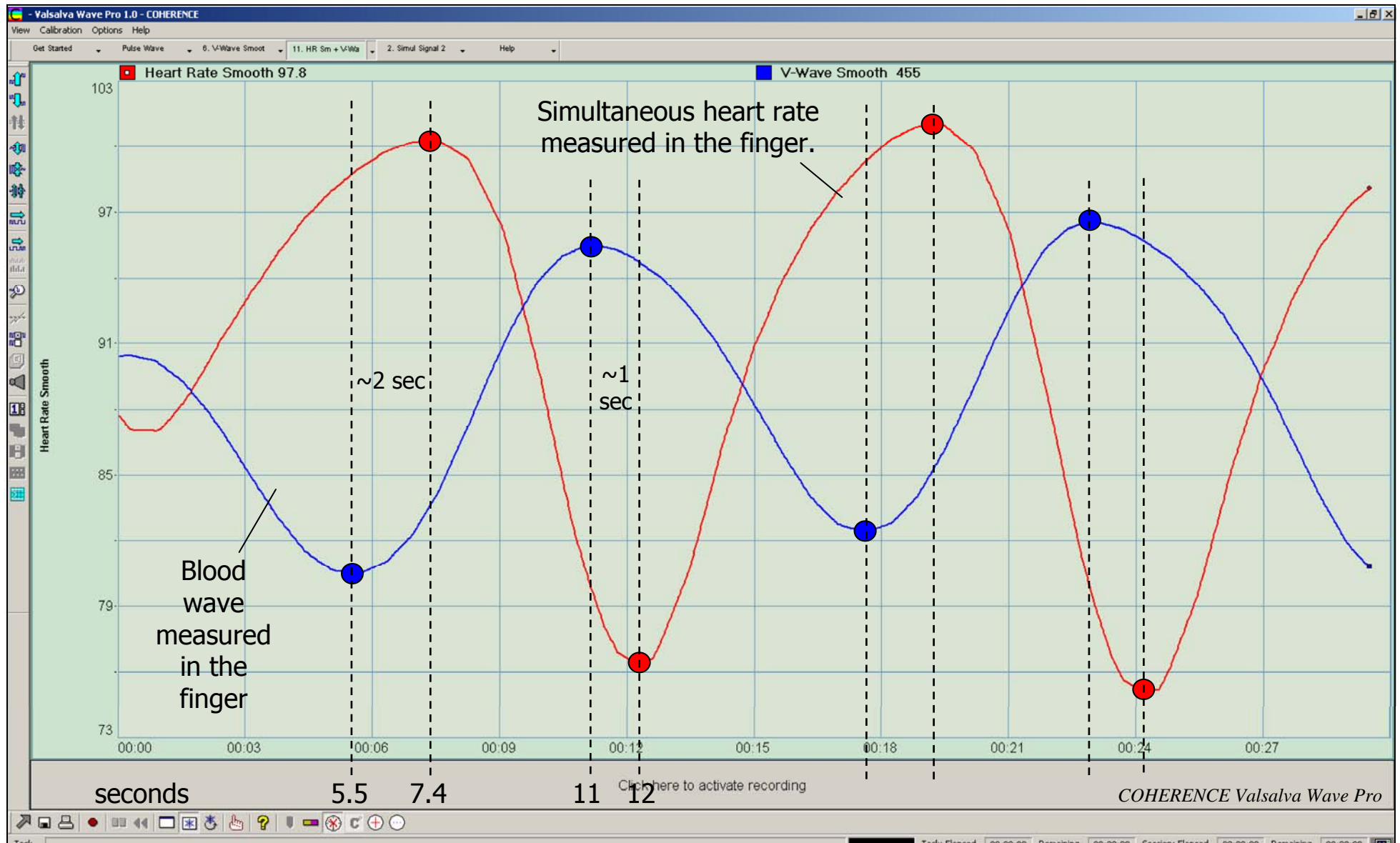
- This supports the theory that “breathing induced HRV” is an outcome of autonomic nervous system regulation of blood flow and pressure.

[Again, this is consistent with what we know about Respiratory Sinus Arrhythmia.]

- If this is so, we can expect to see that changes in blood flow and pressure precede changes in heart rate....

And if we look, this is what we see...

# If We Look...



We see that changes in the blood wave lead changes in heart rate (at resonance).

