Weather and People

Everyone is affected by the weather. It shapes our lives in immeasurable ways. Weather provides the beautiful backdrop for some of our best memories and is the powerful force behind some of our most tragic moments. Regardless of how often it is considered, weather is our constant companion; a thoughtless associate that must always be compensated for by the body.

The human body is homeostatic, that is, it must maintain its internal systems at equilibrium despite external fluctuations. This provides many challenges. One of the largest of which is temperature regulation. Humans are homeotherms, warm-blooded mammals that regulate their internal body temperature within a narrow range. The average temperature is around 37° C (98.6°F). If the body's core temperature varies from this by more than 2° C, life-threatening conditions begin to develop. The body also faces challenges from humidity, wind, ultraviolet radiation, and air pressure. Despite these diverse demands, the body is normally quite proficient at maintaining its equilibrium. However, one must understand the limits of the human body, how to avoid exceeded these limits, and/or how to treat the consequences if they are exceeded.

To better understand how the body copes with heat loss and heat gain, it is helpful to review the body's methods for heat exchange with the environment. This exchange occurs through four principle ways: radiation, conduction, convection, and evaporation of liquid water.

All things with a temperature above absolute zero give off radiation. Humans, like everything else, radiate energy in the form of electromagnetic waves. We do not see this radiation because the waves occur outside of our visible region of the spectrum. The average wavelength that is radiated is indirectly proportional to the temperature of the object as seen in Wein's displacement law:

$$\lambda = \frac{0.002898 m \bullet k}{T}$$

λ is the average wavelength given off from an object with an absolute temperature of T. Thus, if an object has a higher temperature, it will radiate waves at a smaller average wavelength. For human skin temperature, the wavelength radiated is around 9400 nm, which corresponds to the infrared region of the spectrum.

Not only is our skin always radiating energy, it is also continually absorbing it. Our skin and clothing absorb radiation from the sun and convert it to thermal heat. There is a continual give-and-take radiational relationship occurring at our skin. The net effect of outgoing and incoming radiation, the radiation balance, helps determine our skin temperature and sense of comfort. A person at rest in a windless environment loses about 1/3 of their body heat through radiation.[1]

Conduction is the transfer of heat by direct collision of atoms or molecules. The amount of heat transferred by conduction depends on the ability of the object to conduct heat, the heat conductivity, and the difference in temperature between objects. Metals have a very high heat conductivity while air has a very low one. A metal such as copper conducts heat nearly 16,000 times more efficiently than air.[2] In fact, air is such a poor conductor that it is often "trapped" and used as insulation. It provides insulation between windowpanes, in fur and feathers (see Fig. 1), and even in snow. Thus, snowcaves can provide great protection and even warmth for winter enthusiasts. Air that is trapped in the snow cannot easily conduct heat away from a person inside the cave. However, as the snow settles, air will escape and cause loss of much of the insulating power.

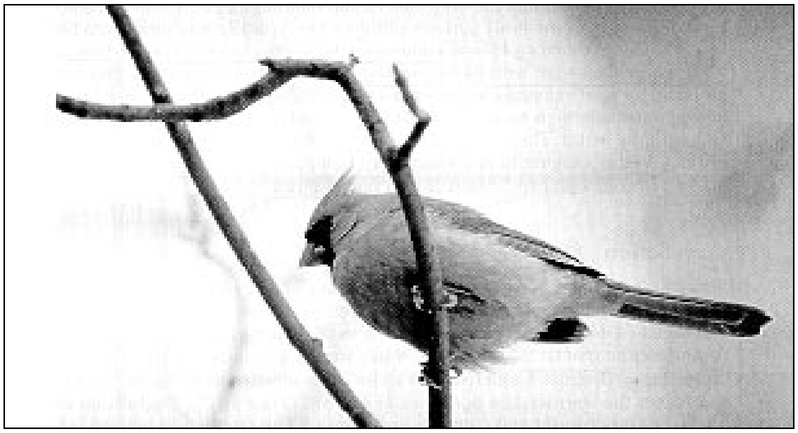

Fig. 1 By fluffing up their feathers, birds add additional pockets of still air which slow heat loss by conduction. [from Morgan and Moran, *Weather and People*. Copyright 1997, Prentice-Hall Inc, Upper Saddle River NJ. p. 7]

Water is a poor insulator. It will conduct heat 25 times faster than air. This is important in the body because muscle and skin contain greater amounts of water than fatty tissue. Hence, people with a higher body fat will retain heat better than thinner people. Interestingly, our perception of temperature not only depends on actual temperature differences, but also on this idea of heat conductivity. We have all experienced this when stepping out of the shower. Which feels cooler?…the bathroom rug or the tile floor? Being right next to each other in the same room, they are actually the same temperature. However, the tile *feels* colder because it is a better conductor. It readily conducts the heat from your feet. The rug is a better insulator and less heat is lost, so it doesn't *feel* as cold.

