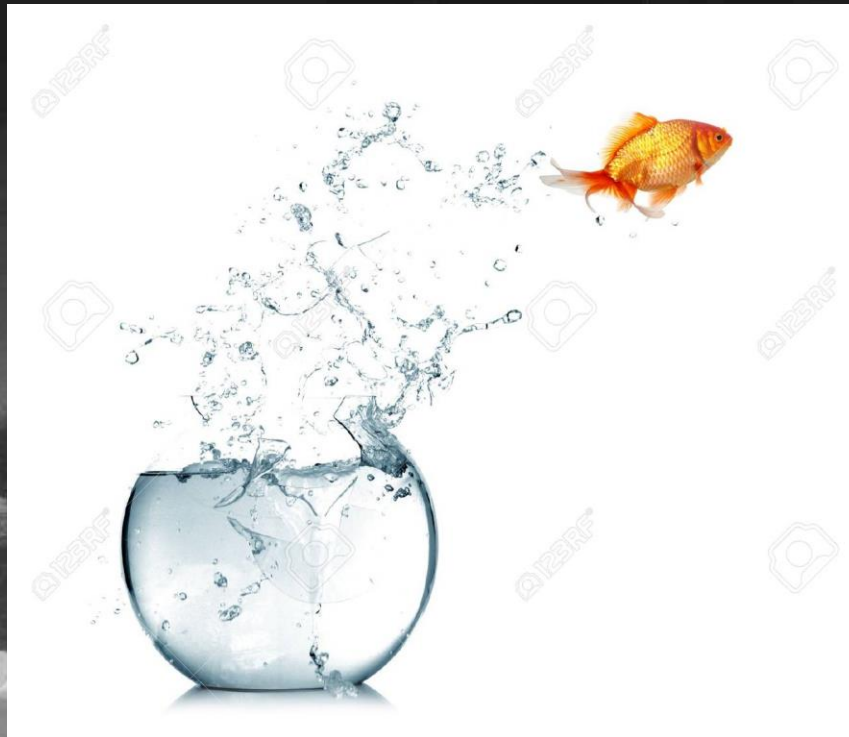
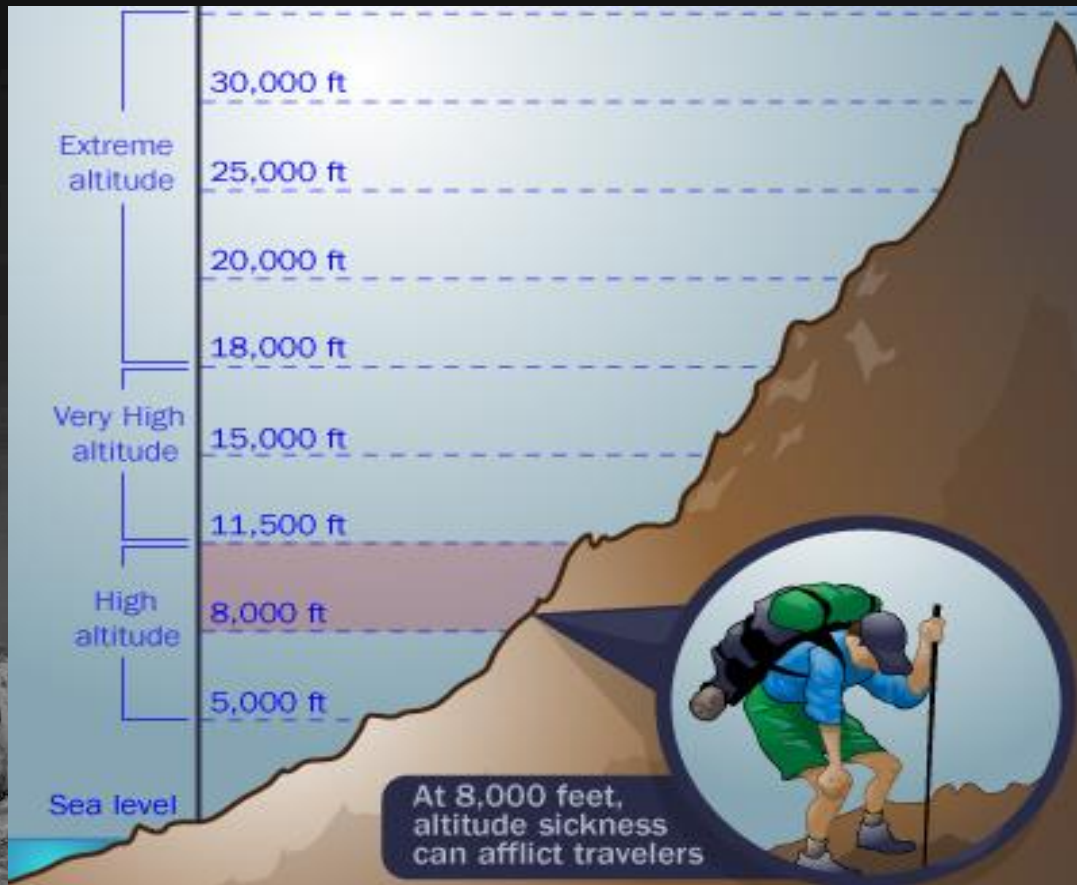


L'homme en hypobarie

Dr. Claudio Sartori
Médecine interne
Consultation de médecine de montagne
CHUV Lausanne



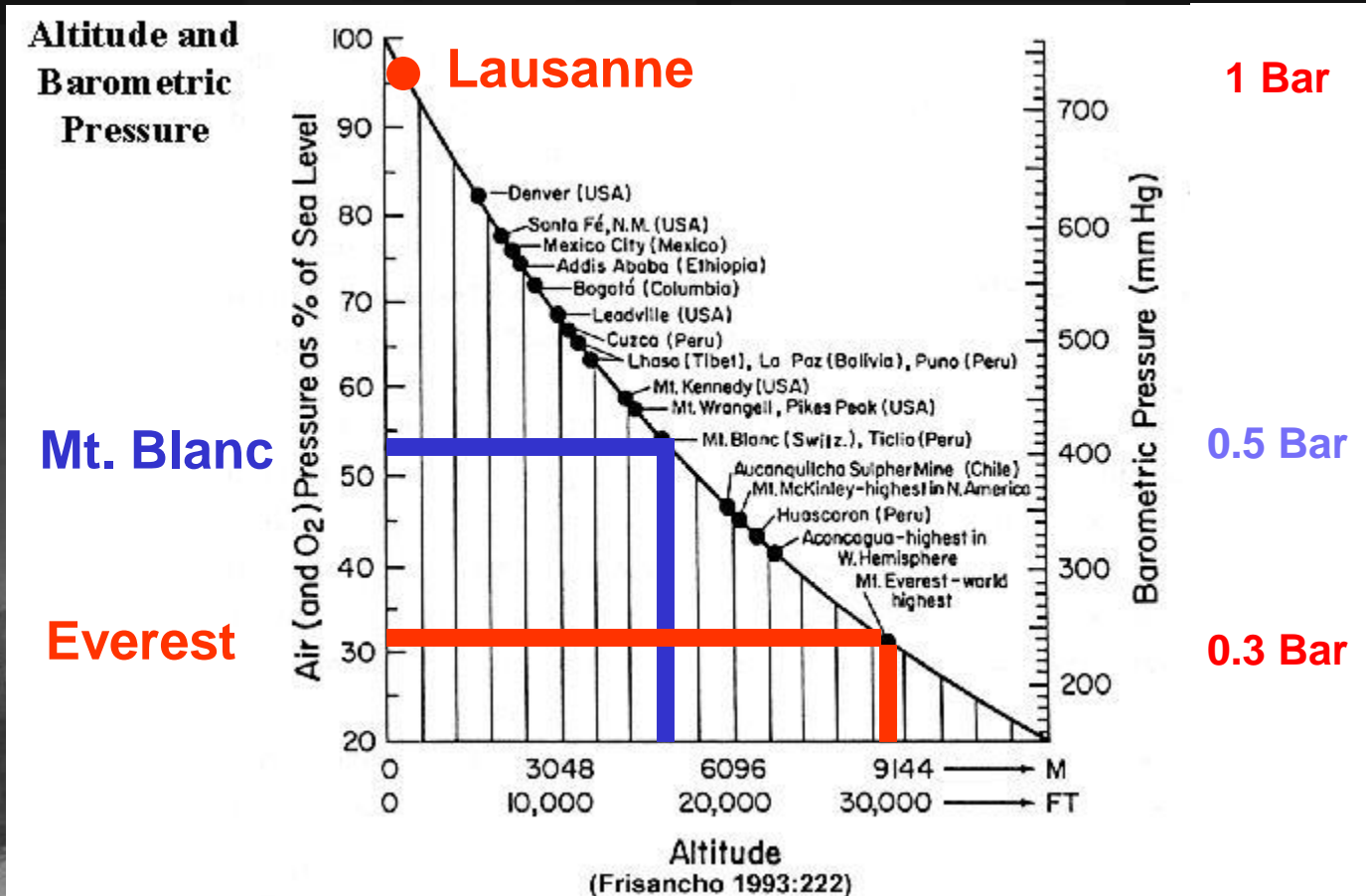
Haute altitude: c'est aussi une question de pression!



