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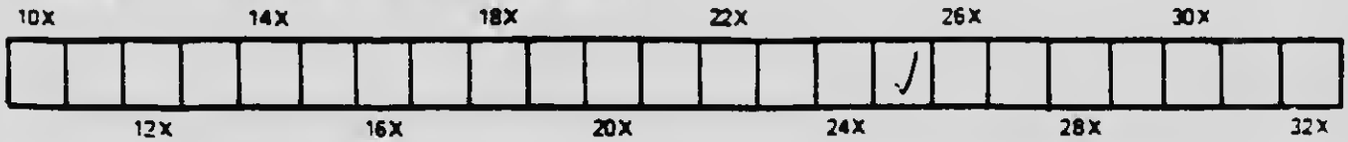

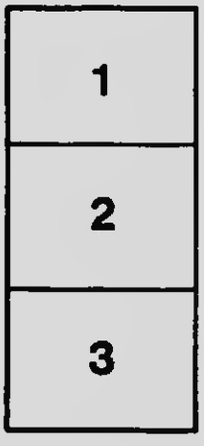

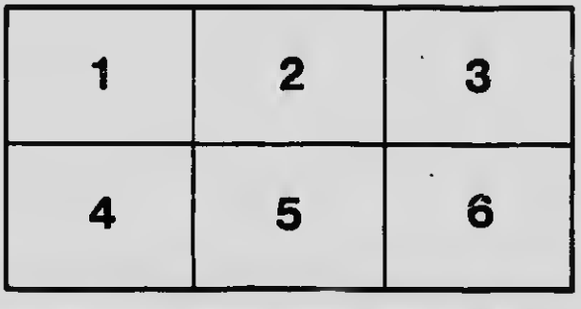

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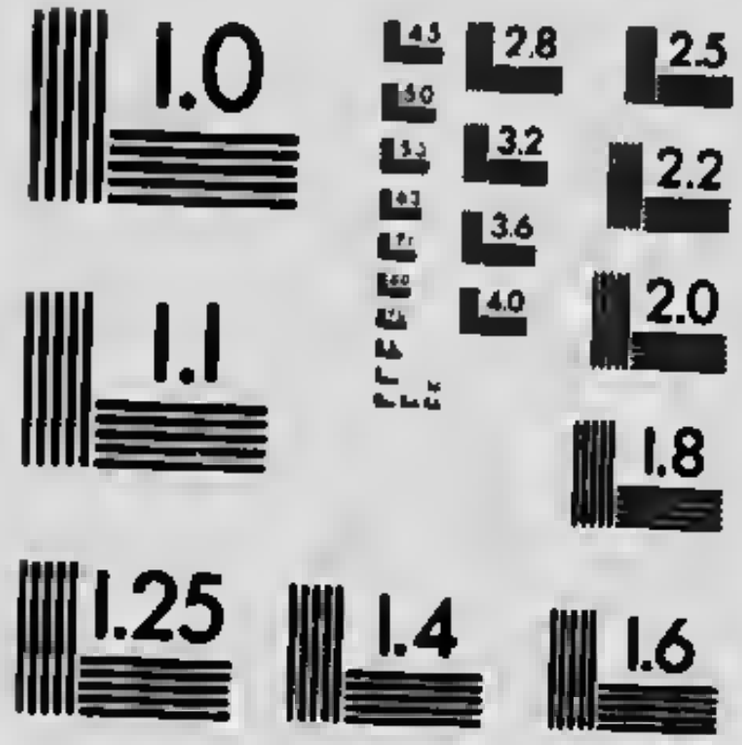

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STUDIES FROM THE ROYAL VICTORIA HOSPITAL, MONTREAL. VOL. I. NO. 5. (PATHOLOGY. II.)

THE CLASSIFICATION AND DISTRIBUTION OF THE INTESTINAL BACTERIA IN MAN.

BY

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MARCH, 1903.

PRINTED BY
J. A. CARVETH & CO., LIMITED,
MEDICAL BOOK PUBLISHERS,
TORONTO, CANADA.

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INTRODUCTION.

THE practical portion of the work reported in this paper was carried out while the author held the Governor's Fellowship in Pathology, McGill University, Montreal. For the material he is indebted to Dr. J. G. Adami, Pathologist to the Royal Victoria Hospital, and to the late Dr. Wyatt Johnston, Pathologist to the Montreal General Hospital, who permitted the most liberal use of the autopsies performed at these hospitals.

Owing to the rebuilding of the Pathological Laboratory of McGill University and to the consequent lack of space for laboratory work at that time, the authorities of the Royal Victoria Hospital extended to him the facilities of their Pathological Laboratory, and it was there that the actual investigation—the preparation, isolation and study of the cultures—was conducted.

The analysis of the notes, the review of the literature, and the writing of the paper were completed during the tenure of a Fellowship in the Rockefeller Institute for Medical Research, and in this way both the Rockefeller Institute and

McGill University have contributed means for the investigation.

A preliminary report of the main results has already appeared in the Journal of Medical Research.

The entire work was performed under the immediate supervision of Professor Adami, for whose unfailing help and constant advice the author would hereby express his most heartfelt gratitude. He is also deeply indebted to Professor W. H. Welch, of the Johns Hopkins University, and to Dr. C. W. Stiles, Pathologist of the Bureau of Animal Industry, who have given most valuable suggestions in regard to the proper nomenclature of the various species. He also would express his indebtedness to the governors of the Royal Victoria Hospital for affording him the opportunity to carry on this work, and to publish it in its present form.

HISTORICAL RESUMÉ.

The earliest observations on the bacteriology of the intestinal tract were made by Bienstock (1884) who, isolated four different microorganisms from human faeces and considered them the most important, if not the only bacteria, to be found in the alimentary canal. Subsequent experience has not confirmed Bienstock's conclusions, either in regard to the paucity of the micro-organisms found in the dejecta, or in regard to the identity of the bacteria which he has described.

To Escherich (1886) belongs the credit of having first established *Bacillus coli** as the principal inhabitant of the lower, and *Bacterium aerogenes*, of the upper bowel in man, although he found various staphylococci and streptococci in the same locations.

Since Escherich's fundamental work numerous investigators have busied themselves with the study of the intestinal flora, in the attempt to classify the different varieties

* Throughout this paper I have followed Migula's classification and nomenclature, except where manifest errors are noticeable in the names employed by him, when slight changes have been introduced. Thus the correct name for the organism described by Petruschky as *Bacillus faecalis alcaligenes*, is, *Bacillus alcaligenes*, Migula 1900, and not *Bacillus alcaligenes* (Petruschky) Migula.

The name *Bacillus faecalis alcaligenes* is a trinomial and does not hold in botanical nomenclature, and a previous author's name is only used when the specific name is retained the species being transferred

of bacteria which may under diverse conditions be found in the contents of the alimentary tract. Gessner (1889) made an especial examination of the duodenum from which he isolated seven different organisms including *Bacillus coli*, *Bacterium aerogenes*, *Micrococcus pyogenes*, *Streptococcus pyogenes*, and two species of sporebearing bacilli.

Gillespie (1893)cultivated twenty-four different organisms from the contents of the stomach ranging in their character from *Bacillus coli* and *Bacterium aerogenes* to *Saccharomyces cerevisiae* and *Pink Torula*, and embracing *Bacillus vulgaris*, *Pseudomonas aeruginosa* (Bacillus pyocyaneus), *Micrococcus candicans* and a large number of sporebearing bacteria.

In the same year Gilbert and Lion (1893) made a bacteriological study of fifteen normal stools, finding not only several forms related to *Bacillus coli* but occasional representatives of the *alkali-producing bacilli*, the so-called "Intermediate" or Hog-cholera group.

During the following year Dallemagne (1894) reported his observations on the stomach, small and large intestine of twenty cadavers; his elaborate tables give incomplete descriptions of a large number of intestinal bacteria, including many of the forms which had already been reported.

From the surgical standpoint Macfadyen, Nencki and Sieber, (1891), on the one hand, and Ciechomski and Jakowski (1894) on the other, have utilized cases of abdominal fistulæ where a favorable opportunity was presented of examining the discharges from the small intestine. The former isolated six varieties of bacilli and a streptococcus from the ileo-cæcal region, while the latter found besides *Pseudomonas aeruginosa* and *Bacillus liquefaciens ilei* of Macfadyen, a number of streptococci and diplococci in the upper portions of the ileum.

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to another genus. In such cases the name of the earlier writer is placed in parenthesis with the year in which the correct specific name was given, followed by the name of the author who gave the correct generic title, and the date when it was given—as in the case of—

Bacillus vulgaris (Hauser 1886), Migula 1900.

That is to say, Hauser in 1886 denominated this form *Proteus vulgaris*, Migula in 1900 transferred the Proteus forms to the group Bacilli.

I have also found Chester's Manual of Determinative Bacteriology of the greatest value and assistance in the identification of species.

Parallel with these observations on man, Dyer and Keith (1893) cultivated *Bacillus equi* from the intestinal contents of horses, an organism similar in its cultural features to *Bacillus coli* of Escherich, and Lembke (1896) in an exhaustive experimental study of the stools of dogs, investigated the changes produced in their bacterial contents by variations in diet; in the progress of his work he examined eighty-one cases and separated the main types of bacteria present in canine dejecta. A year later Kern (1897) published an elaborate monograph dealing with the bacteria of the stomach and duodenum of birds, the first definite contribution to our knowledge of the avian intestine.

On this continent important facts have been brought out by the researches of Booker (1889) on the alvine discharges of patients suffering with cholera infantum, and by Sternberg (1892) who has isolated and described the most constant of the many varieties of bacilli which he found in the intestinal contents of yellow fever cadavers. The most recent and comprehensive study of the subject comes from Cushing and Livingood (1900), who not only demonstrated the possibility of producing, in animals and man, an amicrobic condition of the stomach and duodenum, for surgical purposes, but also made use of exceptional opportunities of examining *during life* the intestinal contents of patients brought to operation for gunshot lesions of the abdominal cavity. In addition to a number of varieties of *Bacillus coli*, Cushing and Livingood obtained almost constantly, members of the Hog-cholera group.

Supplementing these various attempts to establish a definite flora for the different regions of the alimentary canal, there have been numerous observations on special bacteria, or groups of bacteria, which may be encountered with some degree of frequency in the intestinal contents. Thus Gartner (1889) has reported that *Bacillus enteritidis* may be found, very rarely it is true, in normal stools, while Petruschky (1896) has repeatedly isolated from typhoid and from normal dejecta *Bacillus alcaligenes*. The *Bacterium Welchi*, Migula (1900), —or, as it is more commonly known, *Bacillus aerogenes capsulatus*, responsible for many morbid conditions in man, has been shown by Welch (1900) to be almost invariably present in the alimentary canal.

Coincident with this amplification of our knowledge of the number and diversity of the bacteria which may

be isolated from the intestines, the cultural reactions by which the different species may be separated have been greatly increased within the past two decades. Of special interest and value are the observations with the "fermentation tube" introduced and applied by Theobald Smith (1895) to the study of *Bacillus coli* and *Bacillus cloacæ*, and the Durham modification of this appliance, utilized by Durham (1900) for the classification of the members of the Hog-cholera, or, as Durham calls it, the "Intermediate" or Gärtner Group. With the help of carbohydrate solutions Smith has given us a positive means of identifying the two main groups of *Bacillus coli*, one fermenting three sugars—dextrose, saccharose and lactose— the other fermenting but two—dextrose and lactose; while Durham has further pointed out the fact that the organism which leaves saccharose unaffected is the bacillus originally described by Escherich.

