



Innere Medizin VII / Sportmedizin

UniversitätsKlinikum Heidelberg

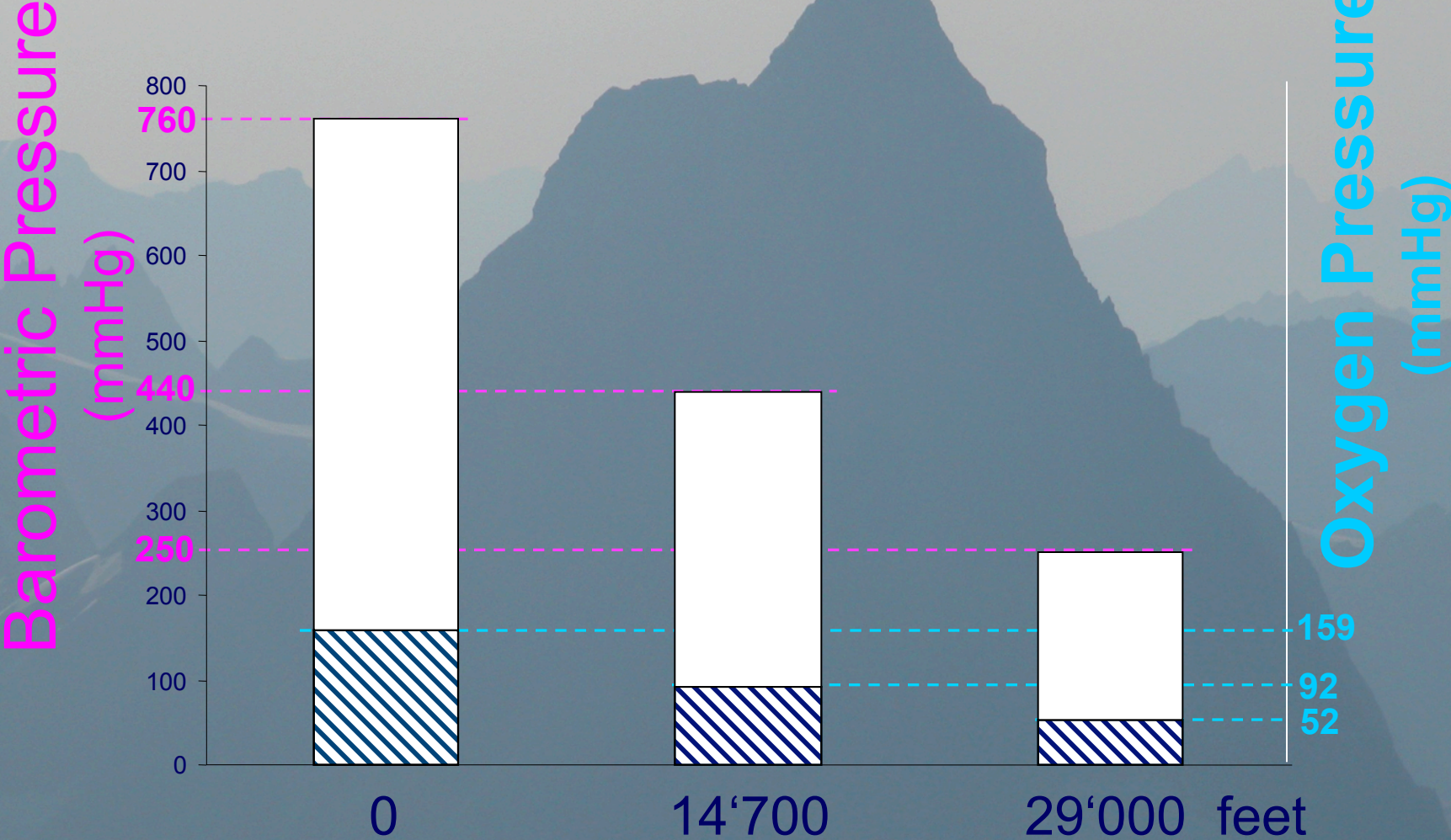
Acclimatization to High Altitude