Because of the insulating properties of air, the body does not lose much heat to the air by conduction. More heat is lost by conduction between the feet and the ground.

However, our feet are usually well insulated with shoes and socks. Basically, the body only loses approximately 2% of its heat by way of conduction.[3]

Even though air is a poor conductor, it plays a significant role in a different type of heat loss: convection. Convection is the vertical movement of air when it is heated or cooled. When air is heated, its density decreases and it becomes lighter than the air around it. Thus, warmer air rises and cooler air sinks to take its place. This sets up a convection current that transfers heat quite readily. A thin layer of air is warmed around us by conduction. This layer of warmer air then rises in a convection current and is transported away from the body. Convection plays a bigger role than conduction in the process of cooling the body. A person loses about 1/3 of their body heat through convection. [4] This helps explain why a breeze feels so good on a hot day. It helps to more quickly carry the heated air away from the body. This is forced convection.

The last way humans lose heat is through evaporation of liquid water. Recall that when liquid water changes to a gas it requires energy. This energy is taken from the skin and results in a cooler skin temperature. This is referred to as evaporative cooling and it occurs in two primary ways: insensible and sensible sweating.

Insensible sweating occurs when water diffuses from deeper tissue to the skin and immediately evaporates. This is sweating in which the skin never really feels wet. It also occurs as water evaporates from the respiratory tract into the air. This becomes obvious in cold weather when we exhale and "see our breath". As the air quickly cools, the vapor in it is immediately condensed into a little cloud.

With sensible sweating, we actually feel like we are sweating. When the body temperature rises above 37° (98.6°F), several million sweat glands are stimulated. They release a solution of water and dissolved salts through pores in the skin. This results in a "sweaty" feeling. The body can produce up to 700 mL of sweat per hour. Sensible sweating removes heat, by evaporative cooling, 5 times faster than the body can produce it at rest. Evaporation of 720 mL requires 420 kilocalories (1 kilocalorie = 1Calorie in nutrition). A typical metabolism will produce about 75 kilocalories/hr. High sweat rates also mean a large loss of fluid and possible dehydration. Dehydration becomes dangerous when loss of fluid exceeds 3% of body weight.[5]

The net flow of heat through radiation, conduction, convection, and evaporation determines whether one feels warm or cold. If the heat gained is more than the heat lost, one feels warm and visa versa. Fig. 2 sums up the body's heat exchange with the environment.

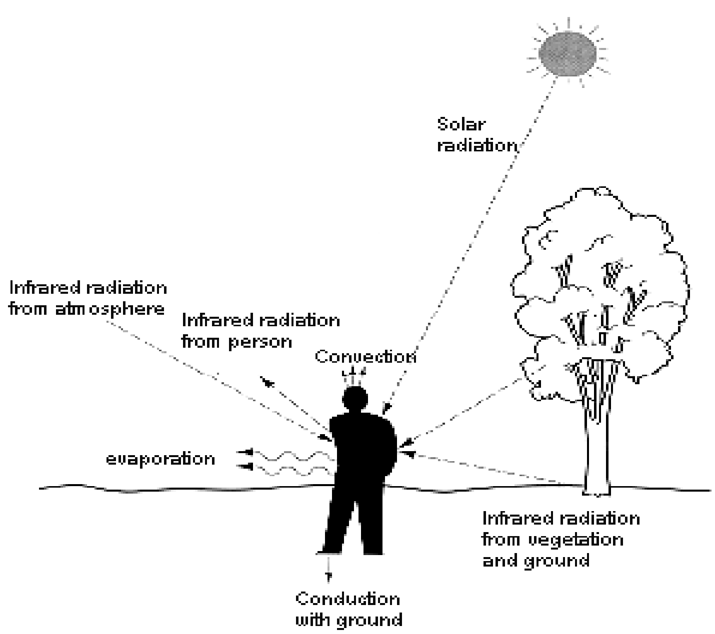

Fig. 2 Processes of energy exchange between the body and it surroundings. [from Morgan and Moran, *Weather and People*. Copyright 1997, Prentice-Hall Inc, Upper Saddle River, NJ. p. 4]