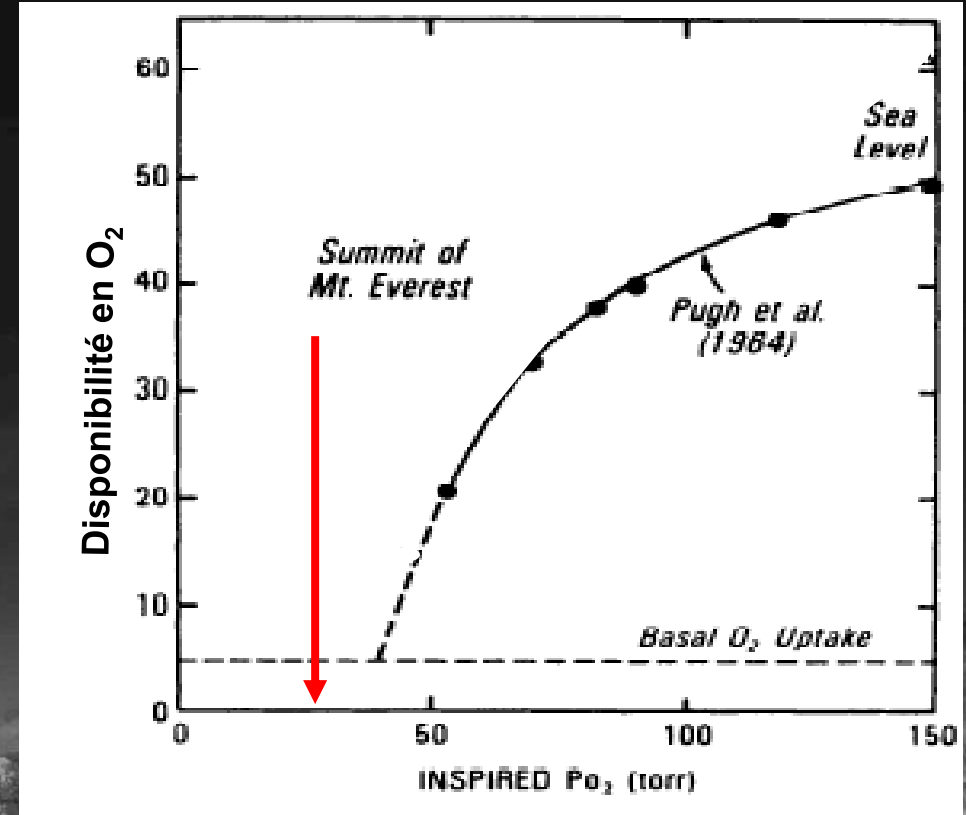
Concentration
oxygène
(21%)

Pression
barométrique

Altitude, pression barométrique et pression partielle en oxygène



Irréalisable sans l'aide d'oxygène !



Au sommet, la capacité d'alimenter l'organisme en oxygène serait inférieure à aux besoins minimaux en oxygène de notre corps

Mais, ... comment c'est possible ?



1978



American Medical Research Expedition to Everest (1981)

22

ANNALS NEW YORK ACADEMY OF SCIENCES



FIGURE 5. Dr. Christopher Pizzo taking alveolar gas samples while sitting on the summit of Mt. Everest on October 24, 1981.

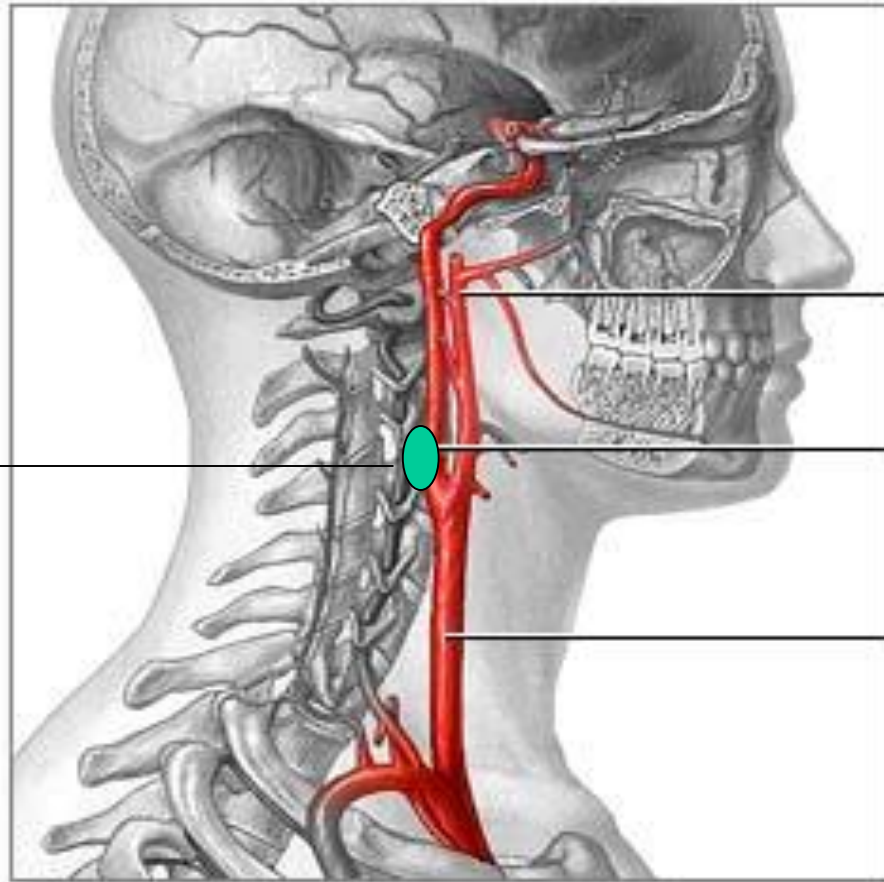
Adaptation à l'altitude



- Augmentation de la ventilation et du débit cardiaque

Qu'est-ce qui détecte le manque d'oxygène?

*glomus
carotidien*

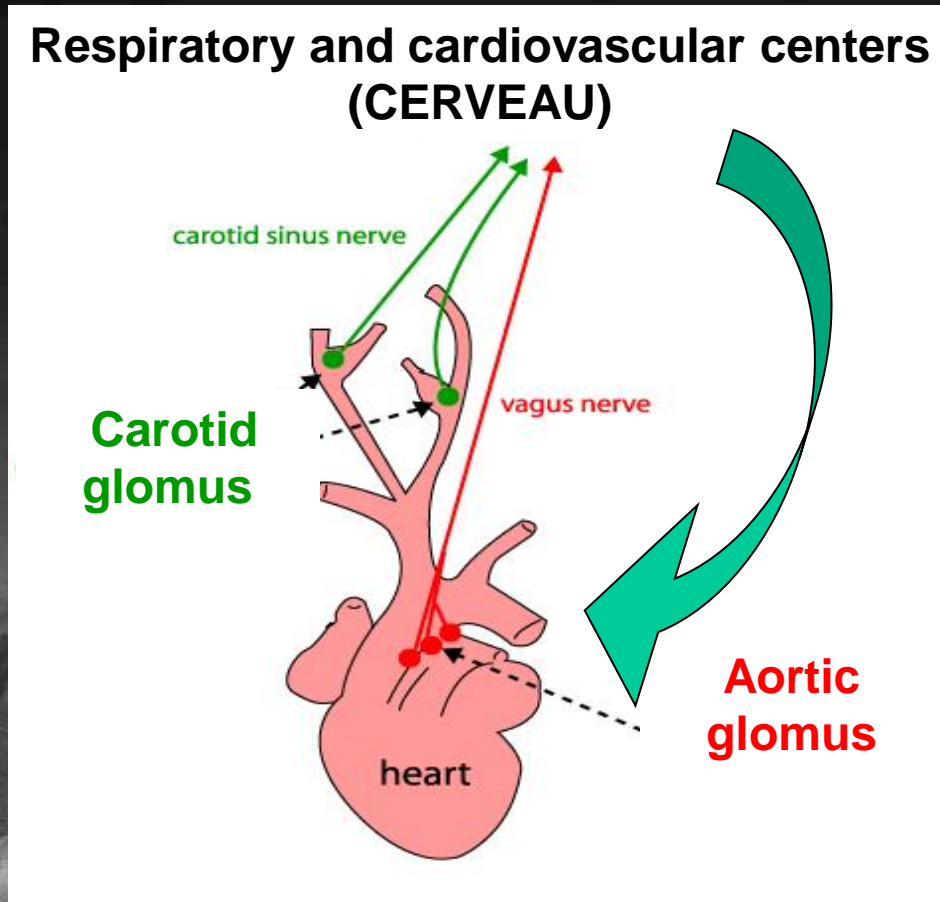


a.carotide externe

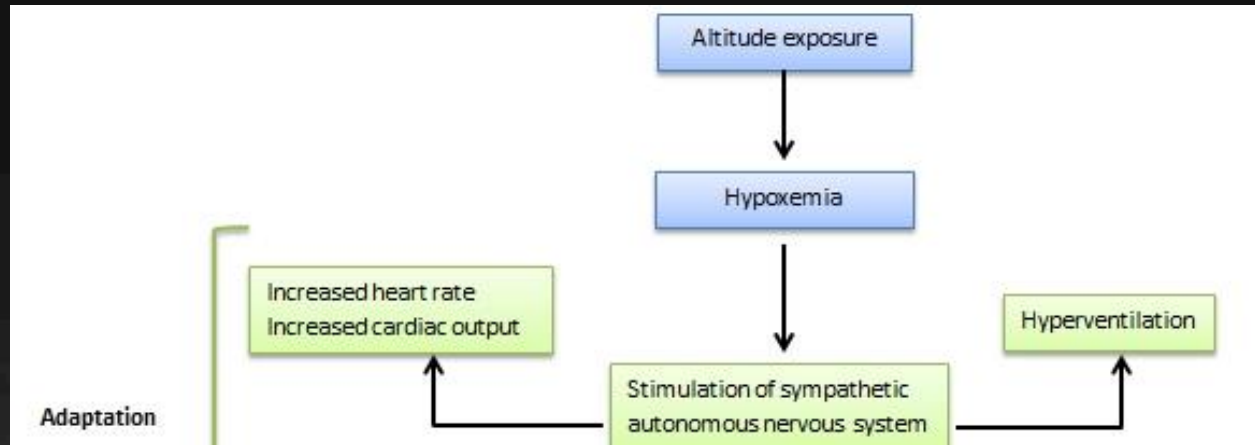
a.carotide interne

a.carotide commune

Manque d'oxygène stimule la ventilation et la fonction cardiaque par un feed-back



