Acute respiratory failure

Continued development of BASIC Collaboration courses is supported by unrestricted educational grants from:

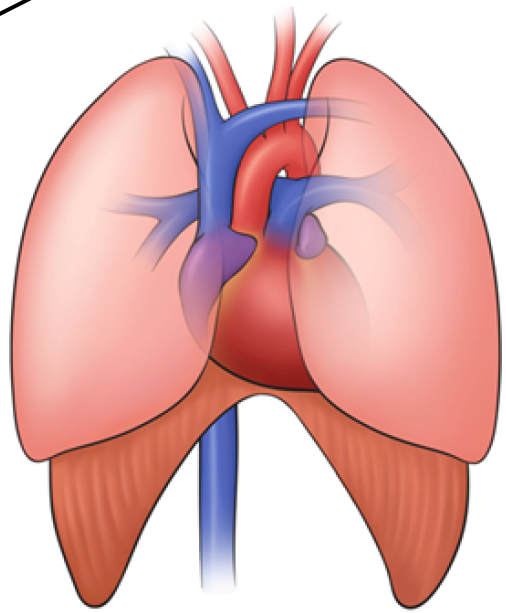
Dräger HAMILTON MEDICAL MAQUET Fisher&Paykel HEALTHCARE VYGON Value Life

Definition

Acute respiratory failure occurs when the pulmonary system is no longer able to meet the metabolic demands of the body

Hypoxaemic respiratory failure

$PaO_2 \leq 8$ kPa
when breathing room air



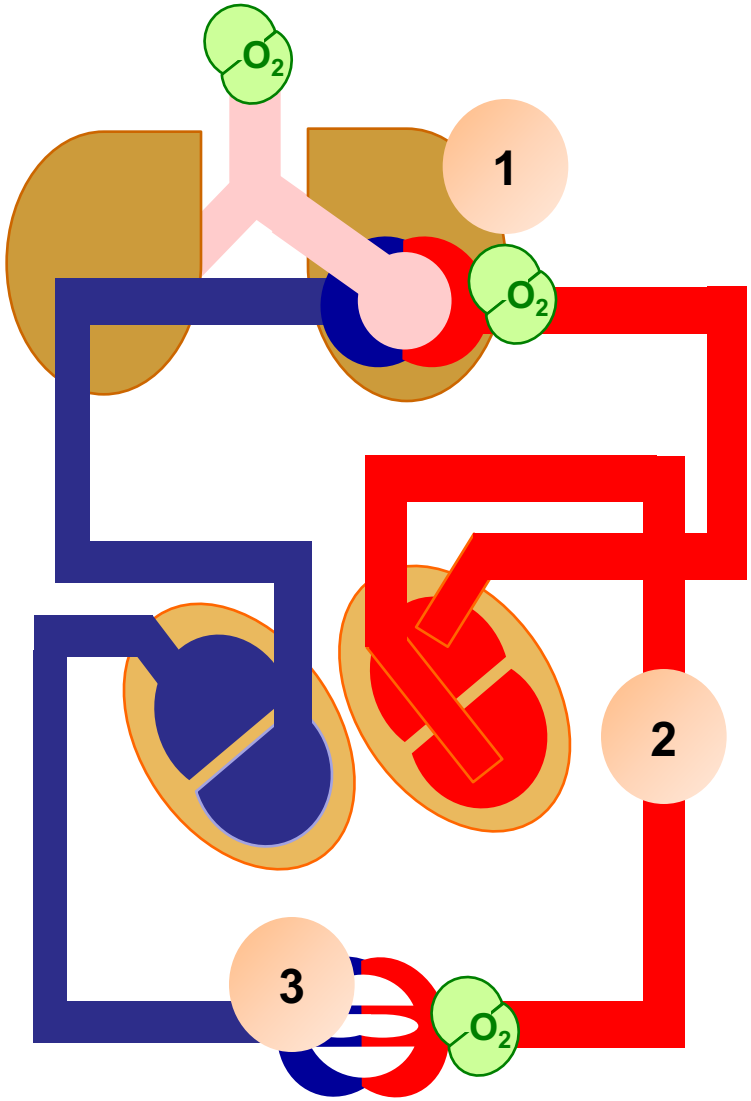
Hypercapnic respiratory failure

$PaCO_2 \geq 6.7$ kPa

combination of both

Basic phyisology

Oxygen



Continuous delivery of oxygen from inspired air to tissue cells

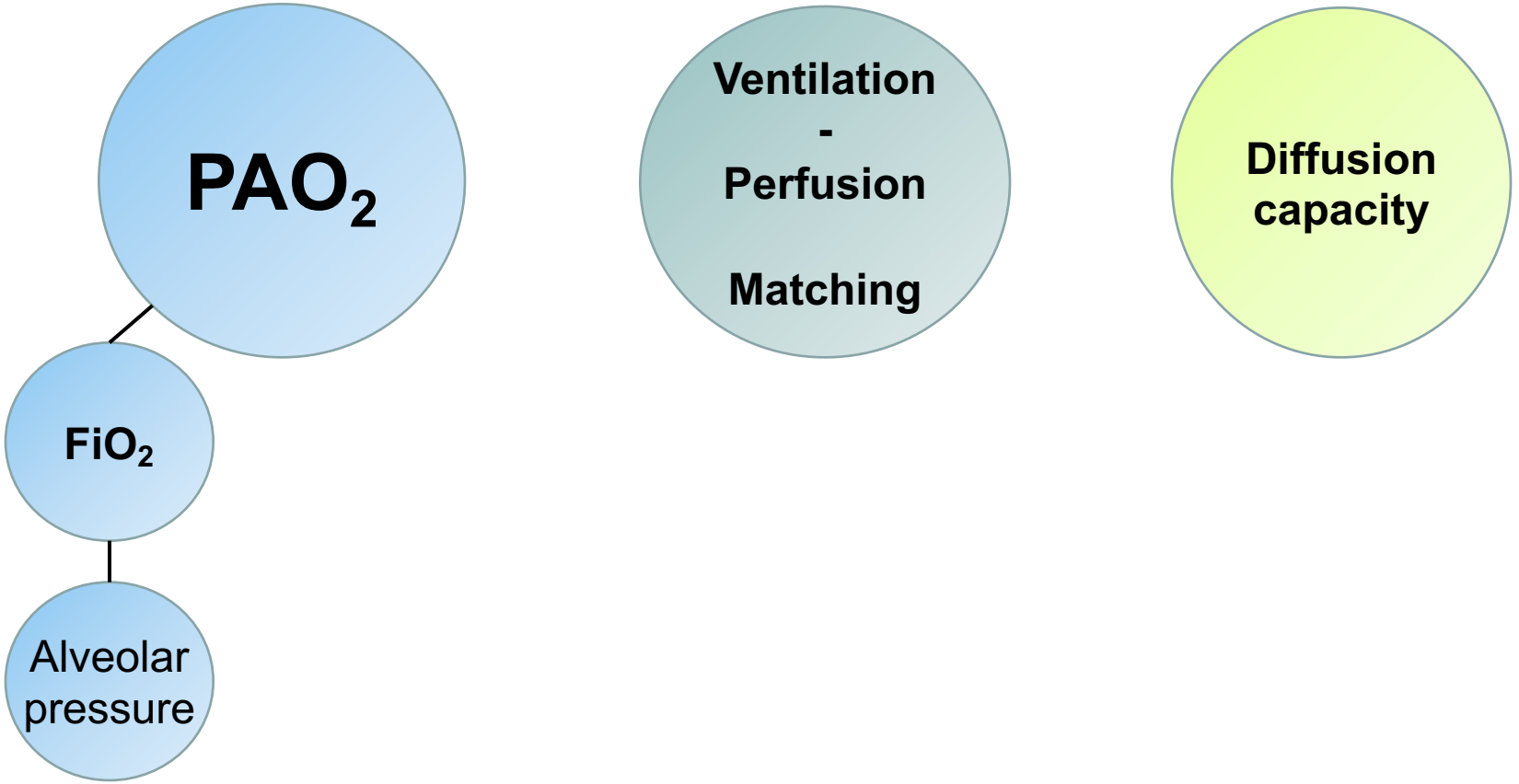
3 sequential events

1. **Uptake** of oxygen from alveolar air into the lungs
2. **Transport/delivery** of oxygen in blood from lung to tissues
3. **Release** of oxygen from blood to tissues