~ANS Governance of  
Blood Flow & Pressure ~

**Heinbecker's Respiratory Waves - 1927**

← respiration

← systolic pressure

← diastolic pressure

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*(See Coherent Breathing – The Definitive Method)*

( Lauson et al, 1946)

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*(See Coherent Breathing – The Definitive Method)*

**Effects of respiration on volumes and pressures**  
*(reprinted with permission of The American Journal of Medicine)*

# Four Factors

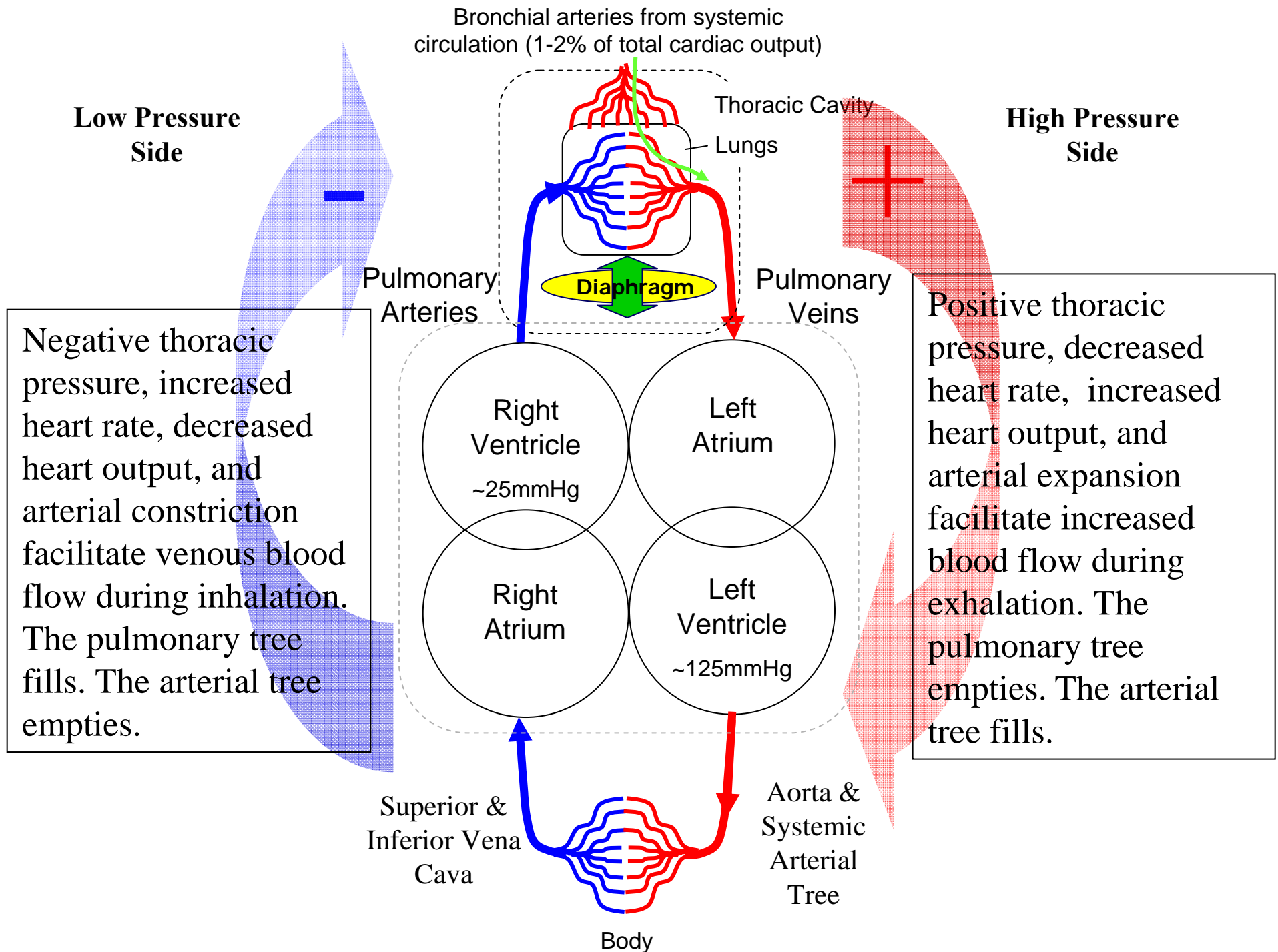
- There are 4 major mechanisms that result in circulation:
  - 1) The heart beat
  - 2) Respiration (the thoracic pump)
  - 3) Vascular relaxation and constriction
  - 4) Gravity
- The ANS employs them in unison to govern blood flow and pressure.