Augmentation débit cardiaque et ventilation



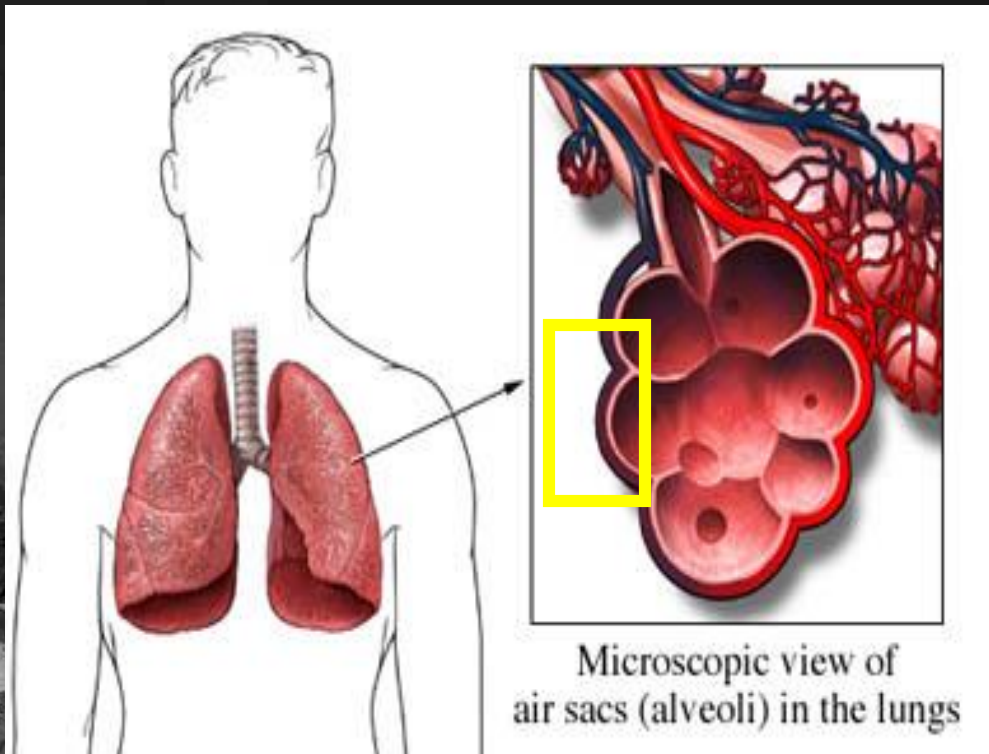
Meilleure circulation du sang vers les tissus



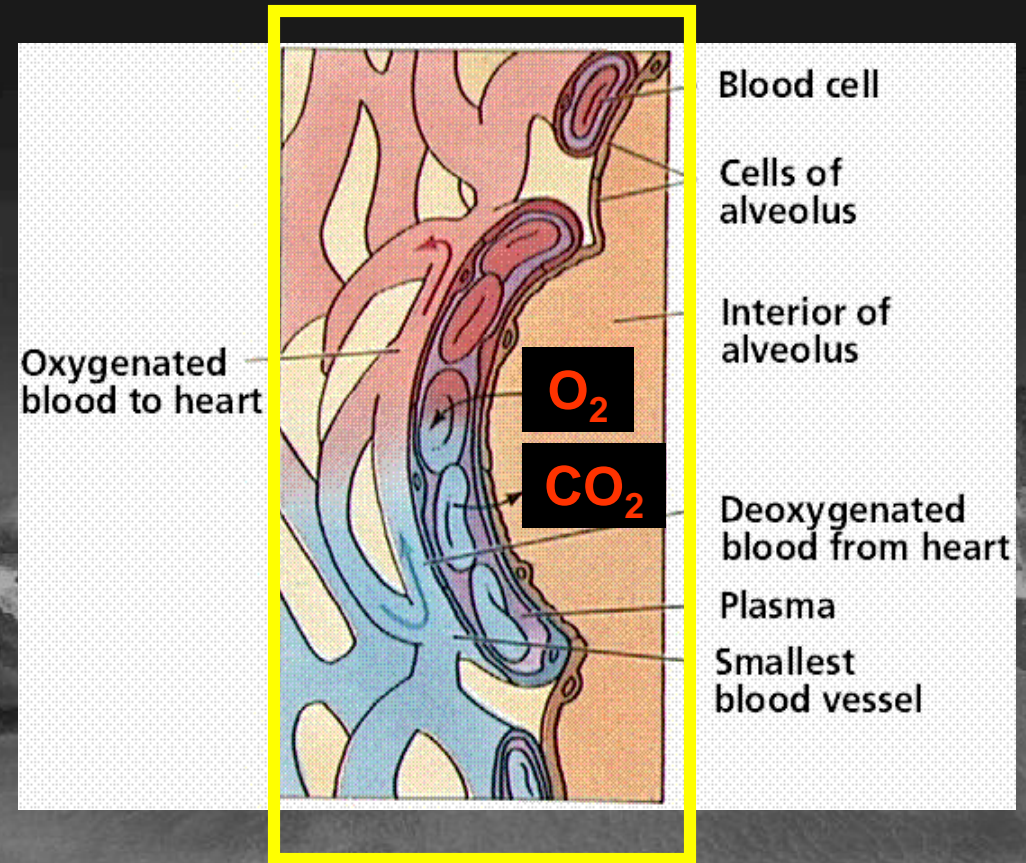
Meilleure oxygénation du sang

Gaz exchanges

Lung and alveoli



Alveolar-capillary barrier



Gaz exchanges at the summit of Everest

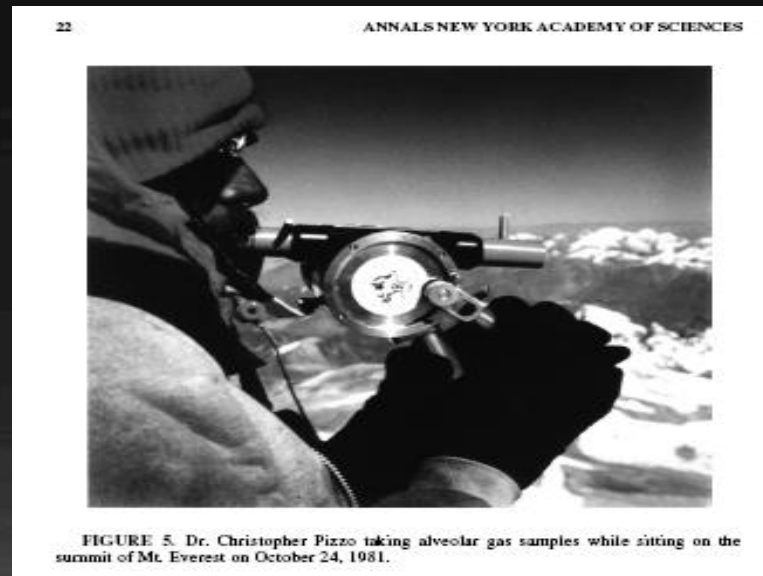


Table 2 Alveolar gas and arterial blood values on the summit of Mt. Everest

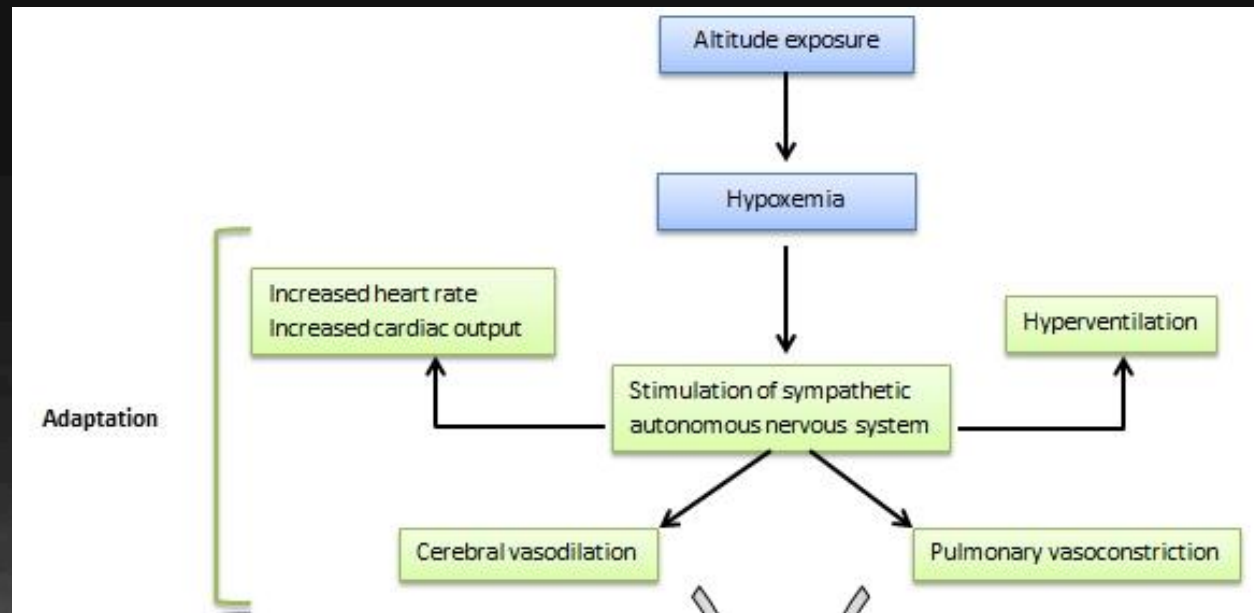
Altitude meters	Barometric pressure mmHg	Inspired PO ₂ mmHg	Alveolar PO ₂ mmHg	Arterial		
				PO ₂ mmHg	PCO ₂ mmHg	pH mmHg
8848 (summit)	253	43	35	28	7.5	>7.7
Sea level	760	149	100	95	40	7.40

Adaptation à l'altitude



- **Vasoconstriction pulmonaire**
- **Vasodilatation cérébrale, cardiaque et musculaire**
- Augmentation de la ventilation et du débit cardiaque

Vasodilatation systémique et vasoconstriction pulmonaire



Meilleure distribution de l'oxygène aux organes nobles:

