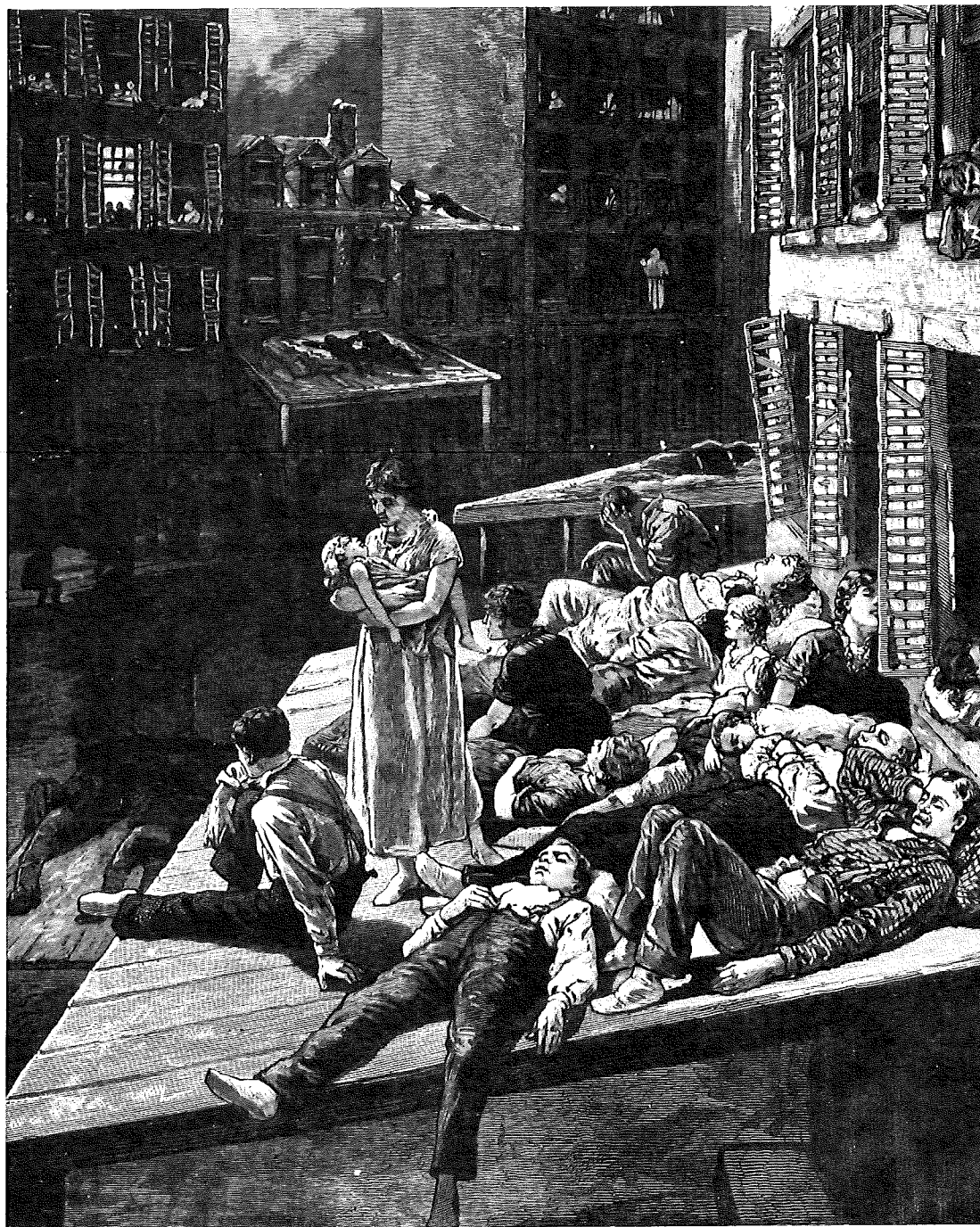


# HEAT STRESS



In the 40-year period from 1936 to 1975, nearly 20,000 people were killed in the United States by the effects of excessive heat (Posey, 1980). The overall effect of excessive heat on the body is known as heat stress. Important factors contributing to heat stress are: (1) air temperature; (2) humidity; (3) air movement; (4) radiant heat from incoming solar radiation (insolation), bright lights, stove, or other source; (5) atmospheric pressure; (6) physiological factors which vary among people; (7) physical activity; and (8) clothing.

