Passage II

Many scientists believe that comets form in frigid temperatures at the edge of our solar system or beyond and consist of rocky material, dust, and water ice. This theory is called the dirty snowball theory. According to the dirty snowball theory, a comet is a dense nucleus, about 50 percent to 80 percent of which is water ice, surrounded by a cloud of diffuse material called a coma (see Figure 1). A few comets have highly elliptical orbits that bring them very close to the Sun. As comets approach within a few AU of the Sun (an AU or astronomical unit is equal to the mean distance between the Earth and the Sun or about 93 million miles), the surface of the nucleus heats up, and volatile materials boil off carrying along small solid particles that reflect sunlight. Comets develop long tails of luminous material extending for millions of miles from the comet head. The theory, which virtually all astronomers accepted for years, explained the “outgassing” of comets as the effect of heating by the Sun. When a comet moves closer to the Sun, ices in the nucleus “sublimate,” or evaporate into space, simultaneously ejecting dusty material held within the ices.

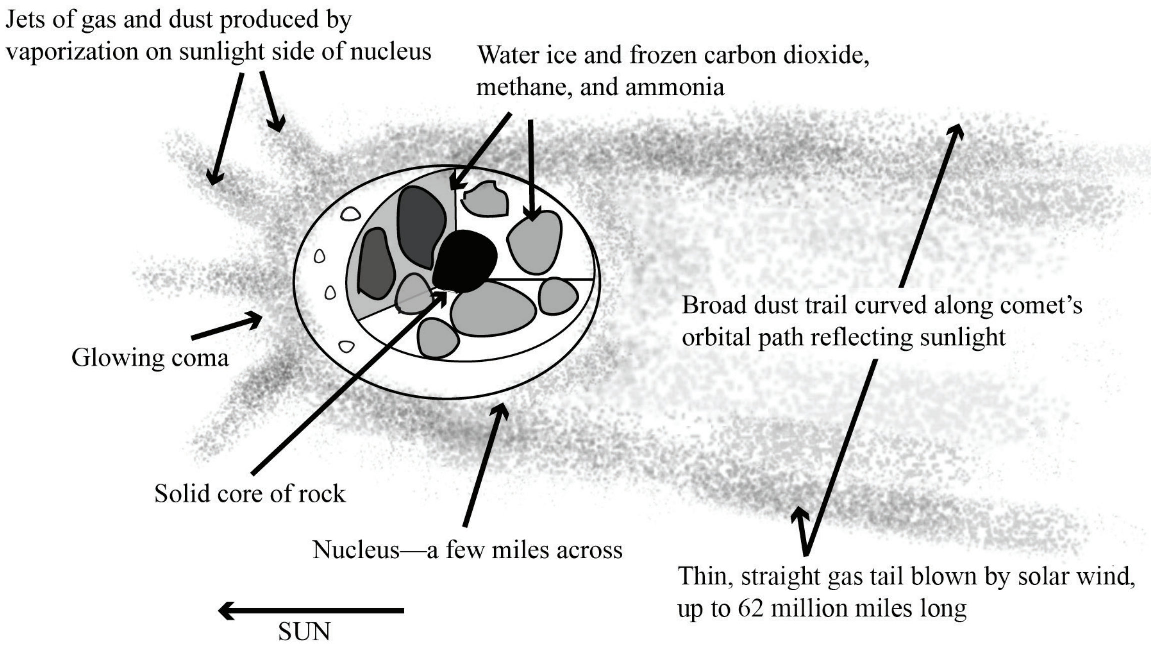

Figure 1

Scientist 1

In 1986, visits to Halley’s Comet by the European *Giotto* and Russian *Vega* probes failed to locate surface water and raised the distinct possibility that the nucleus might not be ejecting water into space. In 2001, the *Deep Space 1* craft did a close flyby of the Comet Borrelly and detected no frozen water on the surface. Instead, a spectrum analysis suggests that the surface of the comet is dry. In 2004, the *Stardust* spacecraft passed by Comet Wild 2 and could not find even a trace of water on the surface. In 2005, the NASA *Deep Impact* mission found a smattering of water ice on the surface of comet Tempel 1. The problem is that, to account for the water supposedly being “exhaled” by Tempel 1, the investigators needed the comet to have 200 times more exposed water ice than was found. So far, it has not been possible to find very much ice in these so-called dirty snowballs.

Scientist 2

The dirty snowball model is still the best theory we have. It is not surprising that very little ice has been observed on the surfaces of comets. Readings are taken when the comets are in the inner solar system, where the Sun would have vaporized any water ices on the comet surface, leaving behind a crust of dark dust and rock particles. The majority of a comet’s water ice is below the surface, and it is these reservoirs that feed the jets of vaporized water that form the coma.