1. Cerveau
2. Cœur
3. Muscles

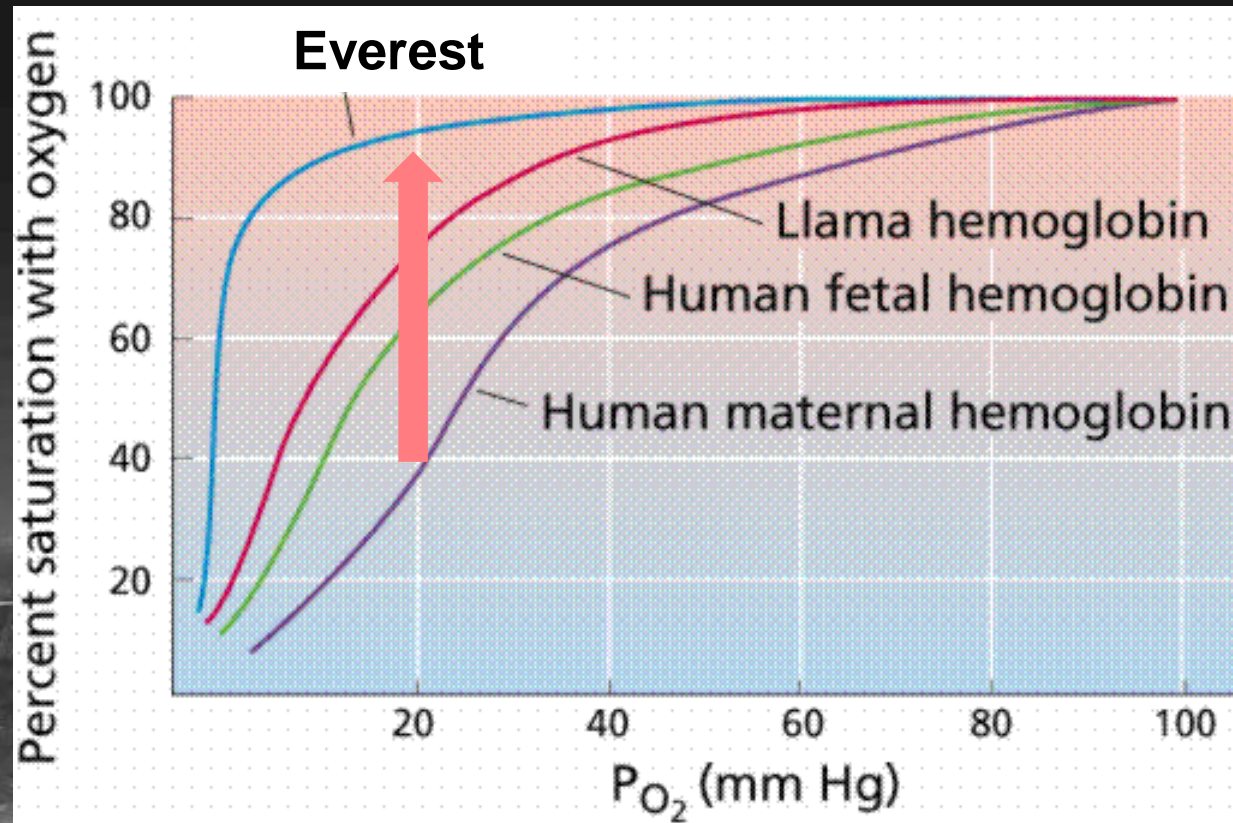
Echange gazeux air-poumon plus uniforme et efficace, meilleure oxygénation du sang

Acclimatation à l'altitude



- **Augmentation de l'affinité hémoglobine-oxygène**
- Vasoconstriction pulmonaire
- Vasodilatation cérébrale
- Augmentation de la ventilation et du débit cardiaque

Increased affinity Hb-O₂ is an universal mechanism of adaptation to hypoxia



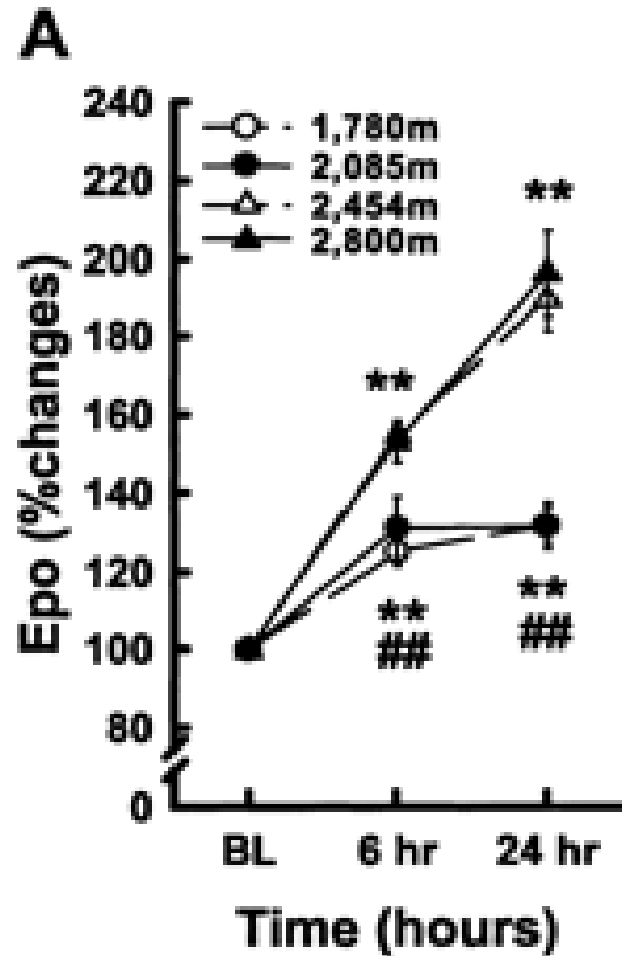
Acclimatation à l'altitude



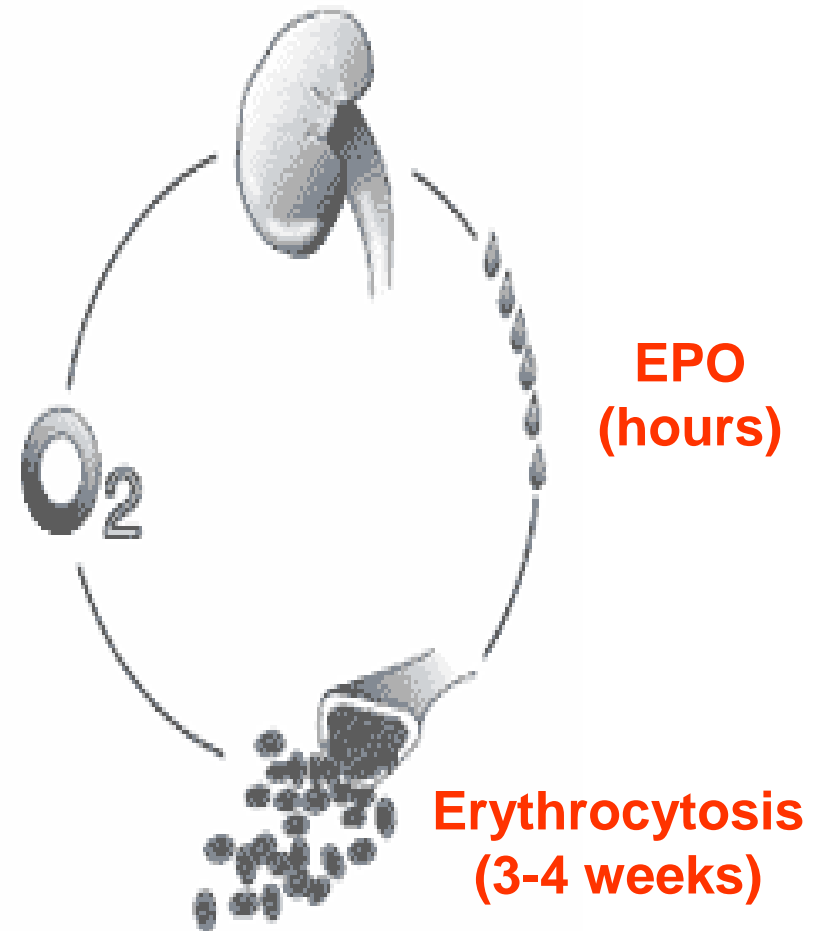
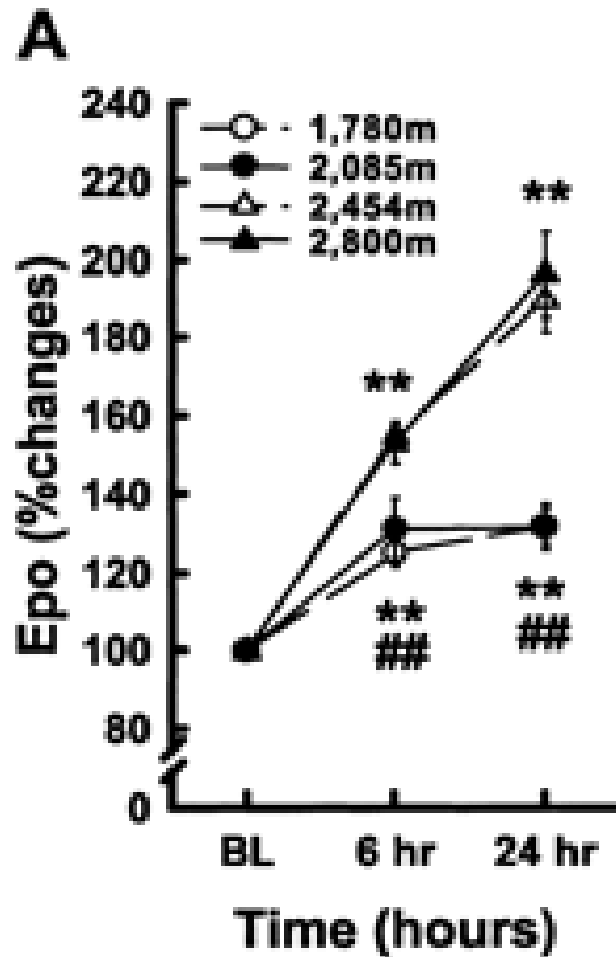
- **Augmentation du nombre de globules rouges**
- Augmentation de l'affinité hémoglobine-oxygène
- Vasoconstriction pulmonaire
- Vasodilatation cérébrale

- Augmentation de la ventilation et du débit cardiaque

Synthèse d'érythropoïétine et stimulation de la moelle osseuse pour produire des globules rouges



Synthèse d'érythropoïétine et stimulation de la moelle osseuse pour produire des globules rouges



Nombre maximal de globules rouges en altitude atteint seulement après 3-4 semaines d'exposition

