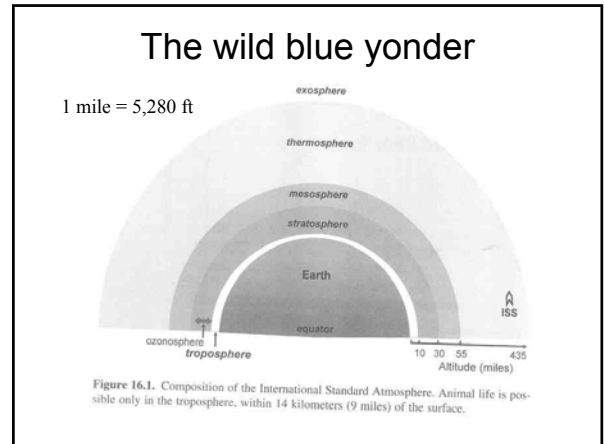
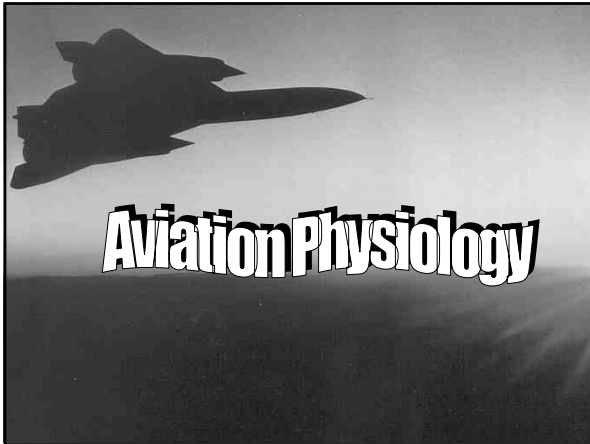




Into the stratosphere

- 1875, Zenith, 2 men die from lack of O₂ at 28,000 ft (5.3 miles)
- 1931 August Piccard, first into the stratosphere, 9.8 miles in a pressurized gondola and breathing oxygen
- 1961, Ross and Prather, highest altitude reached in a balloon (21.5 miles)



1999, Bertrand Piccard and Brian Jones, Around the world in 20 days

Aviation

- 25,000-35,000 ft commercial aircraft
- 60,000 ft, Concorde
- 85,000 ft, Blackbird
- planes are pressurized to about 8,000 ft
- dangers of sudden decompression
 - hypoxia
 - unconsciousness in 2 min or less at 25,000 ft
 - Payne Stewart example

Physiological Limits

- 33,000 ft, lose consciousness
- 48,000 ft, limit with pure O₂
- 52,000 ft, limit with high pressure breathing
- 62,800 ft, Armstrong line
 - fluids will boil at body temperature
 - Embullisms as O₂ and CO₂ form bubbles
 - pressurized suit or capsule
 - altitude decompression sickness in U2 pilots

Aviation Protective Measures

- breathe oxygen
- pressurize the cabin
- pressurized clothing
- pressurized breathing
- Chuck Yeager
 - first to break the sound barrier in 1947, 760 mph at sea level, Mach 1



Astronaut EVA suit



Pre-breathe options



Pre-breathe 100% O₂
4-12 hrs
Depression Shuttle 10 hrs

ISS
Camp Out Option

Exercise Pre-breathe Countermeasure

- Exercise during pre-breathe
- Reduces time for nitrogen elimination
- Saves crew time and oxygen



Hypergravity

- Sudden changes in acceleration result in g-loc, gravitational induced loss of consciousness
- g tolerance is dependent on
 - intensity
 - duration
 - direction of gravitational forces
- g tolerance ~ body mass
 - distance from heart to brain

G force nomenclature

Front to back	+G _x
Back to front	-G _x
Right to left	+G _y
Left to right	-G _y
Head to foot	+G _z
Foot to head	-G _z

Normal g-force limits

- “unprotected”, 3-4 g
- “protected”, 9-10 g
- capacity of aircraft, > 12 g



Limits for g-tolerance

- Limiting factors
 - ability to maintain Q
 - ability to maintain lung perfusion ($> 5g$)
- Methods to maintain Q and $\uparrow$ g toler.
 - straining maneuvers
 - anti-g garment
 - positive pressure breathing
 - reclining seats

Video

- Reaching New Heights
- History of the Mayo Clinic Aero Medical Unit
 - oxygen masks
 - pressurized regulators
 - M-1 straining maneuvers
 - g-suit
 - parachute oxygen delivery system