Oxygen uptake

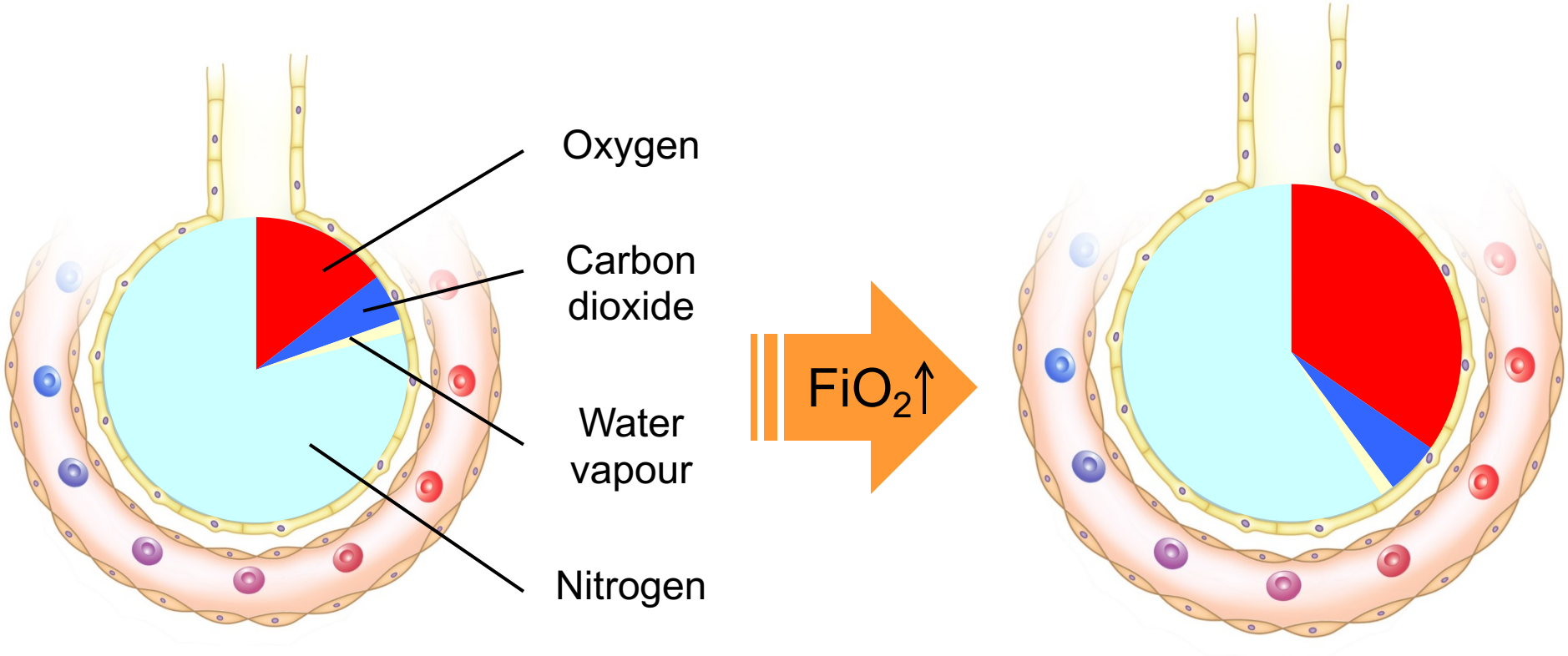
Key parameter: PaO_2

PaO_2 in arterial blood is the result of oxygen uptake via diffusion through the alveolo-capillary membrane from the lungs to the blood



Oxygen uptake: PAO_2 - FiO_2

$$Alveolarpressure = P_AO_2 + P_ACO_2 + P_AH_2O + P_AN_2$$



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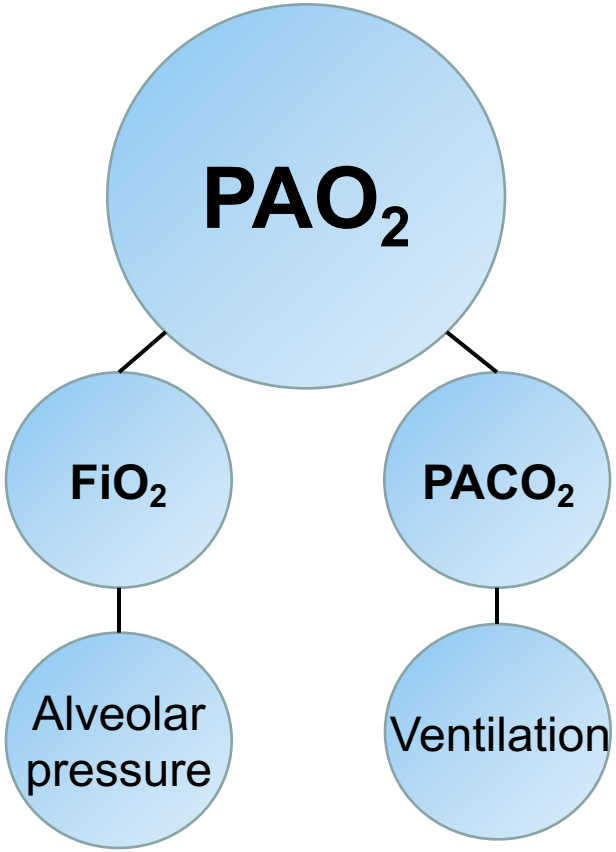
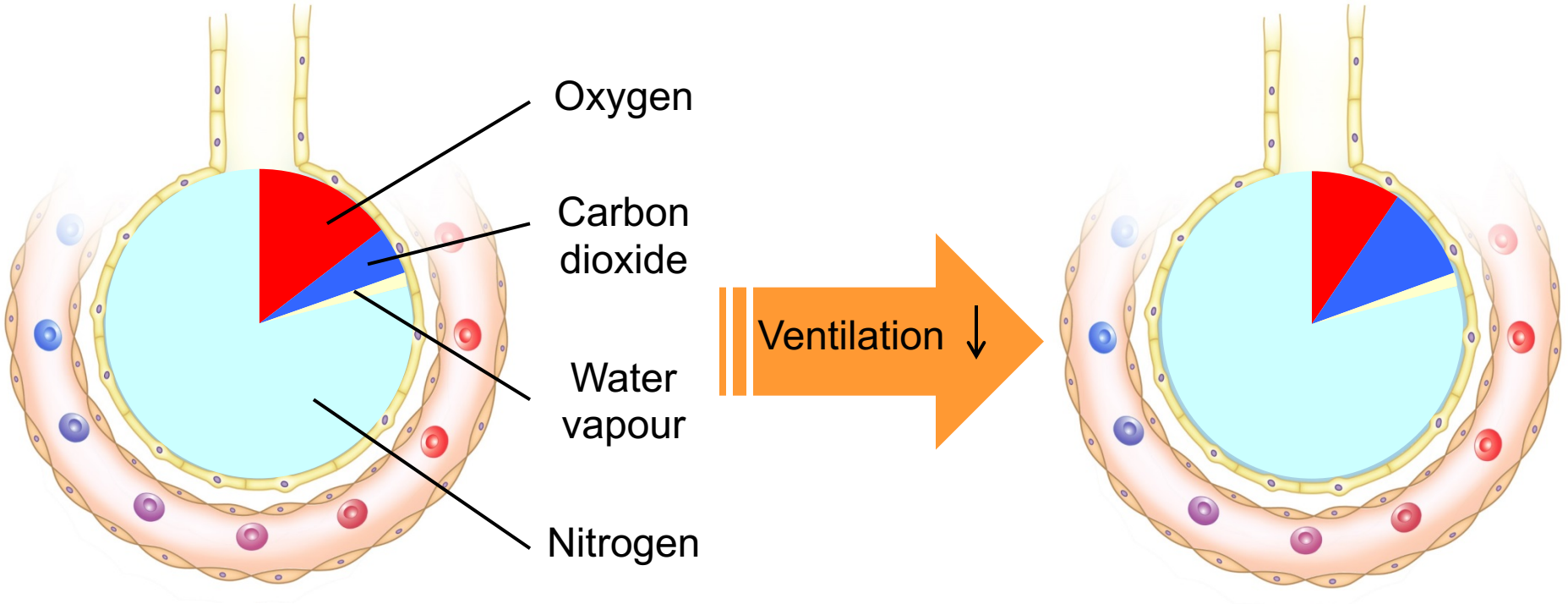