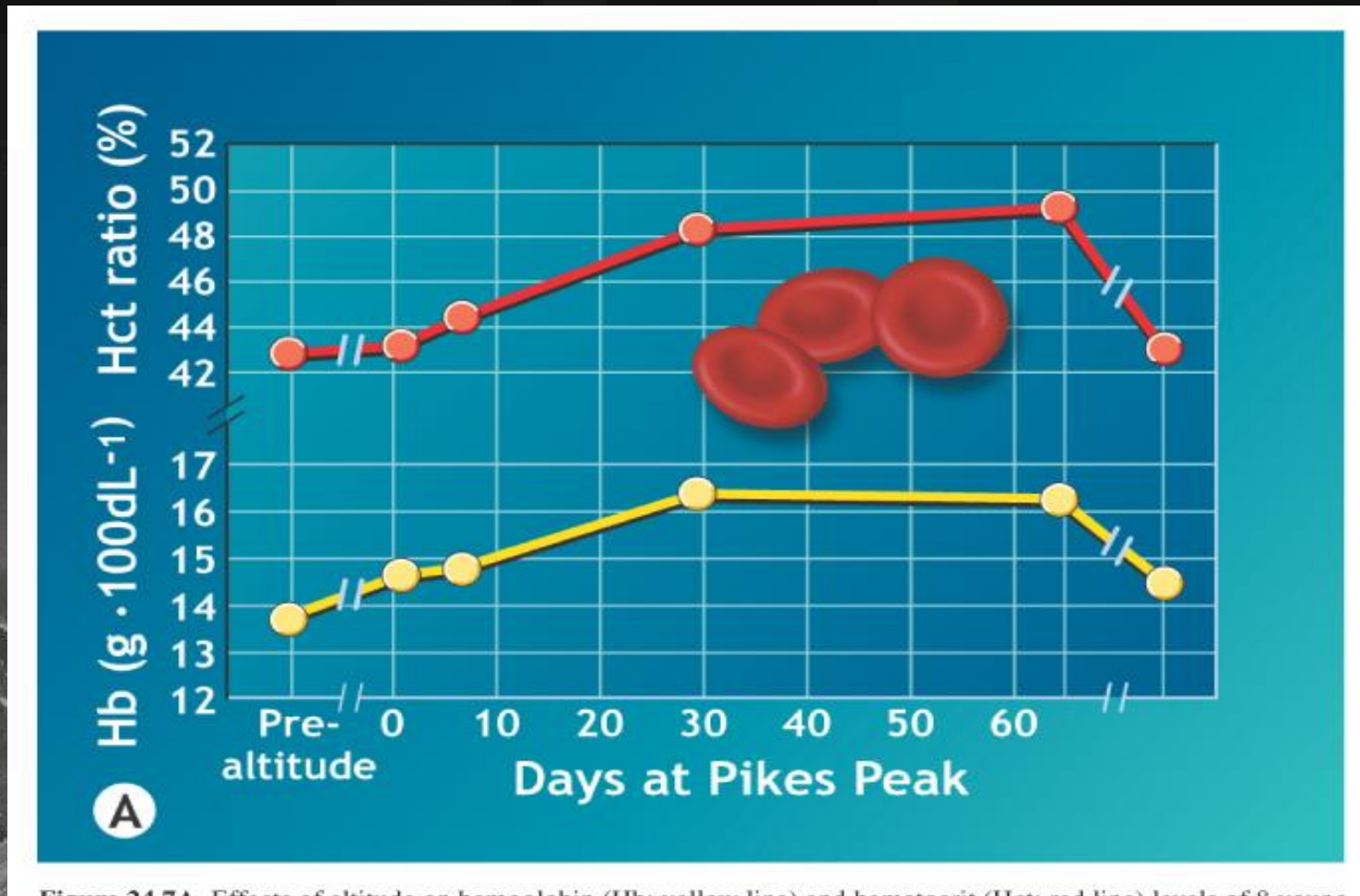
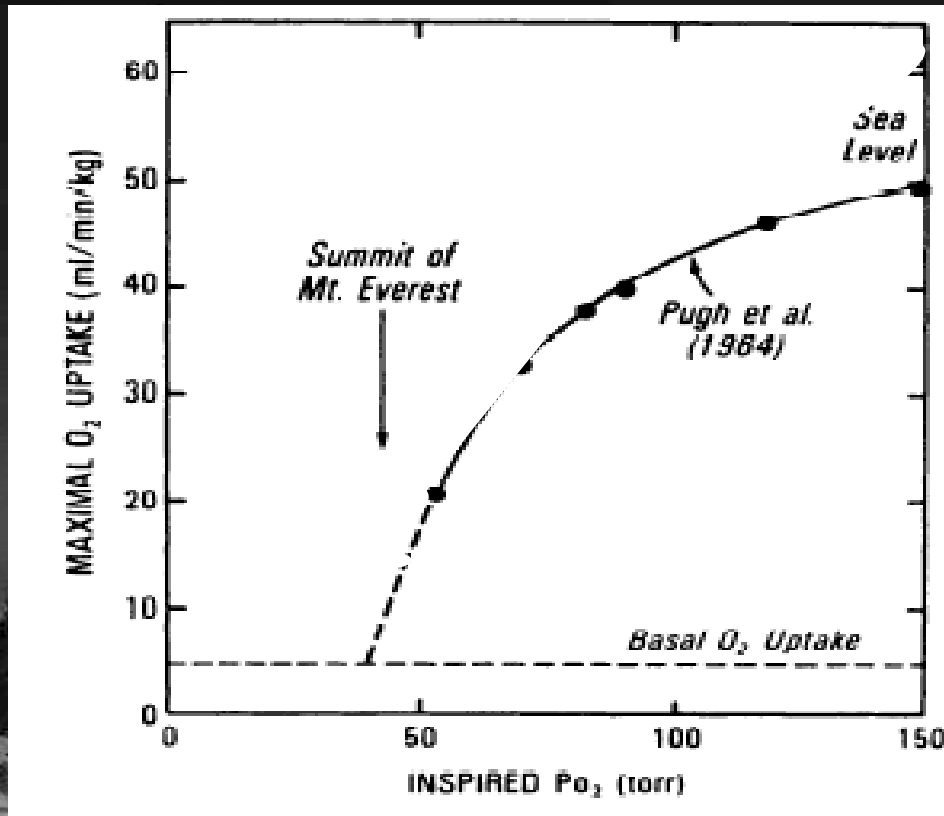
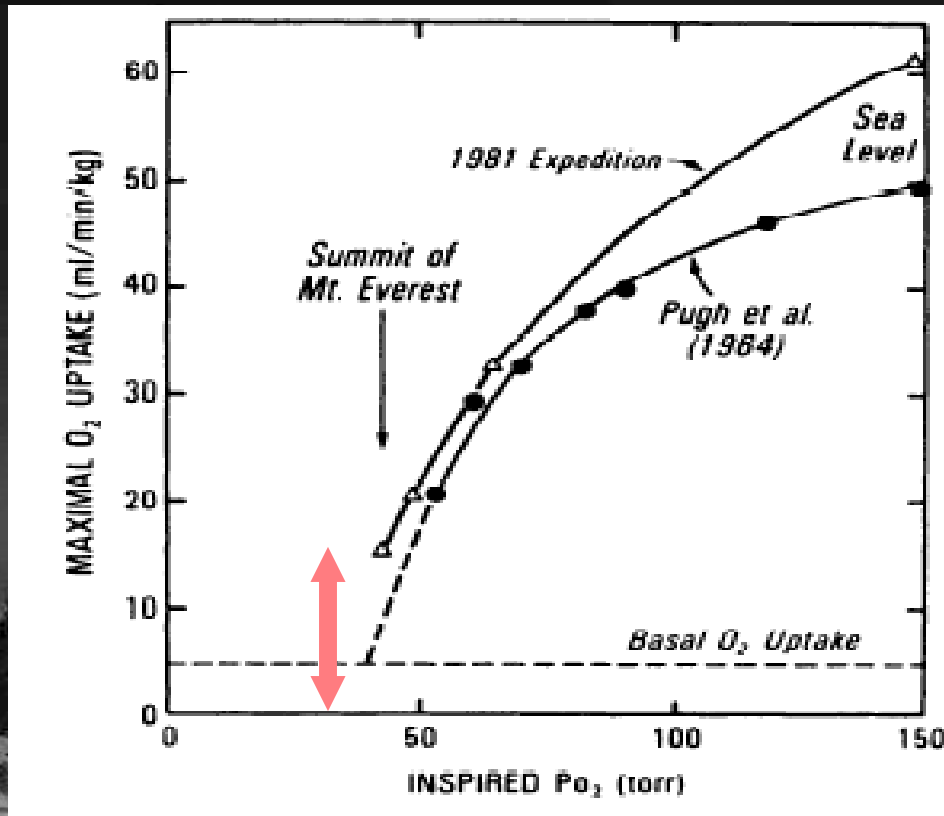


Figure 24.7A Effects of altitude on hemoglobin (Hb; yellow line) and hematocrit (Hct; red line) levels of 8 young

Pourquoi est-il possible d'escalader l'Everest sans oxygène ?



Pourquoi est-il possible d'escalader l'Everest sans oxygène ?



Hyperventilation +++
Alcalose respiratoire +++
Affinité Hb- O_2 ++
Pression barométrique +

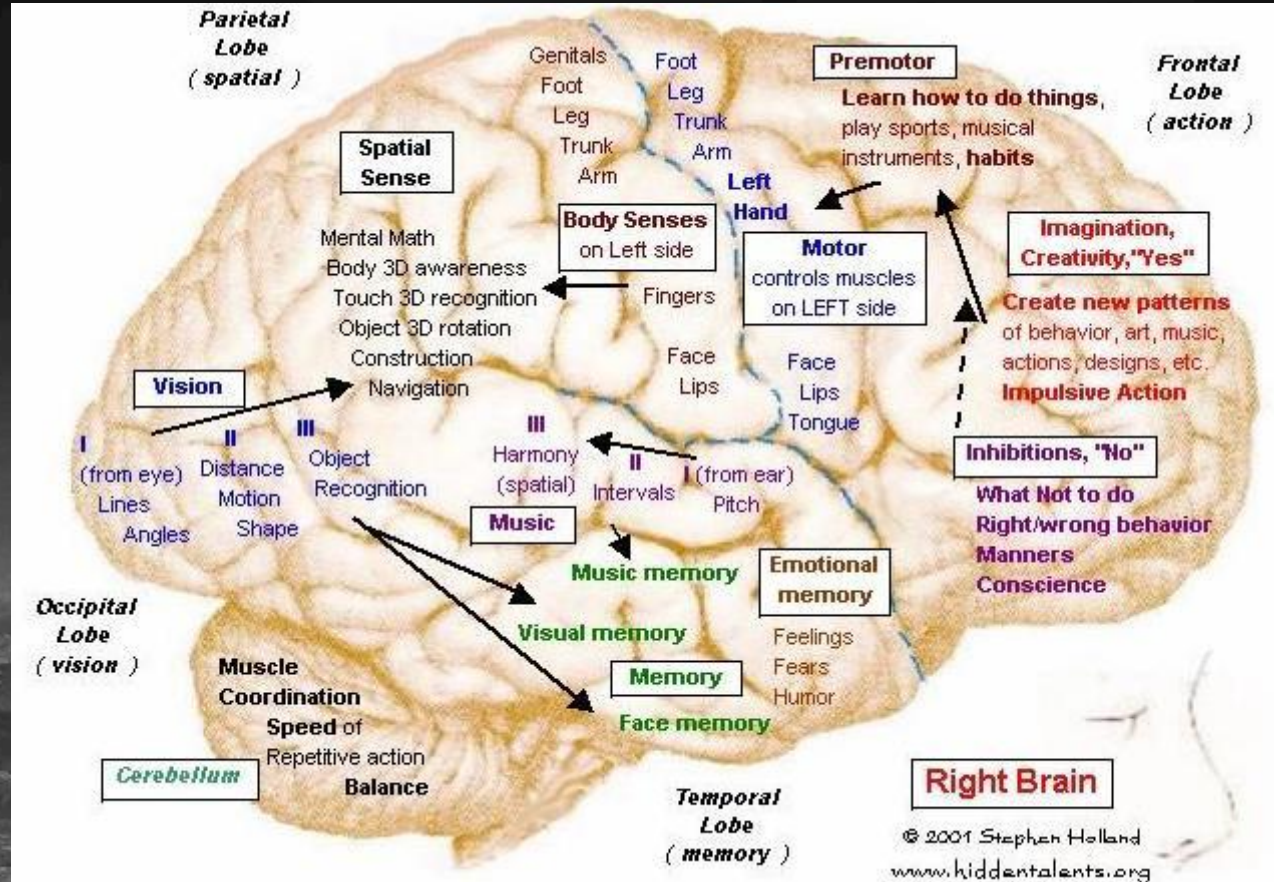
VO_2 max = 1 L/min
(Normalement: >4-6 L/min)

Adaptation and acclimatation

100% efficace ?



