

# Breathing at Altitude

## *Why Bother?*

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Lapsed internist/AME  
Elderly soaring pilot

Reference: <https://tinyurl.com/SoarOxygen>

Updated: February 19, 2023

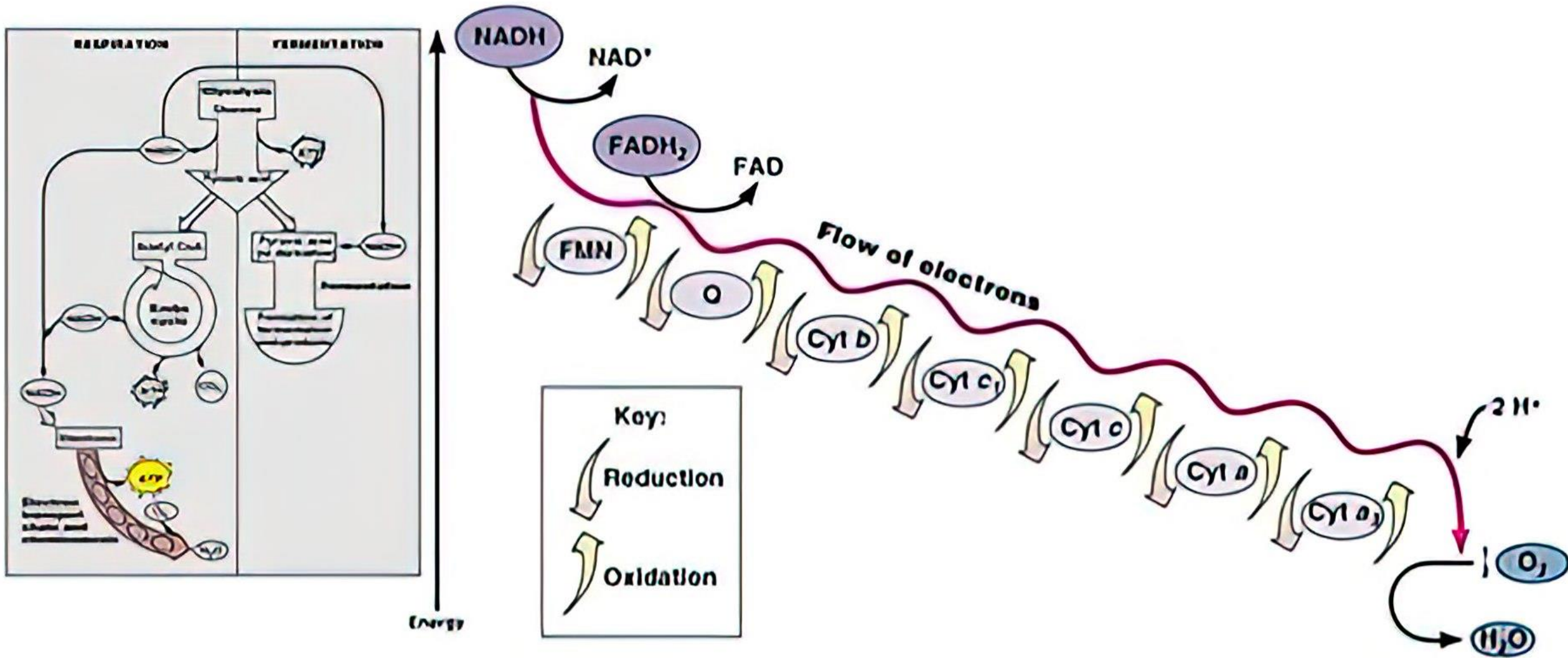
# Topics and Truths

- Respiration vs Breathing
- Why gas partial pressure has consequences
- Why we hyperventilate and its outcomes
- When is oxygen a Good Idea? What's the Purpose?  
(hint: staying legal is not it)
- Can you trust an oximeter?
- What could possibly go wrong?
- What if something is already wrong with my lungs?
- Should I wear a mask?