Scientist 1

If a thin crust of dust hides the water below the surface of the nucleus, one would think that a newly formed crater would be exactly what was needed to stimulate the comet to produce water. In the case of Deep Impact and Comet Tempel 1, the probe crashed into the comet and removed many thousands of tons of material. Prior to impact, the calculated "water" output was 550 pounds per second; and not long after the impact, the calculated output was still 550 pounds per second. So despite the impressive explosion, the hypothesized sub-surface water was never observed.

Scientist 2

The scientific instruments used to study comets do not observe water directly. Instead, they detect the most abundant companion of cometary dust: the "hydroxyl" radical, OH. The coma's water has been broken down by the Sun's ultraviolet radiation, forming the hydroxyl radical along with atomic hydrogen and oxygen. The abundance of hydroxyl radical in a comet nucleus is a direct pointer to the abundance of water held by the nucleus.

Scientist 1

In their analysis of the coma, conventional astronomers begin with the assumption that water is evaporating in the heat of the Sun off the surface ices of the nucleus. They do not observe the water, but cite the effects of solar radiation on assumed water to account for the abundant hydroxyl radical in the coma. The hydroxyl radical is more likely the result of electrical activity. The role of electricity also explains the cometary coma, the spherical envelope around the nucleus. It could not be maintained by gravity because gravity is too weak. As the comet speeds around the Sun, the nucleus continues to hold in place the giant spherical cloud, up to 16 million miles or more in diameter.

Passage III

Relative humidity is a measure of how much water vapor is in the air relative to the total amount of water vapor that the air is capable of holding at a given temperature. Heat index is a combined measure of relative humidity and air temperature. The heat index provides a more accurate indication of the perceived—that is, felt—temperature than is provided by the air temperature alone.

A psychrometer is used to monitor heat index and consists of two traditional bulb thermometers: one “dry” and one “wet.” The dry-bulb thermometer indicates the ambient temperature (current air temperature without regard to humidity or wind). The wet-bulb thermometer is covered with a wet cloth, or wick, and is exposed to moving air for a period. The moisture from the wick evaporates and cools the bulb, lowering its temperature. Once both bulb temperatures are stable, the readings are recorded. A small difference between bulb temperatures—due to a low evaporation rate on the wet-bulb wick—indicates a high relative humidity. A large difference between bulb temperatures—due to a high evaporation rate on the wet-bulb wick—indicates low relative humidity.

To determine the measure of relative humidity, the intersection of the dry-bulb and wet-bulb temperatures is located on a psychrometric graph (Figure 2). Absolute humidity is the amount of water carried in the air, as measured in grams of water per kilogram of air. The ratio of the absolute humidity to the maximum amount of water that the air can hold gives the relative humidity, expressed as a percentage.