Of the above factors, temperature and humidity can be controlled by air conditioning. Air movement may be controlled by fans; even a slight breeze is usually effective in reducing heat stress in hot, muggy, weather. However, at very high temperatures (above normal body temperature of about 98.6°F), winds above 10 miles per hour can increase heat stress in a shaded area by adding more heat to the body, whereas when the body is exposed to direct sunlight the effect of wind is nearly always to reduce heat stress. Radiant heating can be mitigated by shielding or by moving away from the source (for example, seeking shade). Atmospheric pressure is not usually a significant factor; however, at very high elevations, decreased pressure (and therefore decreased air supply) can contribute to heat exhaustion.

There are natural limits on how much physical conditioning can alter physiological heat responses. Two obvious physical necessities in reducing heat stress are: (1) getting enough fluids to replace perspiration loss, and (2) reducing physical activity during periods of extreme heat. The choice of clothing can be helpful since absorbent, light colored materials provide more comfort under hot, humid conditions.

Under normal conditions, temperature and humidity are the most important elements influencing com-

fort. Research by R.G. Steadman (1979) on "sultriness" assessment led to development of a special temperature-humidity index based on human physiology and clothing science. This index is called apparent temperature and is a measure of what hot weather "feels like" to the average person for various temperatures and relative humidities. Fig. 1 and Table 1 give apparent temperature versus actual air temperature and relative humidity.

As an example of how to read the graph in Fig. 1 or Table 1, an air temperature of 90°F, combined with a 60% relative humidity, feels like 100°F. The general assumptions are that the wind speed equals 5.6 miles per hour, pressure is normal sea level pressure (29.92 inches), and insolation (incoming solar radiation) is zero (i.e., shade). While interpretation of what a given apparent temperature feels like may vary from one person to another, the differences among various apparent temperatures are objective and based on physiological research. In areas of low relative humidity; i.e., 30% or less, the apparent temperature will be about the same as the air temperature or even lower.

Fig. 2 is a map of average midsummer (July) noon apparent temperatures for the contiguous U.S. Adjustment has been made for average wind speed and insolation in addition to relative humidity.

During periods of "heat waves," apparent temperatures may be about 15° to 20°F higher and can be as much as 30°F higher in unventilated city areas, thus approaching or exceeding heat stroke danger categories, which are listed in Figure 1.

Fig. 3 is a map of normal daily maximum temperatures for July without considering relative humidity, insolation or wind.