The body is very adept at regulating heat flow. Like mentioned earlier, the core temperature must stay within 2°C of 37° C (98.6°F). The body core is made up of the vital organs: brain, heart, lungs, kidneys, and digestive tract. Enzymes within these organs assist in vital biochemical reactions. These enzymes operate best in a temperature range of 35-40°C (95-104°F). Outside of this range, enzymes may undergo loss of function or death. Bodily functions may become impaired due to the loss of enzyme activity. Compared to enzymes, tissue has a much wider temperature range. Tissue can survive temperatures close to freezing without permanent damage, but the enzymes in the body could never handle such temperatures. Water that is only 25°C (77°F) could be cold enough to kill. Shipwreck victims immersed in water of this temperature die of respiratory and circulatory failure, despite the fact that the temperature isn't low enough to damage the tissue directly.[6] (This is a prime example of how water is a much better conductor than air. Most people would feel quite comfortable with an air temperature of 25°C.)

A fully–clothed person indoors feels comfortable at 20-25°C (68-77°F). In this air temperature range the body is easily able to keep the core temperature about 37°C. Basically, normal heat lost is equal to heat gain in this range. This is called the thermoneutral zone.

The hypothalamus, a portion of the brain stem, is the body's main thermometer where most of the information from the temperature receptors in the core and skin are integrated. The hypothalamus monitors these temperatures and when they start to vary, it signals the body to bring the temperature back by voluntary and involuntary means. The voluntary means are actions that we control. If Josh feels cold, he goes inside or puts on more clothing. If he feels too warm, he takes off clothing or maybe finds some shade. These are conscious responses to change in body temperature.

Even more important are the involuntary responses. A good example of this is shivering. Shivering is involuntary, rhythmic muscle contractions that typically occur at a rate of about 10-20 per second. It increases the heat production at a cellular level and generates 4-5 times as much heat as the body at rest.[7] Shivering is not just the body's way of signaling how cold it is, but is a very practical way of generating more heat.

Vasoconstriction and vasodilation are also important involuntary responses. When the body starts to get cold, the blood vessels in the skin contract and restrict blood flow. This is vasoconstriction and it prevents the body from having to keep the outer regions as warm. This helps to preserve heat loss. By allowing skin temperatures to fall, the body is able to decrease the temperature gradient between the skin and the surrounding air. This decreases the rate of cooling. Vasoconstriction can reduce blood flow to the fingers and toes by as much as 99%! [8] Although this is helpful in reducing further heat loss, it can also be harmful. The heat-creating capacity of an area of the body is directly proportional to its volume. The heat-loss capacity is directly related to the amount of surface area that is exposed. Extremities, because of their small size and large surface area, are very susceptible to heat loss. This is why the body restricts blood flow to these areas. When tissue that is already rapidly losing heat experiences a reduction in warm blood supply, it is more likely to freeze. Freezing of the tissue is known as frostbite.

As tissues freeze, cells dehydrate due to water being pulled from them to form ice crystals. The most permanent damage caused by frostbite is not the result of frozen tissue itself, though. It actually occurs when low skin temperature damages the lining of the blood vessels. Plasma from the blood is then allowed to seep out of the vessels and into surrounding tissues (swelling is a common sign of frostbite which results from this seepage). This causes blood flow to slow down, permits blood cells to congregate, and begins to form a blockade in the vessel – a blood clot. The flow is then further reduced and may eventually stop. Once cells are deprived from the nutrients and oxygen that the blood brings, they die. A blue-black discoloration is usually a sign of dead tissue (gangrene). The pictures in Fig. 3 illustrate some of the visible damage.