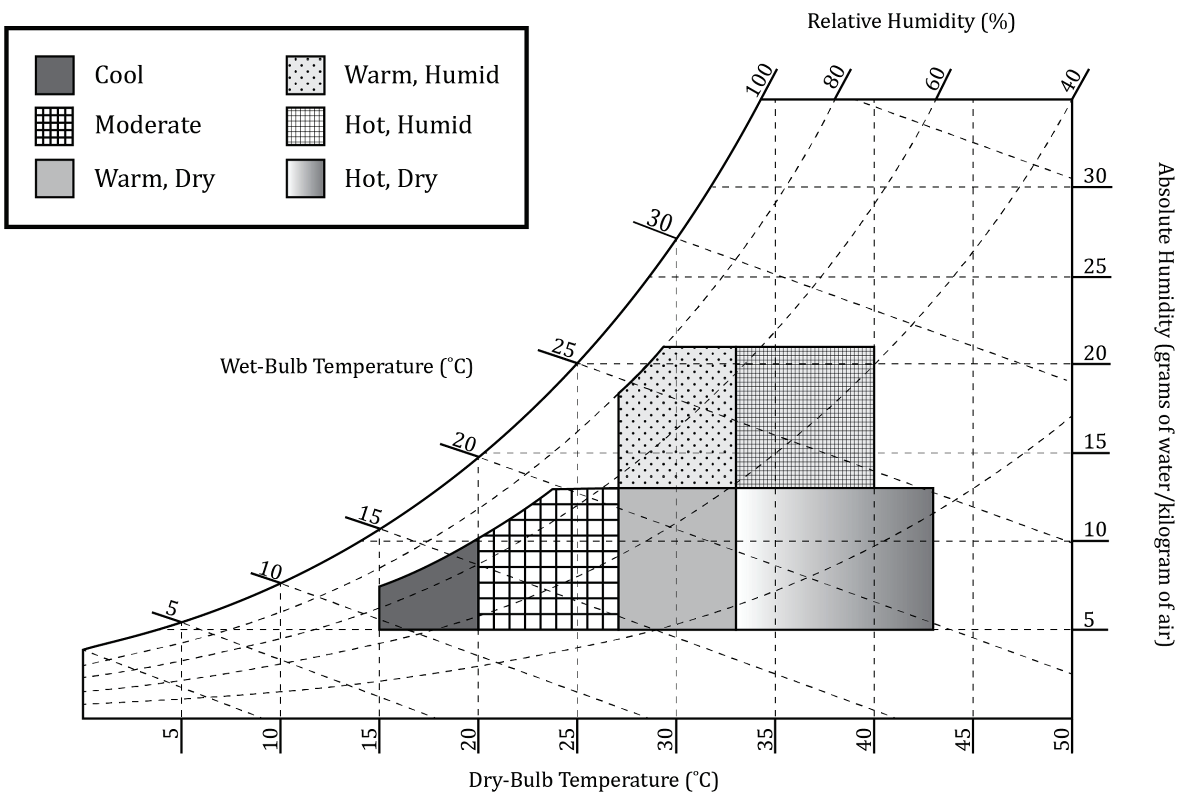

Figure 2

To determine the heat index, the intersection of the dry-bulb temperature and the relative humidity is located on a heat index graph (Figure 3). Certain ranges of heat indices correspond to warning level categories regarding sunstroke and heat exhaustion. There are four main warning levels as indicated in Table 1.

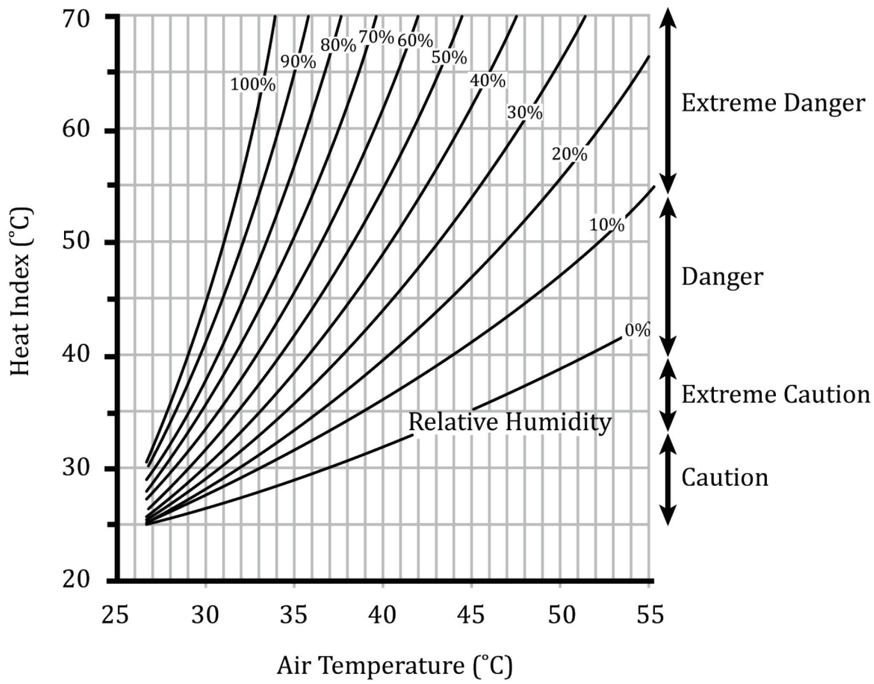

Figure 3

Table 1: Heat Index Warning Categories	
Caution	Fatigue is possible with prolonged exposure and/or physical activity.
Extreme Caution	Sunstroke, heat cramps, and heat exhaustion are possible with prolonged exposure and/or physical activity.
Danger	Sunstroke, heat cramps, and heat exhaustion are likely. Heatstroke is possible with prolonged exposure and/or physical activity.
Extreme Danger	Heatstroke/sunstroke is highly likely with continued exposure.

A group of students used a psychrometer to conduct dry- and wet-bulb measurements at several locations in and around their school. The results are summarized in Table 2.

Table 2: Experimental Measurements			
Measurement Location	Dry-Bulb Temperature (°C)	Wet-Bulb Temperature (°C)	Relative Humidity (%)
Classroom	23	13	30
Basement	16	11	50
Shower room	27	24	80
Greenhouse	32	26	60
Outdoors	30	27	80