From this short historical summary, it may be seen that considerable contradictions are noticeable in the results of the different systematic investigations of the intestines, and that a necessity has arisen for a more thorough study of this subject by the use of larger numbers of bacteriological reactions, and the employment of a broader technique. But the number of new methods which have been introduced is so great, however, while every new reaction, in the hands of its discoverer, seems to be so important and far-reaching in its application, as to render a systematic study of the many species of micro-organisms which may be derived from the alimentary tract, well-nigh hopeless.

As a necessary preliminary to further routine species work, some reliable investigation of the exact value to be ascribed to the various bacteriological reactions was imperative. This necessity was met by Fuller and Johnson (1900) when they published their classical paper on Water Bacteria, embodying the results of a long study of forty-two different species, by means of nearly all the cultural reactions now in use, and giving most comprehensive data of the constancy with which these reactions occur.

Stimulated by the publication of Fuller and Johnson's results, the writer has endeavoured to apply the principles which they have laid down to the study of the bacteria of the

intestine and, working along similar lines, to classify the principal species which may be encountered in the different regions of the bowel. A synopsis of his results, so far as they concerned the non-pigmented, non-sporebearing 'alkali-producers' and 'acid-producers' respectively, was contributed by him to the first meeting of the Association of American Pathologists and Bacteriologists in 1901.

THE MATERIAL UTILISED

Material for this work was obtained from autopsies at the Royal Victoria and at the Montreal General Hospitals, including ten foundlings from the Montreal Foundling and Baby Hospital. The autopsies were selected regardless of the morbid conditions present, those cases being employed in which the post-mortem examinations were conducted within a few hours after death. The results thus only approximately represent living conditions, inasmuch as a considerable post-mortem development of the bacteria present in the stomach and intestines must be admitted. From the *qualitative* standpoint, however, such observations may be considered reliable, as the changes occurring during the few hours immediately after death, involve a development of the different microorganisms present during life rather than an invasion by new forms.

Immediately after the abdominal cavity was opened, different portions of the bowel were carefully lifted to the surface, a short incision made in the intestinal wall, a sterile cotton swab introduced and a small portion of the slimy material lining the mucous membrane removed for bacteriological examination. In this way material was collected from the stomach, upper portion of the duodenum, lower portion of the ileum close to the ileo-caecal valve, and the sigmoid flexure of the rectum.

In twenty-five cases cultures were immediately made on agar, the mixed growths resulting being plated the following day. In another twenty-five cases the intestinal material was transferred directly to neutral broth, which was thoroughly shaken for fifteen to twenty minutes to disintegrate the mass of mucus and to separate the bacteria. The broth emulsions were then utilized for the preparation of agar plates. In all cases the colonies were examined with a low-power lens and

the different colonies, even those presenting only minor variations in appearance, were transferred to agar. The cultures resulting were examined after twenty-four hours' growth and if suspicion of their purity arose, they were again plated and fresh colonies were picked out.

In rare instances the cultures were plated repeatedly before their purity could be assured, such is the tenacity with which microorganisms cling to each other when freshly removed from the intestinal contents.

The pure cultures isolated from the bowel by this method were now subjected to the *preliminary cultivation*, shown by Fuller and Johnson to be necessary before bacteria assume their normal characteristics and exhibit surely the cultural reactions for their species. Their activity was heightened by cultivation on agar and in broth for three days each in the incubator, and in gelatine plates for three days at the temperature of the room. After this procedure they were transferred to agar again, from which, after the conventional three days, the various cultural media were sceded.

THE MEDIA EMPLOYED.

The media employed were of the composition proposed by the 1897 Report of the Bacteriological Committee of the American Public Health Association, and consisted of Agar-Agar, Neutral Broth, Gelatine, Potato, Blood Serum, Litmus Milk, Potassium Nitrate Broth and Sugar Broths, made up from one per cent. solutions of Dextrose, Saccharose and Lactose.

The meat infusion from which the broth was made was first inoculated with fresh fluid cultures of *Bacillus coli* to destroy by fermentation the muscle sugar and the occasional traces of glucose. The stock was then filtered and sterilized in the usual way. From the stock the ordinary broth tubes were filled and the carbohydrate solutions prepared by the addition of the requisite amounts of the three sugars employed.

The Dextrose was sterilized for ten minutes in the autoclave at a temperature of 115° and a pressure of one atmosphere, the Saccharose and Lactose for fifteen minutes in streaming steam for three consecutive days. The integrity of the Dextrose is maintained at the temperature and pressure mentioned, while the use of steam will not ordinarily cause the reduction of Saccharose and Lactose to mono

saccharids. In all cases the carbohydrate solutions were tested with known microorganisms before being employed to demonstrate the usability of the sugars.

Considerable browning of the medium results whatever method of sterilization be used, and this browning, while not always an index of the destruction of the carbohydrates, is often suggestive of it. It is possibly due to some combination between the meat extracts and the sugars, for watery solutions of the sugars alone do not change colour from sterilization.

I have, moreover, repeatedly seen very dark solutions of Saccharose and Lactose respond readily and quickly to the fermentative action of bacteria which affect these sugars alone.

For the sake of accuracy, however, all lots of sugar broth which showed any marked change in colour or which failed to give a gaseous fermentation within forty-eight hours, were discarded.

ON THE ESTIMATION AND VALUE OF REACTIONS.

After the routine inoculation of the different culture media the tubes were examined at the end of the first, second, fourth and tenth days, during which time the majority of cultural reactions appear and after which conclusions are notoriously uncertain. An exception must be made in the case of the liquefaction of the proteids which may appear after a much later interval. On this account the tubes containing gelatine, milk and blood serum were preserved for three weeks and a positive diagnosis established then.

The actual occurrence of the different phenomena was deemed of far greater importance than the time in which they appeared or the manner in which they developed, only those reactions which had been shown by Fuller and Johnston to be constant in their appearance and unvarying in their nature being deemed worthy of careful scrutiny.

Inasmuch as the conclusions reached in these pages depend upon the use of only a small number of cultural media and the identity of the different species was established from a limited series of reactions, it is fitting to briefly consider the manner in which these reactions were utilized and the value which was ascribed to each.

Morphology.—Despite minor variations in the appearance of stained preparations, non-sporebearing, non-pigment-producing bacilli closely resemble each other when seen under the microscope. Thus, while the morphology of *Bacillus coli* is usually distinct from that of *Bacillus vulgaris*, yet

cultures are constantly seen in which the elements are not characteristic, or in which the morphology speaks for one species and the cultural reactions decide for another. Moreover great latitude exists in the appearances furnished by the same microorganisms under different conditions of growth. The confusion which arises in estimating this character is considerably diminished when the bacteria are examined unstained just at the edge of a hanging drop, where a slight drying of the fluid suspension occurs and the organisms are deposited in a single layer on the coverslip. In this location the long, thin bacilli of the Proteus group can easily be differentiated from the shorter, thicker elements of *Bacillus coli.*

Certain species possess characteristic morphological appearances however, and to them considerable value attaches. Thus the individuals of *Bacterium aerogenes* are always thick and stumpy, the capsule surrounding each element contributing to this formation, while *Bacterium liquefaciens* of Eisenberg closely resembles *Bacterium aerogenes* in morphology although the bacteria are always considerably longer. The large sporebearing bacteria can be identified in part by their morphology, while very minute bacilli can always be differentiated from the more numerous intestinal forms by this feature alone. For these latter, unstained preparations are positively essential, as the contraction and shrinkage incident to the heating and staining, cause them to look almost exactly like micrococci.

Size.—The size of the different organisms was estimated in micromillimeters by a Bausch & Lomb eye piece attached to an oil immersion lens, and twenty-four hour agar cultures were always employed.

The length is subject to the greatest variations, while the diameter is fairly constant in different cultures of the same species; to the diameter must therefore be attributed the greater differential value.

Motility.—Young cultures on agar or in broth, twelve to eighteen hours old, examined in neutral solutions, offered supposedly the best means for a diagnosis of motility. It was soon learned, however, that these should be supplemented by an examination of old cultures, where active motility may be observed, when young growths show only sluggish or merely vibratory movements. Possibly during the greater interval of time, longer and more vigorous flagella develop, or possibly the changes in the reaction of the medium occasioned by the

development of the bacilli, permit the manifestation of a greater activity. As a routine measure, all cultures marked "non-motile" after eighteen hours' growth were subsequently examined in older preparations.

Agar-Agar. Relatively little information can be gained from the appearances of cultures on slant agar, as the different species of intestinal bacteria develop on this medium in much the same way. Certain organisms like the "proteus" spread widely over the surface and slope to the bottom of the tube, while rare species of very minute bacilli grow almost imperceptibly. The formation of deep colonies is likewise of little importance. The surface colonies, however, are apt to be characteristic for each species, and are sometimes so peculiar as to enable the separation of closely allied forms. The colonies of sporebearing bacteria are especially of diagnostic value.

Broth.—Variations in the cloudiness, the heaviness of the precipitate and the extent of the surface growth occur in different specimens of broth inoculated with the same organism, thus lowering the differential value of this medium. The actual production of a dense surface pellicle as distinguished from a scum easily dislodged and settling to the bottom of the tube, and the production of a turbidity in comparison with the clearness left by organisms enjoying only a superficial development, may both be employed, however, for species descriptions.

Potato.—Numerous ineffectual attempts were made to obtain potato of such a constant composition that reliable observations could be made with it. Its variability is so great that conclusions from its use are apt to be of little importance. The characteristic dirty yellowish-brown growth produced by *Bacillus coli* and the dark reddish growth of the Petruschky Bacillus, when actually seen are very convincing, yet with the same culture other potatoes show little or no definite formations. It is of greatest value in the identification of *Bacillus vulgatus* and other sporebearing bacteria.

Nutrient Gelatine.—This medium is of the greatest importance in the identification of microorganisms and the classification of species. Liquefaction itself is one of the most constant of bacteriological reactions, whether it occurs on the third or fourth day, as with the Proteus Group, or on the eighth or tenth as with *Bacillus cloacæ*. The [illegible]nation of colonies is more regular and constant than on agar, as Fuller and Johnston have pointed out, and from their study reliable conclusions can always be drawn and sometimes positive diagnoses established.

Blood Serum.—Ordinary bacteria grow on blood serum in much the same manner as on agar, and the consideration of this medium as of positive value in species differentiation is dependent upon the capacity of certain microorganisms to cause its complete liquefaction. This liquefaction occurs later than that of gelatine with which it is invariably

associated, and with all liquefying species the tubes must be observed for a considerable time before negative conclusions can be drawn.

Fermentation Tube: Dextrose Broth.—The use of this appliance and the phenomena observable in it have not only increased our knowledge of fermenting microorganisms, but have given us certain group reactions which may be applied to all species. Three groups of bacteria may be distinguished. In the first group are the organisms which are quite incapable of attacking the carbohydrates, their growth being limited to the bulb of the fermentation tube where it extends as far as the neck only, the broth in the closed arm remaining perfectly clear. The reaction in the bulb is usually *alkaline*. The second group includes the bacteria which ferment the carbohydrates, with the production of acidity but no gas, the growth extending not only in the bulb but throughout the entire arm. The reaction in the arm is always *acid*, and in the bulb either *acid or alkaline*. In the last division may be placed those species which show a *gaseous fermentation* of the sugars, coincident with an *acid production*, the gas collecting in the closed arm and the broth everywhere becoming turbid.