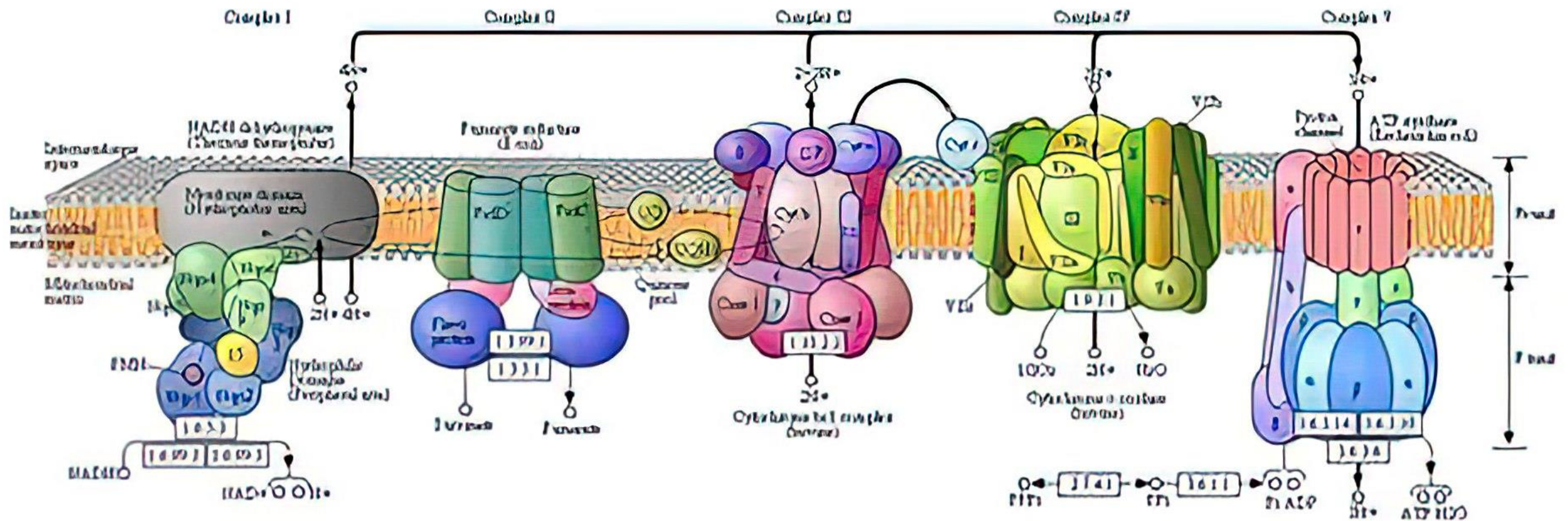
# Required Equipment

- Oxygen system
  - (Listen to DeRosa, up next)
- Oximeter
  - There is no other way to assess your system
  - ...Well, blind faith; not recommended above ~FL180
- Common sense
  - Not available for purchase
- Glider
- Weather