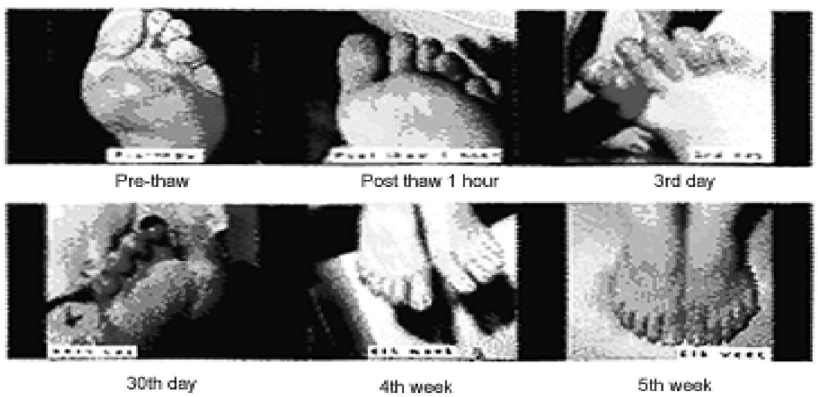

Fig. 3   Time series of recovery from frostbite following rapid rewarming in a warm water bath. Toe joints of prethaw foot were immobile and insensitive. Thawing was followed by the development of a burgundy coloaration. Over the next 48 hours, large, clear blebs developed on the toes. In subsequent weeks, skin is lost and tissues are revascularized. One year post-injury, the gross anatomy is intact and sensation was improving progressively. [from Morgan and Moran, *Weather and People*. Copyright 1997, Prentice-Hall Inc, Upper Saddle River, NJ. p. 89]

One of the body's protections from frostbite is sensory receptors in the skin. As skin temperature drops, the cold receptors increase the frequency of their messages to the brain. If cooling continues, pain sensors are triggered. The brain interprets this as a burning sensation. As the temperature at the skin nears zero, the pain is replaced by numbness. People often mistake this as an improvement and don't seek the help they need.

The best remedy for frostbite is to warm the skin as quickly as possible. Apply towels soaked in warm water or immerse the limb in warm water. Avoid heat lamps or rubbing the skin because they can burn or damage the tissue. The best prevention for frostbite is to cover all exposed skin, especially the face and ears, and to avoid long exposure to severe cold and wind.

Hypothermia is a condition classified by core body temperatures below 35°C (95°F). It is categorized by mild (32-35°C), moderate (28-32°C), or severe (below 28°C). Hypothermia can happen quite quickly. An unclothed man of average build will be helpless in water of 5°C (41°F) after only 20 to 30 minutes. With normal clothing this time can be lengthened to close to an hour.[9] Symptoms of hypothermia are lethargy, violent shivering, difficulty speaking, and impaired mental abilities (see Fig. 3).

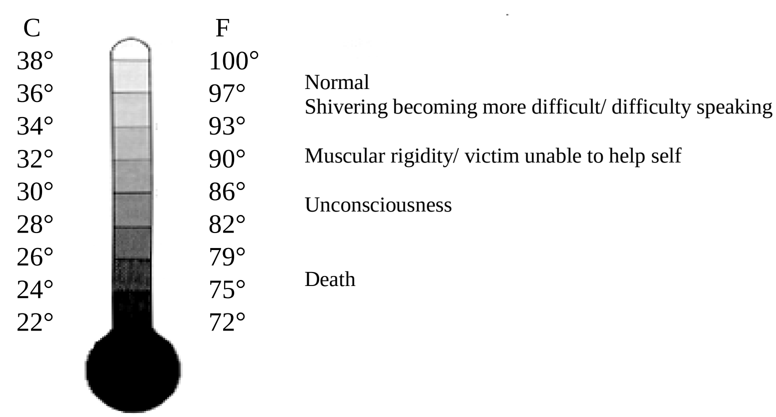

Fig. 3 As the core temperature drops under 35°C (95°F), a succession of symptoms of hypothermia develop. [from Morgan and Moran, *Weather and People*. Copyright 1997, Prentice-Hall Inc, Upper Saddle River, NJ. p. 18]

As little as a 5°C drop in core temperature can be a great strain on the thermoregulatory system. After reaching 29°C (84°F), thermoregulation is unsuccessful at bringing the body temperature back up. Symptoms of hypothermia simply can not be ignored! The treatment is, first, preventing any further heat loss by replacing wet clothing with dry clothing, finding shelter, and insulating the person from the ground. Second, warming the victim with heat or a human body. If conscious, drinking warm fluids is recommended. Finally, get medical attention as soon as possible.

Contrary to popular belief, hypothermia is not restricted to the coldest parts of the country. In fact, it is more common in the warmer areas of the U.S. in spring and fall. Strong winds and a cold drizzle are typical weather conditions for hypothermia.

Vasodilation is the antithesis of vasoconstriction. Vasodilation is an expansion of the tiny blood vessels in the skin coupled with increased heat rate to get more blood flow to the skin. This gives the skin a reddish or flushed look. Vasodilation increaes the skin temperature, which increases the skin-air gradient and thereby increases the cooling rate. An increased skin temperature also triggers the release of sweat and further cooling by evaporation.

