In conclusion, I desire to pay a tribute to the teachers of anatomy whom I have been privileged to meet. As a body, their enthusiasm and energy for the advancement of knowledge and for the teaching of the students under their care is more striking than in any other body of teachers I have met.

ART. XXIV.—*A Note on Bacterial Symbiosis.* By J. CHARLES JOHNSON, M.A., M.Sc., Demonstrator in Biology, University College, Cork.

ALTHOUGH the action of two species of bacteria grown in the same culture medium is mutually antagonistic and destructive, symbiotic relations between bacteria and other fungi and among the various species of bacteria are well known. The question of how the symbionts interact is not quite clear. Ward holds the secretion of one bacterium may stimulate the other by containing "some body which acts as an exciting drug to the other." Food may be provided each for each, or one species may protect another from unfavourable influences, as in the case of an aërobe absorbing the surrounding oxygen so that an anaërobe can propagate. Winogradsky pointed out that the anaërobic *Clostridium pasteurianum*, if supplied with dextrose, can fix atmospheric nitrogen only when protected from oxygen by the presence of aërobic species. On the other hand, neither *Bacillus coli* nor *B. denitrificans* can reduce nitrates alone, but when both together act on a solution of sodium nitrate free nitrogen is evolved. In human infection by *B. tetani* many have shown that other bacteria or some foreign body must be present or the bacillus will not exercise its virulence. The rarity of tetanus, in spite of the fairly wide distribution of the causative micro-organism, is thus explained by the absence from wounds of auxiliary varieties. In this case the auxiliaries are believed to damage the tissues to such an extent that resistance of the latter to the multiplication of the tetanus bacillus is greatly weakened. A remark-

able example of symbiotic action is seen in the effects of growing *Bacillus chauvæi* and *Micrococcus acidi-paralactici* in a solution of cane-sugar. If the latter act alone optically active para-lactic acid is obtained, while *B. chauvæi* alone forms normal butyric acid, inactive lactic acid, carbon-dioxide and hydrogen. Acting together they produce large quantities of normal butyl alcohol.

Typical examples of symbioses between bacteria and higher fungi are observed in the "ginger-beer plant" and in "kephir." The former is composed essentially of a yeast (*Saccharomyces pyriiformis*) which co-operates with the *Bacillus vermiciformis*. Other yeast fungi, bacteria and other moulds were found in different specimens by Marshall Ward. The "kephir-grains" which produce the effervescent, alcoholic, sour-milk beverage of the Caucasus owe their fermentative properties to threads of rod-shaped bacteria, called *Dispora caucasica* by Kern, certain yeasts and moulds being invariably present. The brandies and saké obtained by oriental nations from the fermentation of rice are also due to symbiotic interactions. Among the many common-place but important phenomena due to bacterial symbioses may be mentioned the "rising" of bread. Peters says three yeasts and a *Mycoderma* are concerned in the fermentation of black bread—the former producing carbon-dioxide, the latter alcohol, fatty acids, and water. The volatisation of these and the expansion of air cause the "rising" of the dough. Lehmann considers that *Bacillus levans* predominates, but that the yeast present assists in the process. In certain cases yeast is the only active ferment of white bread.