water to outside through a permanent pore in the pellicle.

6.5 BEHAVIOUR

Paramecium responds to various stimuli. It moves towards a beneficial stimulus (**positive reaction**) and move away from a harmful stimulus (**negative reaction**). Thus, *Paramecium* is sensitive to touch, different concentrations of chemicals, oxygen and carbon dioxide levels, and changes in light intensity. It avoids too hot or too cold waters and also strong light. *Paramecium* shows positive response towards a weak electric charge and weak acidic environment (This is advantageous to *Paramecium* as a slightly acidic medium contains more bacteria).

Types of Taxes in *Paramecium*

Paramecium show the following responses to different stimuli (Fig. 6.16):

1. Thigmotaxis (= Reaction to contact). Response to contact is varied in *Paramecium*. ts anterior end is lightly touched with a fine point, a strong avoiding reaction occurs.

2. Chemotaxis (= Reaction to chemicals). Generally *Paramecium* responds to a chemic imuli by means of avoiding reaction. If a drop of weak salt solution (0.5 per cent) is introduc a *Paramecium* population on a microslide, the animals respond with the avoiding reaction a ne enters the drop. But for acid, the response of paramecia is positive.

3. Thermotaxis (= Reaction to temperature). *Paramecium* seeks an optimum temperat 24 to 28°C. Greater heat stimulates rapid movement and avoiding reaction.

4. Phototaxis (= Reaction of light). Except green *Paramecium bursaria* which is positi totactic, paramecia exhibit a negative phototactic reaction to bright light and to ultraviolet