# Electron transport: Why we breathe

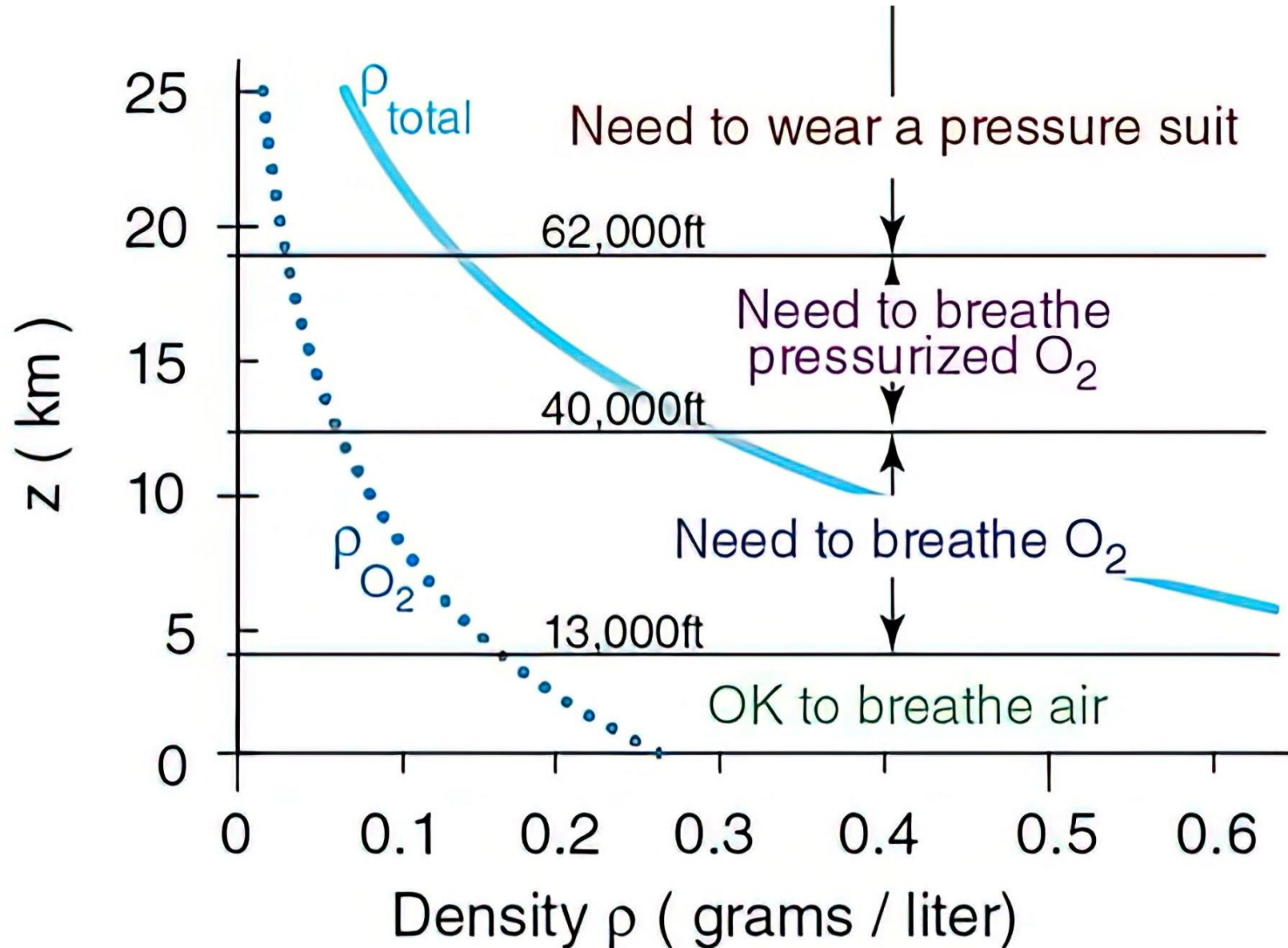


# Electron transport: A fancier cartoon





# What technique to use?