Peter Bärtsch

www.klinikum.uni-heidelberg.de/sportmedizin



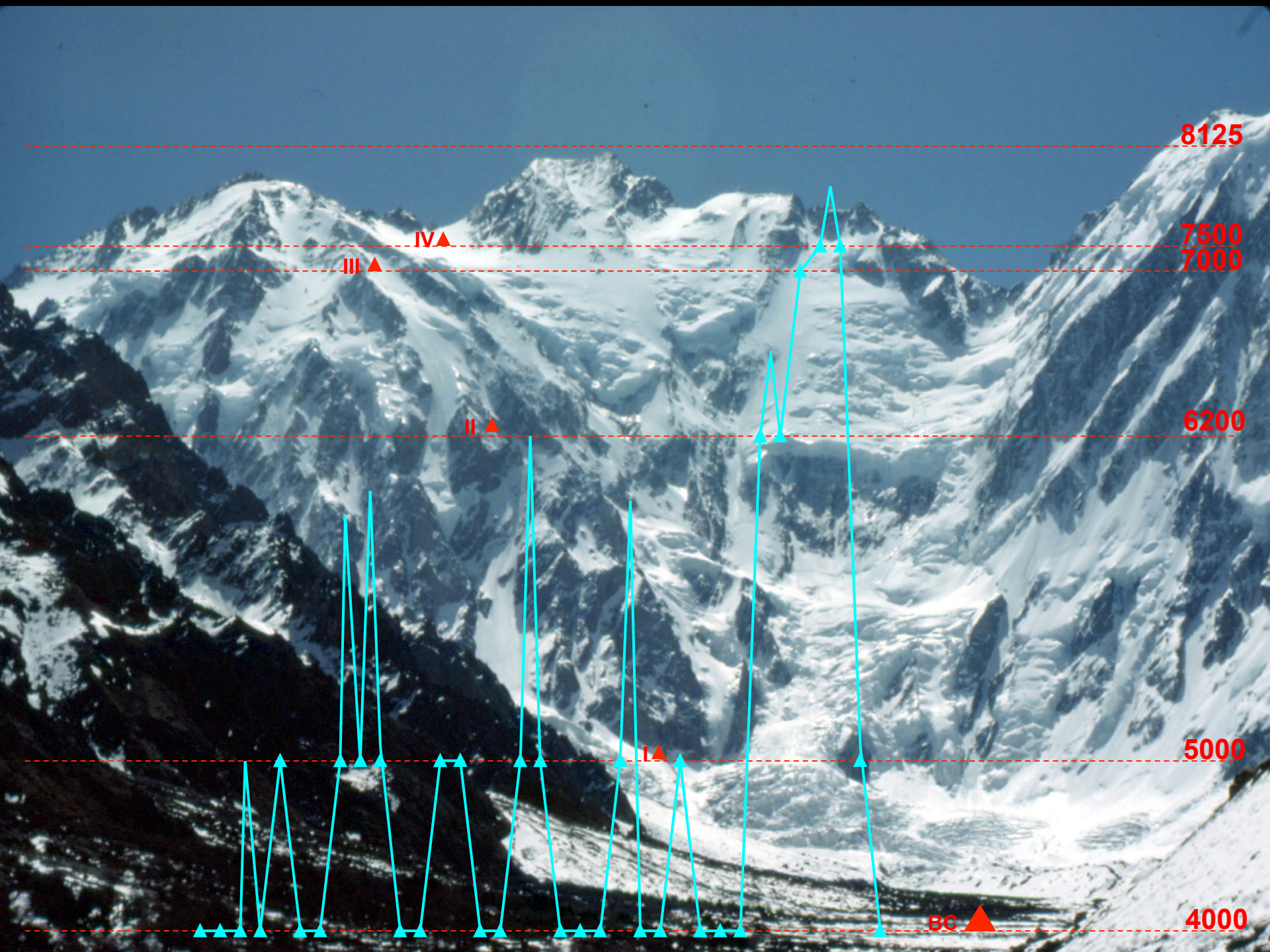
Barometric Pressure decreases with Altitude



