attraction on the organism the reader is referred to his treatise, “Locomotorische Richtungsbewegungen durch chemische Reize,” in *Unters. aus dem bot. Inst. zu Tübingen,* i. Hft. 3, 1884.

*Fermentation and Butrefaction.—*The growth and development of a Schizomycete in any organic medium results in a breaking down of the complex food-materials into simpler bodies, which may then become oxidized and still further decomposed. Such processes are known as fermentation in the wider sense. The particular kind of fermentation depends on the medium and on the species of Schizomycete, and may be affected by other circum­stances ; as the process goes on volatile substances may escape and others remain behind. Where proteid substances are being decom­posed by Schizomycetes and evil-smelling gases escape, the fer­mentation is spoken of as putrefaction ; in certain cases, where intense oxidation follows and still further consumes the products of decomposition, the process has been termed eremocausis. In a few instances a process of reduction sets in, as when sulphur salts are decomposed by *Beggiatoa.* The theory of Fermentation (*q.v*.) cannot be treated in detail here, but it is important to note that side by side with the actions referred to another kind of action may go on. Many Schizomycetes excrete what are called “ soluble ferments,” which are capable of changing proteids into peptones, sugar into glucose, and so on. These processes of inversion, &c., result simply in an alteration of the proteid, &c., from the non- diffusible and non-assimilable condition to the diffusible and assimilable one, and are in no way destructive as are the fermenta­tions described above. Nevertheless it is the custom to speak of both as cases of fermentation ; the one series of changes renders the medium less and less capable of supporting life at every stage, the other series does not do so, yet the same name is frequently given to both kinds of action. It is a curious fact that the same Schizomycete may produce a different fermentation in each of two different media. The various fermentations are distinguished and valued according to the products which result ; these bye-products are usually injurious to the ferment organism as they accumulate, and often complicate the investigation.

Of important fermentations due to Schizomycetes may be men­tioned those concerned in the making of vinegar and cheese, in the preparation of flax, hemp, &c., in the souring and diseases of beer, wines, &c., the destruction of sugars, preserved food, &c. Others are of importance in the soil, and in the destruction of organic matter in ponds, rivers, drains, &c. In fact, much of the *raison d'être* of sanitary science may be referred here ; and it may turn out to be still more true than we now know that Schizomycetes are important in agriculture.

In pathology the changes due to these organisms are at length being duly recognized. Apart from the comparatively harmless actions of those forms normally existing in the alimentary canal— *Leptothrix* aids in the decay of teeth, &c.—it is now certain that some invasions are dangerous. The injurious effects of some Schizomycetes when introduced into open wounds, &c., against which the brilliant labours of Lister have been so successfully directed, are acknowledged everywhere ; but it is important to recognize that on the whole the diseases due to organisms in the blood depend fundamentally upon changes of the same category as those referred to. Of course the fluids of a living body present complicated conditions, and the action of a pathogenous Schizo­mycete cannot be treated and studied simply as a typical fermenta­tion; but, although the conditions presented are involved and special, it cannot be doubted that common principles lie at the base of all the phenomena, and that the fluids of the diseased organism must be treated, so to speak, as fermentable media.

Numerous other fermentations of scientific interest are due to Schizomycetes : *e.g.,* those in which colours are formed, certain cases of phosphorescence, the ammoniacal fermentation of urine, &c. @@1

Schizomycetes and Disease.—The presence of Schizomycetes in the blood, tissues, or organs of animals and man suffering from certain specific diseases is admitted, and has naturally suggested the question—Are they accompaniments only or have they any causal relations to the diseased conditions ? Their constancy in given cases excluded the former view. Next arose the discussion as to how the causal connexion comes about and in what it consists, a discussion which is still going on as to the details. The chief points now established may be expressed generally somewhat as follows.

In a given specific disease, due to the action of a definite Schizomycete, the latter may be conceived to be injurious in

several ways. If it robs the blood or tissues of oxygen or of any other valuable constituent, or if its activity results in the excre­tion of poisonous substances or in their formation as products of degradation of the matrix, or if it simply acts more or less as a mechanical obstruction or irritant,—in any of these cases harm may result to the delicately adjusted organism of the host. It being known that Schizomycetes act thus in nutrient pabula outside the body, their rapid growth and multiplication inside can of course only be explained as due to their success in the pabula there met with, and are indications that they produce changes there which must result in abnormality so far as the host is concerned. This does not end the matter, however. The living tissues of a healthy animal exert actions which are antagonistic to those of the parasitic invader ; and it is now generally admitted that the mere admission of a Schizomycete into an animal does not necessarily cause disease. Were it otherwise it is difficult to see how the higher organisms could escape at all. Schizomycetes abound all over, about and around us ; many, of course, are unable to live in the fluids of the body, but many are able to do so. Something must therefore be placed to the action of the tissues of the host, which when healthy can “ resist ” the attempts of a Schizomycete to settle, grow, and multiply with fatal effect. Much can undoubtedly be explained by this struggle for existence between the cells of the parasite and those of the healthy tissues invaded. But the higher organisms, again, present obstacles of other kinds to the lodgment of Schizo­mycetes : ciliary actions, active excretions, isolating processes of tissue-formation, &c., may be mentioned. Thus not every Schizo­mycete met with in the body can do harm.