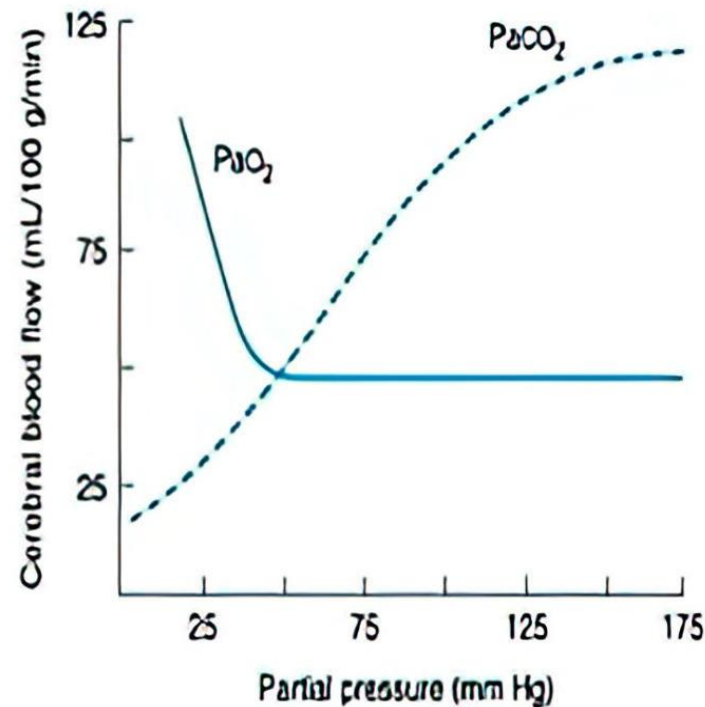
*The actual pressure of oxygen and carbon dioxide in the lungs is the key to understanding*