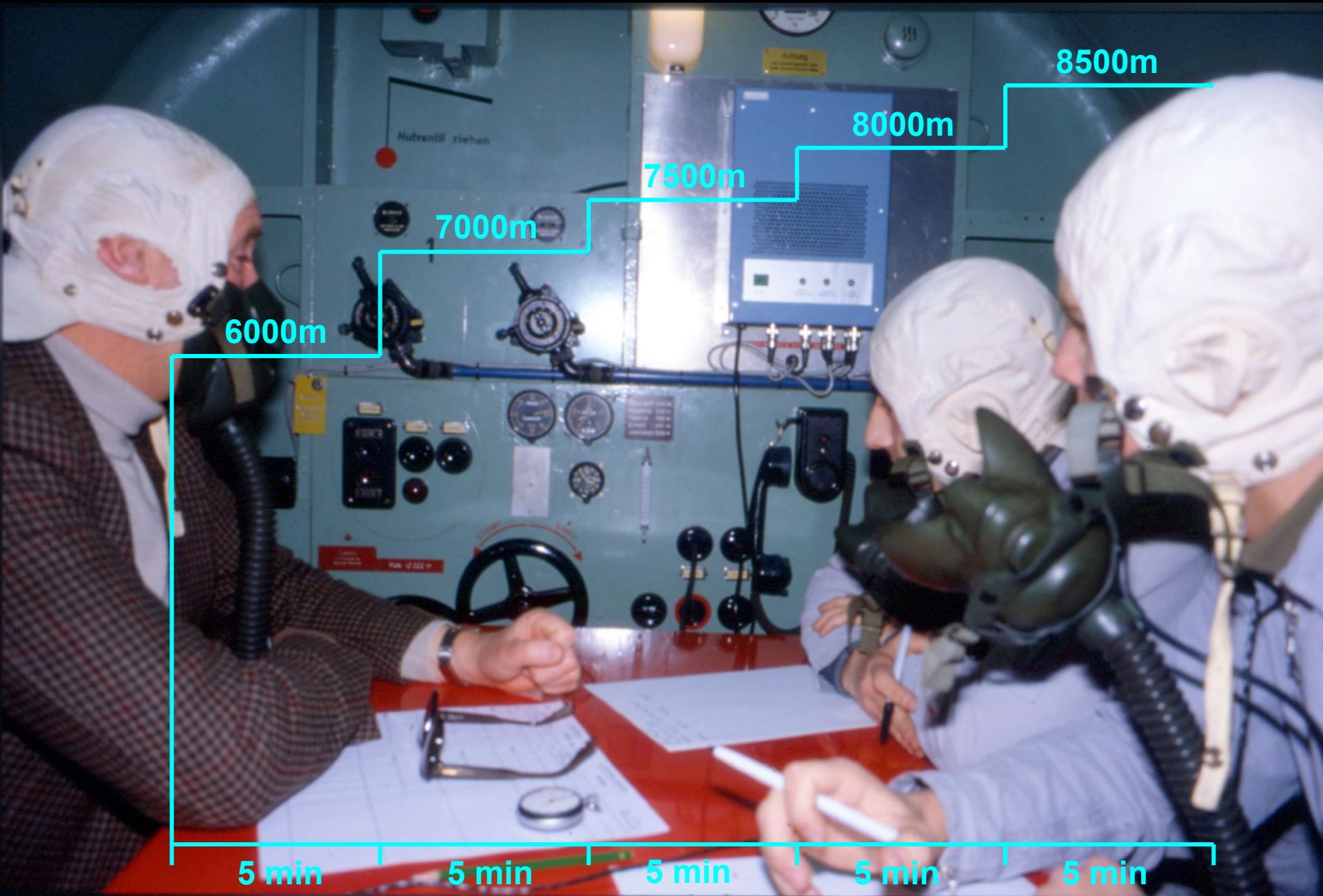


Acute Adjustment to High Altitude

	300 feet	17'000 feet
Exercise (W)	120	120
O2 demand (L/min)	1.7	1.7
O2 pressure	normal	50 % ▼
Breathing (L/min)	30	45
O2 loading (%)	95	63
O2 in blood (ml/L)	174	135 - 22 %
Heart rate (/min)	110	159
Perception	moderate	very hard







6000m

7000m

7500m

8000m

8500m

5 min

5 min

5 min

5 min

5 min



SUGESTIVO

Régula de

E.D.

1.º

(2)

852

Kpl Kro [redacted]
Schüfungentweg 15
8302 Kloten/ZH

0009

849 846 843 840



... des Krippeln in den Finger
suchen, Blickwinkel engt sich ein
Kopf relativ heiss.