Effets négatifs de l'altitude



Alterations (transient ?) observed at 2500 m

affect

character

manual ability

mood, impulse control

orientation

personality trait

decision making

sense of reality

reaction time

visual sensitivity

hearing sensitivity

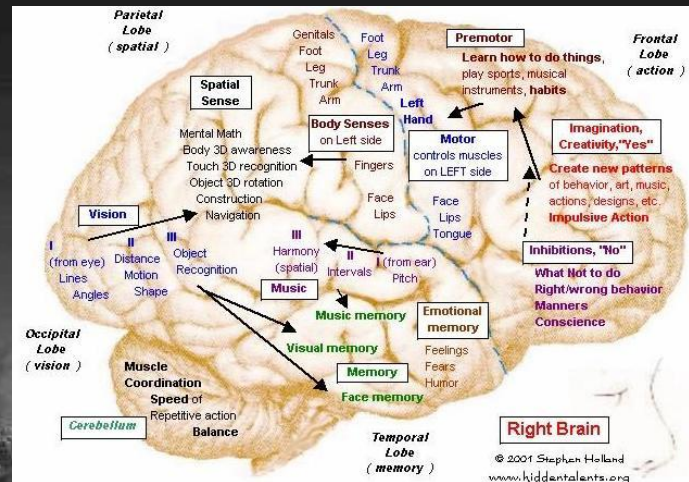
balance

judgment

concentration

behavior

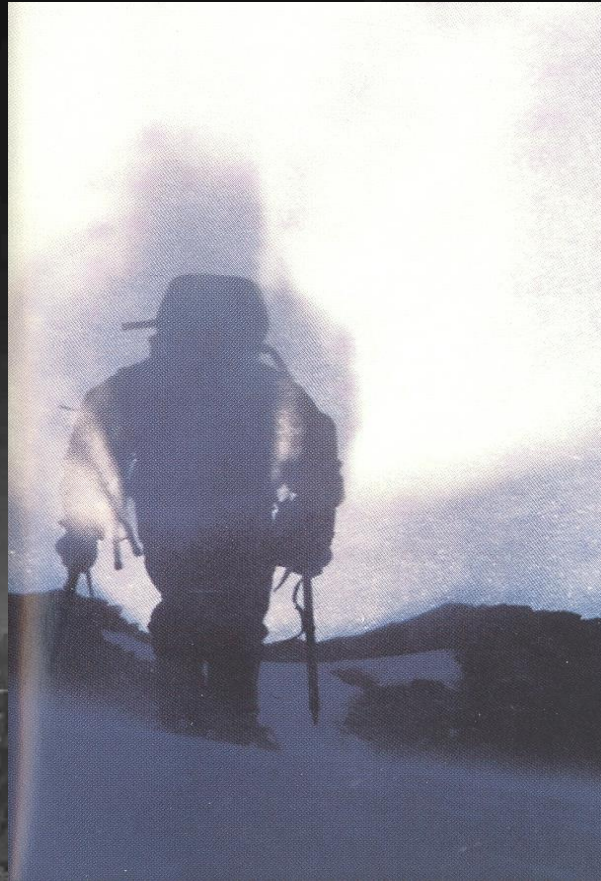
memory



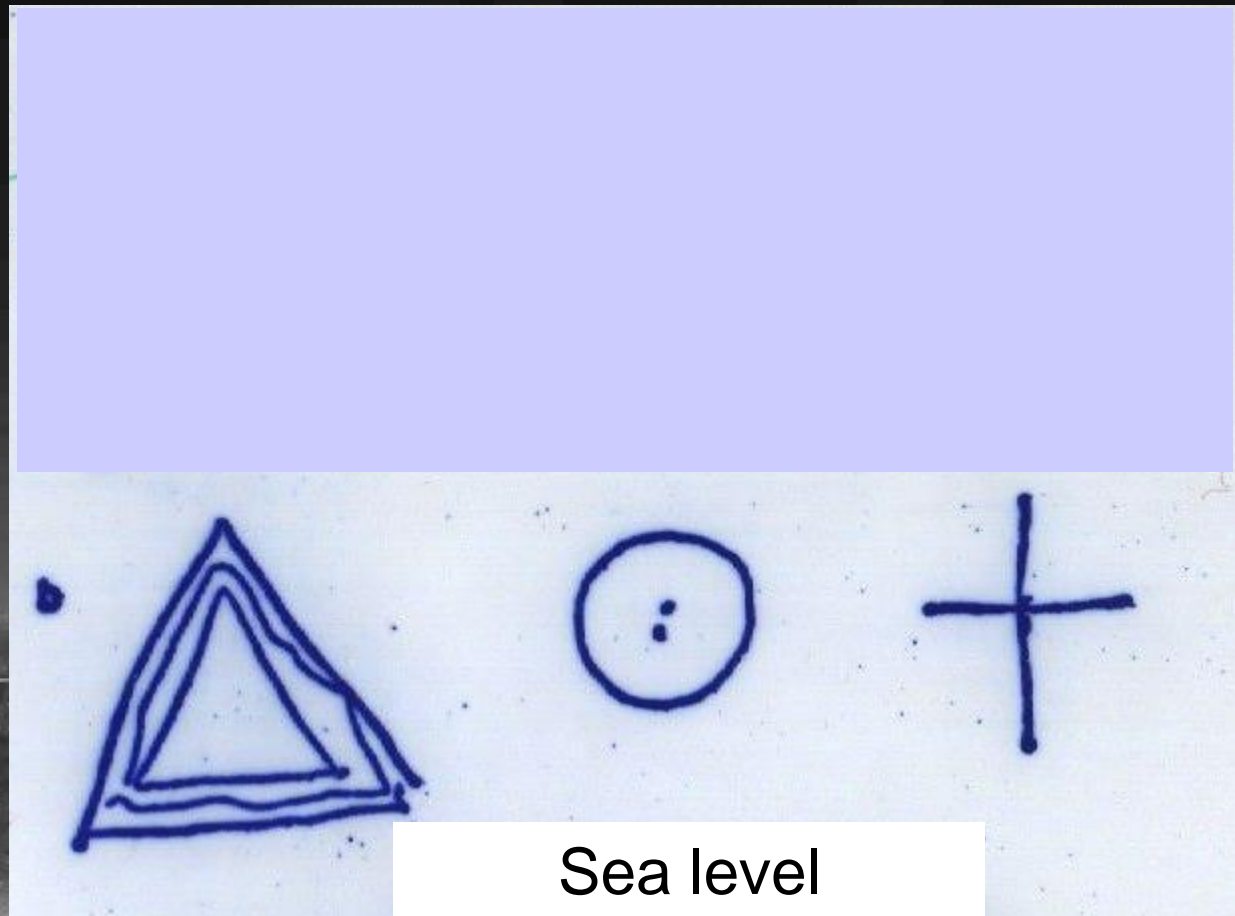
Reaction time – “well-being”



Hallucinations



Coordination



Résumé

Table 1 *Cognitive capabilities as a fraction of sea-level performance for unacclimatized subjects according to [McFarland \(1972\)](#)*

Altitude (m)	Visual sensitivity	Attention span	Short-term memory	Arithmetic ability	Decision making
2500	83%	100%	97%	100%	100%
3500	67%	83%	91%	95%	98%
4200	56%	70%	83%	92%	95%
5000	48%	57%	76%	86%	90%

Note: Adapted from [McFarland, 1972](#).



Maladies liées à l'altitude



Mal aigu des montagnes

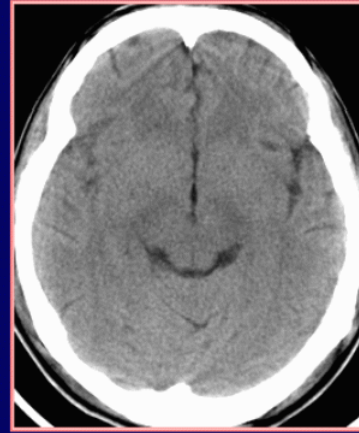
(AMS: Acute Mountain Sickness)

Maux de tête +

- Nausées, vomissements
- fatigue importante
- vertiges
- insomnie

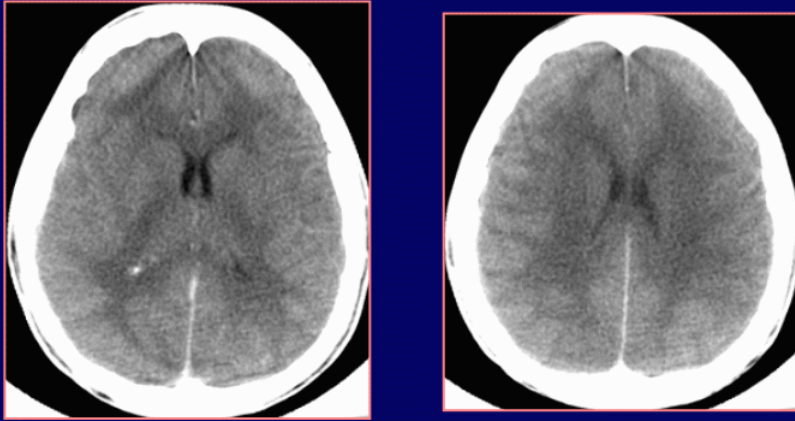


Normal brain

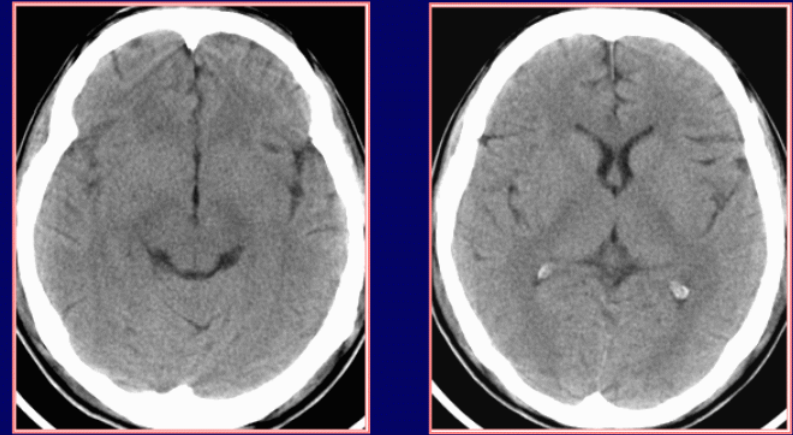


High-altitude cerebral edema (HACE)

