APPENDIX B

FACTS ABOUT THE ATMOSPHERE

The composition of the Earth's atmosphere is discussed on page 14. The atmosphere exerts a pressure at sea level of 14.7 psi. Based upon temperature, it separates itself into 7 distinct layers (Reference 6).

Troposphere. The lowest layer is the troposphere and is the portion within most of the clouds and weather occur. The Troposphere is about 10 miles thick at the equator and about 6.2 miles thick at the Polar Regions. With every 1000 feet of elevation, the temperature decreases by 5.4F. It reaches a minimum temperature of -95F at its upper limit.

Tropopause. The tropopause is an area of nearly constant temperature between the troposphere and the stratosphere.

Stratosphere. Temperatures increase with altitude in the stratosphere from about -75F to 30F. This temperature increase is due to the ozone in the stratosphere converting ultra violet light to heat as it absorbs solar radiation. The stratosphere extends from about 14 to 28 miles at the Equator.

Stratopause. Above the stratosphere is the stratopause, a region of fairly constant temperature.

Mesosphere. The temperature in the mesosphere decreases with altitude until it reaches -185F at an altitude of 50 miles.

Mesopause. This is an area of relatively constant temperatures of -185 F.

Thermosphere. This is an area where temperature again rises with elevation, attaining temperature of 120-175F at ~70 miles altitude, depending on latitude and the season of the year. From there it rises to 930F at a 75-mile altitude. It remains at 930F until an altitude of 620 miles is achieved. At an altitude of 400 miles, the mean free path of an air molecule is 400 miles. This is called the ***critical level***.

The **ionosphere** is a layer of the thermosphere in which the atmospheric gases are ionized and ranges from 62 to 250 miles in altitude where the maximum amount of ionization occurs. However, at this altitude, only 1 molecule in 2000 is actually ionized. Ionization occurs as a result of bombardment by the solar winds, a plasma of high speed electrons and protons emitted by the sun. This is the layer which reflects commercial radio signals back to earth, resulting in the ability to send low frequency radio signals around the world.

The **exosphere** is the portion of the thermosphere above the ionosphere and extends to empty space. In this region, the temperature of the air is 930 to 2730F, depending on sun spot activity; however, there are so few molecules of air that the heat content is minuscule.

Temperature is a measure of the average kinetic energy of the molecules. Mathematically, this is the product of one half the mass of the molecule times the square of its velocity. Temperature and heat are distinctly different concepts. The total heat in the air depends on the temperature ***and*** the number of molecules per unit volume. At 250 miles altitude, there are 2 trillionths of the number of molecules of air as there are at sea level. Even though the molecules are at high temperatures (930 to 2730F), the heat transferred by their impact is 2 trillionths of what would be transferred at sea level at these temperatures.

Gee Whiz Numbers (Reference 2)

Air Pressure. Air pressure decreases with altitude. Half of the atmosphere lies above 18,000 feet; thus, the pressure is 7.35psi at 18,000 feet. At the top of Mount Everest, 31% of the atmosphere lies above it, and the pressure is 4.56 psi. At a 40-mile altitude, the air pressure is $1/10{,}000^{th}$ of sea level pressure. At a 65-mile altitude, the pressure is $1/1{,}000{,}000^{th}$ of that at sea level.

Temperature Drop. As previously noted, for every1000 feet of altitude in the troposphere, the temperature drops 5.4F. Thus, a 5000-ft. mountain peak is typically 27 degrees Fahrenheit cooler than at sea level.

Air Composition. The composition of the air is essentially the same up to about 53 miles high and changes very little up to 62 miles of altitude. This excludes water and, I assume, carbon dioxide. The water molecule has a molecular weight of 18, whereas, the average molecular weight of air is 28.964. Therefore water vapor, being only 62% as heavy as air, will rise up, condense, and form clouds. Carbon dioxide is 52% heavier than air, so it is slightly more concentrated near ground levels. That's where the plants need it, anyway. There are also diurnal and seasonal variations of its levels.

Numbers of Air Molecules. At sea level, there are 440 billion billion (440×10^{18}) air molecules ***per cubic inch***. Contrast that to the fact that there are 350 billion billion gallons of water in all the oceans!

The mean free path of the molecules at sea level is 2.76 millionths of an inch. (The mean free path is the average distance a molecule goes before colliding with another molecule.) At 370 miles altitude, the mean free path is 6 miles. An air molecule at sea level collides about 7 billion times per second, whereas, at a 100 mile-altitude, each molecule collides about 1.5

times per second. The velocity of an average air molecule at sea level is 1025 miles per hour. At a 100-mile altitude, the average molecular velocity is 1775 miles per hour.

Ozone Layer. The ozone layer extends up to 45 miles altitude. The maximum concentration occurs at about 18.5 miles altitude at the Equator and is between 1 and 10 parts per million. If all of the ozone in the ozone layer were at atmospheric pressure, the layer would be one eighth inch thick (0.125 in.). At the critical ultraviolet wave lengths of 240-290 nm, ozone absorbs virtually all of the lethal radiation. At 250 nm, less than 1 part in 10^{30} penetrates the ozone layer. (Reference: R.I. Collins, University of Alaska, Fairbanks Seminar, 2005.)