837	834	831	828	825	822
819	816	813	810	807	804
801	807 798	795	792	789	786
783	780	777	774	771	767
758	755	752	749	746	

↓
∴

Kpl Kro [redacted]
Schüfungentweg 15
8302 Kloten

0007



Werde müde, schmerzter Kopf
Konzentration lässt & rasch
nach.

!	743	740	737!	730	727	724
!	74			∴	→	

721 718 715 712 709 (3)
 708 703



Schwerer Kopf, leichte Kopf-
 schmerzen, keine Konzentration

!! Kal 1502 K [redacted] OST
 Schüßelgurtweg 15
 830 15 loten

KE 700 697 697 694

691 K 688 685 682
 879 ~~797~~ ~~787~~ 767 ~~767~~

758 755 752 749 ~~749~~
 746 743 740 737



! 778
 Gesichtsfeld-
 einschränkung

6





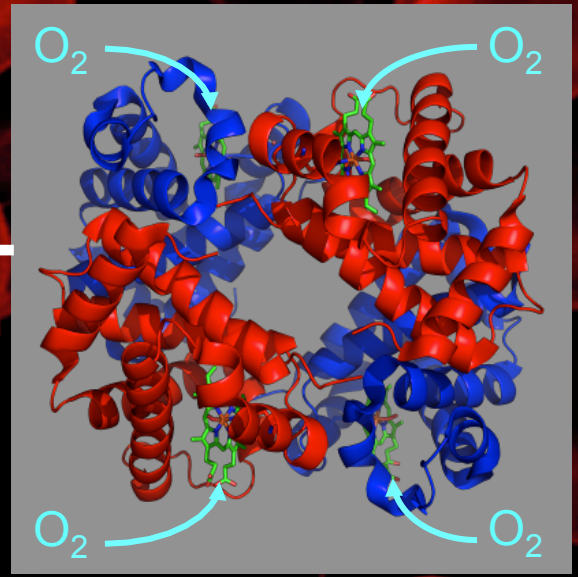
Acclimatization to High Altitude

1. Increase of oxygen-carrying capacity of blood:
 - Decrease of plasma volume starts within hours
 - Increase of red blood cells, effective within several days - weeks
2. Ventilatory acclimatization:
 - Ventilation increases over 2 weeks, starts within hours

Red Blood Cells

SaO₂: % of occupied O₂ binding sites
(≈ 95 % at sea level)