## Autonomic Governance of Blood Flow & Pressure

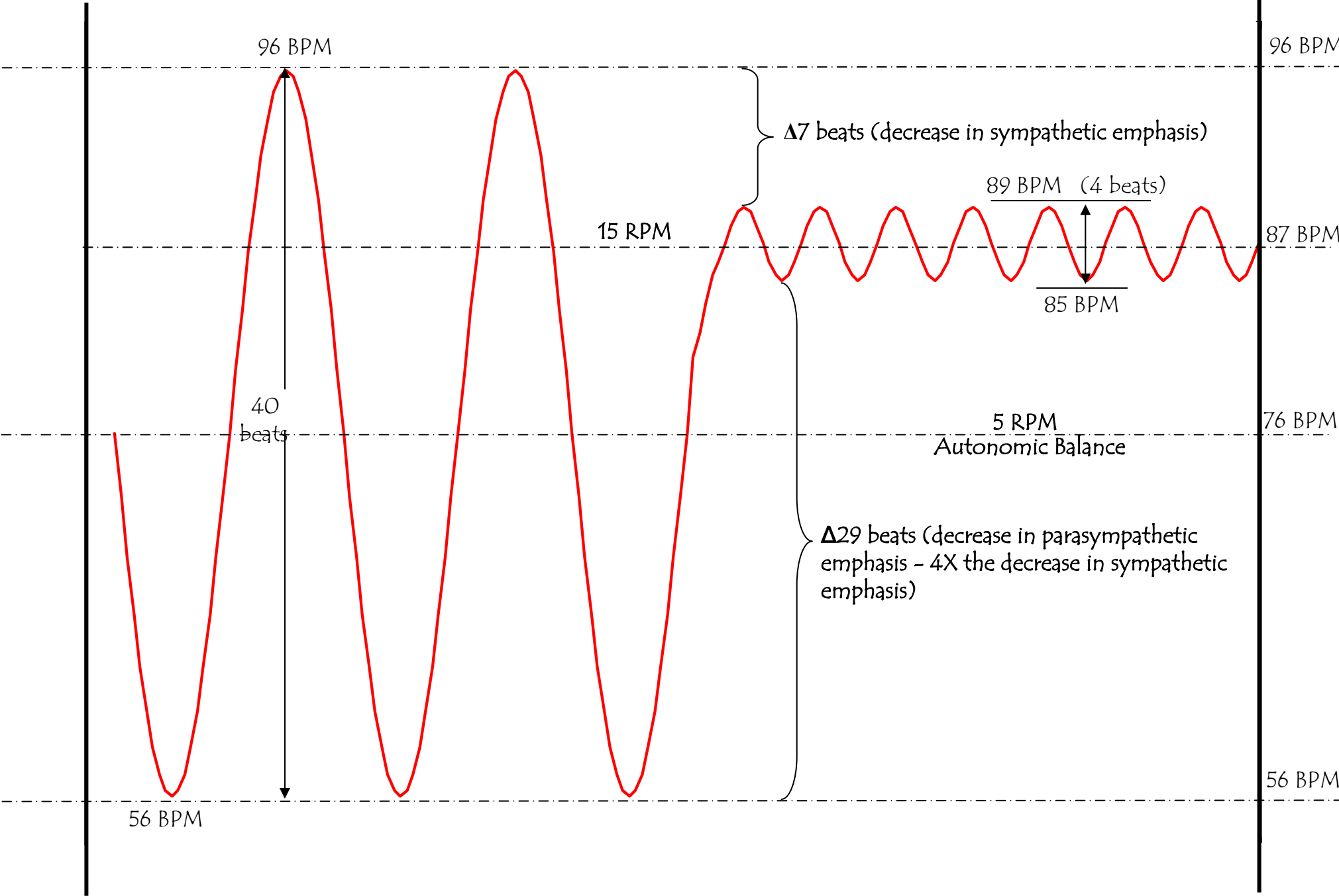
Autonomic Action	Blood Flow	Arterial Pressure
Increasing heart beat rate	Increases	Increases
Decreasing heart beat rate	Decreases	Decreases
Increasing heart output	Increases	Increases
Decreasing heart output	Decreases	Decreases
Increasing arterial capacity	Increases	Decreases
Decreasing arterial capacity	Decreases	Increases

Reprinted from *Coherent Breathing – The Definitive Method*, Elliott & Edmonson, 2008.