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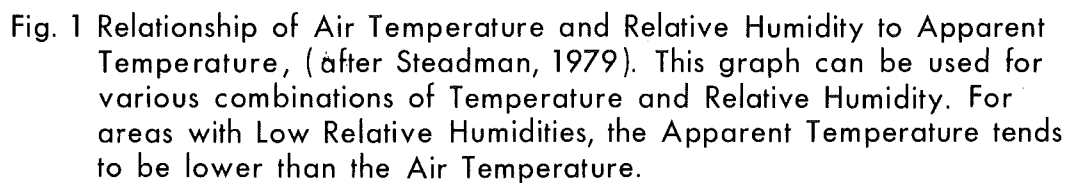
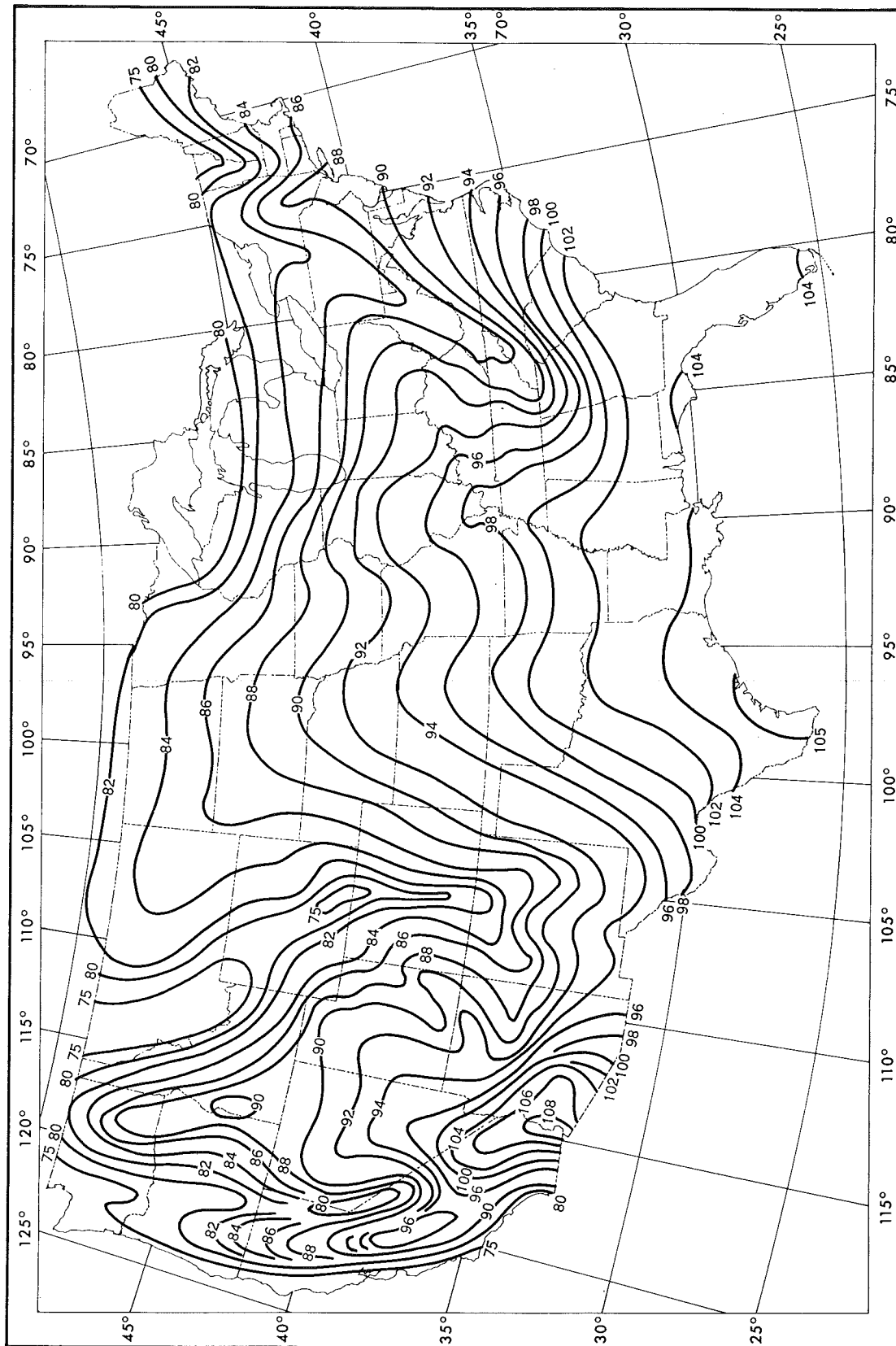
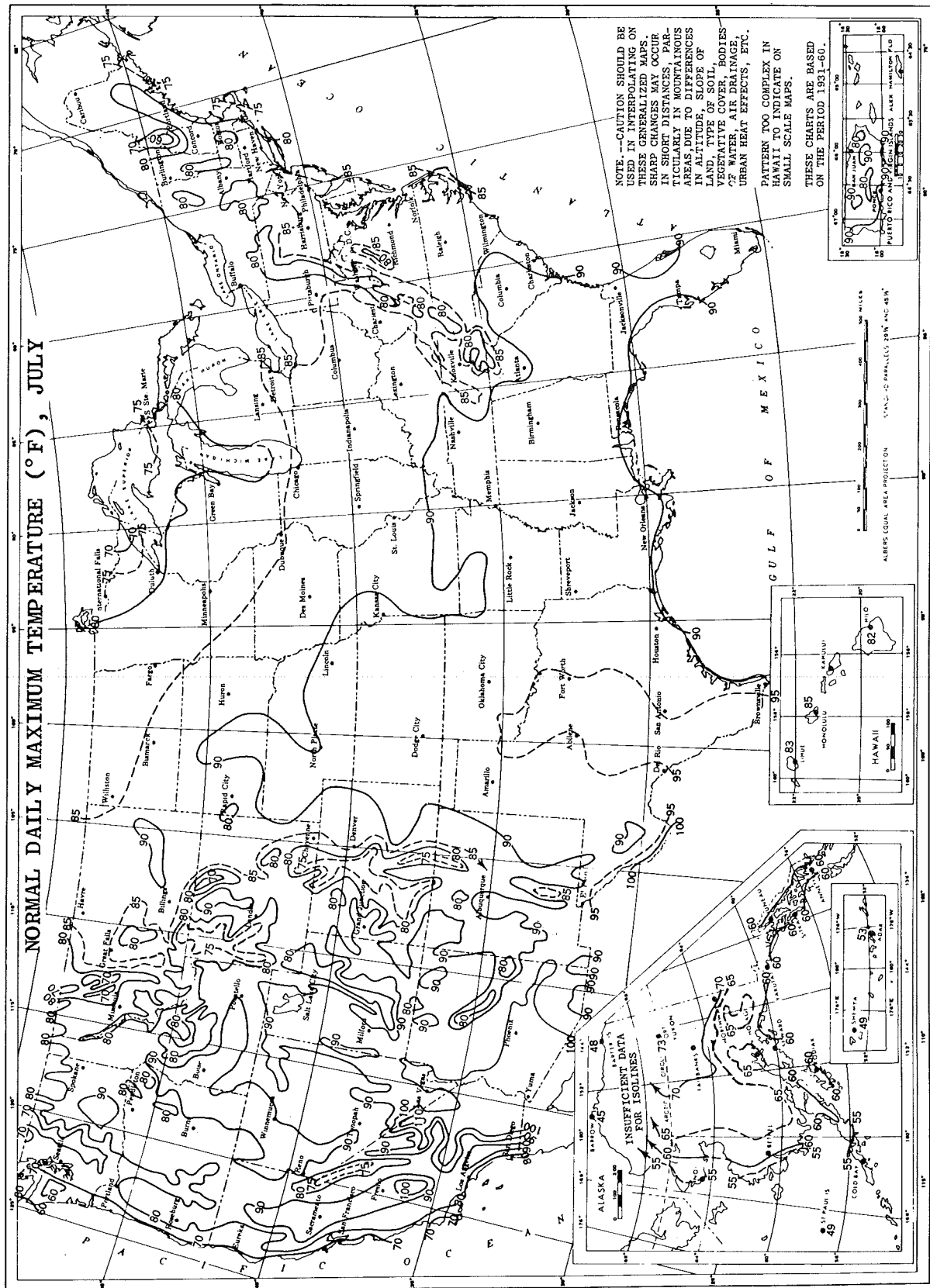