Hemoglobin

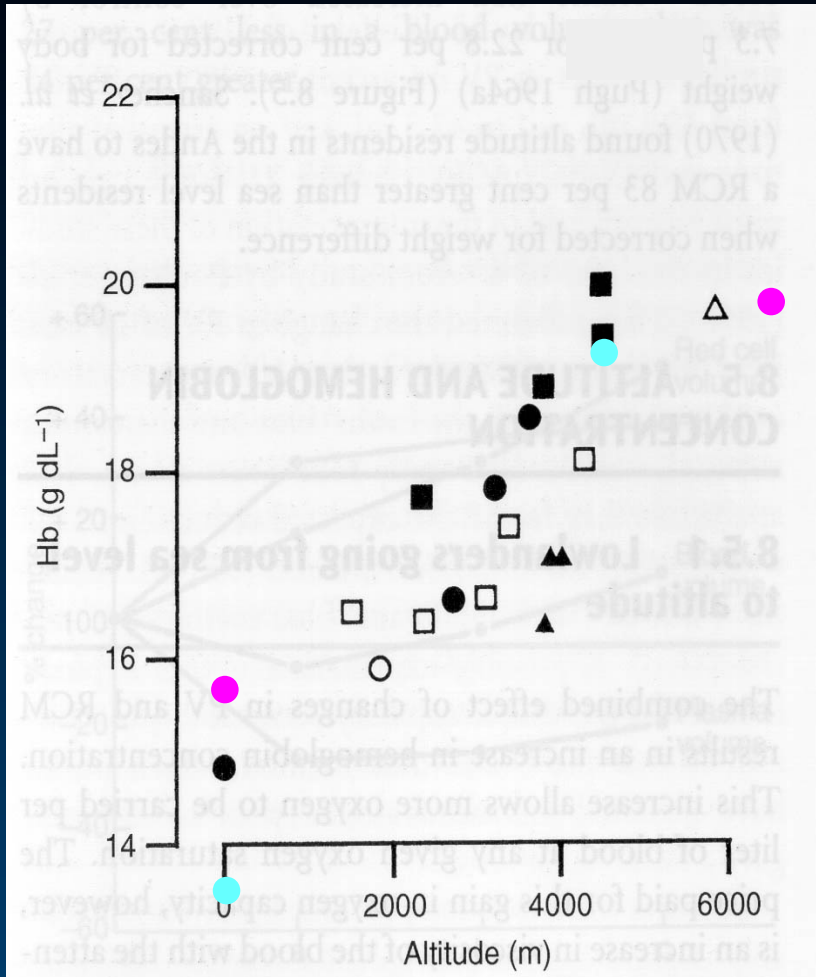


↑
↑
↑
Fluid between red blood cells: plasma





Acclimatization: Red Blood Cells



60 days on Mt. Everest
→ 25% increase
(AMREE study)

65 days at 17'000 feet
→ 35 % increase
(Chacaltaya study)

8000 feet: 5% increase
after 3-4 weeks

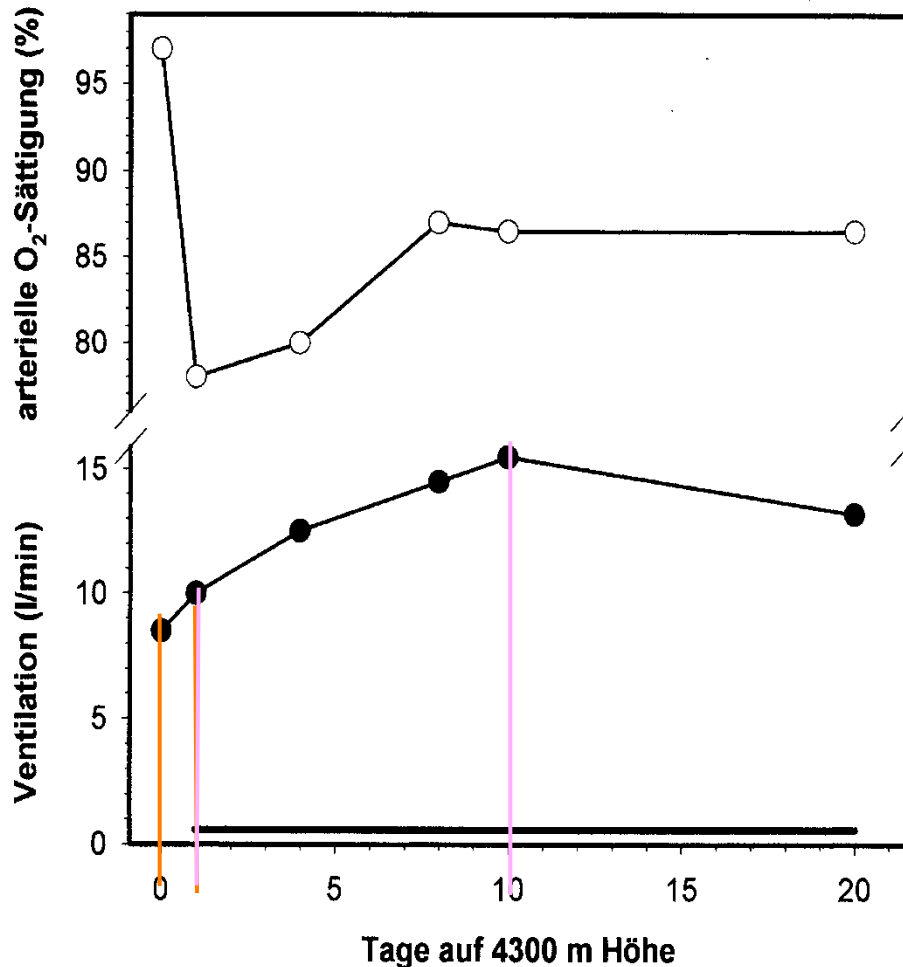


Acclimatization to High Altitude

1. Increase of oxygen-carrying capacity of blood:
 - Decrease of plasma volume starts within hours
 - Increase of red blood cells, effective within several days
2. Ventilatory acclimatization:
 - Ventilation increases over 2 weeks, starts within hours