Ventilation - Perfusion Matching

Diffusion capacity

Oxygen uptake: PAO_2 - $pACO_2$

$$Alveolarpressure = P_AO_2 + P_ACO_2 + P_AH_2O + P_AN_2$$



<u>A-a gradient</u>

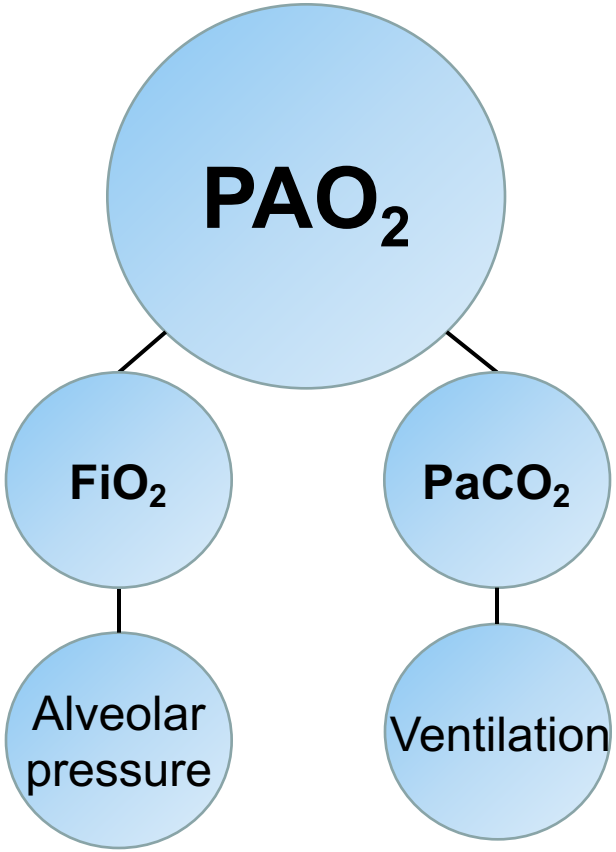
normal: hypoxia due to hypercapnia

increased: hypoxia due to shunt or diffusion abnormality

Oxygen uptake

Key parameter: PaO_2

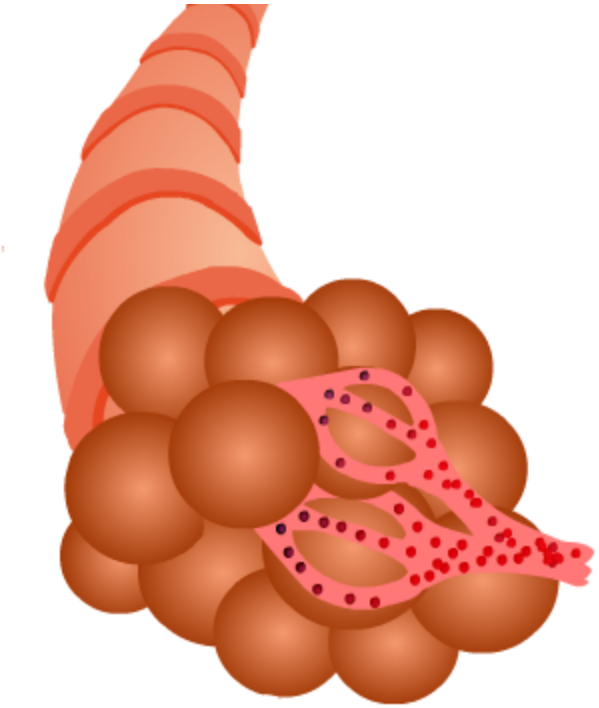
PaO_2 in arterial blood is the result of oxygen uptake via diffusion through the alveolo-capillary membrane from the lungs to the blood

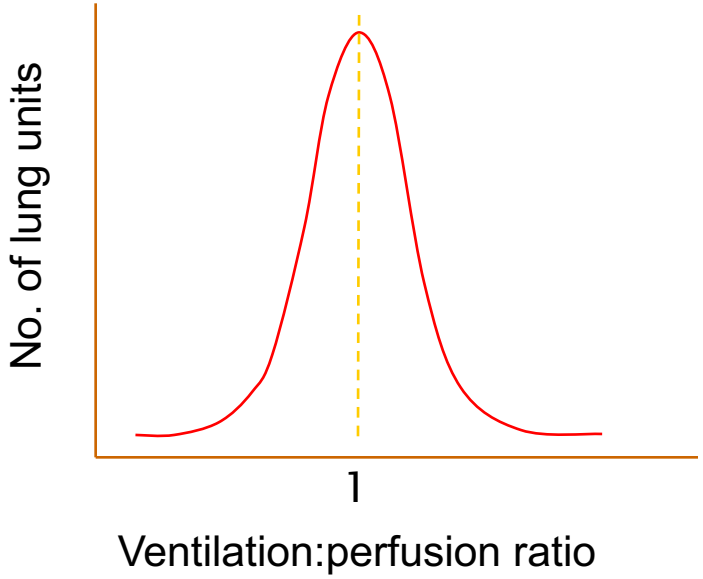


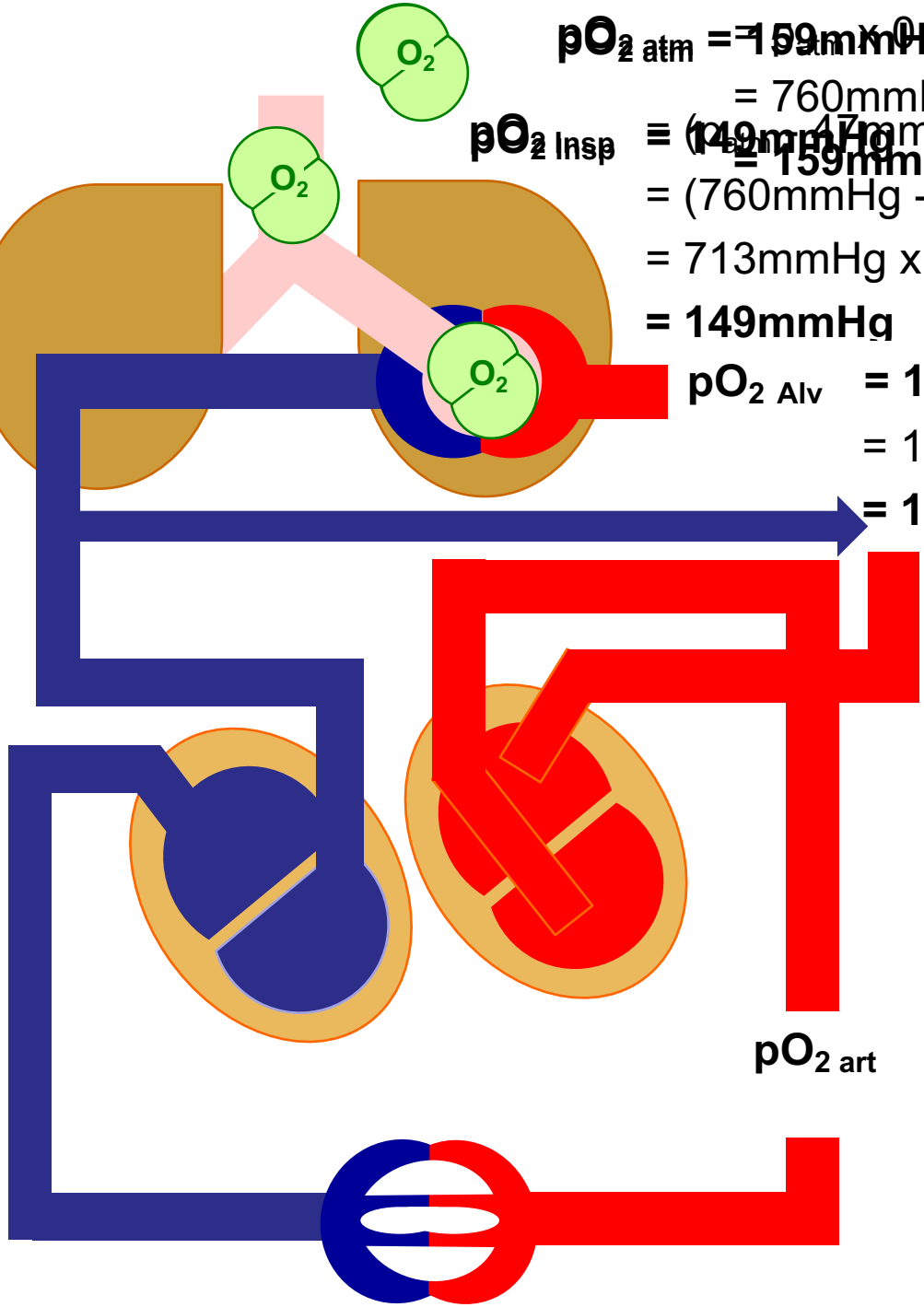
Ventilation - Perfusion Matching

Diffusion capacity

Oxygen uptake: Ventilation-perfusion matching







$pO_{2\ atm}$ = 159mmHg

= 760mmHg x 0.21

$pO_{2\ Insp}$ = (760mmHg - 47mmHg) x 0.21

= 159mmHg

= (760mmHg - 47mmHg) x 0.21

= 713mmHg x 0.21

= 149mmHg

$pO_{2\ Alv}$ = 100mmHg (PCO_2/R)

= 149 - (40/0.8)