Table 1 Air Temperature and Relative Humidity versus Apparent Temperature. (As interpolated from Fig. 1).



**Fig. 2 Average Mid Summer (July) Noon Apparent Temperatures.**  
 (adjusted for Relative Humidity, Wind, and Insolation;  
 after Steadman (1979) with supplemental data added by NCC).



**Fig. 3 Normal daily maximum temperature (°F) for July.**

# Heat Wave Safety Rules

(FROM U.S. DEPARTMENT OF COMMERCE, 1969)

1. **Slow down.** Your body can't do its best in high temperatures and humidities, and might do its worst.

2. **Heed your body's early warnings** that heat syndrome is on the way. Reduce your level of activity immediately and get to a cooler environment.

3. **Dress for summer.** Lightweight, light-colored clothing reflects heat and sunlight, and helps your thermoregulatory system maintain normal body temperature.

4. **Put less fuel on your inner fires.** Foods (like proteins) that increase metabolic heat production also increase water loss.

5. **Don't dry out.** Heat wave weather can wring you out before you know it. Drink plenty of water while the hot spell lasts.

6. **Stay salty.** Unless you're on a salt-restricted diet, take an occasional salt tablet or some salt solution when you've worked up a sweat.

7. **Avoid thermal shock.** Acclimatize yourself gradually to warmer weather. Treat yourself extra gently for those first critical two or three hot days.

8. **Vary your thermal environment.** Physical stress increases with exposure time in heat wave weather. Try to get out of the heat for at least a few hours each day. If you can't do this at home, drop in on a cool store, restaurant, or theater—anything to keep your exposure time down.

9. **Don't get too much sun.** Sunburn makes the job of heat dissipation that much more difficult.