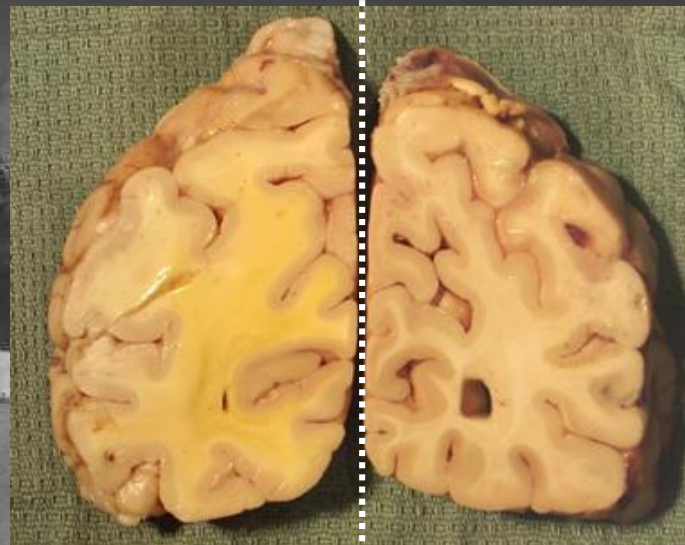
Cerebral edema



Normal brain



Troubles de la coordination et de l'état de conscience, coma, décès



Physiopathology

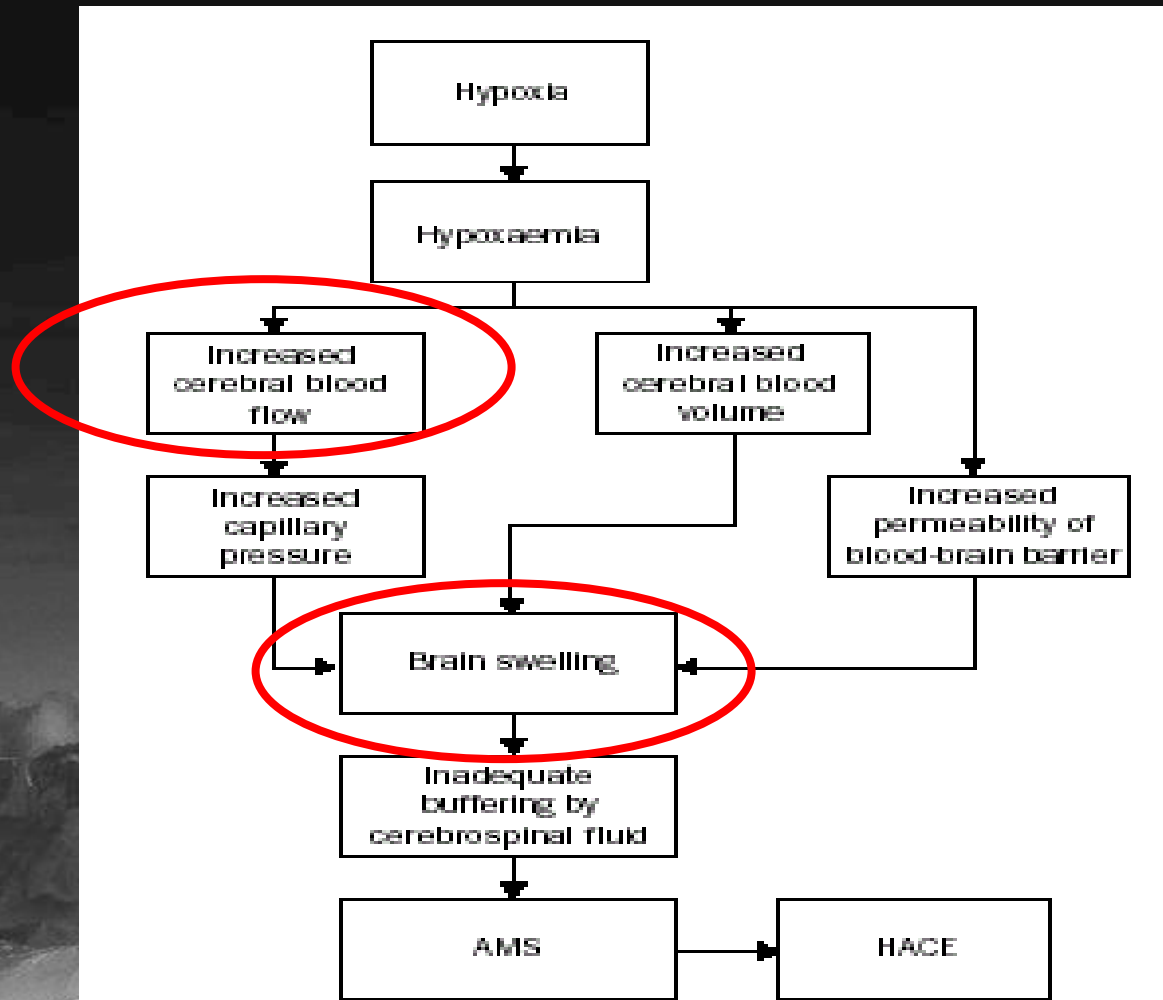
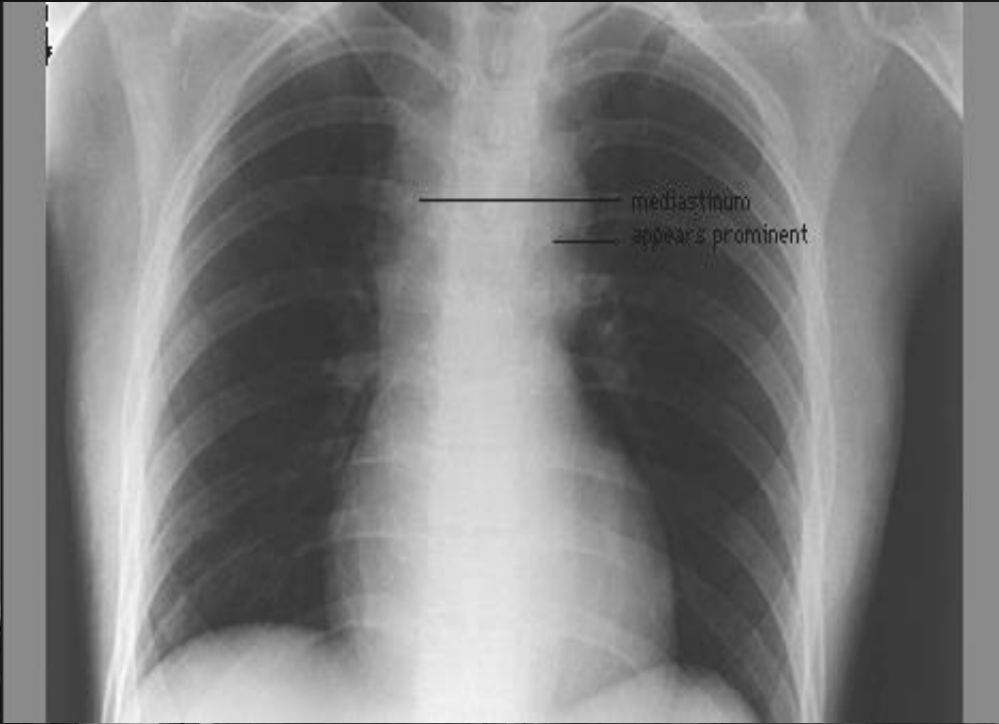
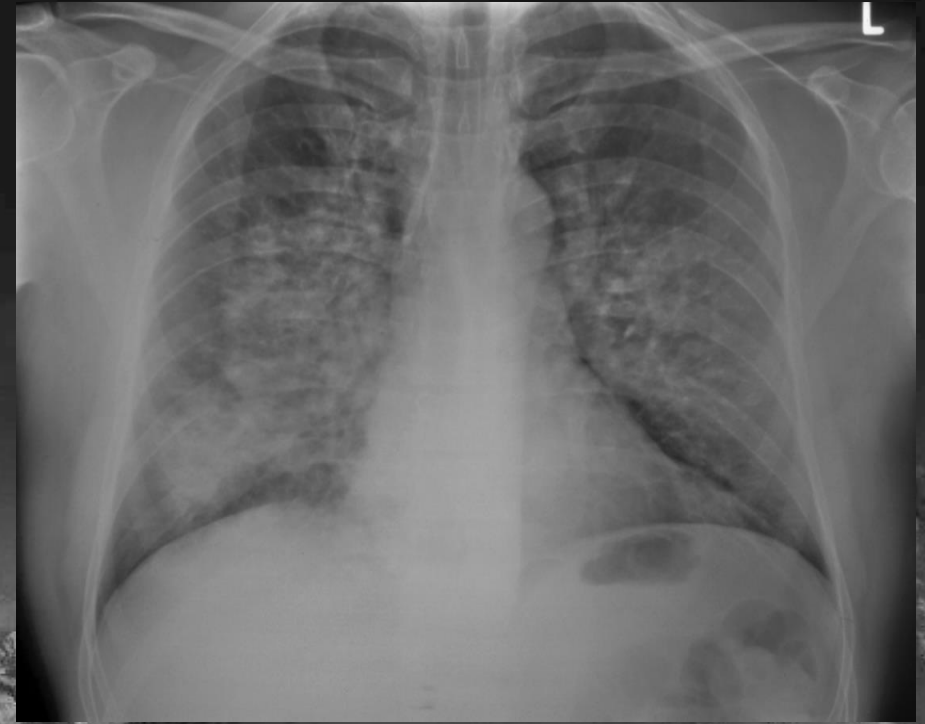