Hyperthermia is the condition reached when the core temperature exceeds 39°C (102°F). It is classified as either heat exhaustion or heat stroke. Heat exhaustion is characterized by profuse sweating, vomiting, and weakness. Treatment for it includes getting the person to a cooler environment, sponging with them water, and giving them fluids. Heat cramps may accompany heat exhaustion or occur independently. Heat cramps are extremely painful contractions in large muscles because of excessive loss of sodium and potassium in sweat. These are not the same as cramps experienced in an overworked muscle. The heat cramps only involve an isolated bundle of muscles in one location for a few minutes and then move on to a different bundle. A person experiencing them should rest in a cool environment and, if nauseated, drink an electrolyte solution such as Gatorade or salt water.

If heat exhaustion is not treated the body temperature will continue to rise. Once it is greater than 41°C (106°F), it is classified as heat stroke. Heat stroke must be treated immediately because once the thermoregulatory system has failed, death can occur within a few hours. Symptoms include a rapid, strong pulse, psychotic behavior, and unconsciousness. Treatment is as for heat exhaustion but the victim requires hospitalization as quickly as possible.

As discussed previously, feelings of hot and cold are not dependent only on temperature. They are also contingent upon humidity and wind. Both are related to how efficiently our bodies lose heat. Humidity is a measure of how much water vapor is in the air. The drier the air, the more readily water will evaporate. If air has a greater relative humidity, it evaporates more slowly and does not effectively cool the body. Recall that the greater the difference in vapor pressures between the skin surface and the air, (vapor pressure gradient), the greater the rate of evaporation. If high water vapor exists in the atmosphere, the vapor pressure gradient will be small and so the rate of evaporation will also be small.

Scientists have developed indices that help estimate how hot it feels. The heat index or apparent temperature index is one that takes into account both temperature and humidity and attempts to quantify how hot it feels. If the temperature is 85°F and the relative humidity is 70%, the apparent temperature index would indicate that it feels closer to 93°F. There is some controversy with these indices. Arguments suggest that how hot it actually feels will depend on many factors, including: what an individual is used to, body size (a larger person has more heat producing cells/surface area), one's attitude toward the weather, and personal levels of comfort. At any rate, the indices can be helpful in gauging possible hazards due to heat. There are four categories of apparent temperature and hazard to humans.

Table 1. Hazards Posted by Heat Stress by Range of Apparent Temperature

Category	Apparent temperature	Heat syndrome
I	54°C or higher (130°F or higher)	Heat stroke *Imminent*
II	41° to 54°C (105 to 130° F)	Heat stroke, heat cramps, or heat exhaustion *likely*
III	32° to 41° C (90 to 105°F)	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and physical activity
IV	27° to 32°C (80° to 90°F)	Fatigue *possible* with prolonged exposure and physical activity.

[from Morgan and Moran, *Weather and People*. Copyright 1997 Prentice Hall Inc, Upper Saddle River, NJ. p. 31.]

Low humidity facilitates more evaporation and thus a cooler feeling. However, problems are also associated with this process. Dry air produces irritation to the mucous membranes in the nose, sinus glands, and throat. This is especially prominent in the winter. When it's cold outside, the air has a fairly low vapor pressure. When that same air is breathed in and warmed, it still has a low vapor pressure but now the temperature is much higher and so the relative humidity is quite low. Below freezing outside temperatures can translate into indoor room temperatures with "desert- like" relative humidities of only 5-10%.[10] Consequently, humidifiers are often used in the winter to increase the moisture content of the air indoors. This can improve comfort, be better for plants and furniture, and even make the air feel warmer because moisture will not evaporate from the skin as easily.

The windchill factor or windchill- equivalent temperature is an attempt to quantify how cold it feels by using windspeed and temperature. As stated earlier, wind assists in carrying away heat by forced convection. A stronger wind will carry more heat away from the body in the same amount of time and thus feel colder. If the temperature is 30°F and the windspeed is 30 mph, the windchill equivalent temperature is -2°F. This means that a person will lose heat at the same rate as when it's -2°F in still air. This does not mean that the skin temperature will drop to -2°F. The skin temperature can only drop as low as the air temperature, in this case 30°F. Remember, the body will lose heat at the same rate as when it's -2°F. It will feel that cold, but it will not be that cold. Just like the apparent temperature index has some problems, so does this index. It doesn't take into account any warming by solar radiation, local variations in wind speed, or a person's body size. It also does not account for varying levels of heat loss for different portions of the body. Nonetheless, it too is a useful approximation of how cold it feels.