Ventilatory Acclimatisation

Ventilation and SaO₂ at 14'100 feet



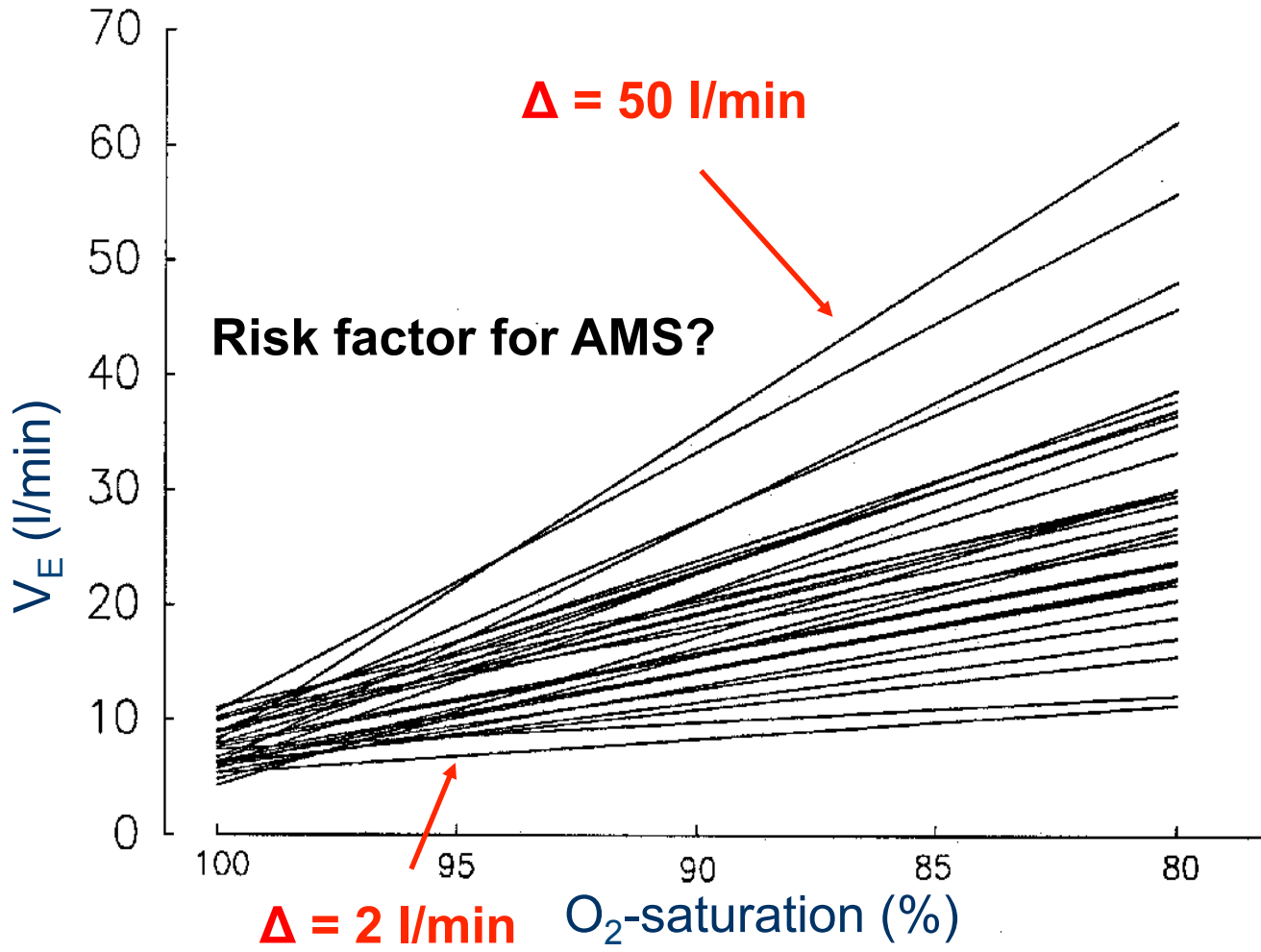
Normal values of SaO₂ depend on days spent at altitude