Saccharose and Lactose Broth.—While the reactions with the other carbohydrates are generally supplementary to those obtained with Dextrose, the capacity of fermenting one sugar being accompanied by a similar capacity for others, the use of Dextrose, Saccharose and Lactose together gives us far more information of diagnostic value than the employment of Dextrose alone. Provided the sterilization of the double sugars be conducted with the necessary precautions there is every reason to believe that different micro-organisms will possess peculiar affinities for each sugar. A species which exhibits at one time an ability to ferment Saccharose, for instance, will always possess that property when brought to its highest point of activity by preliminary cultivation. We are thus able to divide the "coli" group into two sub-divisions, by observing the action of the different cultures on Saccharose, as Theobald Smith has already pointed out. This diversity of action on Saccharose expresses a general rule in intestinal bacteria, for members of the Hog-cholera, Proteus and Cloacae groups may be judged by the same criterion.

The action of bacteria on Lactose is more uniformly associated with a splitting of Dextrose than is the fermenta-

tion of Saccharose, and only in rare instances are the more complicated sugars broken up when the simpler remains intact. That such an action can occur, however, is demonstrated by *Bacterium havaniense* of Sternberg, which ferments Saccharose with the production of acidity and gas, although producing no acid whatever when grown in Dextrose and Lactose solutions; and by *Bacillus arachnoideus*, a sporebearing bacillus whose cultural features are similar to those of *Bacillus subtilis*, but which ferments Saccharose alone with the production of acidity and the evolution of a few bubbles of gas. In like manner *Bacterium galactophilum*, an anomalous member of the Hog-cholera group, ferments Saccharose and Lactose to the exclusion of Dextrose which is not even fermented to the point of acidity.*

Litmus Milk.—This medium furnishes not only valuable and accurate data for the identification of particular species of micro-organisms, but **a broad criterion by which all the non-sporebearing bacilli may be divided into two great groups, the acid- and the alkali-producers.**

In the division of **acid-producers,** of which *Bacillus coli* is the type, the acidification of the milk follows immediately upon the inoculation of the tubes, and after a shorter or longer interval the casein is coagulated. This coagulation may occur within the first forty-eight hours, or it may be delayed for some days. In organisms of this type the casein remains as a dense, firm mass.

Other acidifying bacteria, of which *B. illus cloacæ* is the type, enjoy a further action on the casein which is slowly but completely dissolved and the litmus reduced.

In the division of **alkali-producers,** three main subdivisions may be outlined. To the first subdivision belong the organisms of which the Petruschky Bacillus is the main representative, which, failing to act on either the lactose or the traces of glucose in the milk, produce within the first twenty-four hours a pronounced alkalinity which steadily

* No attempt has been made to estimate the percentage composition of the gases evolved from the various carbohydrates, although their ratio to each other may be definite and unchanging. A very sure diagnosis of the species to which different bacteria belong, may be obtained without recourse to this procedure, which, as Durham has pointed out, must be carried out under careful regulation of the temperature and the pressure at which the gases are evolved; moreover, it is highly probable that different organisms can split up dextrose with the production of the same gas formulæ.

increases from day to day. In the second subdivision are included bacilli which, like the Shiga Bacillus, split up the dextrose in the milk to the point of an initial acidity, but whose alkali-production is sufficient to subsequently neutralize the acidity and cause an alkaline reaction. In both these divisions the alkali-production may be so great as to saponify the proteids in the milk and simulate a peptonization of the casein, or rather the caseinogen. Neutralization with weak acid shows the casein completely intact. In the third subdivision are found organisms, which, like *Proteus vulgaris*, produce an initial acidity and a subsequent alkalinity, but which further peptonise the caseinogen and completely reduce the litmus; with such cultures neutralization of the alkali reveals only a thin, ropy fluid.

Production of Nitrites.—Tested in the nitrate broth culture by means of naphthylamine and sulphanilic acid. Few species of intestinal bacteria fail to give this reaction, no matter how carefully it be carried out and its value in species differentiation is correspondingly diminished.

Indol.—This substance, while usually produced by cultures of *Bacillus coli*, and other intestinal bacteria, is completely lacking at times with positive indol-producing organisms, and its differential value cannot be considered very great. It was found repeatedly with cultures of *Bacterium aerogenes*, ordinarily supposed not to produce it, even when such cultures were isolated from the stomach and duodenum.

Fæcal Odor.—This is more noticeable in cultures freshly grown from the intestinal contents than with any particular species. It occurs indiscrimately with bacteria of the stomach or of the rectum.

THE MICROORGANISMS ISOLATED.

Nearly seven hundred cultures were obtained from the fifty autopsies studied, each organism being brought to its highest activity by preliminary cultivation, after which its cultural reactions were estimated by the methods already indicated. Eliminating minor cultural peculiarities and a few anomalous reactions due clearly to deficiencies in the culture media, these seven hundred organisms were found to belong to practically 50 (fifty) distinct species of bacteria. While it is possible that a number of other species may exist at times in the intestinal contents, the results here described being obtained from but one series of cases, it seems probable both from the actual number of microorganisms studied and from the constancy with which the different species were en-

countered, that the most common forms of intestinal bacteria were cultivated.

Of the seven hundred organisms found, two hundred were typical *Bacillus coli*, if one includes here the forms distinguished by the action of the species on saccharose. Durham pointed out that the organism originally described by Escherich does not ferment this carbohydrate, and has suggested the name *Bacillus coli communior* for the species breaking up saccharose as well as dextrose and lactose. The name *Bacillus communior*, more strictly in accord with botanical nomenclature, may be substituted for this latter species, leaving the name *Bacillus coli* (Migula 1900) for the true organism of Escherich.

In this way nearly two hundred other cultures were typical *Bacterium aërogenes*, the more numerous organisms fermenting dextrose, saccharose and lactose alike and representing the main type of this species. For this form the name *Bacterium aërogenes* (Migula 1900) may be reserved, and for another organism of the same group breaking up only dextrose and lactose, I would suggest the name *Bacterium duodenale*, this indicating its favorite location in the intestinal tract.

The above four species, namely, *Bacillus coli*, *Bacillus communior*, *Bacterium aërogenes* and *Bacterium duodenale*, are the most frequently encountered and the most widely distributed of all the intestinal bacteria, and at one time or another may occupy every region of the bowel.

Two other well known forms, *Bacillus vulgaris* and *Bacillus cloacæ*, have already been reported present in the intestinal contents, and in point of frequency they stand next to the above-mentioned species. The *Bacillus vulgaris* of Hauser ferments dextrose and saccharose but not lactose, and the typical form is but rarely seen in the intestinal contents. The more common representative of this group differs from the "Proteus vulgaris" only by its fermentation of lactose its colony formation, its alkali production and its peptonizing action on the proteids being identical with these properties of the organism of Hauser. For the latter species the name *Bacillus plebeius* may be employed, while for a third species fermenting dextrose and lactose but not saccharose and identical with *Bacillus vulgaris* in other respects, the name *Bacillus infrequens* is suggested.

The more commonly isolated cultures of *Bacillus cloacæ* ferment dextrose, saccharose and lactose alike, although another species, not splitting up saccharose, was also found. For the latter the name *Bacillus subcloacæ* may be utilized.

Closely related to the "Cloacæ group," and indeed to be classed with it, is an organism with the same properties of liquefaction and milk coagulation, but which is distinguished by its morphology, its colony formation and by its failure to ferment lactose, while fermenting dextrose and saccharose. This organism originally cultivated from the small intestine may appropriately be known as *Bacillus ileacus*.

Two other organisms, *Bacillus alcaligenes* of Petruschky and *Bacterium liquefaciens* of Eisenberg, were cultivated in a considerable proportion of cases, their cultural reactions agreeing with those given for these species by their discoverers. In two instances organisms were isolated which correspond in cultural features to *Bacillus enteritidis* of Gärtner, and broadly represent the group of "Paracolons" of Widal and Gwynn, *Bacillus O*, of Cushing, *Bacillus icteroides* of Sanarelli and the various "Paratyphoids" of Schottmüller.

While minor differences in morphology and in cultural appearances enable the separation of these organisms from each other, a separation made more pronounced by their serum-reactions, nevertheless the properties of the different organisms are so much alike as to show that all may be included in one group. This group has long been recognized in America by Welch, Salmon and Smith, as the *Hog-cholera* group, or *Suipestifer* group, from its pathogenic representative, the *Bacillus of Hog-cholera*. The same group has recently been called the "*Enteritidis*," or *Gärtner* group, by Durham in England, from *Bacillus enteritidis* of Gärtner, that member of it which is chiefly pathogenic for man. Organisms belonging to this group are normal inhabitants of the human intestinal tract, and from the lack of further and more accurate means of distinguishing the various members of the group, the facts of priority may be considered of decisive value; the group may therefore best be known as the Hog-cholera group, and its intestinal representative in man, as *Bacillus enteritidis* of Gärtner.

In addition to these organisms which have for long been known to occupy the intestinal canal, several species of

bacteria were found, which either resemble certain well-recognized species in their cultural reactions, but are clearly differentiated by important features, or which belong to certain groups of intestinal bacteria, other members of which have already been reported. In many cases a lack of adequate description of the species, rendering positive identification practically impossible, has made new nomenclature and more extensive description necessary. I would here emphasize that new species have been created only when absolutely essential, old names being retained whenever the cultural characters of the organisms isolated could be correlated with those of previously described species. In all cases well-defined groups of intestinal bacteria could be made out, including both the new and the old forms.

The most numerous organisms in the first category are bacilli, which, in their cultural reactions, are identical with *Bacillus dysenteriæ** shown by Shiga (1898), to be the cause of epidemic dysentery in Japan, since confirmed by the observations of Kruse (1900) for Germany, by Flexner (1900) for the Philippine Islands, and by Vedder and Duval (1902) for the United States. The organisms in the group here referred to are nevertheless clearly distinguished from *Bacillus dysenteriæ* by the *failure to react with the blood serum* of patients sick with dysentery. Kruse (1901) has already pointed out the existence of this group of bacilli in the intestines, in his study of the cases of "Pseudodysenterie" in whose dejecta he found organisms differentiated from the Shiga Bacillus only by their failure to agglutinate. To the organisms of this type Müller (1902) has given the name *Bacillus pseudodysentericus*, a name which must therefore be employed for all those organisms having the morphological and cultural features of *Bacillus dysenteriæ*, but which fail to give characteristic serum-reactions.

NOTE.—* For this organism the name bestowed by Migula in 1900, that of *Bacillus japanicus* is clearly incorrect. To the organism described by Ogata in 1892, as the cause of epidemic dysentery, Kruse (1896) gave the name *Bacillus dysenteriæ liquefaciens*, a trinomial whose use is not permissible; subsequently Migula (1900) gave to it the name *Bacillus dysenteriæ* (Kruse) Migula. But the name *Bacillus dysenteriæ* had already been utilized two years previously by Shiga, who in 1898 definitely gave it to the species which he found in epidemic dysentery. It follows, therefore, that [illegible] species described by Shiga the name *Bacillus dysenteriæ*, Shiga (189[illegible] retained, the name *Bacillus japanicus*, Migula (1900) be discarded, and [illegible] species described by Ogata, some new name must be substituted for the una[illegible] trinomial suggested by Kruse.