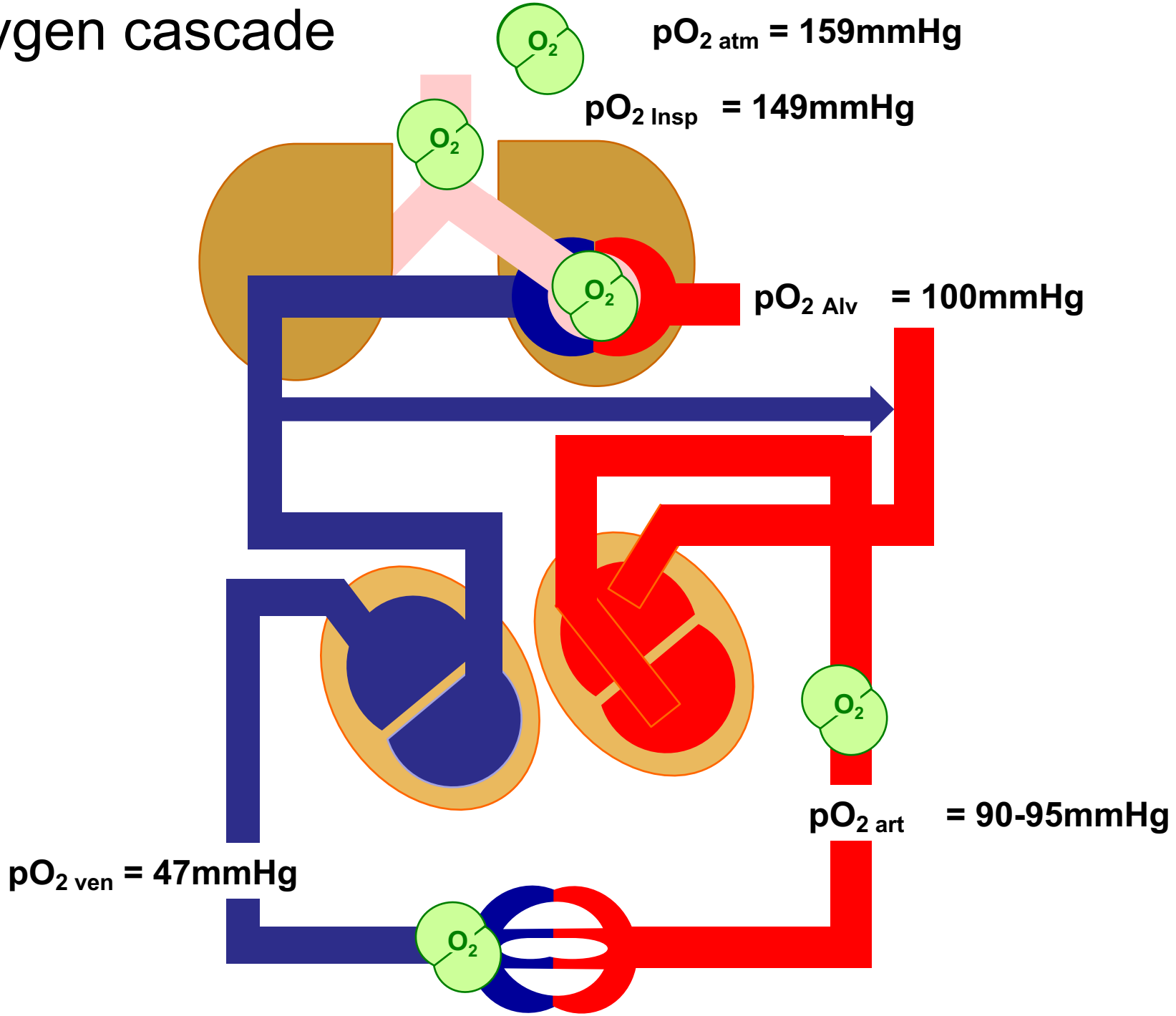
= 100mmHg

$pO_{2\ art}$ = 90-95mmHg

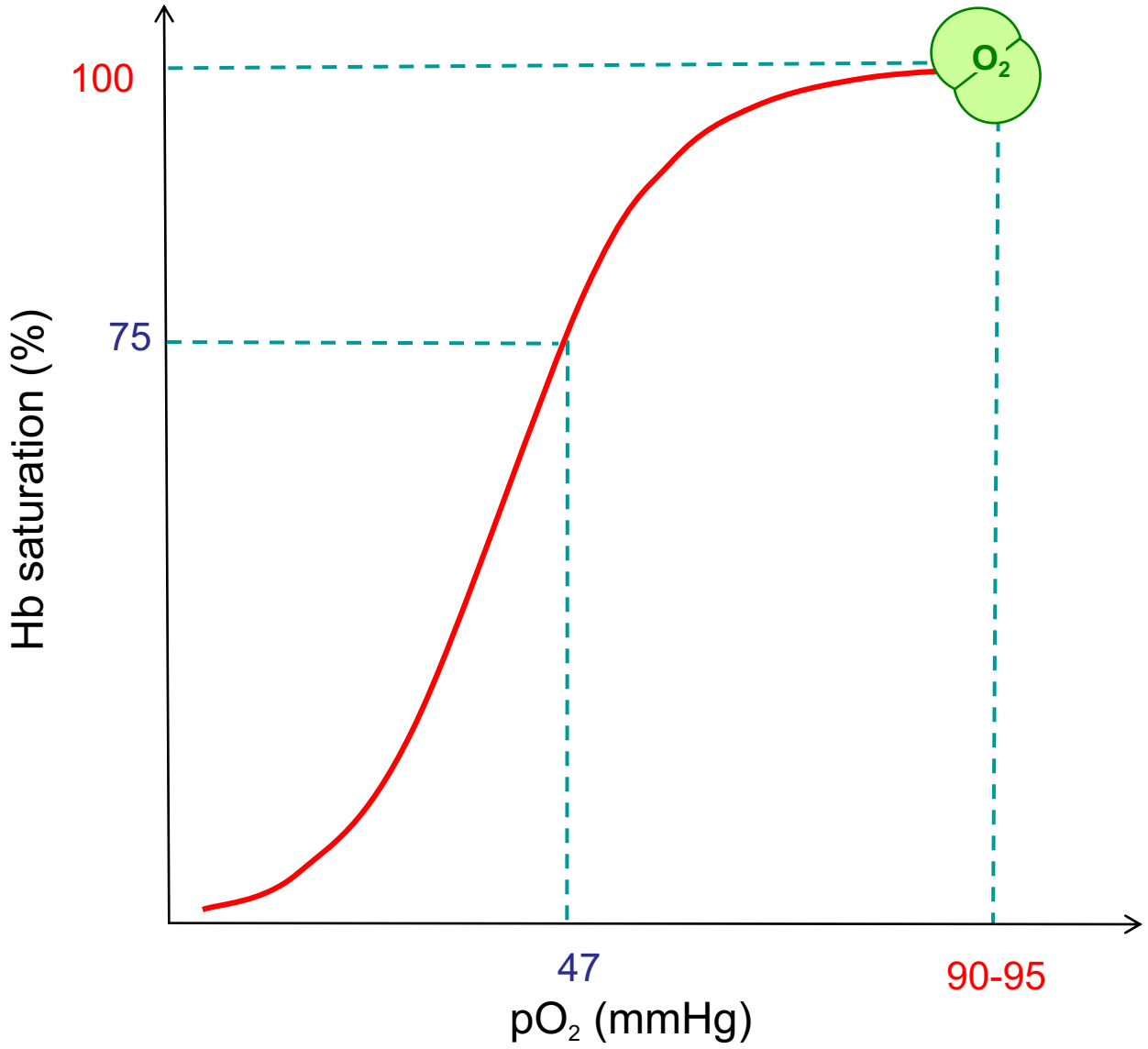
= 90-95mmHg

Oxygen cascade

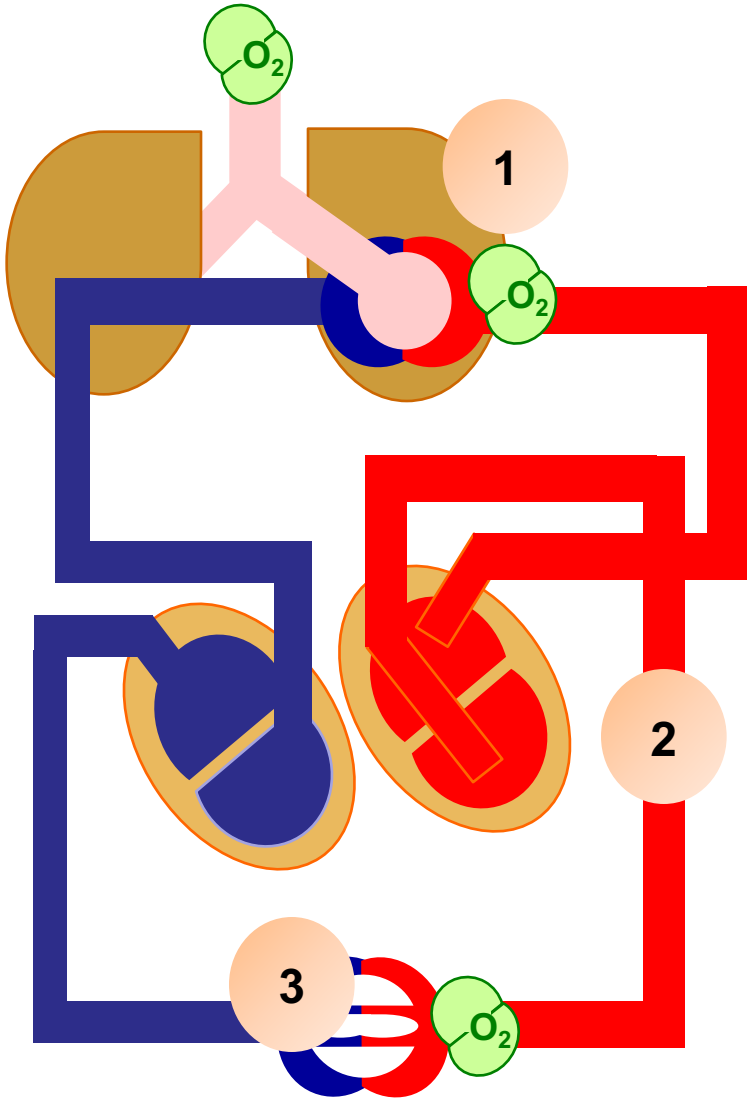
Oxygen cascade



Pulse oximetry



Oxygen



Continuous delivery of oxygen from inspired air to tissue cells