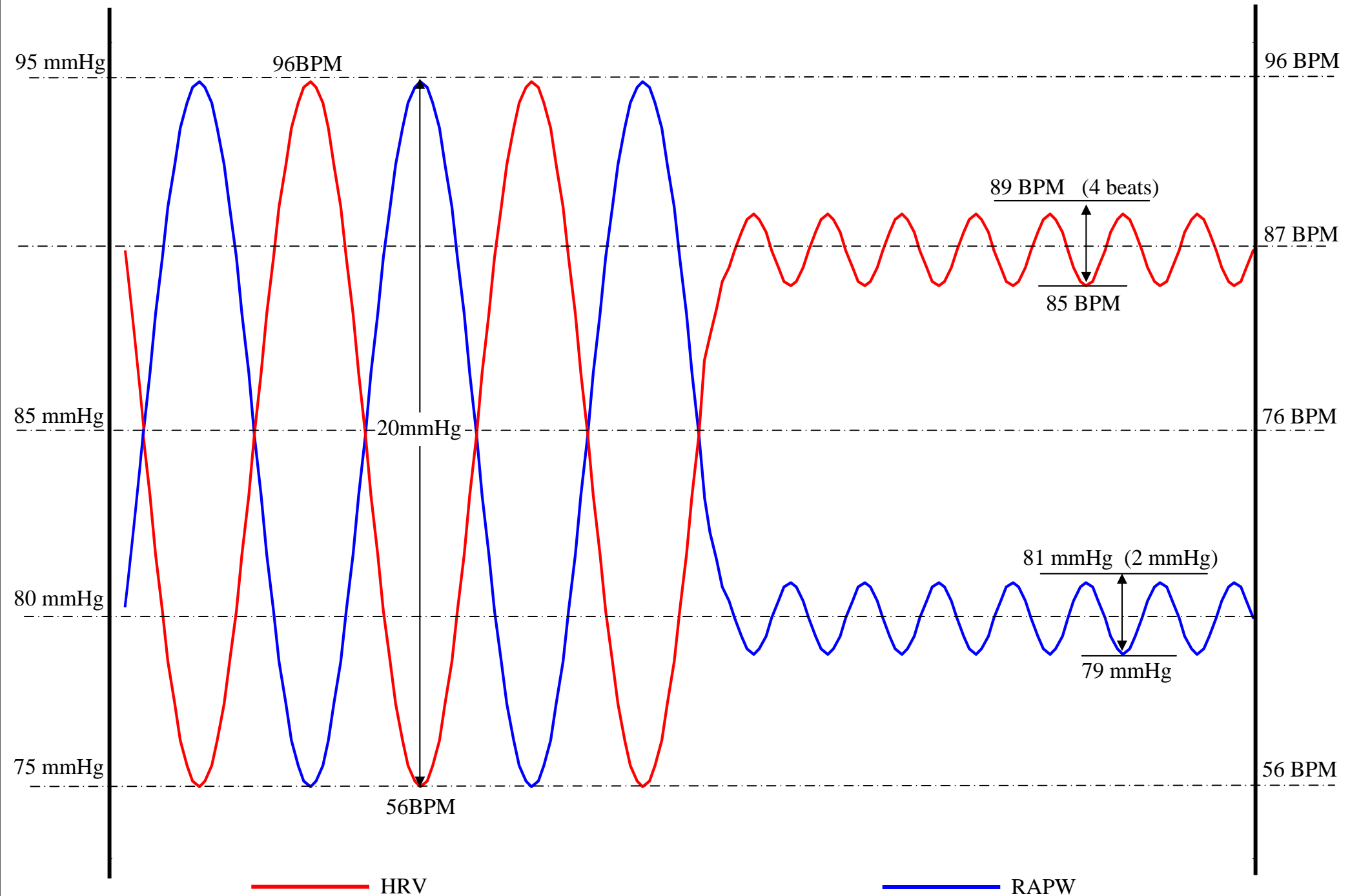
# The Mechanics