Altitude  Ft/m	Air press  mmHg	ppO2  mmHg  Air=21 %	Alv pO2  mmHg  on air	% sat O2  > 90%  desired	Alv pCO2  > 35  best	Alv pO2 with O2=100 %	% sat O2  100% O2	Alv pCO2  100% O2
Sea level	760	159	104	97	40	673	100	40
10k/3k	523	110	67	90	36	436	100	40
20k/6.1k	349	73	40	73	24	262	100	40
30k/9.1k	226	47	18	24	24	139	99	40
40k/12k	141	29				58	84	36
50k/15.2k	87	18	■	■	■	16	15	24
			■	■	■			

*Table 1: Alveolar oxygen and carbon dioxide pressure by altitude, atmosphere vs. 100% O2. (After Guyton & Hall: Textbook of Medical Physiology, 12<sup>th</sup> ed.)*

# Why we hyperventilate at altitude

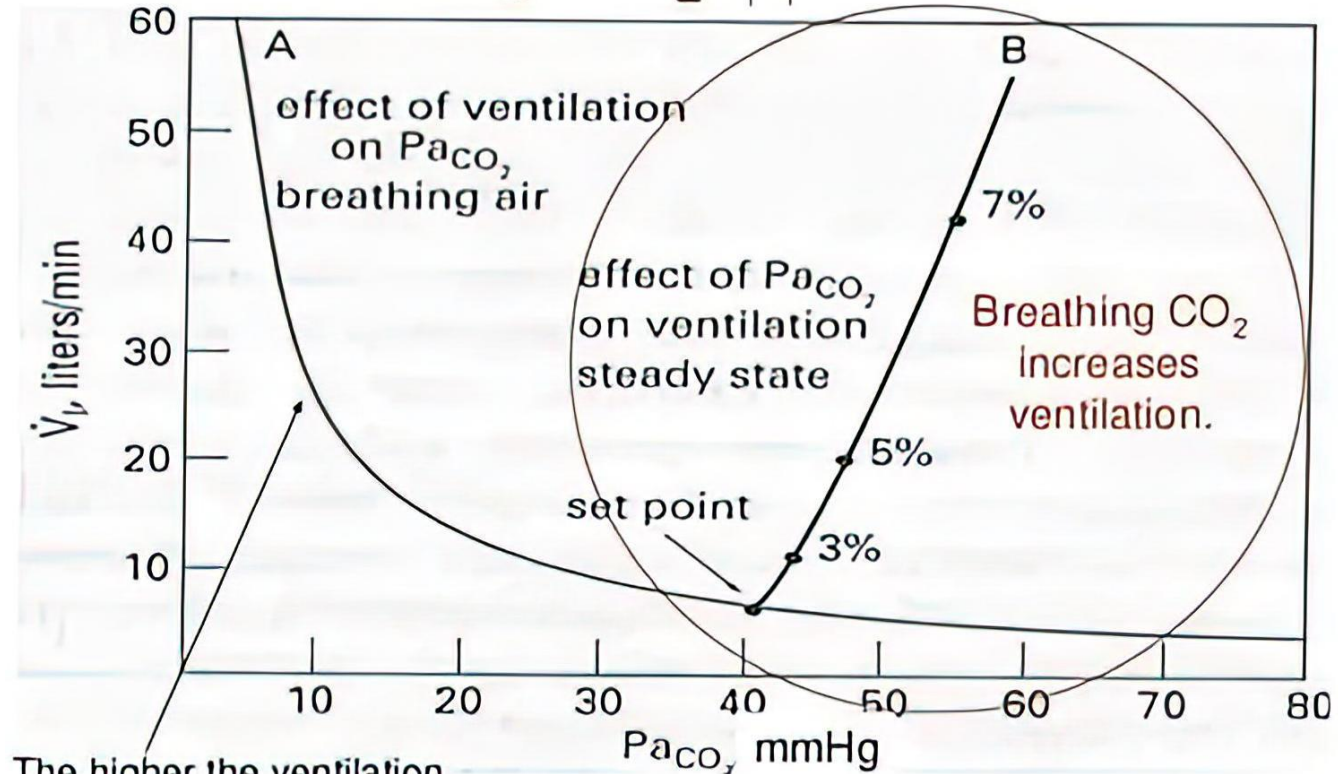
- Breathing is regulated by **carbon dioxide** pressure, not oxygen.
- Cerebral blood flow is regulated by CO<sub>2</sub> pressure, not oxygen
  - CBF is directly proportionate to PaCO<sub>2</sub> between tensions of 20 and 80 mm Hg
  - Blood flow changes 1–2 mL/100 g/min per mm Hg change in PaCO<sub>2</sub>.
  - effect is almost immediate and is due to secondary to changes in the pH of CSF and cerebral tissue.