Almost everyone has experienced a bad sunburn and understands the pain that can be involved. However, not everyone understands the detrimental effects of ultraviolet (UV) rays from the sun on humans. Just as visible light is made up of a variety of colors, UV light is also made up of more than one variety. There are three types or bands of UV rays: UVA, UVB, and UVC. UVC rays are the most energetic. They will kill living cells. Fortunately, these rays are filtered out by the ozone layer in the stratosphere and do not reach the earth's surface. UVB rays can also damage cells and are only partially filtered out by the ozone layer. These can be dangerous. Excessive UVB exposure causes sunburn and may lead to skin cancer. It can also cause damage to the lens of the eye. UVA rays are the least energetic, but still cause some level of damage. This form of radiation will accelerate the natural aging process. It damages the elastic fibers of the skin and makes it leathery, wrinkled, and spotted with irregular pigmentation (liver spots). These effects can occur prematurely, before the age of 30, with too much exposure. For a person who monitors their UV exposure, the effects are usually not seen until after 40 years of age.[11]

One reason people do not take protective measures against UV rays might be because many of the effects are long-term, occurring years down the road. Since many people put a higher priority on looking tan, they may simply ignore the potential problems and pay later.

As mentioned, UV rays can damage the lens of the eye. The lens focuses images onto the retina, which translates the images into signals to the brain. The retina is quite sensitive to UV rays. To protect it, the lens absorbs most of the harmful UVB rays. After years of exposure to UV, the lens properties may gradually change, creating a condition known as cataracts – cloudy regions that impair vision by scattering and absorbing light. UV rays may account for 20% of cataract problems.[12]

Nearly 90% of skin cancer is due to overexposure to UVB rays. With 800,000 new cases of skin cancer each year and one in seven people getting skin cancer some time during their life, it is essential that people understand the danger of UV exposure.[13]

The body has natural defenses to combat UV rays. The skin or epidermis is the largest organ in the body and provides this protection. At the skin surface is a layer of dead cells about as thick as a piece of paper. This layer is called the stratum corneum and exists to protect the tissue beneath it. This layer is continually being shed and replaced by the body. At the base of the epidermis, skin cells divide and continually produce new cells. Some of these cells start moving up to the surface and die on the way. These are referred to as squamous cells. They eventually reach the surface layer and become part of the stratum corneum. Although this layer is protective, it doesn't absorb all of the UV light. When UV light penetrates this layer it accelerates the division of cells. This produces a thicker, more protective layer of dead cells in the stratum corneum. These penetrating rays also stimulate special cells called melanocytes that produce a brown-blackish pigment called melanin (see Fig. 5). Melanin absorbs UV rays. This melanin moves into squamous cells, which soon become part of the stratum corneum. The skin then becomes “tan” because of the darker colored melanin in many of the cells. This provides the body with a natural sunscreen. It takes several days until the skin darkens from the UV rays, so a person is vulnerable to tissue damage and should be careful. Even with a good tan, some UV rays still penetrate the skin and can damage cellular DNA, the body’s genetic blueprints. The DNA pattern is then altered, or mutated. These mutated cells may lead to uncontrolled reproduction within the body. This is a disease process known as cancer. When it occurs in the skin, it’s skin cancer.

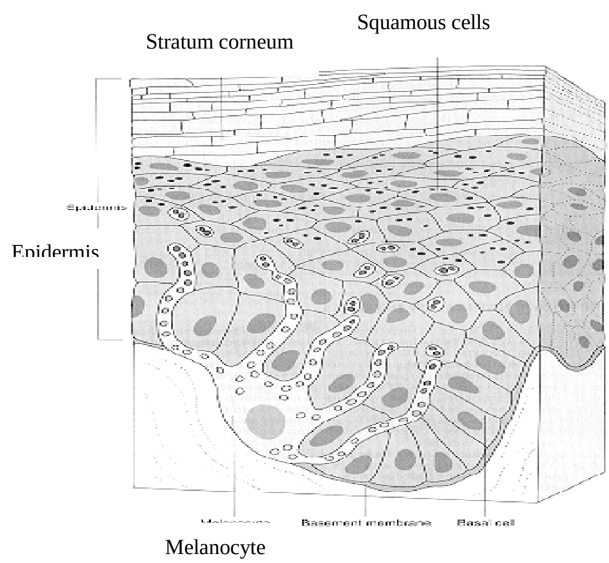

Fig. 5 The epidermis has several lines of natural defense against UV radiation. [from Morgan and Moran, *Weather and People*. Copyright 1997, Prentice-Hall Inc, Upper Saddle River NJ. p. 46]