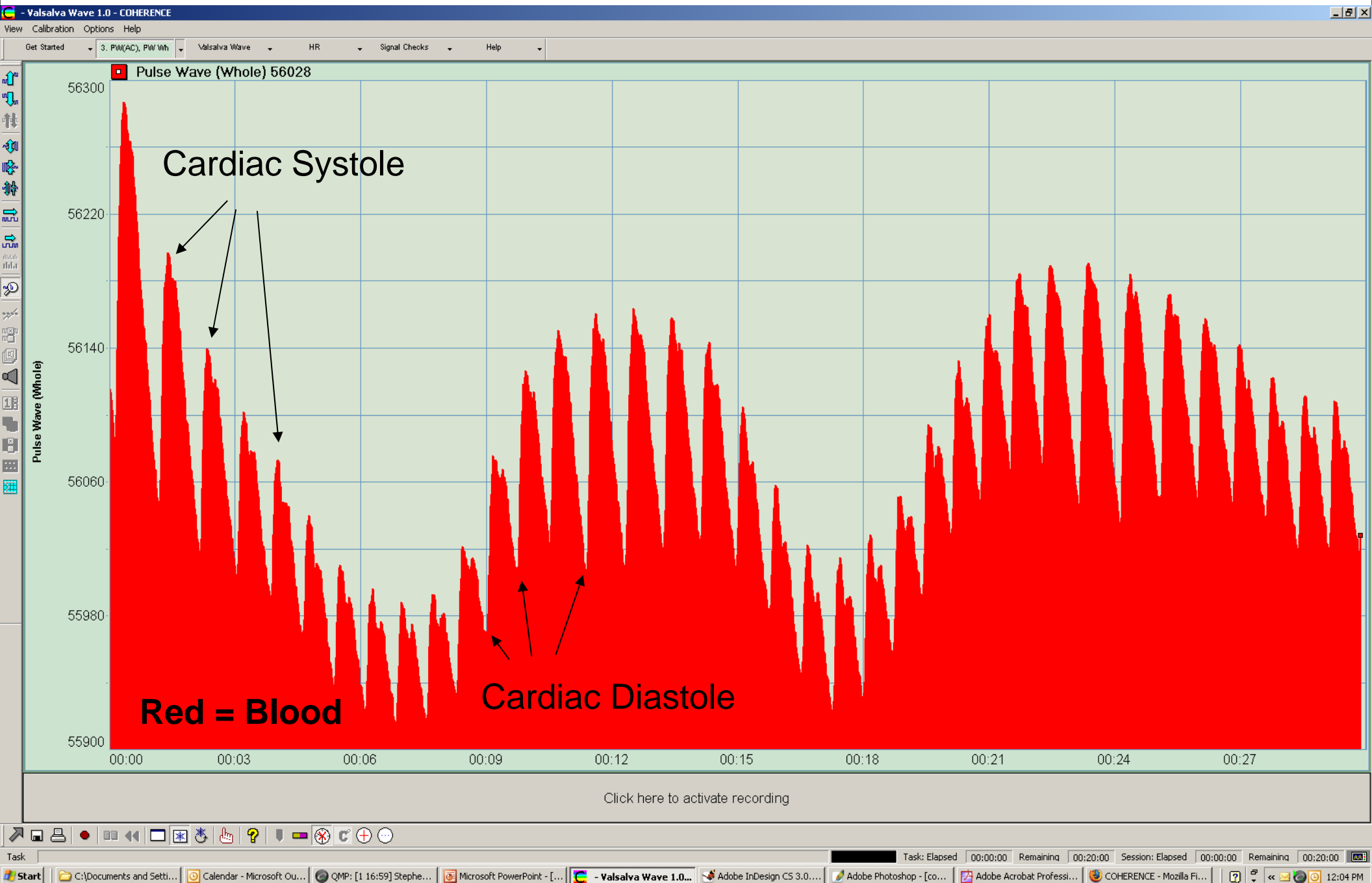
# Variation in HRV With Breathing Frequency



