solutions of these compounds at all, and may be said to be negatively chemotactic toward them.

In the former group (substances toward which the Paramecia show positive chemotaxis) belong all acids, and salts whose solutions have an acid reaction or contain hydrogen ions, as in salts of the heavy metals. In the group of substances toward which the Paramecia are negatively chemotactic belong all alkalies and substances having an alkaline reaction, as well as almost all compounds which contain ions of the alkali and earth alkali metals in their solutions. Certain substances take an intermediate place. Containing the ions of an alkali or earth alkali metal, they produce the motor reaction when the Paramecia enter a drop of fluid containing them; but having likewise hydrogen ions, they also cause the animals to react when they leave the drop. Examples of such substances are potassium and ammonium bichromate. In these cases the hydrogen ions seem to be active (in their characteristic way) in a more dilute solution, and, therefore, farther from the center of a diffusing drop than are the ions of the metals. The Paramecia, therefore, enter the outer margin of the drop and are unable to leave it, while at the same time they are unable to pass to the center of the drop. They thus gather in a ring about the drop, leaving the center empty.

The classification of substances into those toward which the Paramecia are positively chemotactic on the one hand and those toward which they are negatively chemotactic on the other, thus follows the lines of a chemical classification; the former including acids, the latter alkalies and salts of the alkali and earth alkali metals.

Experimentation showed that the relative injuriousness of solutions has comparatively little to do with the nature of the chemotaxis. Paramecia are repelled strongly by many substances that are scarcely injurious at all, while they enter without hesitation other substances in which they are at once killed. The repellent powers of different chemical compounds are in no way proportional to their injurious effects.

The researches on chemotaxis have thus far been restricted almost entirely to Paramecium, but the general laws obtained for this animal promise to throw much light on related phenomena in others.

As described above, positive and negative chemotaxis, or the collecting in or avoidance of certain chemicals, takes place through the mechanism of the general motor reaction first described. The only activity of the Paramecia concerned in it all is the swimming backward, turning toward the aboral side, then swimming forward, when stimulated. The qualitative differences that seem apparent in their reactions toward different substances depend merely upon what does and what does not act as a stimulus.

The mechanism of collecting in or avoiding agencies or conditions, other than chemical, is exactly the same as that just described. In the case of temperature, for example, certain grades of heat or cold produce motor reaction, so that the Paramecia do not enter these; or, if already within a zone of such temperature, they continue moving about violently till a chance movement carries them into a region where the temperature is not such as to cause a reaction; there they remain. In general, therefore, the Paramecia gather and remain in substances or conditions which do not cause the motor reaction, while they leave empty such substances or conditions as do cause their one motor reaction. It follows that they collect in regions of a certain temperature, avoiding great heat or cold, and that they collect in water holding in solution substances of an acid character, avoiding alkaline solutions. Under natural con-