3 sequential events

1 **Uptake** of oxygen from alveolar air into the lungs

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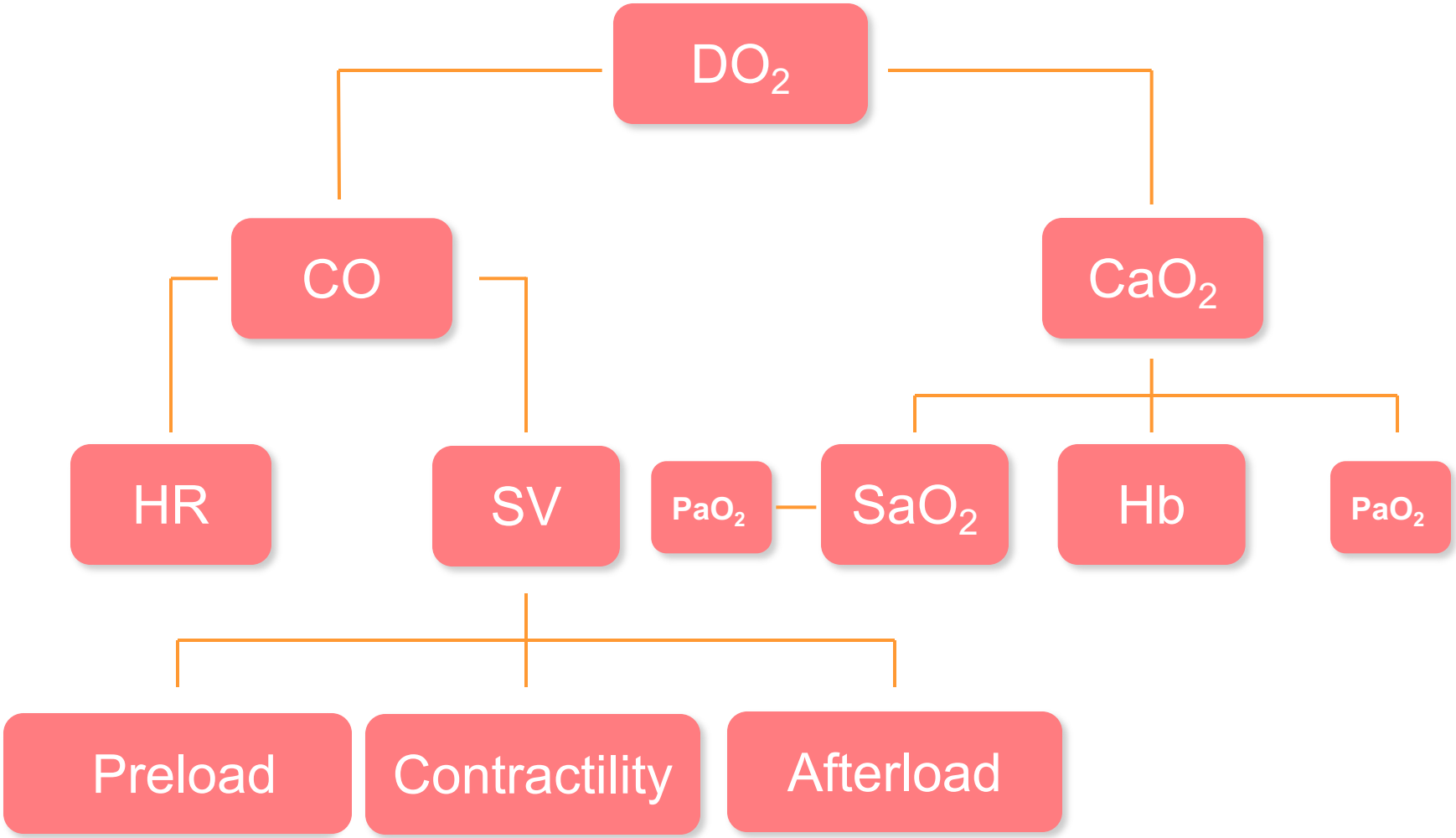
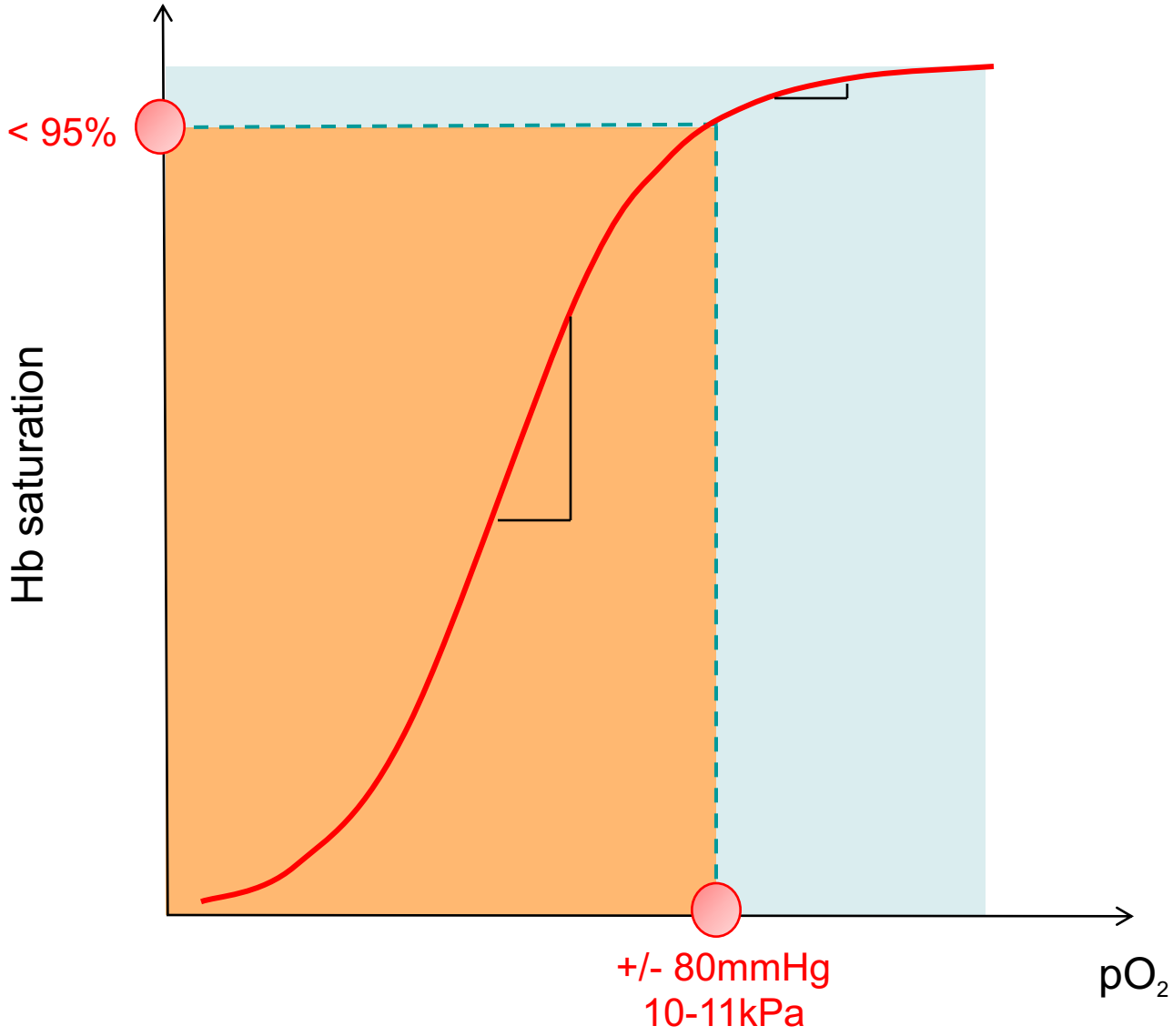
3 **Release** of oxygen from blood to tissues

