

# AEROMEDICAL FACTORS

**HYPOXIA** is a condition that results from having an insufficient amount of oxygen in the body. There is a tendency to associate hypoxia only with flights at a high altitude. However, many other factors interfere with the blood's ability to carry O<sub>2</sub>.

- **Drugs.** Many medications have an unexpected effect when combined with high altitudes. Never self-medicate, even with over the counter drugs.
- **Alcohol.** 1 ounce of alcohol can give the body a physiological altitude of up to 2,000'.
- **Smoking.** The hemoglobin molecule of RBCs has a 200 to 300 times greater affinity for CO than for O<sub>2</sub>. Smoking 3 cigarettes in rapid succession or 20 to 30 cigarettes within a 24 hour period gives a physiological altitude of 5,000' at sea level and a 20% reduction of night vision.

## CLASSIFICATIONS

**Hypoxic:** Occurs when there is insufficient oxygen in the air that is breathed or when conditions prevent its diffusion from the lungs to the bloodstream. This is the type that is most likely to occur at altitude.

**Hypemic:** Hypemic, or anemic hypoxia, is caused by a reduction in the oxygen carrying capacity of the blood. Anemia and blood loss are the most common causes. Carbon monoxide, nitrates, and sulfa drugs also cause it by forming harmful compounds with hemoglobin and reducing the hemoglobin that is available to combine with oxygen.

**Stagnant:** In stagnant hypoxia, the oxygen carrying capacity of the blood is adequate, but there is inadequate circulation. Such conditions as heart failure, arterial spasm, occlusion of a blood vessel and the venous pooling encountered during positive G-maneuvers predispose an individual to hypoxia.

**Histotoxic:** Results when there is interference with the use of oxygen by body tissues. Alcohol, narcotics and certain poisons, such as cyanide, interfere with the cell's ability to use an adequate supply of oxygen.

## STAGES

**Indifferent. (0' -10,000')** Night vision deteriorates at about 4000'. When approaching 10,000', visual acuity begins to decrease.

**Compensatory. (10,000' -15,000')** The circulatory and the respiratory system provide some defense against hypoxia at this stage. Your pulse, systolic blood pressure, circulation, and cardiac output increases. Respiration increases in depth and sometimes in rate. At 12,000' to 15,000', however, the effects of hypoxia on the nervous system become increasingly apparent. After 10 to 15 minutes, impaired efficiency, drowsiness, and frequent errors in judgment are common. It becomes difficult to do even simple tasks.

**Disturbance. (15,000' - 20,000')** In this stage the physiological responses can no longer compensate for the oxygen deficiency. Impaired flight control, handwriting, speech, vision, intellect, judgment, decreased coordination and memory, euphoria, aggressiveness, overconfidence, or depression can occur.

**Critical Stage. (20,000' and above)** All life support systems begin to fail. Within 3 to 5 minutes, judgment and coordination usually deteriorate. Subsequently, mental confusion, dizziness, incapacitation, and unconsciousness occur followed by death.

**SIGNS** Cyanosis, diminished visual acuity, headache, dizziness, euphoria, belligerence, and tunnel vision. *Hypoxia usually occurs above 10,000'.*

## HYPERVENTILATION

An excessive rate and depth of respiration. This increase in breathing rate leads to a decrease in the carbon dioxide content of the body as well as to a change in the body's acid-base balance. Among the factors that can initiate the cycle are emotions, pressure breathing and hypoxia.

**SIGNS** Nerve and muscle irritability, intermittent muscular contractions, and an increased respiratory rate. Hyperventilation will usually occur below 10,000'.

## PRESSURE CHANGE EFFECTS

Refers to the various manifestations of gas expansion induced by decreased barometric pressure.

**Trapped Gas Disorders.** During ascent, the free gas normally present in various body cavities expands. If the escape of the expanded gas is impeded, pressure builds up within the cavity and pain is experienced. Any time pain persists after landing, seek medical aid as soon as possible.

•**Abdominal Pain.** The chief sources of gas in the stomach are swallowed air and gas formed as a result of digestive processes. If you participate regularly in high-altitude flights, avoid foods that disagree with you and chew your food well. Air is unavoidably swallowed when drinking or chewing gum. Therefore, avoid drinking large quantities of liquids, particularly carbonated beverages, before high-altitude flights or chewing gum during ascent. Belching or passing flatus will ordinarily relieve the gas pains. If pain persists, descend to a lower altitude.