## 10. Know these heat syndrome symptoms and first aid:

Heat Syndrome	Caused by	Symptoms	First Aid
Heat asthenia (or calasthenia)	Excessively hot, humid environment.	Easy fatigue, headache, mental and physical inefficiency, poor appetite, insomnia, heavy sweating, high pulse rate, shallow breathing, and sometimes circulatory stress in the ill.	Respite from high heat and humidity, plenty of fluids, and, if sweating is heavy (and no dietary restrictions prevent it) a salt tablet and rest.
Heat cramps	Strenuous activity under conditions of high heat and humidity, when evaporative cooling is impaired, stimulating excessive sweating and loss of salts from blood and tissue, causing cramps.	Painful spasms of voluntary muscles, contraction in flexor muscles in fingers, then larger muscles in legs and abdominal wall. Pupils dilate with each spasm, there may be heavy sweating, skin becomes cold and clammy. Unlike severe abdominal disease symptoms, heat cramps are intermittent.	Usually respond better to firm pressure on cramping muscles than to vigorous kneading. Application of warm wet towels also gives relief. Three or four doses of salt solution (½ teaspoon dissolved in 4 fl. oz. water) administered at 15-minute intervals. Large quantities of water without salt may precipitate the disease.
Heat exhaustion	Prolonged hot spell, excessive exposure, physical exertion cause thermoregulatory breakdown involving loss of vasomotor (blood-vessel diameter) control and circulatory shock.	Profuse sweating, weakness, vertigo, and sometimes heat cramps; symptoms similar to calasthenia may herald by several days. Skin is cold and pale, clammy with sweat; pulse is thready and blood pressure is low. Body temperature is normal or sub-normal. Vomiting may occur. Unconsciousness is rare.	Move to cooler environment immediately. Provide bed rest, salt solution (see above); victims, sometimes nauseated at first, can usually take fluids after a period of rest. Seek medical help for severe heat exhaustion.
Heat stroke (or sunstroke, heat collapse, thermic fever, heat hyperexia)	Failure of thermoregulatory and cardiovascular systems brought about when intensive sweating under conditions of high heat and humidity restrict heat-dissipation by sweating, which finally ceases. Advanced age and hot, humid, windless environment are factors.	Weakness, vertigo, nausea, headache, heat cramps, mild heat exhaustion, excessive sweating. Sweating stops just before heat stroke. Then temperature rises sharply, often to 106° or more, pulse is bounding and full, blood pressure elevated. Delirium or coma is common. Armpit and groin areas are dry (they are wet in heat exhaustion). Skin is flushed and pink at first; however, in later stages, it appears ashen or purplish.	Heat stroke is a very serious emergency. Medical care is urgently needed. Move the victim into cooler, indoor environment, remove his clothing, put him to bed. Primary objective is to reduce body temperature, preferably by iced bath (or by sponging the body with alcohol or lukewarm water) until a tolerable level (about 103° or a pulse rate below 110 per minute) is reached. Caution is necessary here.
HEAT STROKE IS A SEVERE MEDICAL EMERGENCY. SUMMON A PHYSICIAN OR GET THE PATIENT TO A HOSPITAL IMMEDIATELY. DELAY CAN BE FATAL.			
Sunburn	Overexposure to ultraviolet radiation.	Redness and pain caused by dilation of small blood vessels in skin. In more severe cases, tissue injury brings swelling of skin, blisters, and often fever and headache. Because it impairs thermoregulatory efficiency, sunburn may be accompanied by other heat syndrome disorders.	Prevent severe sunburn by limiting the time of initial exposure, depending on comfort and conditions. Treat mild sunburn with cold cream or certain oils or greases (e.g., salad oil, shortening). Wash hands before applying. Do not apply butter or oleomargarine. Dressing should be used if blistering appears, injured area should not be exposed to sunlight until healed. Medical care is needed for extensive or severe cases.

## A NOTE TO COACHES

1. Advise candidates to do their summer conditioning out-of-doors.

2. Require a careful medical history and checkup prior to practice time.

3. Schedule workouts during cooler morning and evening hours.

4. Acclimate athletes to hot-weather activity on a carefully graduated schedule.

5. Provide rest periods of at least 15 minutes during workouts of an hour or more.

6. Furnish extra water and salt generously and regularly.

7. Supply light-colored, lightweight, permeable, loose clothing that helps body heat loss processes.

The use of rubberized apparel and other dehydration devices by players is extremely hazardous.

8. Watch athletes carefully for signs of trouble, especially interior linemen and the determined player who may not report discomfort.

9. Remember that temperature and humidity are critical factors, and keep tabs on them.

10. When intersectional play will take your team into hot, humid weather, get them thermally conditioned in pre-game practice, and make frequent substitutions during the game.

