**Mechanisms of Low- and High-Temperature**

**Injury to Plants**

The mechanisms by which high and low temperatures

injure plants are quite different. High temperatures

apparently inactivate certain enzyme systems and accelerate

others, thus leading to abnormal biochemical reactions

and cell death. High temperature may also cause

coagulation and denaturation of proteins, disruption

of cytoplasmic membranes, suffocation, and possibly

release of toxic products into the cell.

Low temperatures, however, injure plants primarily

by inducing ice formation between or within the cells.

The rather pure water of the intercellular spaces freezes

first and normally at about 0°C, whereas the water

within the cell contains dissolved substances that,

depending on their nature and concentration, depress

the freezing point of water several degrees. Furthermore,

when the intercellular water becomes ice, more vapor

(water) moves out of the cells and into the intercellular

spaces, where it also becomes ice. The reduced water

content of the cells depresses further the freezing point

of the intracellular water. This could continue, up to a

point, without damaging the cell, but below a certain

temperature ice crystals form within the cell, disrupt the

plasma membrane, and cause injury and death to the

cell.

Ice formation in supercooled water within leaves is

influenced greatly by the kinds and numbers of epiphytic

bacteria that may be present on the leaves. Certain

strains of some pathogenic (e.g., *Pseudomonas syringae*)

bacteria and of some saprophytic bacteria, when present

on or in the substomatal cavities of leaves, act as catalysts

for ice nucleation. By their presence alone, such ice

nucleation-active bacteria induce the supercooled water

around them and in the leaf cells to form crystals,

thereby causing frost injury to the leaves, blossoms, and

so on at temperatures considerably higher (-1°C) than

would have happened in the absence of such bacteria

(approximately -5 to -10°C).

The freezing point of water in cells varies with the

tissue and species of the plant; in some tissues of winterhardy

species of the north, ice probably never forms

within the cells regardless of how low the temperatures

become. Even when ice forms only in the intercellular

spaces, cells and tissues may be damaged either by the

inward pressure exerted by the ice crystals or by loss of

water from their protoplasm to the intercellular spaces.

This loss causes plasmolysis and dehydration of the protoplasm,

which may cause coagulation. The rapidity of

the temperature drop in a tissue is also important, as

this affects the amount of water remaining in a cell and,

therefore, the freezing point of the cell contents. Thus,

a rapid drop in temperature may result in intracellular

ice formation where a slow drop to the same low temperature

would not. The rate of thawing may have similarly

variable effects, as rapid thawing may flood the

area between the cell wall and the protoplast and may

cause tearing and disruption of the protoplast if the

latter is incapable of absorbing the water as fast as it

becomes available from the melting of ice in the intercellular

spaces.