Closely related to *Bacillus enteritidis*, and to be included in the Hog-cholera group, are three alkali-producing, non-liquefying microorganisms, which differ from the Bacillus of Gärtner, solely in their different capacities of breaking up the carbohydrates. One of these ferments dextrose, saccharose and lactose alike, and is fairly frequent in the contents of the bowel. To it the name *Bacillus alcalescens* may be given, applying to the closely related species not fermenting saccharose, the name *Bacillus subalcalescens*. A third species was found which also belongs to this group, but which differs markedly in morphology, motility and colony formation. From its alkali-production and non-coagulation of milk, and from its fermentation of saccharose and lactose, it must be classed with *Bacillus enteritidis*. For it the name *Bacterium galactophilum*, proposed by Dr. Welch, may be employed.

We may next consider a number of microorganisms which resemble the Proteus group in certain reactions but which can be accurately differentiated from this group by other properties. The formation of colonies on agar and gelatine is somewhat similar, the colonies, however, being distinguished by their failure to spread over the surface of the medium. The liquefying powers are exerted on gelatine alone, both casein and blood serum remaining unaffected. These bacilli are active fermenters, one species breaking up dextrose, saccharose and lactose, the other dextrose and lactose. For these alkali-producers the name *Bacillus enterigens* and *Bacillus subenterigens* may be utilized.

In like manner two species of microorganisms were cultivated, usually from the stomach, which, from their acidification and coagulation of milk, their fermentation of the carbohydrates and their liquefaction of gelatine, are allied to *Bacillus cloacæ*, but which, however, do not peptonize casein nor liquefy blood serum. For these two species the name *Bacillus gastricus* and *Bacillus subgastricus* may be adopted, thus pointing out that region of the intestine in which they are more frequently present. They are readily separated from *Bacterium liquefaciens* of Eisenberg, to which their cultural features are closely similar.

In addition to these species, which represent the most

common forms of intestinal bacteria, a number of organisms were cultivated which occur but rarely, but whose group reactions point to the intestinal contents as their habitat in ordinary. From their scarcity they can hardly be regarded as of any great importance in the economy of the bowel. Representatives of each group have already been described by Sternberg, Booker and others, and with the organisms which they have reported may be grouped the forms which have been encountered during this study.

Among them is found *Bacillus A.* of Booker, for which the name *Bacillus Bookeri* is more fitting, an organism producing alkali, liquefying gelatine, casein and blood serum, but not fermenting any carbohydrate solution to the point of gas production or acidity.

Three species similar to *Bacillus Bookeri* in alkali-production and non-fermentation, but differing in their capacity to peptonize the proteids, were isolated at different times. Each of them possessed definite cultural peculiarities and to them the names, *Bacillus pylori*, *Bacillus caci* and *Bacillus recti*, were given, suggesting those portions of the intestine from which the organisms were cultivated.

Bienstock's original investigations of the faeces disclosed the presence of certain acid-producing, non-liquefying, non-fermenting microorganisms, which form a distinct group in the intestines. The minute *Bacterium Bienstockii*, was obtained but once, but an analogous organism, *Bacterium oxygenes*, differing much in morphology and slightly in cultural features, was found in several cases. Somewhat in the same way *Bacterium minutissimum* of Kruse and *Bacterium acidoformans* of Sternberg, were cultivated in rare cases, the more general representative of this group being an organism which differed considerably in cultural features from the species mentioned, but which must be classed with it because of its non-liquefaction, its acidification and coagulation of milk and its fermentation of the carbohydrates with the production of acid but no gas. To this species the name *Bacillus oxyphilus* was given.

Finally an additional group of bacteria was made out, which may be separated from previous species by its acidifi-

cation and coagulation of milk, its liquefaction of various proteids and its fermentation of the carbohydrates with the production of acid alone, thus differing from *Bacillus cloacæ*. The members of this group already known are *Bacillus leporis*, originally found by Gibier, and later by Sternberg in autopsies on yellow fever patients, and *Bacillus dubius* of Kruse isolated from faeces by Bleisch. Three other representatives of this group liquefying different proteids, but agreeing in other particulars were occasionally encountered, and to them the name *Bacillus chylogenes*, *Bacterium chymogenes* and *Bacillus jejunalis* were severally applied.

Beyond these species of microorganisms the bacteria cultivated could in all cases be identified with well-known spore-bearing or pigment-producing species whose habitat is the air, the soil, or water. The only exception to this was the isolation in one instance of *Bacterium havaniense*, an organism producing a carmine-red pigment which Sternberg originally found in the intestines of yellow fever cadavers. *Pseudomonas aëruginosa* (commonly known as *Bacillus pyocyaneus*) was repeatedly grown, and *Pseudomonas ovalis* of Ravenel and *Bacterium lutescens* of Migula were each cultivated but once.

Ten different species of sporebearing bacteria were found, but their cultural features pointed so positively to their identification as extra-corporeal microorganisms that they could not be considered peculiar to the intestinal contents, but rather transitory inhabitants of it.

The *Staphylococcus albus* and *Staphylococcus aureus* were present in a number of individuals, but no evidence was present to show that they were not the ordinary species. The *Streptococcus* was rarely found and it is highly probable that its slow-growing colonies were either overlooked or crowded out by the hardier species. Their presence in the intestine has been attested by numerous observations.*

*No attempt was made to cultivate *anaerobically* any of the many organisms growing exclusively in the absence of oxygen, although their frequency and importance in the intestinal tract are well known. It was, however, quite beyond the scope of this work to consider any species of bacteria requiring special methods of isolation and cultivation, and hence this very large and important division was left for future investigation.

SPECIES DIFFERENTIATION AND CLASSIFICATION.

From this brief consideration of the species of bacteria cultivated from the intestine, the great diversity of its flora is at once apparent. In attempting to make a systematic classification of the various forms, however, it may be well to first examine the main principles which guide one in arranging groups of microorganisms by purely artificial arbitrary characters. The points involved are in no way better brought out than by a short study of *Bacillus pseudodysentericus*, the proper classification of which introduces one of the most interesting and important problems in bacteriology, whose solution will depend largely upon the value which is assigned by different observers to different cultural reactions.

I have placed these organisms in the same group with *Bacillus dysenteriæ* because their morphology and moderate motility are identical with that of several cultures of the Shiga Bacillus which I have examined (properties which indeed are common to many intestinal bacilli) and because of their cultural reactions. Thus a colourless, glistening, non-spreading, or slightly spreading growth is produced on agar; a white, or slightly yellowish growth on potato and blood serum. On gelatine the growth extends along the line of puncture, very slightly on the surface. There is no liquefaction of either gelatine or blood serum. In broth an abundant turbidity and sediment are produced without surface pellicle or scum, nitrates are reduced to nitrites, a trace of indol occasionally produced, but no fæcal odor. Characteristic reactions occur with the fermentation tube and litmus milk. In the fermentation tube, filled with dextrose broth, an abundant turbidity and a heavy sediment are produced in the bulb, a profuse growth rapidly extending throughout the closed arm. The reaction in both bulb and branch becomes acid but no gas is produced. In litmus milk an initial acidity is produced, followed within a short time (48 to 72 hours) by an alkali production which rapidly overcomes the acidity and renders the litmus deep blue. Coagulation of the milk at no time ensues. Neutralization of the alkali shows that the casein is undissolved. *All of these reactions are identical with the corresponding reactions of Bacillus dysenteriæ.*

The colony formation of *Bacillus pseudodysentericus* differs somewhat from that of *Bacillus dysenteriæ*, although considerable variations are seen in this respect with both species. The agar and gelatine colonies of *Bacillus pseudodysentericus* are usually round and regular with clean-cut circular margins, resembling those produced by *Bacillus typhosus*. Occasionally the colonies spread slightly with crumpled or faintly striated edges. It never produces "proteus-like" colonies. While the variation in the size of the colonies may be considerable, the circumscribed clean-cut colonies are typical of the species. Transfers from the spreading colonies will always later throw down colonies of characteristic formation.

Similar variations in the appearance of the colonies of *Bacillus dysenteriæ* have also been noted. Thus Shiga (1898) describes the colonies of his bacillus as small, round, finely granular and yellow. Flexner (1900) calls them "typhoid-like." Kruse (1901) speaks of them as "spreading, leaf-like, typhoid-like," and finally Vedder and Duval (1902) state that the colonies of the organisms which they have isolated more closely resemble those of *Bacillus coli*, from which they are distinguished with difficulty, than they do the organism of Eberth.

Lastly, *Bacillus pseudodysentericus* is distinctly pathogenic. Dr. Cantlie, working with it at the Royal Victoria Hospital, found that 1.00 to 2.00 ccm. doses of a 24 hour fluid culture constantly killed mice, guineapigs and rabbits, the animals dying in 1-4 days from a general infection, the typical organisms being recovered from the peritoneal cavity and from the internal organs. The cultural reactions of those recovered organisms were identical with those of the bacillus injected.

In contradistinction to these cultural and pathogenic characters, *Bacillus pseudodysentericus fails to agglutinate* with blood serum of patients suffering from dysentery, which blood serum gives a positive reaction with *Bacillus dysenteriæ*.* *The two species are thus positively differential.* From their cultural features, however, it is apparent that the organisms must be classed in the same group.

* I am indebted to Professor Flexner of Philadelphia for a study of the serum reactions of this organism.

This group is distinguished from the other alkali producers by a number of reactions, and occupies a definite place in classification. From *Bacillus alcaligenes* of Petruschky, on the one hand, it may be distinguished by its heavy sediment in broth with absence of scum, by its abundant growth in the closed arm of the fermentation tube and its coincident acid production in dextrose broth; by its initial acidity in litmus milk followed by a moderate alkali-production, and by its failure to produce a red growth on either potato or blood serum. The Petruschky bacillus produces a heavy scum in broth and also a sediment, an alkaline reaction in the fermentation tube, with a growth limited to the bulb, an immediate alkali production in litmus milk without initial acidity and a red growth on potato and blood serum.

This organism is separated from the various members of the Hog-cholera group, on the other hand, by its acid production only in solutions of dextrose or other carbohydrates, gas being at no time evolved. The members of the Hog-cholera group invariably ferment some one of the carbohydrates to the point of gas and acidity. It is, of course, easily differentiated from the Proteus group by its failure to liquefy gelatine casein and blood serum.

The existence of several species of bacteria belonging to the same group of organisms, possessing similar cultural features yet separated from each other by their serum-reactions or more specifically by the agglutinins which each organism produces in an artificially immunised animal, has already been emphasized by Cushing (1900) in his study of the Hog-cholera group of bacilli, and by McCrae (1900-01) in his investigations of the agglutinating properties of the same group. It has been shown by these men that *culturally* a number of different members of this group may be found in *Bacillus enteritidis*, Gärtner, in *Bacillus Variety Hatton* of Durham, the "*Paracolons*" of Widal and Gwynn,* and *Bacillus O.* of Cushing. With these organisms must be included *Bacillus icteroides* of Sanarelli, falsely assumed by him to be the cause of yellow fever.

* The name "paracolon" is distinctly a misnomer for these organisms which are in no way related to Bacillus coli.