The body’s last line of defense is to repair UV damaged DNA molecules. This is a very important step. If the body did not have a way to repair damaged cells, the damaged cites would build up over time. This repair process helps to continually repair damage. Research suggests that overexposure to UV radiation may overwhelm the ability of the DNA repair mechanism to fix the damage. This may be how cancer occurs. The damaged cites may become too numerous to control their growth and a tumor forms. In addition, the ability to repair damaged molecules appears to decline with age, so that skin cancer often forms later in life.[14]

Indices have been developed to help access the risk of exposure to UV rays. The UV-index predicts the relative risk of sunburn by forecasting the amount of UV radiation that should strike the Earth's surface. It is set up to gauge this risk for the time of greatest radiation, when the sun is highest in the sky. The index varies for people of different skin sensitivities.

As Morgan and Moran state in their book about weather, "Studies indicate that one or more severe sunburns greatly increases a person's chances of contracting skin cancer later in life. For instance, only one sever sunburn doubles a child's chances of developing basal cell or squamous cell carcinoma as an adult".[15]

A person can not live without being in the sun, nor would they want to, so protection from UV radiation is very important. The first tip is to limit exposure until a protective tan develops. The time of greatest risk for UV radiation is around June 22, the summer solstice, when days are longest. The problem is that the warm weather is barely beginning and people are just starting to develop their tans. This leaves them very vulnerable to damage. The second tip is to avoid exposure when rays are most intense, from 10am to 2pm. A good rule of thumb is the shadow rule. If your shadow is shorter than you, avoid the sun or apply sunscreen. If the shadow is taller than you, your risk is greatly reduced. "Short shadow? Seek shade!" [16] Remember that air temperature doesn't necessarily correlate to UV exposure. It may not be hot outside when the body is receiving the most damaging rays. Third, wear sunscreen, hats, protective clothing and UV rated glasses whenever possible during the times of intense radiation.

The amount of sunshine a person absorbs can play an important role in their well-being. Some people experience periods of depression, lack of energy, and sleepiness during mid-fall to spring. This appears to be directly related to the level of available sunshine due to shorter winter days. This ailment is known as SAD, seasonal affective disorder. Although this condition is not fully understood, it appears to be related to melatonin and serotonin hormones. Melatonin plays a role in our sleep/activity cycle. An increase in melatonin increases drowsiness. Darkness stimulates this hormone, so longer winter nights may very well contribute to this problem. Serotonin is a chemical messenger in the brain. It is also involved in the sleep/activity cycle and in moods. A decrease in serotonin levels causes a decrease in energy levels. Treatment for SAD includes phototherapy: exposure to additional light for 1-2 hrs a day. The treatment has been found to reduce the symptoms in 3-7 days in 50-70% of SAD patients.

Another way weather affects the body is through pressure changes. Air pressure has a definite effect on our ability to consume life-sustaining oxygen. According to the kinetic theory of gases. Air pressure is due to the many collisions of air molecules with an object. At sea level, gravity pulls all the air molecules close to the earth's surface, making the air more dense. As the altitude above sea level increases, the density of the air decreases. That is, there are less molecules of air for the same volume. This means that in one breath at a high altitude there will be less oxygen molecules than in a breath at sea level. At altitudes of 8,000 to 10,000 ft., the density of oxygen is about 40-45% that of sea level.[17] When the body does not get enough oxygen, problems develop such as acute mountain sickness or the more severe high altitude pulmonary edema. In general, a deficiency of oxygen in the blood is called hypoxia.

A cell liberates energy by combining oxygen with sugar in a process called cellular respiration. Cells need oxygen or they will die. The body monitors the oxygen level in the blood to ensure a sufficient supply. It actually does this most effectively by monitoring carbon dioxide levels. When those levels rise, the body compensates by increasing the rate and depth of breathing and increasing the heart rate and volume pumped. This gets more oxygen into the bloodstream and gets the oxygenated blood to the cells faster.

Symptoms of hypoxia typically effect the brain: headaches, nausea, and insomnia. Treatment involves getting more oxygen. This can simply be done by decreasing one's altitude, especially at night to sleep.