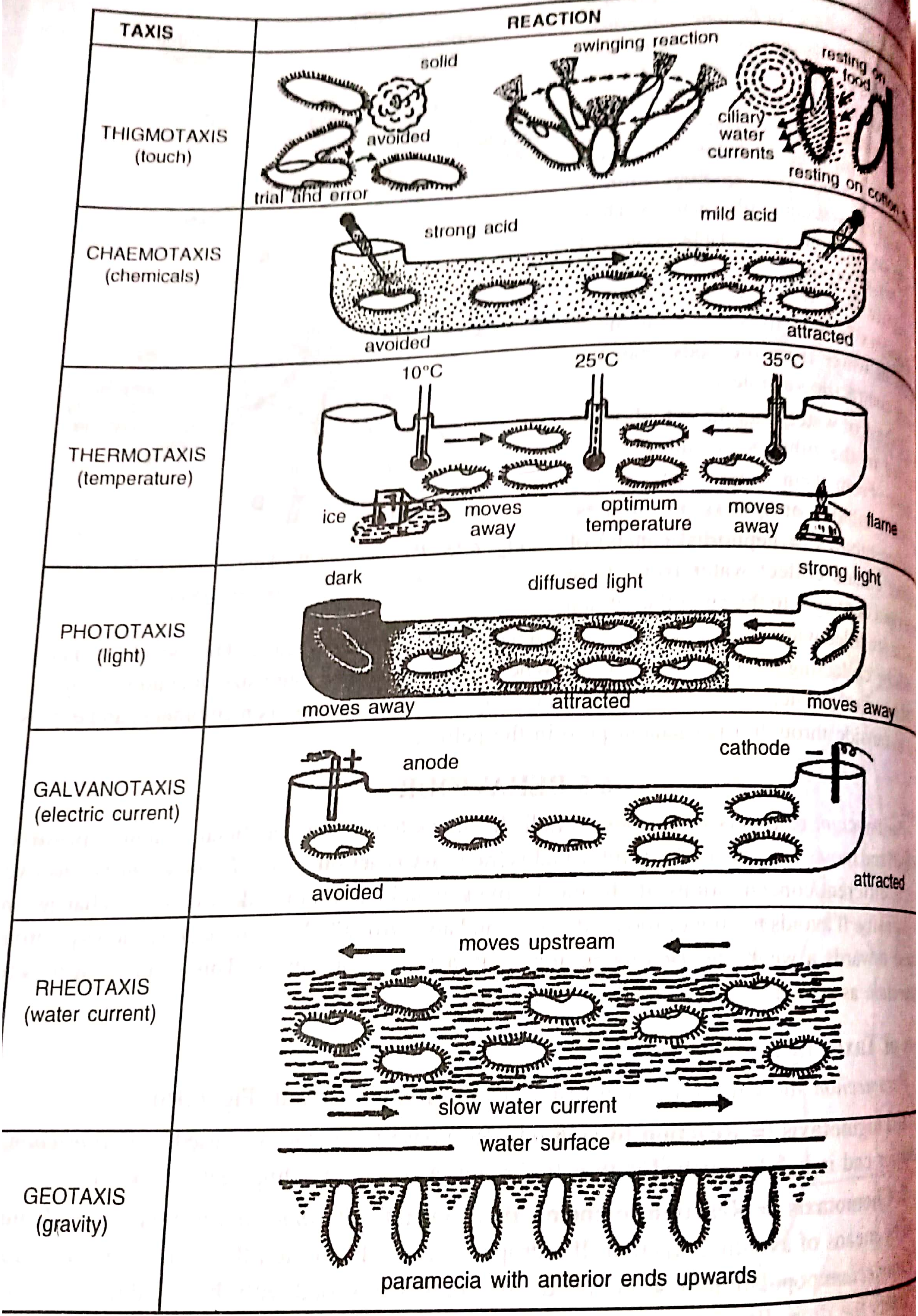

Fig. 6.16. Various taxes of *Paramecium.*

5. Galvanotaxis (= Reaction to electric current). Paramecia show positive response to negative electric pole, *i.e.*, they swim toward and concentrate at cathode (negative electrode).

6. Rheotaxis (= Reaction to water current). Paramecia show positive rheotaxis.

7. Geotaxis (= Reaction to gravity). Paramecia generally show a negative response to gravity. In a culture of *Paramecium*, many individuals gather close under the surface film with their anterior ends upper most.

Physiology of Stimuli Detection

Previously it was held that detection of external stimuli probably takes place through stiff, non-locomotory cilia at the caudal end of *Paramecium* (see **Green** *et al.*, 1990). Now it is believed that like animal receptors, *Paramecium* and other protozoans receive external stimuli as signal substances that bind to specific membrane molecules. Binding can cause a specific **ion channel** to open, allowing ions (often Na^+ and K^+) to flow down their concentration gradients (Na^+ in, K^+ out). Because the resting cell membrane is polarized with respect to the distribution of these ions opening of the ion channels depolarizes the membrane. When the membrane is depolarized, **Ca^{++} channels** open and calcium ions enter the cell. Entry of calcium into the cell triggers other changes such as, reversal of ciliary beat, which causes the *Paramecium* to withdraw from the disturbance

Paramecium has at least *nine* different ion channels, some of which are localized at the fro[nt] and others are at the rear of the cell. Such localized receptor fields differentiate "head" from "tai[l]" and are, thus, analogous to the concentration of receptor organs of many animals (**Ruppert** a[nd] **Barnes**, 1994).

Trial and Error Reaction

When a *Paramecium* comes in contact with an obstacle or harmful substance, it immediate[ly] reverses its ciliary beat (*i.e.*, power stroke is exerted in the opposite direction) and the ciliate swi[ms] backward and rotates, causing it to change orientation. *Paramecium* then switches beat direct[ion] again and swims forward. This process continues until the orientation of swimming causes the cili[ate] to miss the object and swim pass it (For physiology of this behaviour see Box 6.2).

Box 6.2. Physiology of trial and error behaviour of *Paramecium*

1. Contact of the *Paramecium* with an object causes a depolarization of the plasma membrane and subsequent opening of voltage-gated Ca^{2+} channels.
2. Inflow of calcium ions acts (in connection with calcium binding protein, **calmodulin**) on the axoneme to cause the reversal of the direction of the beat and the backward "retreat" of ciliate.
3. Closure of calcium gates causes a drop in Ca^{2+}-levels and a return to forward swimming.
4. The rate of forward movement is regulated by cyclic AMP (cAMP) levels. If the *Paramecium* should encounter a stimulatory agent, such as chemical attractant, **K^+ – channels** open and the plasma membrane becomes **hyperpolarized** which activates the enzyme, **adenyl cyclase**, that synthesizes **cAMP**.
5. The elevated cAMP level triggers the phosphorylation of certain axonemal protein (*e.g.*, dynein) causing an increased ciliary beat frequency and an acceleration of forward directed – swimming.