Although distinct differences in morphology and colony formation, and minor differences in cultural reactions, exist among these different organisms, yet from the characters of *non-pigment production, non-liquefaction, fermentation of various carbohydrates* to the point of *acidity* and *gas production* and of *initial acidity* followed by *alkali-production in litmus milk*, a cultural-complex diagnostic for the Hog-cholera group is indicated. As Cushing has pointed out, however, the isolation of organisms identical in their cultural reactions with known pathogenic bacteria in no way affects the question of the etiology of the diseases caused by these bacteria, as a number of pathogenic and non-pathogenic members of the same group of organisms may exist, having cultural reactions agreeing in their main details, but distinguished by their pathogenic action and serum-reactions.

The question of the causation of epidemic dysentery by *Bacillus dysenteriæ* of Shiga is not therefore necessarily affected by the cultivation of organisms from the intestine identical in their cultural reactions but failing to give corresponding agglutinations, but the possibility is merely suggested that organisms normal to the intestinal tract giving characteristic cultural reactions, may assume extraordinary pathogenic properties and become the cause of diseases in which intestinal lesions play the most important, while not the only part.

Briefly then, in the present state of our knowledge of bacteriological reactions, it is necessary to lay down certain arbitrary rules which furnish us a cultural-complex for each species of bacteria and which will aid us in the further separation of these various species into certain artificial groups.

Under the same species we include those organisms whose cultural and morphological characters are identical and which are capable of producing the same agglutinins. Wherever we find closely allied microorganisms, after long preliminary cultivation, differing from each other by any one constant feature, whether that feature be morphological, cultural or biochemical, we must consider these organisms as distinct species. We thus make as many distinct species in the "Cloacæ Group" as we find different combinations of carbohydrates to be acted on by the different cultures. When the feature by means of which these cultures are to be distinguished is *motility*, then it is, of

		BIOCHEMICAL FEATURES.										
		Gas Production						Milk			Agar	
		Dextrose.	Saccharose	Lactose.	Nitrites.	Indol.	Fecal Odor	Acidity.	Coagulation.	Alkali.	Chromogenises	Fluorescence
Alkali-Pro												
GROUP I.	Bacill–	–	–	–	–	–	–	–	–	+	–	–
GROUP II.	Bacill–	–	–	+	+	–	+	–	+	–	–	
GROUP III.	Bacill+	+	+	+	+	+	+	–	+	–	–	
	Bacill+	–	+	+	+	+	+	–	+	–	–	
	Bacill+	–	–	+	–	–	+	–	+	–	–	
	Bacter–	+	+	+	–	–	+	–	+	–	–	
GROUP IV.	Bacill+	+	+	+	+	+	+	–	+	–	–	
	Bacill+	–	+	+	+	+	+	–	+	–	–	
GROUP V.	Bacill+	+	+	+	+	–	+	–	+	–	–	
	Bacill+	–	+	+	+	–	+	–	+	–	–	
	Bacill+	+	–	+	+	–	+	±	+	–	–	
GROUP VI.	Bacill–	–	–	+	–	–	+	–	+	–	–	
	Bacill–	–	–	+	–	–	+	–	+	–	–	
	Bacill–	–	–	+	–	–	+	–	+	–	–	
	Bacill–	–	–	–	–	–	+	–	+	–	–	
Spore-Bear												
	Bacte–	–	–	+	–	–	+	+	–	–	–	
	Bacte–	–	–	+	+	–	+	+	–	–	–	
	Bacill–	–	–	–	–	–	–	–	+	–	–	
	Bacill–	–	–	+	–	–	+	–	+	–	–	
	Bacte–	–	–	+	–	–	+	+	–	–	–	
	Bacte–	–	–	+	–	–	+	+	–	–	–	
	Bacill–	–	–	+	–	–	–	–	+	–	–	
	Bacill–	–	–	+	–	–	+	–	–	–	–	
	Bacill–	–	–	+	–	–	+	+	–	–	–	
	Bacill–	+	–	+	–	–	+	+	–	–	–	

		MORPHOLOGY.				CULTUR			
Alkali-Producers.		Bacillus	Dimensions in microns.	Motility	Spores.	Broth		Aga	
						Scum.	Turbid.	Dull.	
GROUP I.	Bacillus alcaligenes . . .	+	½ x 1-2	+	–	+	+	–	
GROUP II.	Bacillus pseudo-dysentericus	+	½ x 2	+	–	–	+	–	
GROUP III.	Bacillus alcalescens . . .	+	¾ x 1½	+	–	–	+	–	
	Bacillus sub-alcalescens . .	+	¾ x 1½	+	–	–	+	–	
	Bacillus enteritidis . . .	+	½ x 1½	+	–	–	+	–	
	Bacterium galactophilum .	–	¾ x 1½	–	–	+	+	–	
GROUP IV.	Bacillus entericus	+	½ x 1½-3	+	–	–	+	–	
	Bacillus subentericus . .	+	½ x 1½-3	+	–	–	+	–	
GROUP V.	Bacillus plebeius	+	½ x ½-3	+	–	+	+	–	
	Bacillus infrequens . . .	+	½ x ½-3	+	–	+	+	–	
	Bacillus vulgaris	+	½ x ½-3	+	–	+	+	–	
GROUP VI.	Bacillus recti	+	½ x ½-2	+	–	–	+	–	
	Bacillus pylori	+	1 x 3-4	+	–	–	+	–	
	Bacillus cæci	+	¾ x 2-4	+	–	+	+	+	
	Bacillus Bookerii	+	½ x 1½-2	+	–	–	+	+	
Spore-Bearing Bacteria.									
	Bacterium anthracoides . .	–	½ x 2-4	–	+	+	+	+	
	Bacterium implectans . .	–	½-¾ x 3-4	–	+	–	+	+	
	Bacillus cereus	+	¾ x 2-4	+	+	+	+	–	
	Bacillus mycoides . . .	+	1-1¼ x 3-4	+	+	+	+	+	
	Bacterium lacticola . . .	–	1 x 3-5	–	+	+	+	+	
	Bacterium vermiculare . .	–	½ x 6-8	–	+	–	+	+	
	Bacillus vulgatus	+	½ x 3-4	+	+	+	+	+	
	Bacillus brevis	+	½ x 3	+	+	–	+	–	
	Bacillus subtilis	+	½ x 4-6	+	+	+	+	+	
	Bacillus arachnoideus . .	+	½ x 2	+	+	–	+	+	

BIOLOGY.

CULTURAL FEATURES.								BIOCHEMICAL FEATURES.																	
Broth		Agar		Gelatine Plate	Potato		Fermentation tube.				Liquefaction			Gas Production						Milk			Agar	
Scum.	Turbid.	Dull.	Wrinkled	Characteristic appearance.	Visible.	Luxuriant	Growth in closed arm.	Growth at body temperature.	Facultative Anaerobe.	Affected by rapid of ft ation.	Gelatine.	Casein.	Blood Serum.	Dextrose.	Saccharose	Lactose.	Nitrites.	Indol.	Fecal Odor.	Acidity.	Coagulation.	Alkali.	Chromogenises	Fluorescence.
+	+	−	−	−	+	+	−	+	+	+	−	−	−	−	−	−	+	−	−	−	−	+	−	−
−	+	−	−	−	+	+	+	+	+	+	−	−	−	−	−	−	+	+	−	+	−	+	−	−
−	+	−	−	−	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	+	−	+	−	−
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−	+	−	−	−	−	−	−	+	+	+	+	+	+	−	−	−	+	−	−	+	−	−	−	−
+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	+	−	−	+	+	−	−	−
−	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	−	+	−	−	+	+	−	−	−

course, only by the careful staining of the individual elements for flagella, or by a most painstaking examination for the movement of the bacilli, that one is justified in considering organisms whose cultural features are identical as distinct species.

In this connection with regard to the consideration of different mieroorganisms as different species, whenever they differ by positive reactions, may be quoted Migula (1900, System der Bakterien, Bd. 1, p. 222).—"Es ist deshalb zum mindesten überflüssig, zwischen Arten und Varietäten bei den Bakterien einen Unterschied zu machen, da man ein. l berichtigt ist, zunächst noch alles, was sich *konstant* verschieden verhält, bei den Bakterien als Art zu betrachten, dann aber auch jede Handhabe fehlt, umfestzustellen, was Art und was nur Varietät ist."

THE ESTABLISHMENT OF BACTERIAL GROUPS.

Following this separation of the various microorganisms into different species, we may next employ certain cardinal cultural reactions for the further separation of the various species into different groups. These cardinal reactions are most conveniently found in the **acid** or the **alkali-production** in litmus milk, in **liquefaction** of various proteids and in the **fermentation of various carbohydrates.** By including in the same groups those species of bacteria which possess the same broad "group reactions," we are able to make constant but purely artificial divisions of the various microorganisms and to present a convenient and a fairly complete scheme of classification.*

The first group of ALKALI-PRODUCERS, on the one hand, is represented by *Bacillus alcaligenes* of Petruschky, an organism which is characterized, as has already been stated, by *non-liquefaction* of the proteids, by *failure* to *ferment* any *sugars* to the point of acidity and consequent limitation of the growth

* In attempting this purely artificial classification and in seeking for group relationships, no attention has been paid to the division of members of the "bacteriaciæ" into bacteria and bacilli—into non-flagellated and non-motile, and flagellated and motile forms respectively. Let me point out that here I am *not* attempting a *natural classification*, so called, and that accurate observers are frequently at odds over the presence or absence of flagella—as, for example, in the case of the Shiga bacillus. Those who study this paper will, I hope, be convinced as to the convenience of including motile and non-motile forms in the same group.

of the organism to the bulb of the fermentation tube; and by the immediate production of alkali in litmus milk.

Next to this group stands the group which we have considered above, represented by *Bacillus pseudodysentericus*, the "Dysenteric Group," characterized by non-liquefaction of proteids, by the fermentation of carbohydrates to the point of acidity and by an initial acidity in litmus milk followed by intense alkali-production.

This group will naturally be followed by a group embracing those organisms endowed with the capacity of splitting up carbohydrates to the point of acidity and gas production, but agreeing with the previous organisms in non-liquefaction of proteids and in an initial acidity in milk followed by alkali-production. Such organisms are included in the Hog-cholera group, embracing *Bacillus alcalescens*, fermenting dextrose, saccharose and lactose; *Bacillus subalcalescens*, fermenting dextrose and lactose; *Bacillus enteritidis*, fermenting dextrose, and *Bacterium galactophilum*, fermenting only saccharose and lactose.

Following the same line of argument we next have organisms which likewise ferment the carbohydrates, produce an initial acidity in litmus milk, followed by alkali-production, and which are further endowed with the capacity of liquefying the proteids. In one group liquefying gelatine alone, the "Entericus Group," two organisms may be distinguished, the *Bacillus entericus*, fermenting dextrose, saccharose and lactose, and *Bacillus subentericus*, breaking up dextrose and lactose. In another group, liquefying gelatine, casein and blood serum, the "Proteus Group," three members may be made out: 1st, *Bacillus plebeius*, fermenting dextrose, saccharose and lactose; 2nd, *Bacillus vulgaris*, breaking up dextrose and saccharose, and 3rd, *Bacillus infrequens*, breaking up dextrose and lactose.