# Paradoxical Hyperventilation

Hyperventilation: ↓ ↓  $\text{PaCO}_2$   
breathing  $\text{CO}_2$  ↑ ↑ ventilation

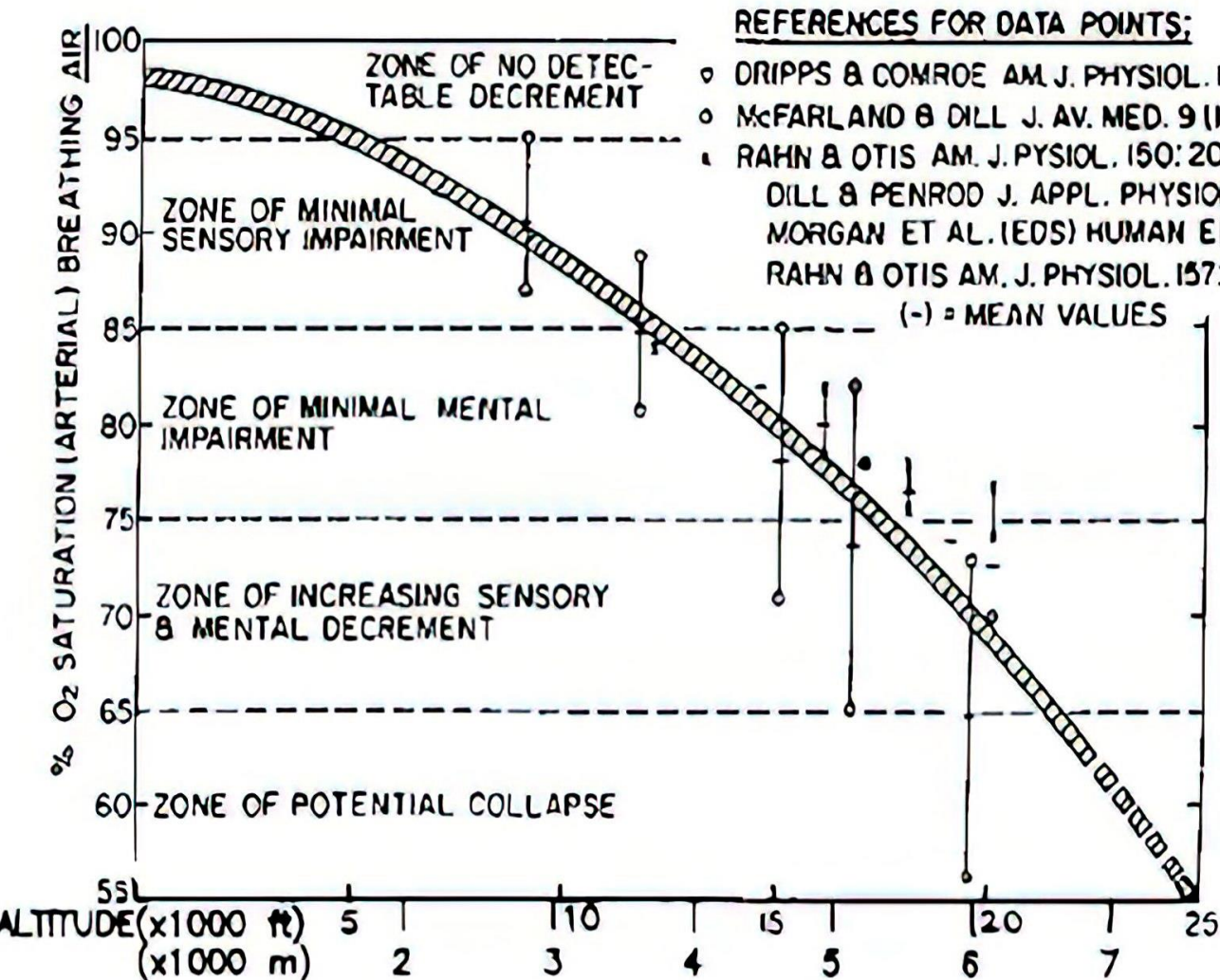


The higher the ventilation  
the lower the  $\text{PaCO}_2$ .

# A Patrick McLaughlin plug

- The Mountain High system detects both
  - Apnea (breathing pauses, usually due to fixation) and
  - Hyperventilation (sounds an alarm, pauses oxygen)
- This is important to
  - detect the risk of decreased blood flow to your brain,
  - in case you plan to use it as backup to your autopilot.

# What do saturation levels mean?



Normal

Your wife notices and you do not

Your passenger notices and you do not

ATC notices and you do not

You begin wondering – is everything OK?

# When to Use Oxygen?

- When do you want your brain to be at its best?  
Example, healthy 40 year old male

Altitude	Atm pressure	Arterial O2	Hgb saturation
Sea level	760	86	97
4000 msl	634	59	91
10000 msl	523	52	87
FL 180	380	33	72
FL 220	321	26	60
FL 250	282	6	9