Figure 1: Proposed pathophysiology of AMS and HACE

High-altitude pulmonary edema (HAPE)



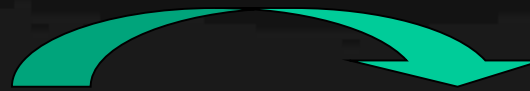
Normal



HAPE

Œdème pulmonaire de haute altitude

36 – 72 heures



Hypoxie



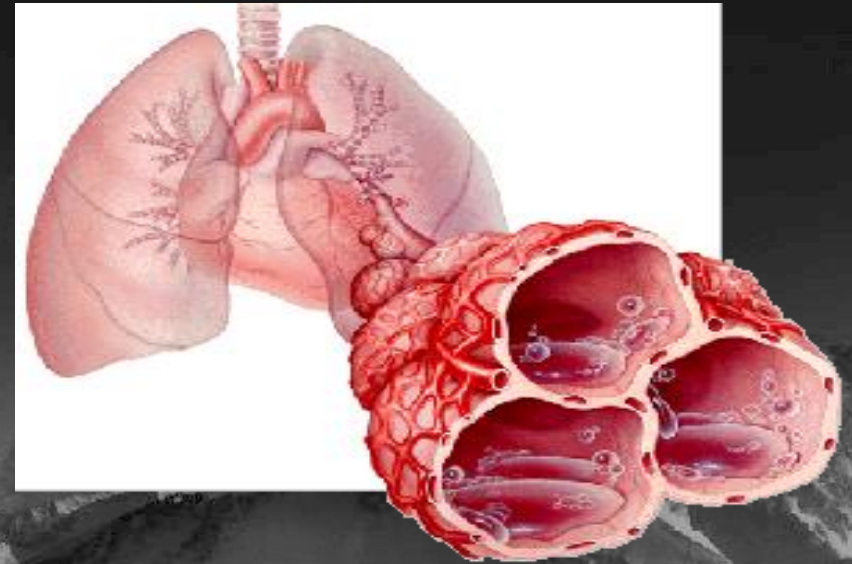
Constriction exagérée des artères
pulmonaires



Pression intracapillaire exagérée

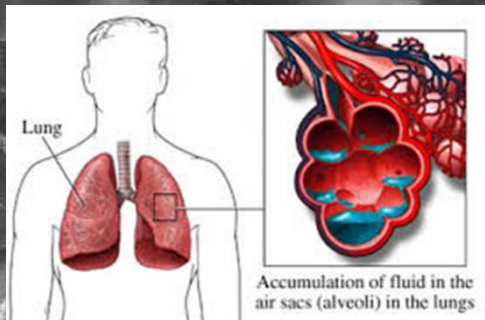
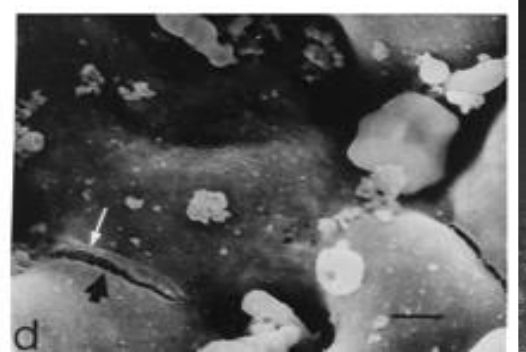
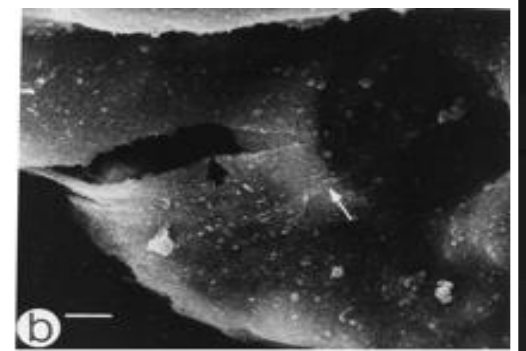


Perméabilité capillaire augmentée

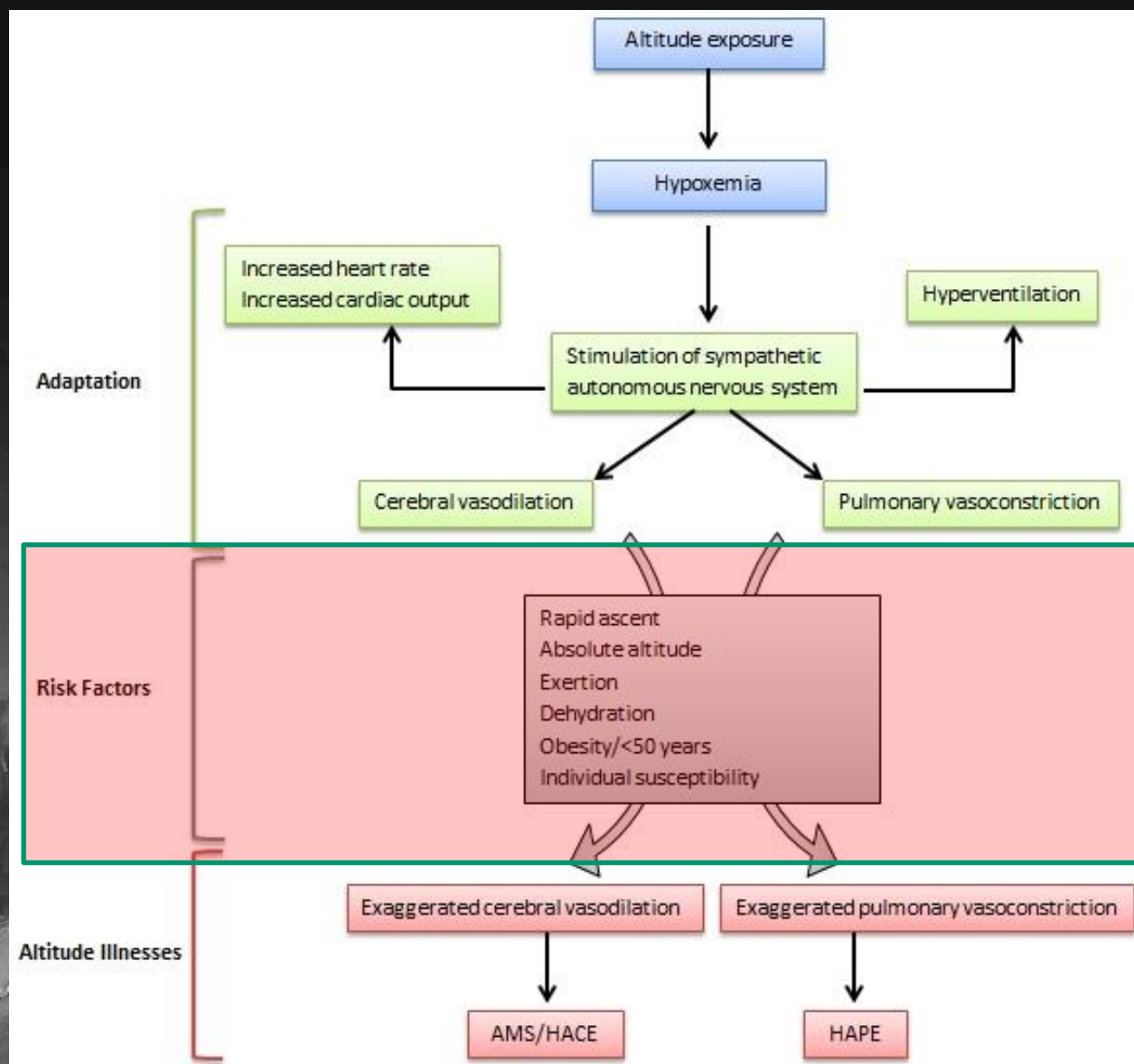


Accumulation de liquide dans les alvéoles

Capillary stress failure

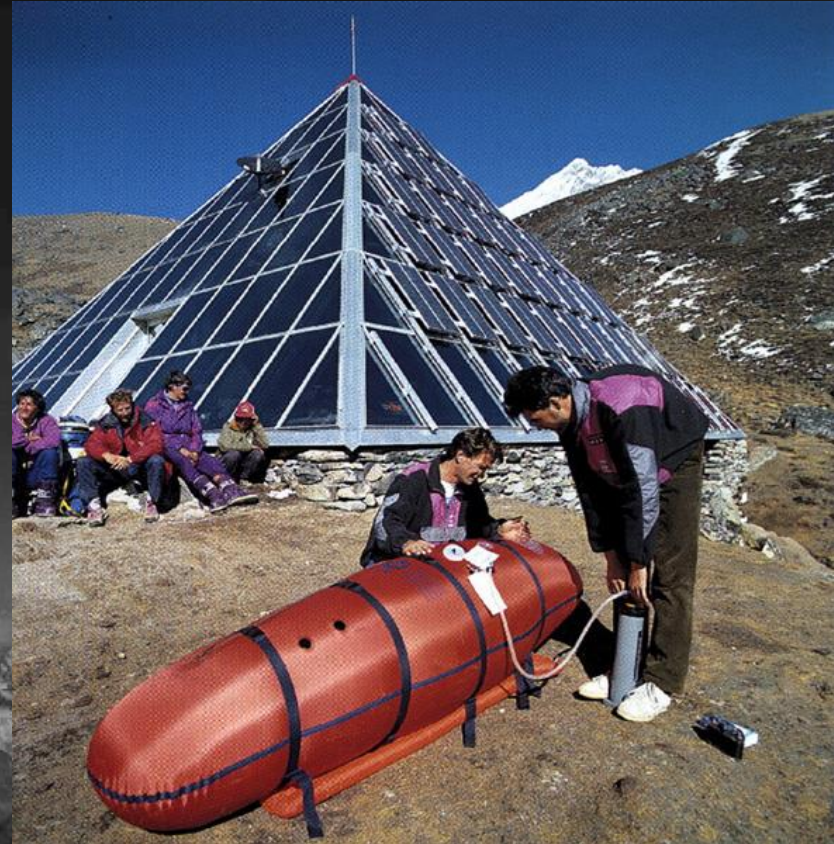


Qui est prédisposé à ces maladies ?



Traitement: c'est aussi une question de pression !

DESCENTE !
Oxygène
Pression O₂



Merci pour votre attention



Consultation de médecine d'altitude

Dr Alban LOVIS

Dr Claudio SARTORI

Tél 021 314 09 30

Dr Jean-Yves Berney