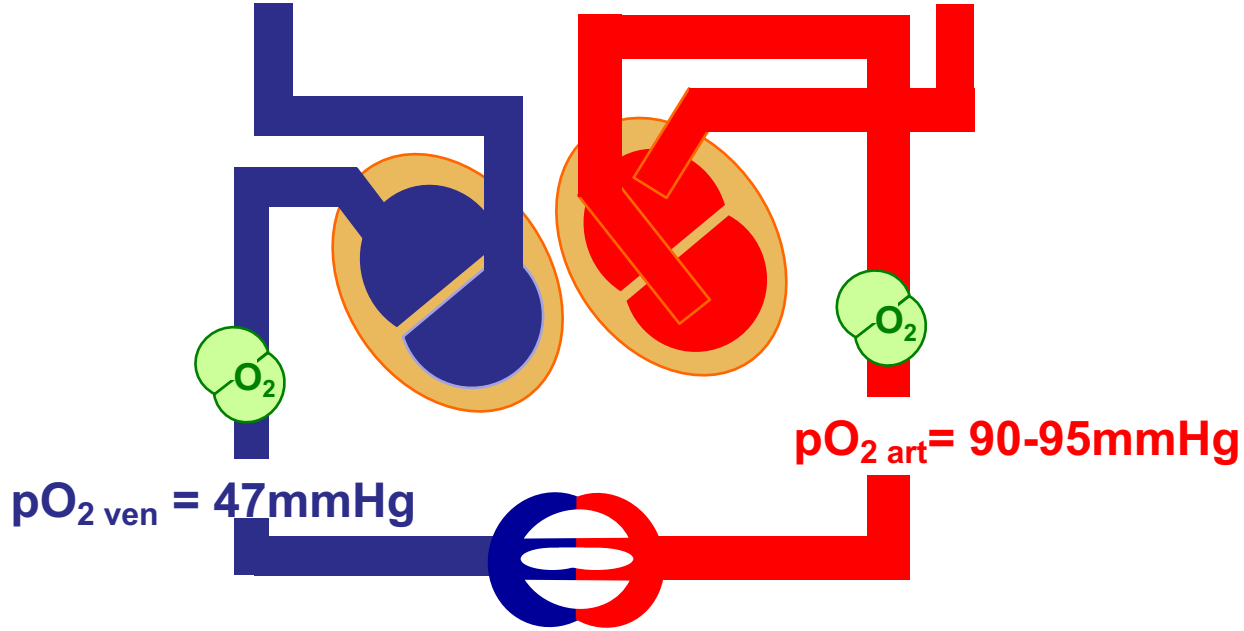
Determinants of oxygen delivery



Oxyhemoglobin dissociation curve



Oxygen delivery - oxygen consumption



CaO_{2ven}
= (Hb x $SmvO_2$ x 1.39) + ($pO_{2\ ven}$ x 0.0031)

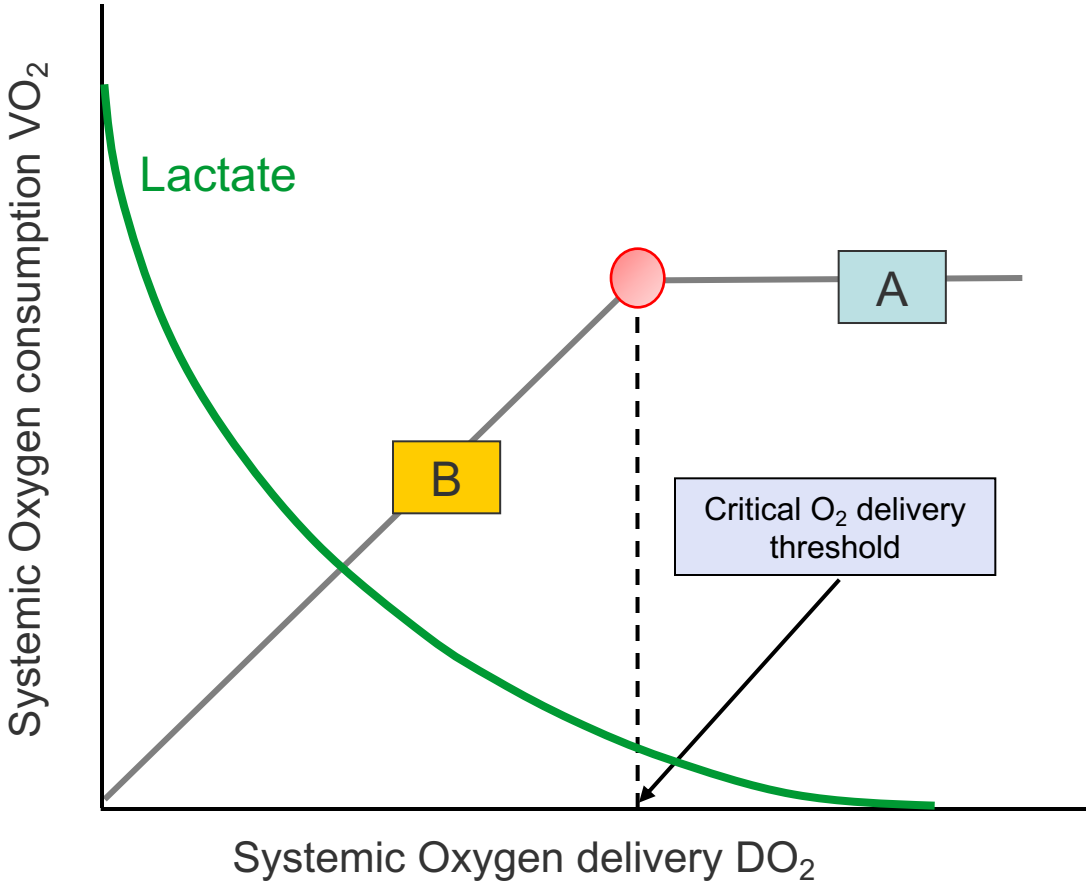
CaO_{2art}
= (Hb x SaO_2 x 1.39) + ($pO_{2\ art}$ x 0.0031)

