

The relation between ciliary and muscular movements.By **ALFRED G. MAYER.**

[*Performed at the Marine Laboratory of the Carnegie Institution at Tortugas, Florida.*]

It appears that in scyphomedusæ the nervous stimulus which produces each pulsation is caused by the constant formation of a uric oxalate of sodium in the marginal sense-clubs. This sodium oxalate precipitates the calcium which constantly enters the sense-club from the surrounding sea-water, and forms crystals of calcium oxalate, while sodium chloride is set free. Thus the stimulus which produces pulsation is due to ionic sodium. Pulsation cannot be maintained by the sense organs unless calcium constantly enters them to form the calcium oxalate, and to set free the ionic sodium.

I find that in annelids, barnacles (*Lepas*), ctenophores, and medusæ, the sodium of the sea-water is a strong neuro-muscular stimulant while the magnesium, calcium and potassium are inhibitors and exactly counterbalance the stimulating effect of the sodium, thus permitting weak internal stimuli to produce movements.

It is, however, remarkable that the effects of the ions, sodium, magnesium, potassium, and calcium, upon the movements of cilia of infusoria, vertebrate spermatozoa, marine larvæ and ctenophores is always the *exact opposite* of their effect upon the neuro-muscular system. Thus sodium is the most powerful stimulant for the neuro-muscular, and the most potent inhibitor for ciliary movement. Similarly considering the ions, magnesium, potassium, and calcium, among themselves, magnesium is most powerful in maintaining ciliary movement, but is the greatest depressant for the neuro-muscular system. Potassium in weak concentration at first stimulates but soon depresses neuro-muscular movements, while conversely it first depresses and then permits ciliary movement. In slightly stronger concentration it at once depresses neuro-muscular, and stimulates ciliary movement. Calcium depresses muscular, but permits of ciliary movement.

Thus in neuro-muscular movements the *stimulus* of sodium is offset by the depression of magnesium, potassium and calcium while in ciliary movement the *depressant effect* of sodium is offset by the stimulating influence of magnesium, potassium and calcium.

While there is wide diversity in the reactions of motile fungi and algæ to these ions, I have found a *Spirillum* living in fresh-water which reacts as do the cilia of animals.

It thus seems possible that the ciliary movements of animals may have been taken over from motile plant-like ancestors and maintained unchanged, whereas their neuro-muscular movements have been developed later, and are controlled by the ions of the blood salts in a manner the exact reverse of cilia.