• **Middle Ear Discomfort.** The Eustachian tube normally allows air to pass outward from the middle ear. However, with an increase in pressure during descent, the pressure of the external ear is higher than pressure in the middle ear and the ear drum is forced inward. If the pressure differential increases appreciably, it may be impossible to open the Eustachian tube. This condition is painful, and the eardrum could rupture if the pressure is not equalized. Normally, you can equalize pressure during descent by swallowing, yawning, or tensing the throat muscles. If this fails, perform the Valsalva maneuver. If the pain increases with further descent, relief can only be obtained by ascending to an altitude where the pressure can be equalized. Then a slow descent is recommended. ***To avoid over pressurization of the middle ear, never attempt a Valsalva during ascent.***

• **Sinus Pain.** Sinus openings may become obstructed when the mucous membrane lining swells as a result of an infection or allergic condition. Viscous secretions may also cause the openings to be covered. These conditions may make it impossible to equalize pressure. Change of altitude produces a pressure differential between the inside and the outside of the cavity, sometimes causing severe pain. Unlike the ears, the sinuses are equally affected by ascent and descent. If the frontal sinuses are involved, the pain extends over the forehead above the bridge of the nose. If the maxillary sinuses are affected, the pain is on either side of the nose in the region of the cheekbones. Avoid flying when you have a cold or congestion and Valsalva often during descent.

• **Tooth Pain.** The toothache usually results from an existing dental problem. Descent brings relief.

• **Evolved Gas Disorders.** Occur in flight as a direct result of a reduction of atmospheric pressure. Also known as decompression sickness.

• **Bends.** At the onset, pain in the joints and related tissues may be mild, but it can become deep, gnawing, penetrating and eventually intolerable. The pain is progressive and gets worse if ascent is continued.

• **Chokes.** Symptoms occurring in the thorax are caused by innumerable small bubbles that block the smaller pulmonary vessels. At first, a burning sensation is cited under the sternum. As the condition progresses, the pain becomes stabbing and inhalation is markedly deeper. There is an almost uncontrollable desire to cough. Finally, there is a sensation of suffocation; breathing becomes more shallow and the skin bluish. An immediate descent is imperative.

• **Paresthesia.** Tingling, itching, cold and warm sensations that are believed to be caused by bubbles formed locally or in the CNS where they involve nerve tracts leading to the affected areas in the skin.

• **CNS.** In rare cases when aircrews are exposed to high altitude, symptoms may indicate that the brain or the spinal cord is affected by nitrogen bubble formation. The most common symptoms are visual disturbances such as the perception of lights flashing or flickering when they are actually steady.

## STRESS

Results from a perceived imbalance between a demand and one's ability to meet that demand. Any event which requires you to adjust or adapt in some way is a source of stress, also called a stressor.

### TYPES OF STRESSORS

**Psychosocial.** A powerful life event that may be positive or negative, like a marriage or divorce.

**Environmental.** Those things found in the work place such as heat, cold, vibrations, or G-forces.

**Physiological.** "DEATH" Helps identify stressors.

• **Drugs.** Most drugs have side effects. Limit or avoid drugs unless prescribed by a flight surgeon.

• **Exhaustion.** Lack of rest, poor sleep, and intense physical exercise can contribute to exhaustion.

• **Alcohol.** Drink in moderation or avoid if able.

• **Tobacco.** Use of any tobacco product is detrimental.

• **Hypoglycemia.** Start your day with a balanced meal.

### CLASSES OF STRESSORS

**Functional.** Any stress that improves your ability to manage stress. Such as meeting a deadline.

**Dysfunctional.** Overwhelms your coping ability. Like trying to end world hunger by yourself.

**Acute.** Has the most immediate impact. It is usually very intense and occurs in a relatively short period of time. Working under acute stress for a prolonged period of time can cause burnout.

**Chronic.** Is not as intense, but can last for months or years. This type of stress is more debilitating and can cause illness. Duty assignments, physiological environment, and illness contribute to chronic stress.

### STRESS ZONES

**Comfort Zone.** Individuals attempt to remain in the comfort zone. Here they experience enough stress to maintain productivity and feel motivated to meet demands, even if those demands seem difficult.

**Deprivation Zone.** When stress drops, individuals may be less motivated to attack difficult tasks. They enter a deprivation zone, which is characterized by a feeling of boredom. While in this zone, individuals want to return to the comfort zone by seeking excitement. Should a lack of stimulation continue, they may become depressed and eventually enter into a state of depression; this may lead to alcohol or drug abuse or to suicide.

**Distress Zone.** With an increase in stress, many people move from the comfort zone into the distress zone. When this happens, they try to reduce the stressors (anxiety) and return to the comfort zone. There are two primary means of reducing anxiety. One is an attempt to overpower the stressor. The other is an attempt to remove one's self from that stressor. Commonly referred to as the "fight or flight" syndrome. Aviators experience this syndrome as they react to acute and chronic anxieties.

•**Reactions to Acute Anxiety.** This type of anxiety is situational. An example is being caught in bad weather. This anxiety will end when the individual is removed from the situation.