. Blut ⟶

VO_2= 4.1ml O_2/dL Blut x 50 = 205mlO_2/min

DO_2= 19.8ml O_2/dL Blut x 50 = 990mlO_2/min

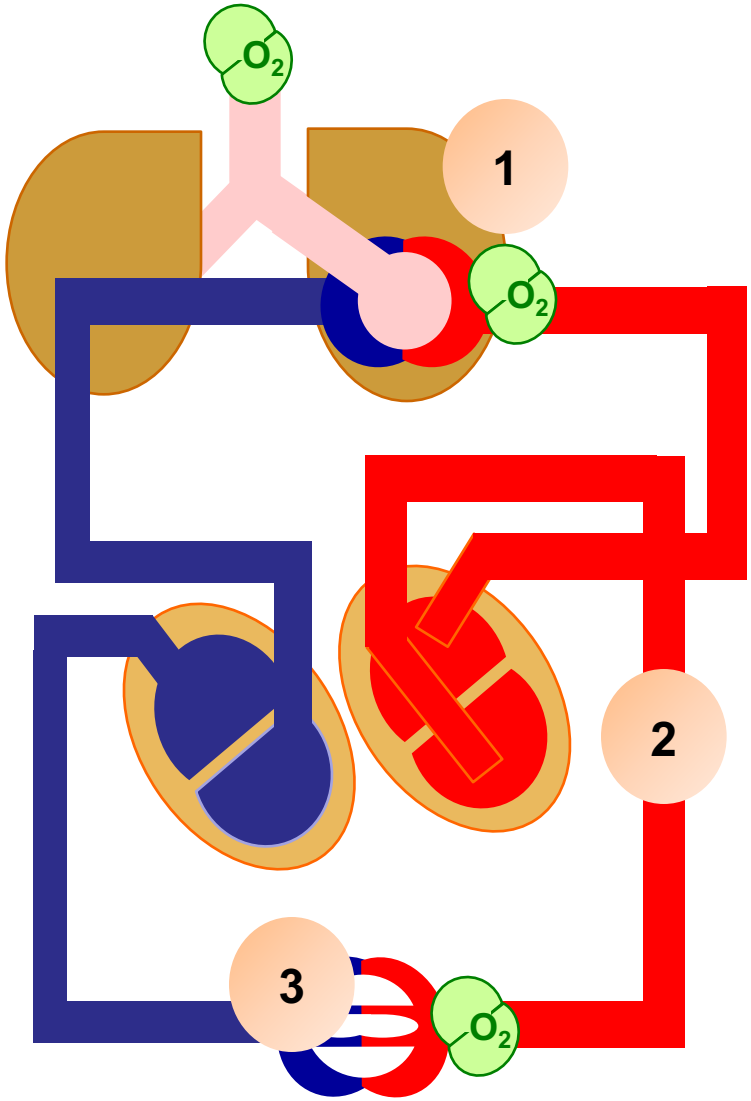
Relationship between DO_2 and VO_2



A = delivery independent phase

B = delivery dependent phase

Oxygen



Continuous delivery of oxygen from inspired air to tissue cells

3 sequential events

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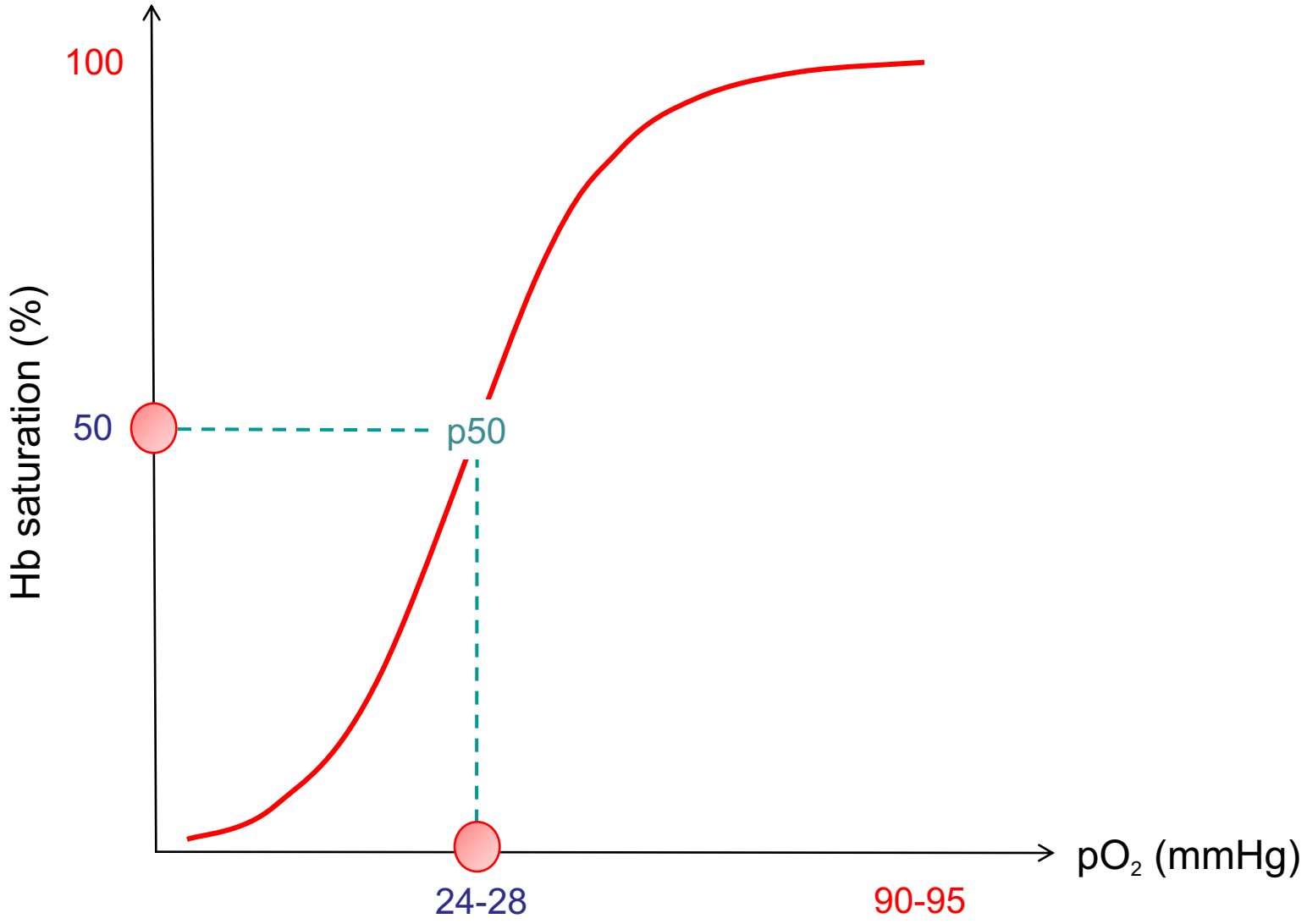
Oxygen release



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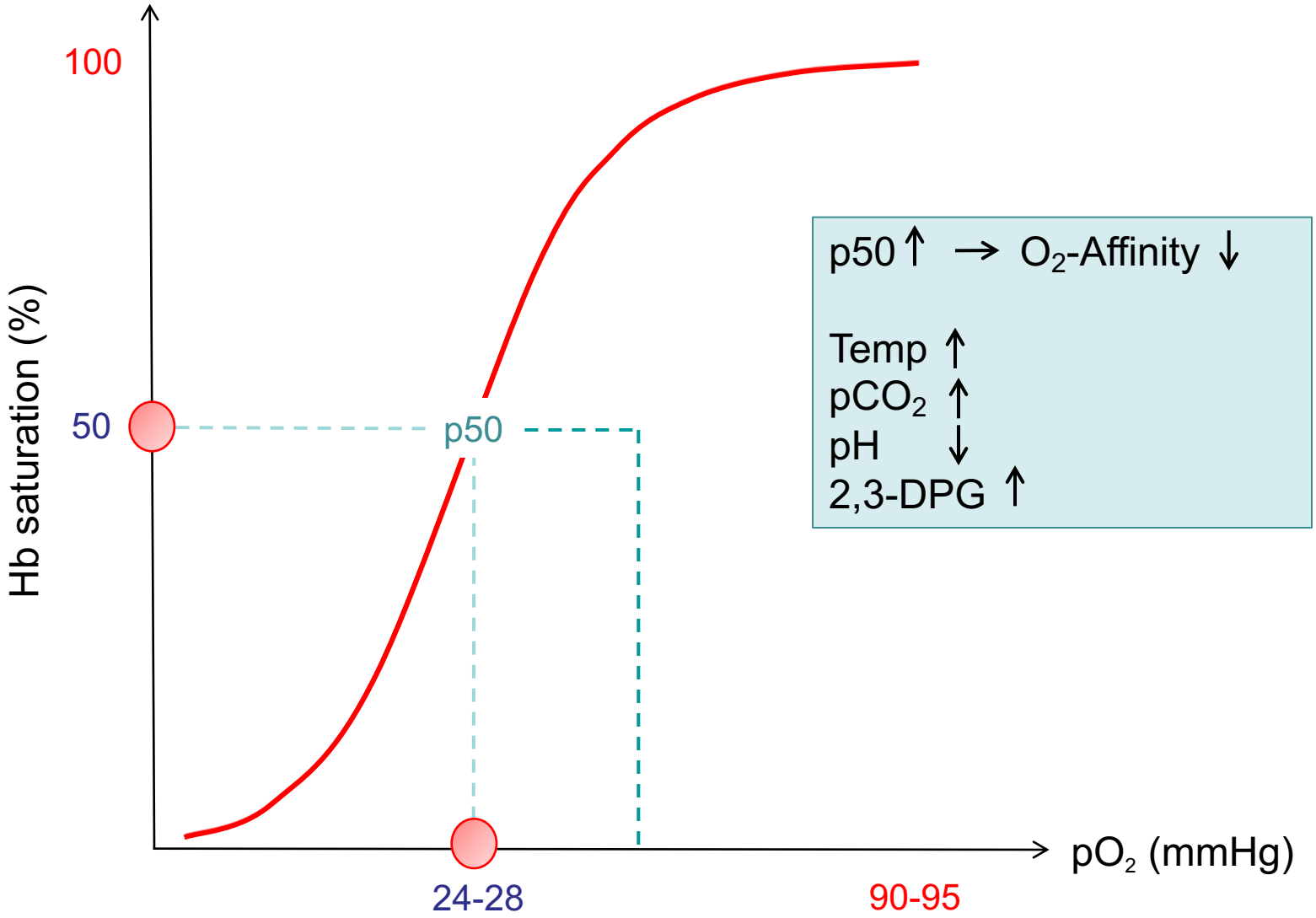