Finally we may make out a last group of organisms characterized by *non-fermentation* of *carbohydrates*, their growth being limited to the open bulb of the fermentation tube, by immediate alkali-production in litmus milk and by the liquefaction of various media. In this group, the "Booker Group," may be distinguished *Bacillus recti*, liquefying gelatine, *Bacillus pylori*, liquefying gelatine and casein, and *Bacil-*

	BIOCHEMICAL FEATURES										
"Acid-Pr	GAS PRODUCTION						MILK			ACID	
	Dextrose	Saccharose	Lactose	Nitrites	Indol	Fecal odor	Acidity	Coagulation	Acid	Saccharose	Dextrose
GROUP I. Bacter–	–		–	–			+	+	–		
Bacter–	–	–	–	–	–	–	+	+		–	–
GROUP II. Bacill–	–	–	+	–	–		+	+	–		
Bacter–	–	–	–	–	–		+	+	–		
Bacter–	–	–	+	–	–		+	+	–	–	–
GROUP III. Bacill+	–	+	+	+	+		+	+			–
Bacill+	+	+	+	+	+		+	+	–	–	–
Bacter+	+	+	+	+	–		+	+	–	–	–
Bacter+	–	+	+	+	–		+	+	–	–	–
GROUP IV. Bacill+	+	+	+	+	+		+	+	–	–	–
Bacill+	+	+	+	+	+		+	+	–	–	–
Bacter+	+	+	+	+	+		+	+	–	–	–
Bacter+	–	+	+	+	+		+	+	–	–	–
GROUP V. Bacill+	+	+	+	+	+		+	+	–	–	–
Bacill+	–	+	+	+	+		+	+	–	–	–
Bacill+	+	–	+	–	–		+	+	–	–	–
GROUP VI. Bacill–	–	–	–	–	–		+	+	–	–	–
Bacter–	–	–	–	–	–		+	+	–	–	–
Bacill–	–	–	+	+	–		+	+	–	–	–
Bacill–	–	–	+	+	+		+	+	–	–	–
Bacill–	–	–	+	–	–		+	+	–	–	–
Pigment-Prod											
Pseud–	–	–	–	–	–	–	–	–	–	–	+
Pseud–	–	–	+	–	–	–	–	+	–	–	+
Bacte–	+	–	+	–	–	–	+	–	+	–	
Bacte–	–	–	+	–	–	–	–	+	+	–	

"Acid-Producers."		MORPHOLOGY						
		Motility	Spores					
GROUP I.	Bacterium oxygenes		$\frac{1}{2}$ x 2-3				+	−
	Bacterium Bienstockii	−	$\frac{1}{2}$ x $\frac{1}{2}$-$\frac{3}{4}$	−	−		+	−
GROUP II.	Bacillus oxyphilus	+	$\frac{3}{4}$ x 2	+		+	+	+
	Bacterium aciliformans	−	$\frac{3}{4}$ x 1-1$\frac{1}{2}$	−	−		+	+
	Bacterium minutissimum	−	$\frac{1}{2}$ x 1	−			+	−
GROUP III.	Bacillus coli	+	$\frac{1}{2}$ x 1-2	+			+	−
	Bacillus communior	+	$\frac{1}{2}$ x 1-2	+	−		+	−
	Bacterium aerogenes	−	$\frac{3}{4}$ x 2	−	−	+	+	−
	Bacterium duodenale	−	$\frac{3}{4}$ x 2	−	−	+	+	−
GROUP IV.	Bacillus gastricus	+	$\frac{1}{2}$ x 2-3	+	−		+	−
	Bacillus sub-gastricus	+	$\frac{1}{2}$ x 2-3	+	−		+	−
	Bacterium liquefaciens	−	$\frac{3}{4}$ x 2	−	−	−	+	−
	Bacterium sub-liquefaciens	−	$\frac{3}{4}$ x 2	−	−	−	+	−
GROUP V.	Bacillus cloacæ	+	$\frac{1}{2}$ x 2-3	+	−	+	+	−
	Bacillus sub-cloacæ	+	$\frac{1}{2}$ x 2-3	+	−	+	+	−
	Bacillus iliacus	+	$\frac{3}{4}$ x 3-4	+	−	+	+	−
GROUP VI.	Bacillus chylogenes	+	$\frac{1}{2}$ x 1	+	−	−	+	−
	Bacterium chymogenes	−	$\frac{1}{2}$ x 2	−	−	−	+	−
	Bacillus leporis	+	$\frac{1}{2}$ x 4-6	+	−	−	+	+
	Bacillus dubius	+	$\frac{3}{4}$ x 2	+	−	−	+	+
	Bacillus jejunalis	+	$\frac{1}{2}$ x 2	+	−	−	+	−
Pigment-Producing Bacteria.								
	Pseudomonas aeruginosa	−	$\frac{1}{2}$ x 2-4	+	−	+	+	−
	Pseudomonas ovalis	−	$\frac{1}{2}$ x 2	+	−	+	+	−
	Bacterium havaniense	−	$\frac{1}{2}$ x 2	−	−	+	+	−
	Bacterium lutescens	−	$\frac{1}{2}$ x $\frac{3}{4}$	−	−	−	+	−

BIOLOGY.

…AL FEATURES								BIOCHEMICAL FEATURES																
…		Agar		Gelatine Plate	Potato		Ferm tube				Liquefaction			Gas Production						Milk			Agar	
[illegible]	[illegible]	[illegible]	Wrinkled	Characteristic appearance	Visible	Luxuriant	Growth in closed arm	Growth at body temperature	Facultative Anaerobe	Affected by range of reaction	Gelatine	Casein	Blood Serum	Dextrose	Saccharose	Lactose	Nitrites	Indol	Faecal odour	Acidity	Coagulation	Viscosity	Chromogenesis	Fluorescence
	+	−	−	−	+	+	−	+	+	+	−	−	−	−	−	−	−	−	−	+	+	−	−	
	+	−	−	−	+	−	−	+	+	+	−	−	−	−	−	−	−	−	−	+	+	−	−	−
+	+	+	−	−	+	+	+	+	+	+	−	−	−	−	−	−	+	−	−	+	+	−	−	
	+	+	−	−	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	+	+	−		−
	+	−	−	−	+	−	+	+	+	+	−	−	−	−	−	−	+	−	−	+	+	−	−	−
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−	+	−	−	+	+	+	−	+	+	+	+	−	−	−	−	−	+	−	·	−	−	+	+	−

lus caeci and *Bacillus Bookeri*, both liquefying gelatine, casein and blood serum.

In the same way the various ACID-PRODUCING BACTERIA may be arranged in certain groups differing from each other by gradations in reactions similar to those seen with the alkali-producers. In the first group, the "Bienstock Group," may be placed organisms which occupy a position among the acid-producers analogous to that of *Bacillus alcaligenes* among the alkali-producers, in that its two members, *Bacterium Bienstockii* and *Bacterium aerogenes*, are both characterized by the acidification and coagulation of milk, the non-liquefaction of the proteids and the failure to produce acid in carbohydrate solutions in the fermentation tube.

Next to this group comes a group with similar properties of acidification and coagulation of milk and non-liquefaction of proteids, but one in which the fermentation of the carbohydrates to the point of acidity occurs. This group is represented by three members, *Bacterium minutissimum*, *Bacterium acidoformans* and *Bacillus oxyphilus*.

Following the same sequence of characters we next have non-liquefying organisms acidifying and coagulating milk, but fermenting the carbohydrates to acid and gas production. The four members of this group, *Bacillus coli*, *Bacillus communior*, *Bacterium aerogenes* and *Bacterium duodenale*, have already been considered at some length. This group occupies among the acid-producers a position similar to that filled by the Hog-Cholera group among the alkali-producing bacteria.

Two groups of organisms next occur which are similar to the bacteria just mentioned in their acidification and coagulation of milk, and in their fermentation of the sugars, but which are capable of liquefying the carbohydrates. In the first group, liquefying gelatine only, *Bacillus gastricus* and *Bacillus subgastricus* have been considered above, as well as the three members of the "Cloacæ Group" which liquefy gelatine, casein and blood serum, namely, *Bacillus cloacæ*, *Bacillus subcloacæ* and *Bacillus iliacus*.

Finally a second series of organisms follows which includes the various cultures acidifying and coagulating milk, breaking up carbohydrates to the point of acidity and liquefying various

media. This group includes *Bacterium chylogenes* and *Bacterium chymogenes*, liquefying gelatine, *Bacillus leporis*, liquefying gelatine and blood serum, and *Bacillus dubius* and *Bacillus jejunalis*, liquefying gelatine, casein and blood serum.

We thus may tabulate the various acid and alkali-producing bacteria of the human intestine, isolated in the course of this work, as follows:—

ALKALI-PRODUCERS.

GROUP I.—Organisms producing alkali in litmus milk not liquefying any media, not fermenting carbohydrates to the point of acidity: FÆCALIS ALCALIGENES, or PETRUSCHKY GROUP. Represented in the forms isolated during the course of this study by

1. *Bacillus alcaligenes*, Migula, 1900.

GROUP II.—Organismss producing alkali, not liquefying any media, fermenting carbohydrates to the point of acidity but no gas:—DYSENTERICUS or SHIGA GROUP. Represented by

2. *Bacillus pseudodysentericus*, Müller, 1902.

GROUP III. Organisms producing alkali, not liquefying any media, fermenting the carbohydrates with the production of acidity and gas: —HOG-CHOLERA or SUIPESTIFER GROUP. Represented by

3. *Bacillus alcalescens*, Ford, 1903—Fermenting dextrose, s. .charose and lactose.
4. *Bacillus subalcalescens*, Ford, 1903—Fermenting dextrose and lactose.
5. *Bacillus enteritidis*, Gärtner, 1888—Fermenting dextrose.
6. *Bacterium galactophilum*, Ford, 1903—Fermenting saccharose and lactose.

GROUP IV.—Organisms producing alkali, liquefying gelatine, fermenting carbohydrates with the production of acid and gas; ENTERICUS GROUP. Represented by

7. *Bacillus entericus*, Ford, 1903—Fermenting dextrose, saccharose and lactose.
8. *Bacillus subentericus*, Ford, 1903—Fermenting dextrose and lactose.

GROUP V.—Organisms producing alkali, liquefying gelatine, casein and blood serum, fermenting carbohydrates with the production of acid and gas:—PROTEUS OR HAUSER GROUP. Represented by

9. *Bacillus plebeius*, Ford, 1903—Fermenting dextrose, saccharose and lactose.
10. *Bacillus infrequens*, Ford, 1903—Fermenting dextrose and lactose.
11. *Bacillus vulgaris*, (Hauser, 1885) Migula, 1900—Fermenting dextrose and saccharose.

GROUP VI.—Organisms producing alkali, liquefying various media but not fermenting carbohydrates to the point of acidity:—BOOKER GROUP. Represented by

12. *Bacillus recti*, Ford, 1903—Liquefying gelatine.
13. *Bacillus pylori*, Ford, 1903—Liquefying gelatine and casein.
14. *Bacillus coci*, Ford, 1903—Liquefying gelatine, casein and blood serum.
15. *Bacillus Bookeri*, Ford, 1903—Liquefying gelatine, casein and blood serum.

ACID-PRODUCERS.

GROUP I.—Organisms acidifying and coagulating milk, not liquefying any media, not fermenting carbohydrates to the point of acidity:—FÆCALIS OXYGENES OR BIENSTOCK GROUP. Represented by

16. *Bacterium oxygenes*, Ford, 1903.
17. *Bacterium Bienstockii*, Schröter, 1886.