Everyone has experienced going up in elevation in the mountains or on a plain and felt their ears "pop". This is the body's method for equalizing outside pressure with the pressure in the middle ear. Air is continually pushing against the body. The body pushes back with an equal force.. The eardrum separates the outside ear from the middle ear chamber. It receives the compressional waves from sound as vibrations in the eardrum. If the outside pressure decreases and the pressure in the middle ear chamber does not, the eardrum is distorted; it bulges outward. This can be uncomfortable and causes the eardrum to vibrate incorrectly producing muffled sound. If the difference in pressure is great enough, the eardrum will rupture. The Eustachian tube compensates for this. This tube connects the middle ear chamber with the pharynx in the oral and nasal cavity. It is normally closed, but when the pressure difference between the outer and middle ear is great enough, it opens and equalizes the pressure. The eardrum then "pops" back to its normal shape. The same process happens when the outside pressure increases; only then the eardrum bulges inward. Yawning or swallowing will frequently help "pop" your ears.

Interestingly, people with arthritis have commonly been heard to say,"I feel a storm coming!" To study this, Dr. J. L. Hollander of the graduate Hospital of the University of Pennsylvania placed some volunteers with arthritis in isolated hospital rooms where the atmospheric conditions could be altered. Simulations of high- and low-pressure systems were done in the rooms. Whenever the pressure fell and humidity increased, like when a storm was approaching, the patients had pain in their joints. Upon examinations, swollen joints were evident. Although the mechanism is not well understood, pressure and humidity do affect joints.[18] Perhaps the joints somehow act like an aneroid barometer.

A similar phenomenon may be responsible for allowing some people to smell rain coming. The "smell" of rain during and after a rainstorm is probably caused by rainwater pushing gases out of the soil that have been created by certain bacteria. These gases have a certain odor. But the explanation for why rain can be smelled beforehand has had little research. Part of it may be that an increase in moisture and warmth and a decrease in pressure tend to cause plants to release more fragrance molecules. Scientists at the Smell and Taste Treatment and Research Foundation in Chicago have done studies on rapid pressure changes and smelling. They found that when some people experience a rapid pressure change like diving into a pool or going up in an airplane that they “report an olfactory window, where they haven’t been able to smell anything for years and they can suddenly smell again for a minute or two.”[19] Although it’s not well understood, it may be that changes in pressure and moisture allow some people to smell rain just before it occurs.

It seems that there is a lot more to weather and the body than we understand. Interesting enough, the actual date of your birth may have been determined by weather. The end of a pregnancy is uncertain to plus or minus 10 days of the due date. Records show that there are a statistically significant greater number of births during weather that is warm and moist with falling pressure than with other types of weather. There are also a greater number of heart attacks, bleeding ulcers, and migraines. Weather can also affect moods. If the number of suicides is used as one indicator of moods, they also occur more frequently during this type of weather.[20]

Weather is an all-encompassing factor in our lives. The body is in a constant exchange of energy with the environment. With all the diversity of weather that is faced, the body does an amazing job of regulating our internal temperature and body processes. Even so, weather dictates much of what we do and puts limits on what we can not do. It shapes our comfort, challenges our body regulation, and even molds our moods. Indeed, weather is an inseparable part of our lives.

[1] Michel D. Morgan and Joseph M. Moran, *Weather and People (Upper Saddle River: Prentice Hall, 1997) 5.*
[2] Morgan and Moran 5.
[3] Morgan and Moran 8.
[4] Morgan and Moran 9.
[5] Morgan and Moran 11.
[6] Rodney A. Rhoads and George A. Tanner, *Medical Physiology* (Boston: Little, Brown and Company, 1995) 589.
[7] Morgan and Moran 14.
[8] Morgan and Moran 14.
[9] G. Edgar Folk, Jr., *Environmental Physiology* (Iowa City: Lea and Febiger, 1974) 144-145.
[10] Morgan and Moran 34.
[11] Morgan and Moran 44.
[12] Morgan and Moran 45.
[13] Morgan and Moran 45.
[14] Morgan and Moran 47.
[15] Morgan and Moran 52.
[16] Morgan and Moran 53.
[17] Morgan and Moran 66.
[18] H. E. Landsberg, "Weather, Climate, and You" *Weatherwise Oct. 1986: 248.*
[19] Robert Henson, "Smells Like Rain" *Weatherwise*, Apr./May 1996: 29.
[20] Landsberg 248.