SaO₂: 78 → 87 %

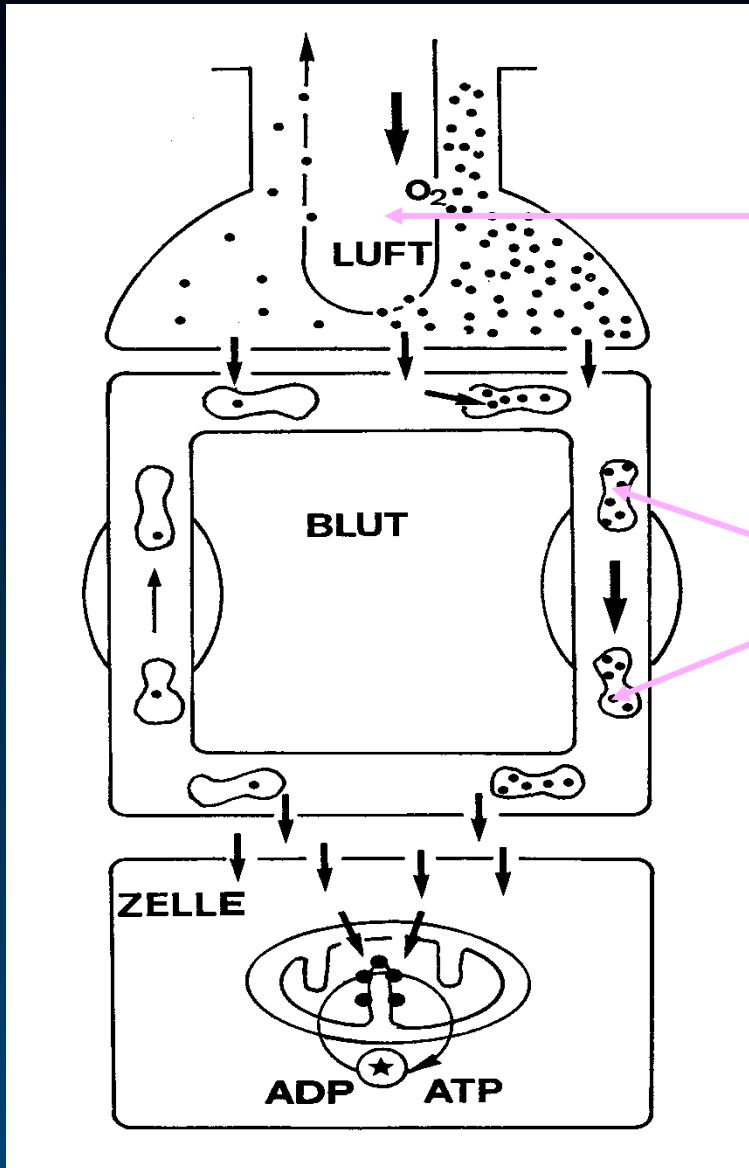
Increase of Ventilation :

- day 1: 8.5 → 10 l (18%)
- day 1-10: 10 → 15 l (50 %)

Variability of Ventilation in Hypoxia



Effect of acclimatization on O₂ transport at ≈ 17'000 feet altitude



Increase of Ventilation
50 %

Increase in red blood cells
≈ 30 %,

At 13'500 feet acclimatization
(ventilation and red cells) is
completed after 2 weeks

Lundby, AJP 2004



Effects of Acclimatization on O₂ Transport

	300 feet	17'000 feet	
		arrival	after weeks
Exercise (W)	120	120	120
O₂ demand (L/min)	1.7	1.7	1.7
O₂ pressure	normal	50 %▼	50 %▼
Hemoglobin (mg%)	13.5	13.8	18.0
Breathing (L/min)	30	45	55
O₂ loading (%)	95	63	75
O₂ in blood (ml/L)	174	135	205 + 18%
Heart rate (/min)	110	159	132
Perception	moderate	very hard	hard

○○ Significance for Acute High Altitude Illnesses

- A considerable part of ventilatory acclimatization occurs already in the first few days and coincides with improvement of acute mountain sickness (AMS)
- Acclimatization prevents AMS
- Diamox increases ventilation – enhances ventilatory acclimatization and prevents AMS
- Acclimatization normalizes increased brain blood flow, which plays a role for preventing AMS and HACE
- Normal values of SaO₂ show a large variation between individuals and also depend on the degree of acclimatization