GROUP II. Organisms acidifying and coagulating milk, not liquefying any media, fermenting carbohydrates to the

point of acidity but no gas:—ACIDOFORMANS or STERNBERG GROUP. Represented by

18. *Bacillus oxyphilus*, Ford, 1903.
19. *Bacterium acidoformans*, Sternberg, 1892.
20. *Bacterium minutissimum*, Migula, 1900.

GROUP III.—Organisms acidifying and coagulating milk, not liquefying any media, fermenting carbohydrates with the production of acidity and gas: —COLI or ESCHERICH GROUP. Represented by

21. *Bacillus coli*, Migula, 1900—Fermenting dextrose and lactose.
22. *Bacillus communior*, Ford, 1903—Fermenting dextrose, saccharose and lactose.
23. *Bacterium aërogenes*, Migula, 1900 Fermenting dextrose, saccharose and lactose.
24. *Bacterium duodenale*, Ford, 1903 Fermenting dextrose and lactose.

GROUP IV.—Organisms acidifying and coagulating milk, liquefying gelatine and fermenting the carbohydrates with the production of acidity and gas :—LIQUEFACIENS or EISENBERG GROUP. Represented by

25. *Bacillus gastricus*, Ford, 1903—Fermenting dextrose, saccharose and lactose.
26. *Bacillus subgastricus*, Ford, 1903— Fermenting dextrose and lactose.
27. *Bacterium liquefaciens*, (Eisenberg, 1892) Ford, 1903—Fermenting dextrose, saccharose and lactose.
28. *Bacterium subliquefaciens*, Ford, 1903 - Fermenting dextrose and lactose.

GROUP V.—Organisms acidifying and coagulating milk, liquefying gelatine, casein and blood serum and fermenting the carbohydrates with the production of acidity and gas: CLOACÆ or JORDAN GROUP. Represented by

29. *Bacillus cloacæ*, Jordan, 1896.—Fermenting dextrose, saccharose and lactose.

30. *Bacillus subcloacæ*, Ford, 1903.—Fermenting dextrose and lactose.

31. *Bacillus iliacus*, Ford, 1903.—Fermenting dextrose and saccharose.

GROUP VI.—Organisms acidifying and coagulating milk, liquefying various media, fermenting the carbohydrates with the production of acid but no gas:—DEBUS or KRUSE. GROUP. Represented by

32. *Bacillus chylogenes*, Ford, 1903.—Liquefying gelatine.

33. *Bacterium chymogenes*, Ford, 1903.—Liquefying gelatine.

34. *Bacillus leporis*, Migula, 1900.—Liquefying gelatine and blood serum.

35. *Bacillus dubius*, Kruse, 1896.—Liquefying gelatine, casein and blood serum.

36. *Bacillus jejunalis*, Ford, 1903.—Liquefying gelatine, casein and blood serum.

The following pigment-producing and spore-bearing organisms were also isolated but are not included in the classification:—

37. *Pseudomonas æruginosa* (Schröter, 1872), Migula, 1900.

38. *Pseudomonas ovalis* (Ravenel, 1896), Chester, 1901.

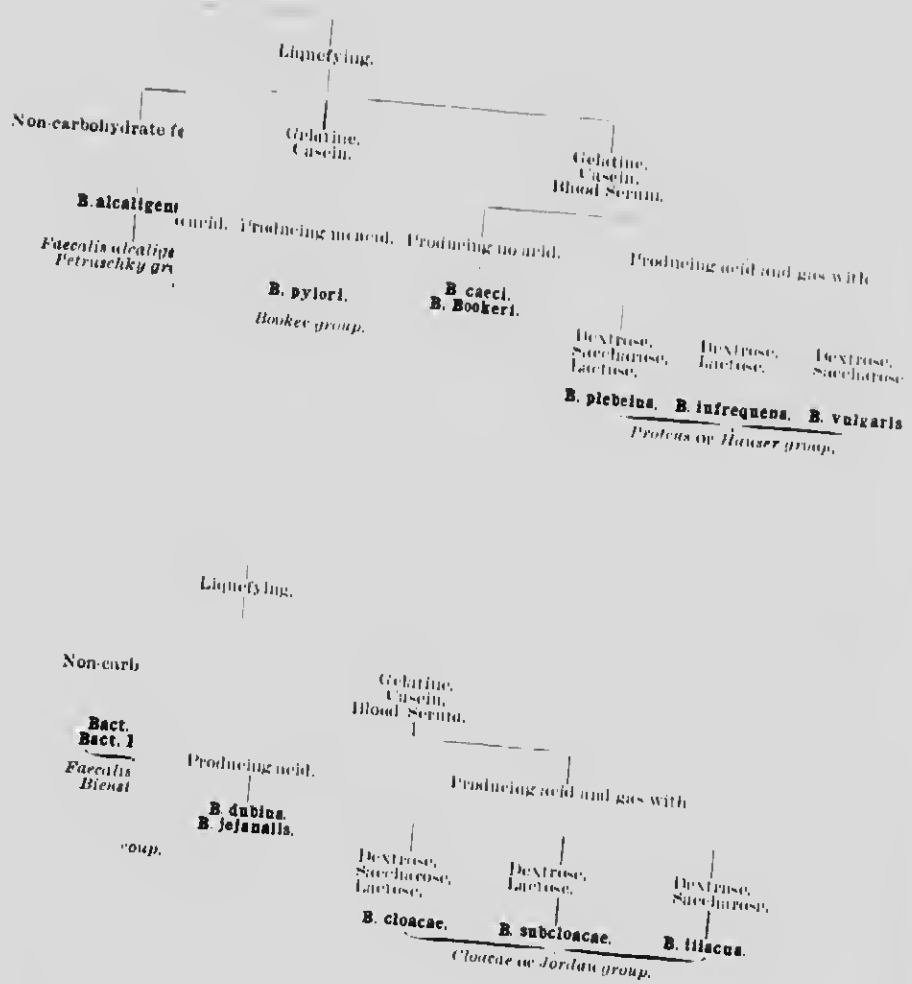
39. *Bacterium havaniense* (Sternberg, 1892), Chester, 1901.

40. *Bacterium lutescens*, Migula, 1900.

41. *Bacterium anthracoides* (Hueppe & Wood, 1881), Migula, 1900.

42. *Bacterium implectans*, Burchard, 1898.

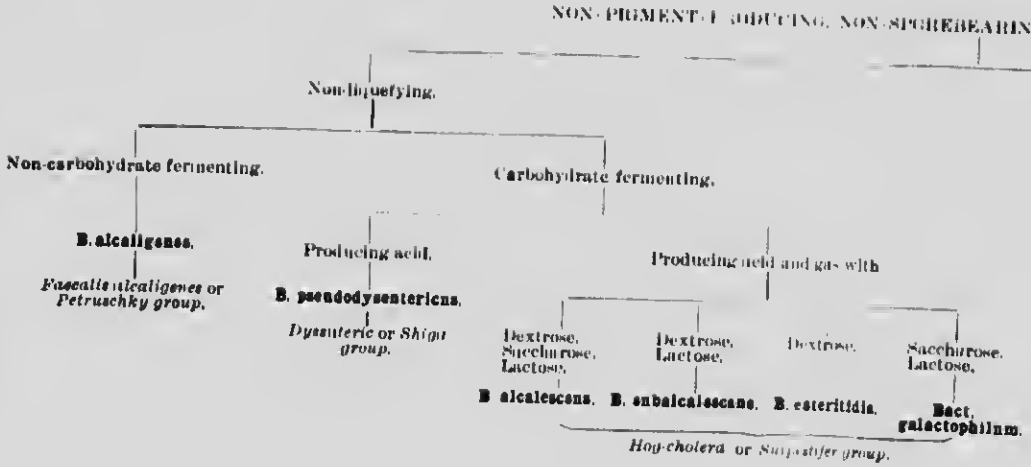
43. *Bacillus cereus*, Frankland, 1887.
44. *Bacillus mycoides*, Flügge, 1886.
45. *Bacterium lacticola*, Migula, 1900.
46. *Bacterium vermiculare* (Frankland, 1889), Migula, 1900.
47. *Bacillus vulgatus*, Trevisan, 1889.
48. *Bacillus brevis*, Migula, 1900.
49. *Bacillus subtilis*, (Ehrenberg, 1833), Cohn, 1872.
50. *Bacillus arachnoideus*, Migula, 1900.

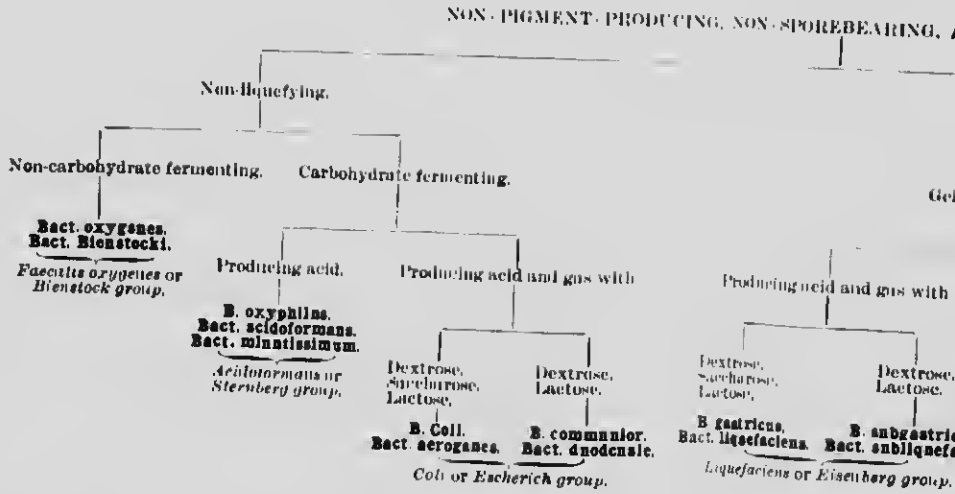


In consider chemata do not include by any means all the organisms which are known to exist in nature, organisms actually found during the progress of this investigation. A large group of organis ficient acid to coagulate milk—is not included, inasmuch as neither *Bacillus typhosus* nor any

Several ga alkali-producing liquefying bacteria, which have no action on carbohydrate solutions, no pro se Group" includes bacteria which produce acid, liquefy various media and ferment carbohy action on carbohydrates other than lactose. Both these extra groups are, from a theoretica

Again, und ose have been utilized. Not only are further combinations of carbohydrates available for stu in certain cases have already been cultivated from sources outside the human body. Thus i the "Coli Group," but which is characterized by the fermentation of dextrose and saccharose, nisms liquefying gelatine and casein but possessing the other features of these groups, are likew