•**Reactions to Chronic Anxiety.** Chronic anxiety is more difficult to deal with than acute anxiety. An effective means of resolving chronic anxiety is hard to find. An example of this type of anxiety might be severe marital problems leading to a lack of communication between the aviator and his or her spouse. In either "fight" or "flight", the stressed aviator is trying to reduce the anxiety. If this is achieved, the individual reenters the comfort zone; if not the anxiety deepens. The individual then becomes subject to developing diseases of adaptation. The individual can develop a psychiatric state of anxiety, with a loss of functional abilities, which may then lead to psychiatric hospitalization or to suicide.

## FATIGUE

A condition that follows a period of excessive mental or physical activity or inactivity.

•**Acute.** This type of fatigue occurs after physical training and is easy to detect. It causes the loss of coordination and awareness of errors. With adequate sleep and rest, it is usually overcome.

•**Chronic.** This is a more serious type of fatigue that occurs over a longer period of time. Besides the physical tiredness, a mental tiredness also develops. It is not overcome with sleep or rest.

**STEPS TO REDUCE FATIGUE** Good physical fitness with an adequate diet and vacation time that includes quality rest

## CIRCADIAN CYCLE

The body's biological rhythmic cycle, about 24 hours long. This cycle is characterized by phases of sleep, wakefulness, and hormonal balances. The circadian cycle can't be changed by extending the wakeful period. Lack of sleep will accelerate the acute fatigue that develops. When undergoing reverse cycle training, you should change your biological clock to coincide with the new duty hours. Eating light and taking naps may help.

## TOXIC HAZARDS IN AVIATION

The greatest toxicological risk during flight is short-term, high-level exposure to toxic agents. Ground support personnel may be affected by chronic exposure to toxic agents. These agents can be inhaled, ingested, or absorbed into the body. The two most common entry points are *the respiratory tract and the skin*.

**AIRCRAFT CONTAMINATION** Normally results from exhaust gases, tetraethyl lead, fuel, carbon monoxide, engine lubricants, and oxygen contaminants in the cockpit. **Carbon Monoxide:** A colorless, odorless gas that is lighter than air. The effects are subtle and deadly. Results from incomplete combustion. It is the most common gaseous poison in aviation

## ACCELERATION

A change in velocity with respect to time.

•**Linear.** A change in speed without a change in direction.

•**Radial or Centripetal.** Can occur in any change of direction without a change in speed.

•**Angular.** This type acceleration involves a simultaneous change in both speed and direction.

## G-FORCE

Inertial force that is equal to but opposite the acceleration force.

•**Positive-G.** Occurs when the body is accelerated in a headward direction.

•**Negative-G.** Occurs when the accelerative force acts on the body in a direction towards the feet.

•**Forward Transverse-G.** Occurs when the accelerative force acts across the body in a back-to-chest direction.

•**Backward Transverse-G.** Occurs when the accelerative force acts across the body in a chest-to-back direction.

•**Right or Left Lateral-G.** Occurs when the accelerative force impacts across the body from shoulder to shoulder.

## SPATIAL DISORIENTATION

Spatial disorientation is an individual's inaccurate perception of position, attitude and motion relative to the center of the earth.

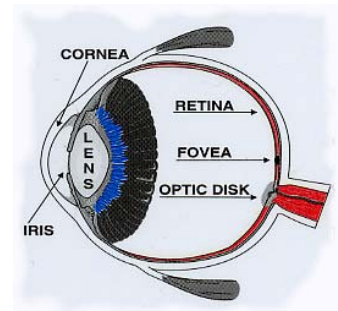
- **Equilibrium.** Involves an individual's accurate perception of his position, attitude, and motion relative to the center of the earth.
- **Sensory Illusion.** Occurs when the various sensory inputs that affect the brain disagree with each other or disagree with the actual position, aircraft attitude, or motion.
- **Vertigo.** A dizzy or spinning sensation caused by some physiological abnormality.
- **Pilot's Vertigo.** An illusion originally defined as a sensation of rotation occurring in flight. Most aviator's refer to all forms of spatial disorientation, with or without subjective rotation as pilots vertigo.

**EQUILIBRIUM MAINTENANCE** Three sensory systems are important in maintaining equilibrium, orientation, and balance.

## VISUAL SYSTEM

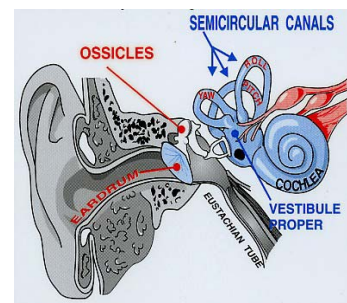
The visual system is the most important in maintaining equilibrium and orientation and is considered the most reliable source of information in flight. Sight accounts for up to 80% to 90% of all sensory perceptions.