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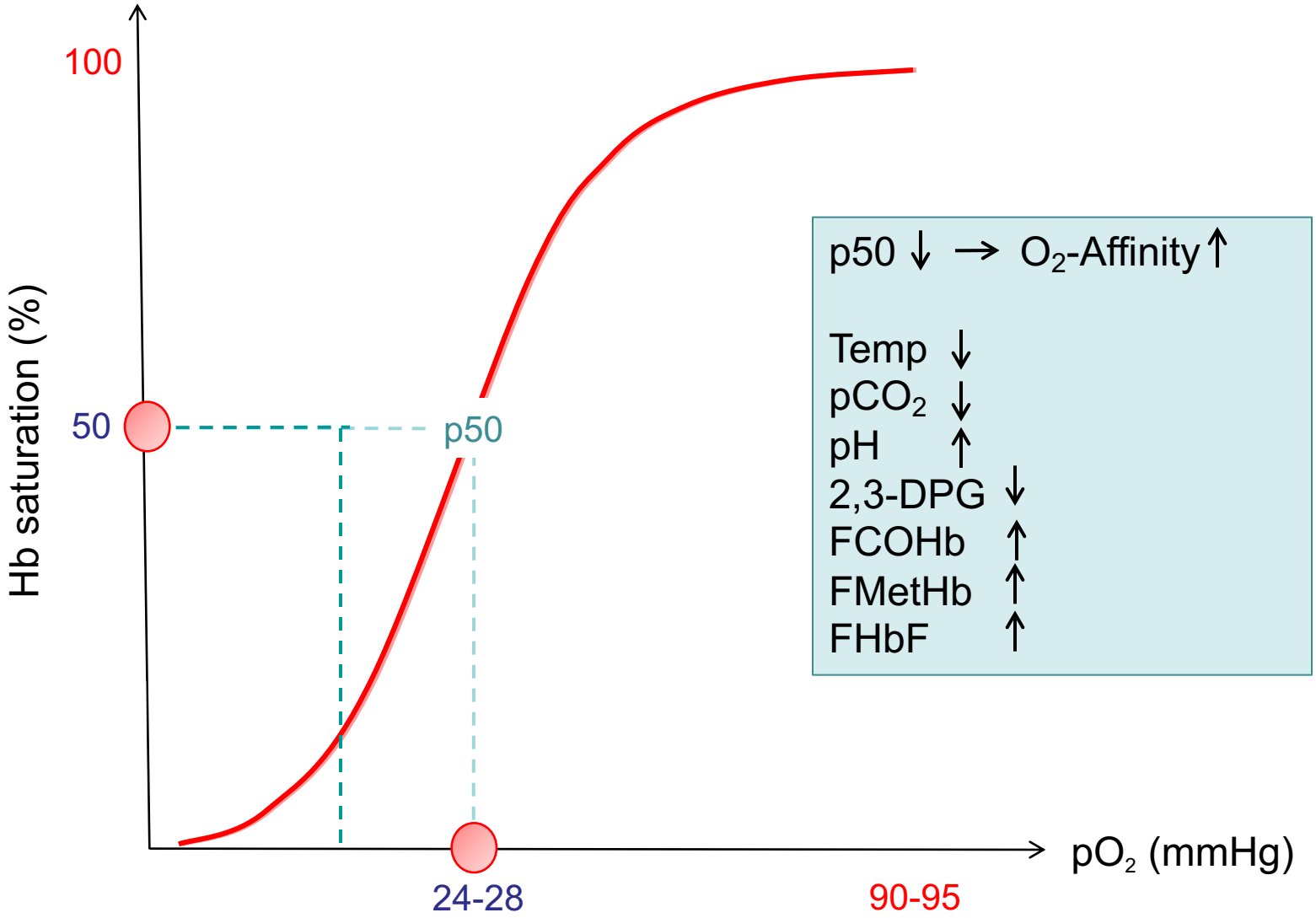
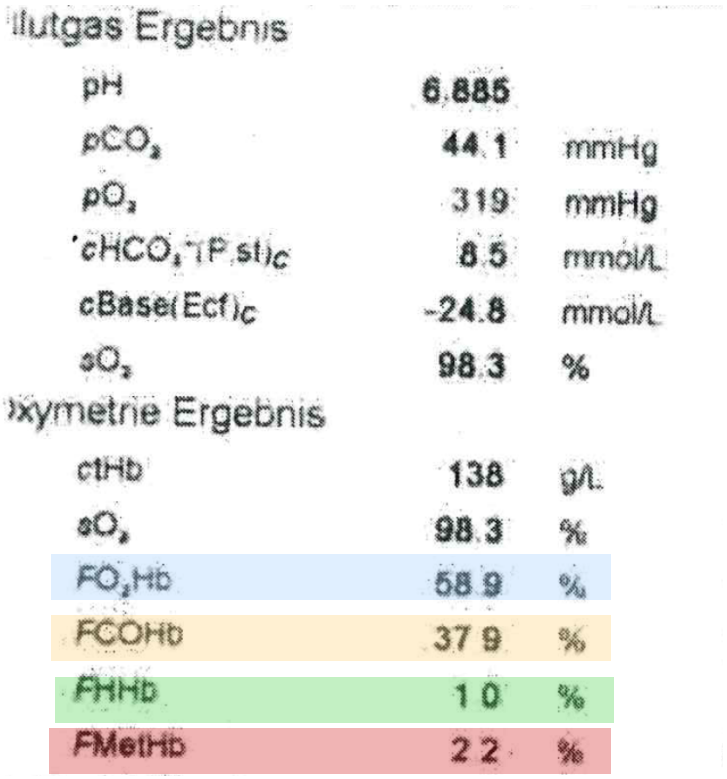


Oxygen status and blood gas analysis

Blutgas Ergebnis		
pH	6.885	
pCO_2	44.1	mmHg
pO_2	319*	mmHg
$cHCO_3^-$(P,st)c	8.5	mmol/L
cBase(Ecf)c	-24.8	mmol/L
sO_2	98.3	%
Oxymetrie Ergebnis		
ctHb	138	g/L
sO_2	98.3	%

* 42.5kPa

Oxygen status and blood gas analysis



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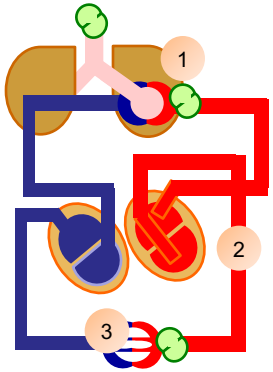
Oxymetrie Ergebnis		
ctHb	138	g/L
sO_2	98.3	%
FO_2Hb	58.9	%
FCOHb	37.9	%
FHHb	1.0	%
FMetHb	2.2	%

Hemoglobin		
	Oxyhemoglobin	FO_2Hb
	Carboxyhemoglobin	FCOHb
	Deoxyhemoglobin	FHHb
	Methemoglobin	FMetHb

$$sO_2\ (\%) = \frac{FO_2Hb}{FO_2Hb + FHHb} \times 100 = 98.3\%$$

$$O_2Hb\ (\%) = \frac{FO_2Hb}{FO_2Hb + FHHb + FCOHb + FMetHb} \times 100 = 58.9\%$$

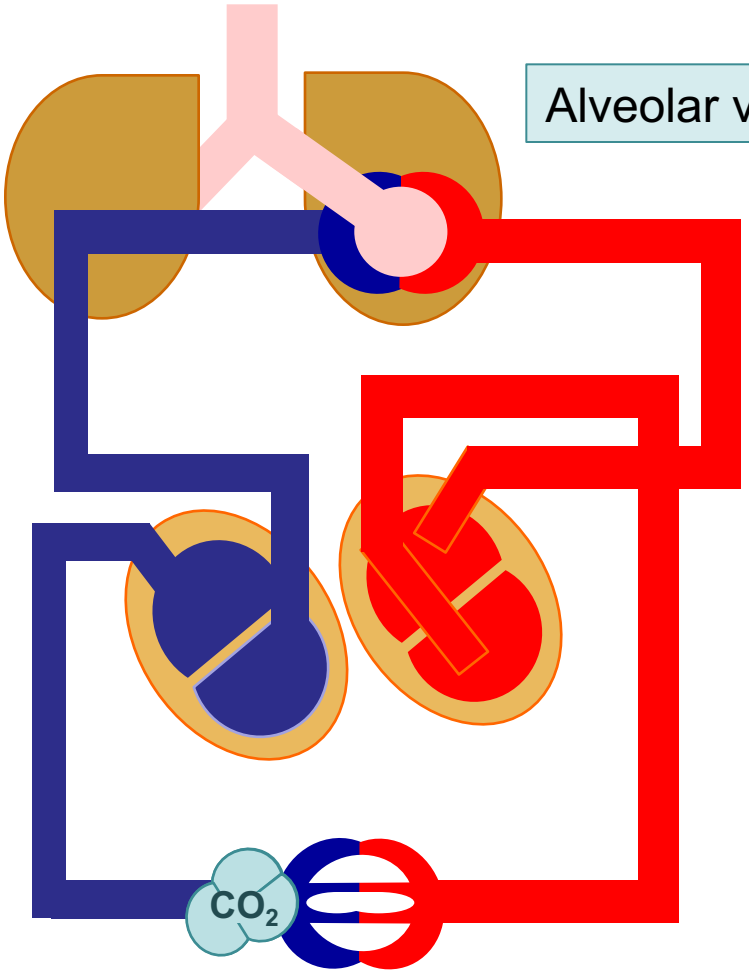
Oxygen status and blood gas analysis



Continuous delivery of oxygen from inspired air to tissue cells

	3 sequential events	Surrogate marker	
1	**Uptake** of oxygen from alveolar air into the lungs	PaO_2	
2	**Transport/delivery** of oxygen in blood from lung to tissues	CaO_2	Lactate
		Hypoxaemia	Hypoxia
3	**Release** of oxygen from blood to tissues	p50	• hypoxemic • ischemic • anemic • histotoxic

Carbon dioxide



55mlCO_2/100ml Blut

VCO_2 = 250ml/min

Alveolar ventilation = RR x (V_T-V_D)

- Largely dependent on alveolar ventilation
- Anatomical dead space constant but physiological dead space depends on ventilation-perfusion matching