But even when a Schizomycete has gained access to the blood­vessels, lymph-passages, &c., and has succeeded in establishing itself and multiplying, there are other facts to be taken into account before we dismiss the question as to its relations to disease. The rapidity of its growth may vary according to many circum­stances,—temperature, oxidation, &c.,—as well as the still partially obstructive action of the invaded organism ; whether the parasite excretes a poison, or simply robs the host, or distributes injurious agents of any kind, it is clear that everything which favours it aids in intensifying its action. And this may be local or general also according to complex circumstances. Of course sores, open wounds, &c., may render the access of a given Schizomycete very easy, and pave the way for its success in the tissues, &c., different strata of which may be exerting less and less resistance to its attacks. The study of this subject has led to the methods of modern surgery devised by Lister. It may be mentioned that Schizomycetes which produce bad effects on injured or dead tissues of wounds are not necessarily able to live in the healthyorganism, however deadly the poisonous products of their action may be when they succeed in establishing themselves.

All these and many other facts, then, point to the conclusion that the mere presence of a Schizomycete in an organ or tissue is not sufficient proof of its causal relation to disease, and lead us to the following requirements to be satisfied before any such relation can be admitted (Koch) :—(1) given a specific disease in which a definite Schizomycete is constantly detected, and with a constant disposition with respect to the tissues, organs, &c.,—this organism should be absent from animals free from the disease ; (2) the Schizomycete should be cultivated in nutrient media outside the body, kept pure for several “generations,” and obtained in some quantity by these means ; (3) inoculation of a small amount of this pure cultivation should reproduce the specific disease in a healthy animal ; (4) the same foreign elements as before should be clearly detected in the tissues of the now diseased subject, and in the same relations as before.

The satisfying of all these requirements is difficult, and the necessity of overcoming the difficulties has led to what may almost be termed a special branch of medical art. At the same time the majority of the principles which are here becoming recognized have long been known to biologists, and especially to botanists, and there are still numerous indications of a want of botanical training on the part of writers on these subjects. It is impossible here to even mention all the methods devised for staining, prepar­ing, and examining tissues, &c, and the Schizomycetes they contain, or for cultivating these minute organisms under constant conditions on sterilized potatoes, bread-paste, jelly, blood-serum, &c., or in animal infusions or fluids, &c. Some of the more important points in cultivation have already been referred to ; the litera­ture must be consulted for further details. @@2 (H. M. W.)

@@@1 Watson Cheyne, *Antiseptic Surgery,* 1882 ; Duclaux, *Chimie Biologique,* 1883; Fitz, “Ueber Schizomyceten-Gährungen,” various papers in *Ber. d. deutsch. chem. Gesellschaft,* 1876-1884; Lister, *Pharm. Jour.,* 1877; Nägeli, *Theorie der Gährung,* 1879 ; Wortmann, *Zeitschr. f. physiol. Chemie,* vi. ; Schützenberger, *Fermentation,* 1876 ; Musculus, “Ueber die Gährung des Harnstoffs,” in *Pflüger's Archiv,* xii. ; Pasteur, *Ann. de Chim. et Phys.,* 1858, and various papers in *Comptes Rendus,* also *Études sur la Bière,* 1876, and *Études sur le Vin,* 1866 ; Schlössing and Müntz, *Comptes Rendus,* lxxxiv., lxxxix. ; *Pasteur: his Life and Labours,* London, 1885; Schroeter in Cohn's *Beitr. zur Biol.,* Hft. 2, 1872; Van Tieghem, “Bacillus Amylobacter,” in *Comptes Rendus,* 1879.

@@@2 Only a few authorities can be mentioned here, for the literature on pathogen­ous Schizomycetes and methods is simply enormous; further references may be made to the works of Babes, Koch, Davaine, Pasteur, Chauveau, Bollinger, Fehleisen, Klein, Gaffky, Miller, Rosenbach, Oertel, Obermeyer, Burdon- Sanderson, Toussaint, Waldeyer, Watson Cheyne, Dreschfeld, and many others. Flügge, “ Ferment und Mikroparasiten,” in Ziemssen’s *Handbuch der Hygiene,* Leipsic, 1883; Magnin, *Les Bacteries,* Paris, 1878; Klein, *Micro-organisms and Disease,* 1884 ; Woodhead and Hare, *Pathological Mycology,* 1885. Valuable papers are also to be found in the following periodicals :—*Brit. Med. Jour., Trans, of the Pathol. Soc., Virchow's Archiv, Archiv f. exp. Pathol., Centralbl. f. d. med. Wiss., Bull. de l'Acad. de Med., Deutsche med. Wochenschrift, The Lancet, Quart. Jour. of Micr. Sc.,* and others.