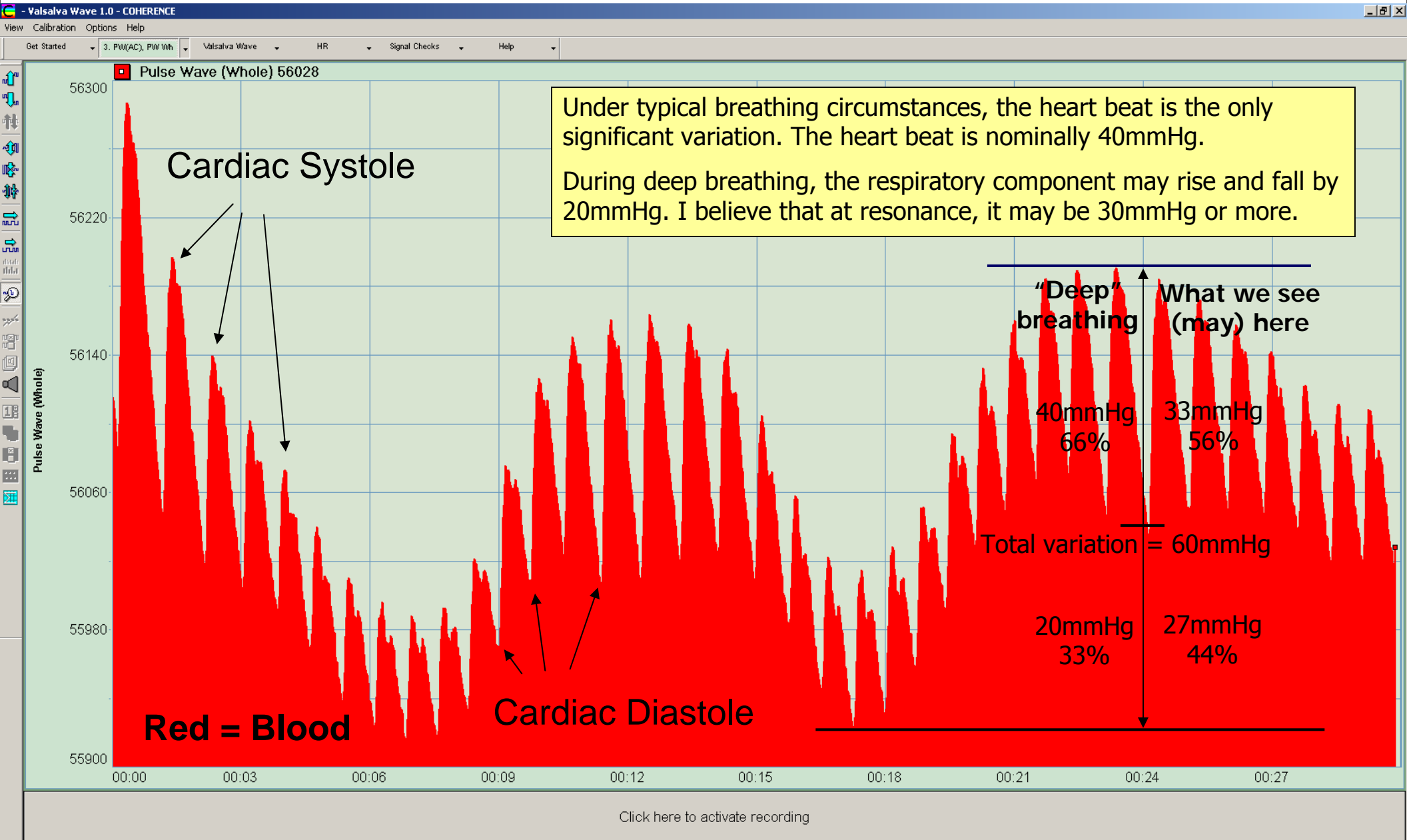
# Theoretical RAPWave and HRV at 5 & 15 RPM



# A View of This Process Measured At Left Thumb



# Measured At Left Thumb



The pulse "normally" contributes to about 33% of blood pressure (40mmHg) at the brachial artery. During very shallow breathing, the respiratory component is effectively zero – the remainder (80mmHg) falls to the vascular system and gravity.

# 10X Relationship?

	A	B	C	D
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The End of  
Part I

Thank You!