• **Light** from an object enters the eye through the cornea, the clear portion of the eye, and passes through the pupil. The size of diameter of the pupils controlled by the IRIS, the color portion of the eye. The lens is located behind the pupil and focuses light on the retina. The retina is composed of many tiny photosensitive cells called rods and cones. Light produces a chemical change in these cells; this initiates a nerve impulse that is transmitted to the brain via the optic nerve. The brain deciphers the impulse and creates a mental image that is interpreted.



**VESTIBULAR SYSTEM.** The inner ear is the motion and gravity detecting sense organ. It is located in the temporal bone of two distinct structures.

- **Semicircular Canals.** The semicircular canals sense changes in angular acceleration. The canals will react to changes in pitch, roll, or yaw. The semicircular canals are situated in three perpendicular planes to each other. They are filled with a fluid called endolymph. The inertial torque resulting from angular acceleration in the plane of the canal puts this fluid into motion. The motion of the fluid bends the cupula, a gelatinous structure located in the ampulla of the canal. This in turn moves the hair cells situated beneath the cupula. This movement stimulates the vestibular nerve. These nerve impulses are then transmitted to the brain where they are interpreted as head rotation.
- **Vestibule Proper.** The otolith organs are small sacs located in the vestibule proper. Sensory hairs project from each macula into the otolithic membrane, an overlying gelatinous membrane that contains chalk-like crystals called otoliths. The otolith organs respond to gravity and linear acceleration. Changes in the position of the head relative to the gravitational force cause the otolithic membrane to shift position on the macula. The sensory hairs bend, signaling a change in the heads position.



## ILLUSIONS

- **Somatogyral Illusions.** Caused when angular acceleration stimulates the semicircular canals.
- **Leans.** The leans occur when you fail to perceive an angular motion. During continuous straight-and-level flight, the pilot will correctly perceive that he is straight and level. However, a pilot rolling into or out of a bank may experience perceptions that disagree with the reading on the attitude indicator and other instruments. To counter the falsely perceived position, the pilot will lean his body until the false sensation leaves.
- **Graveyard Spin.** If you enter a spin and remain in it for several seconds, the semicircular canals will reach equilibrium; no motion is perceived. Upon recovering from the spin, you undergo deceleration, which is sensed by the semicircular canals. You then have a strong sensation of being in a spin in the opposite direction even though the flight instruments contradict that perception. If deprived of external references, you may disregard the instruments and make control corrections against the falsely perceived spin. The aircraft will then enter a spin in the original direction.

- **Coriolis Illusion.** The most dangerous of all vestibular illusions, causing overwhelming disorientation. It can take place when a climbing or descending turn is initiated. As you enter a turn, one semicircular canal in each ear is stimulated. In time, the endolymph reaches equilibrium within the canal. When you move your head in a geometric plane other than that of the turn, the fluid accelerates in the canals originally stimulated. At the same time, the fluid moves in the remaining two semicircular canals. The combined effect of bending the copula in all three semicircular canals is that the pilot perceives the aircraft's motion to be in a different direction than its actual motion. The result is the feeling that the aircraft is rolling, pitching, and yawing at the same time.
- **Soinatogravic Illusions.** Somatogravic illusions are caused from changes in linear acceleration and gravity that stimulate the otolith organs.
- **Oculoagravic.** Occurs when an aircraft is accelerated forward. Inertia from linear acceleration causes the otolith organs to sense a nose-high attitude. A pilot correcting for this illusion without cross checking the instruments would most likely dive the aircraft, catastrophic during an approach. This illusion usually does not occur if adequate outside reference is available.
- **Elevator.** This illusion occurs during upward acceleration. Because of inertia, the pilot's eyes track downward as his body tries, through inputs supplied by the inner ear, to maintain visual fixation on the environment or instrument panel. With the eyes downward, the pilot will sense that the nose of the aircraft is rising.
- **Oculoagravic.** This illusion results from the downward motion of the aircraft. Because of inertia the pilot's eyes will track upward. This usually results in a sensation that the aircraft is in a nose-low attitude. This illusion is commonly encountered during autorotation. **Proprioceptive System.** This system is not very reliable in flight. It reacts to the sensations resulting from pressures on joints, muscles, skin and from slight changes in the position of internal organs. It's closely associated with the vestibular system and to a lesser degree, the visual system

**PREVENTION** Perhaps the single most important factor is to realize that the misleading sensations that come from the sensory systems are predictable. Training, instrument proficiency, good health, and aircraft design all help to minimize spatial disorientation. Spatial disorientation becomes dangerous when pilots believe their sensations rather than trusting in the aircraft instruments.