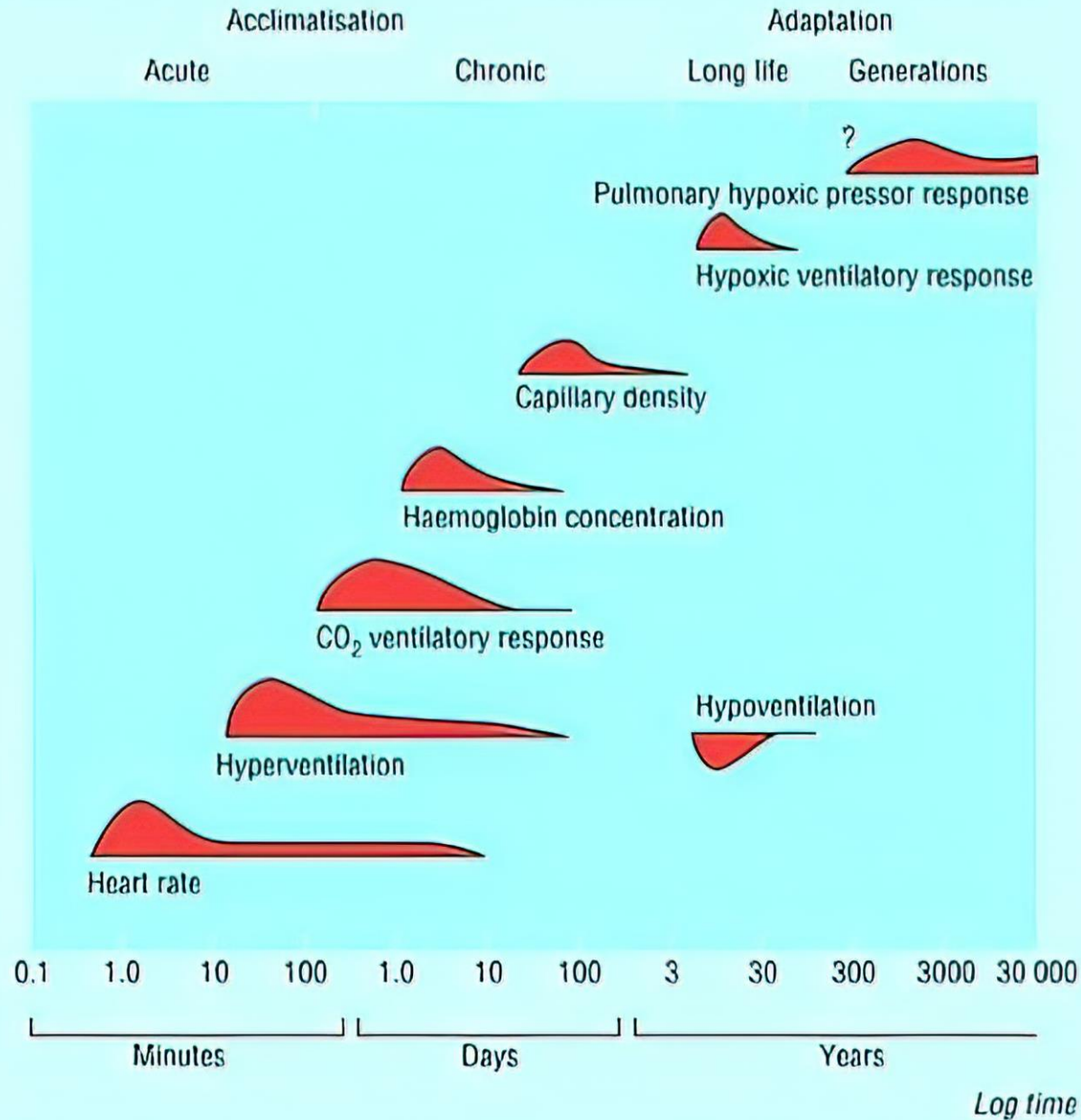
# What about (age)?

age  $\geq 18$  years (n=37 299) from Smith *et al*<sup>19</sup>

Age (years)	n	SpO <sub>2</sub>					
		Minimum	Maximum	Mean	SD	Median	IQR
18–24	1663	80	100	98.0	1.8	98	97–99
25–34	2239	82	100	97.6	1.9	98	97–99
35–44	3412	73	100	97.2	2.1	98	96–99
45–54	4103	76	100	96.8	2.2	97	96–98
55–64	5020	72	100	96.3	2.5	97	95–98
$\geq 65$	20 862	70	100	95.8	2.7	96	95–98

SpO<sub>2</sub>, arterial oxygen saturation measured by pulse oximetry.

# Acclimatisation is slow



# Use a wrist oximeter



- Use the little finger
- *Do not* use nail polish
- *Melanin causes falsely elevated saturation values*  
(comparison flight with a melanin-deficient partner, identical oximeters)
- Isn't needed *every* flight once you know your own baseline

# Winding down

- 1: Masks are not required outside of commercial aviation  
The MH system with cannulae, in ***military-grade*** young men, was shown to be effective above FL300. *Do not do this at home!*
- 2: Always think of: *what could be going wrong here?*
- 3: What is your backup plan for system failure?