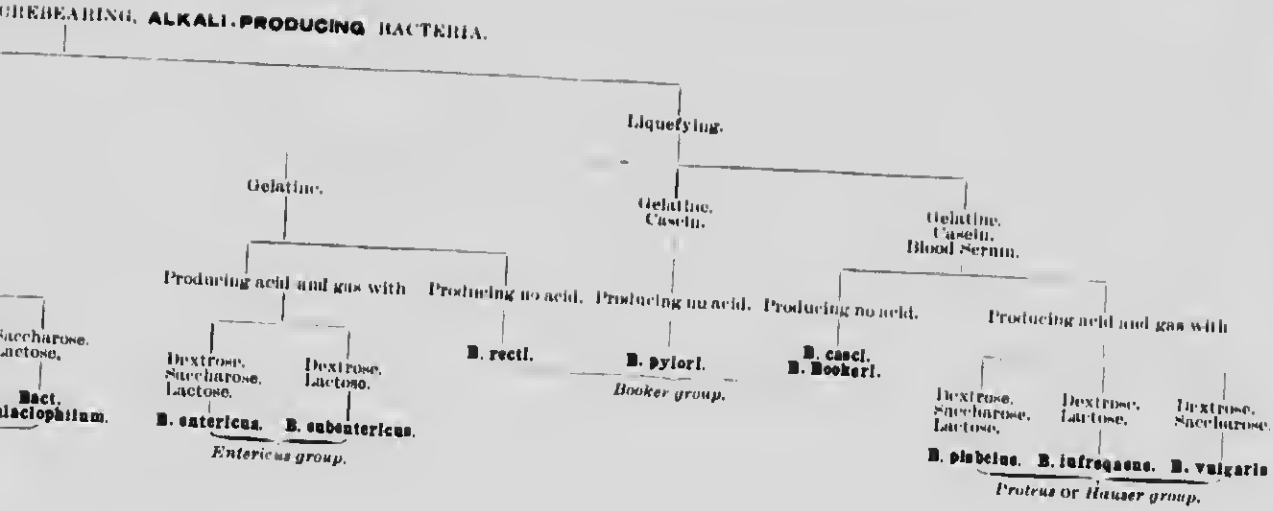


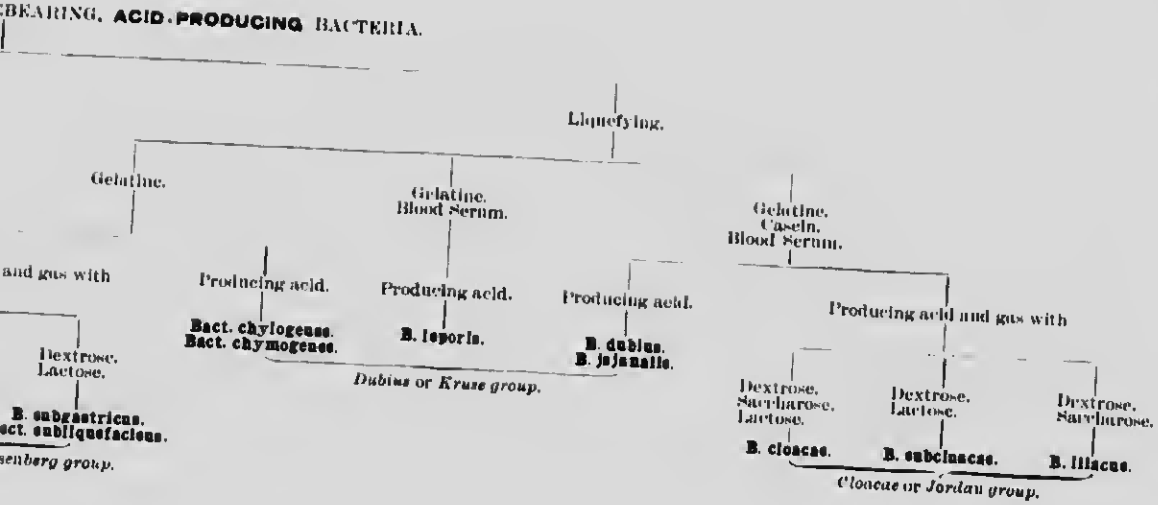


In considering the various groups into which the microorganisms of the intestine have been divided, it bec exist in nature, nor a number of possible forms which on *a priori* grounds might be hypothecated. As a matter group of organisms, of which many cultures of *Bacillus typhosus* are the type—organisms which are neither alka *typhosus* nor any allied bacilli were grown from the intestinal contents.

Several gaps, moreover, are apparent when the acid and alkali-producers are separately considered. Thus solutions, no provision whatever is made for alkali-producing liquefying bacteria which split up the sugars to the poi ferment carbohydrates to the point of acidity, not including, however, a closely allied group of acid-producing li from a theoretical standpoint, perfectly possible.

Again, under the various groups of organisms breaking up the sugars with the production of acid and gas, available for still further differentiation of species, but organisms picking out different sugars than those here body. Thus I have previously described (Ford, 1900) an organism isolated from the kidney of a dog, which in it and saccharose, but not lactose. Again, in the "Booker Group" organisms liquefying gelatine and blood serum groups, are likewise perfectly able to exist in nature.





divided, it becomes at once apparent that these schemata do not include by any means all the organisms which are known to . As a matter of fact they represent merely the organisms actually found during the progress of this investigation. A large e neither alkali-producers, nor which produce sufficient acid to coagulate milk—is not included, inasmuch as neither *Bacillus*

idered. Thus while the "Booker Group" includes alkali-producing liquefying bacteria, which have no action on carbohydrate gars to the point of acidity. Similarly the "Kruse Group" includes bacteria which produce acid, liquefy various media and id-producing liquefying organisms which have no action on carbohydrates other than lactose. Both these extra groups are,

acid and gas, only dextrose, saccharose and lactose have been utilized. Not only are further combinations of carbohydrates in those here described, are not only possible but in certain cases have already been cultivated from sources outside the human og, which in its cultural characteristics belong to the "Coli G· ·up," but which is characterized by the fermentation of dextrose d blood serum, and in the "Kruse Group" organisms liquefy ·g gelatine and casein but possessing the other features of these

I. BACILLUS ALCALIGENES. Migula. 1900.

Literature and Synonyms

Bacillus faecalis alcaligenes: Petruschky, 1895, Bacillus faecalis alcaligenes n. sp. Centralblatt für Bakteriologie, Parasitenk. u. Infektionskr., Bd. 19, p. 657, and *Bacillus faecalis*, Krusé, 1896.

Bacillus alcaligenes (Petruschky) Migula, 1900, Migula, 1900, System der Bakterien, p. 737.

Bacillus alcaligenes Petruschky, Chester, 1901, Manual of Determinative Bacteriology, p. 218.

First isolated by Petruschky from typhoid stools.

Morphology: Bacilli resembling *Bacillus typhosus* in morphology, measuring 0.5 to 1.2 microns in dimensions, often growing in pairs and in long filaments made up of individual bacilli.

Motility: Actively motile, especially in old cultures.

Spores: Not formed.

Agar Slant: White, glistening growth limited to line of inoculation, not spreading nor shaping.

Agar Colonies: Deep colonies, round, uniform, opaque; superficial colonies, usually transparent, circumscribed, but may spread slightly, showing opaque centres and slightly thinner edges, often assuming diverse shapes.

Broth: Heavy thick scum on the surface, the broth itself being fairly clear and often free from sediment.

Gelatine Stab: Abundant growth along line of inoculation. *No liquefaction.*

Gelatine Colonies: Deep colonies, round and regular; superficial colonies, round, translucent, with nail-head appearance.

Potato: Growth varies from a scanty white to an abundant dirty-yellowish or brownish mass covering entire surface of potato. Growth rarely reddish brown.

Fermentation Tube: Dextrose Broth: Growth limited to open bulb where a thick, heavy scum is formed on the surface, and a heavy sediment settles down in the branch. *Reaction* in bulb, *alkaline*. No growth in closed arm.

Saccharose and *Lactose* not fermented to acid or acid and gas.

Blood Serum: Abundant white or yellowish brown growth along line of inoculation. *No liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Produced rarely in old cultures.

Fæcal Odour: Rare, may appear in old cultures.

Litmus Milk: Characteristic Reaction: Production of alkali immediate; within 48 hours milk turns blue; no stage of preliminary acidity; alkali-production continues for some days. *No coagulation* of the milk. After neutralization of the alkali with weak acid the casein is found undissolved.

Pathogenicity: Non-pathogenic to mice, guinea-pigs or rabbits.

Occurrence and Distribution: Found in fourteen cases of fifty examined. Found in rectum alone in five cases, in cæcum alone in two cases, in duodenum alone in three cases. Found in combination, in rectum and stomach, in rectum and duodenum, in cæcum and duodenum and in duodenum and stomach. It is thus seen to be commonly present in the lower portions of the intestinal tract, more rarely appearing in the upper part of the bowel.

2. BACILLUS PSEUDODYSENTERICUS, Muller, 1902.

Literature:

Kruse, 1901, Weitere Untersuchungen über die Ruhr und die Ruhrbacillen, Deutsche Med. Wochenschrift, Nos. 23 and 24.

Ford, W. W., 1901, Classification of Intestinal Bacteria, Journ. of Medical Research, vol. 4, p. 211.

Müller, Paul Theodore, 1902, Ueber den Bakterialogischen Befund bei einer Dysenterieepidemie in Südsteiermark, Centralblatt für Bakteriologie, vol. 31, No. 12, p. 558.

First isolated by Kruse in "Pseudodysenterie" and by Ford from normal intestinal contents.

Morphology: Bacilli measuring 0.5 by 1.2 microns in dimensions, growing in pairs and in short chains.

Motility: Slowly motile in young agar and broth cultures, motility more marked in old cultures.

Spores: Not formed.

Agar Slant: White, glistening growth along line of inoculation; no tendency to spread or slope.

Agar Colonies: Deep colonies, round, regular and opaque; superficial colonies may be round, regular, finely granular, translucent, with clean-cut margins, or present dark centres with slightly spreading peripheries. The latter may spread over the surface of the agar, assuming various bizarre shapes. The formation and appearance of particular colonies cannot be associated with particular cultures as transfers from one variety of colonies will later originate other varieties. The regular non-spreading colonies may be regarded as the more characteristic. In general the agar colonies resemble those of *Bacillus typhosus*.

Broth: Luxuriant growth with the production of a heavy sediment; *no pellicle*.

Gelatine Stab: Abundant growth along line of inoculation, spreading slightly on the surface of the gelatine; *no liquefaction*.

Gelatine Colonies: Deep colonies round, regular and opaque; superficial colonies translucent, finely granular, spreading like those of *Bacillus typhosus*.

Potato: Luxuriant yellowish brown or brown growth.

Fermentation Tube: Dextrose Broth: Characteristic reaction. Abundant growth in both with a thick sediment settling down to the branch. *No pellicle*. *Reaction acid*. Growth extends into closed arm where the broth speedily becomes turbid. *Reaction* of closed arm *acid*; no production of gas.

Saccharose and *Lactose* not broken up with the production of acid or gas.

Blood Serum: Abundant white or yellowish-white growth, *no liquefaction*.

Growth never becomes red.

Nitrates: Reduced to nitrites.

Indol: Produced rarely in small quantities.

Fecal Odour: Not produced.

Litmus Milk: Characteristic reaction. Transient acidity produced within first 24 hours, yielding to a continuous alkali production which turns the litmus milk blue. *No coagulation* of the milk. Neutralization shows undissolved casein.

Pathogenicity: Mice, guinea-pigs and rabbits die after subcutaneous inoculation within 24-48 hours of a septicæmia. Bacilli in pure culture may be obtained from the internal organs.

Occurrence and Distribution: Found in ten different cases. Present in rectum in four cases, in cæcum in one, and in stomach in one. Found in combination in four cases, in rectum and cæcum twice, in cæcum and duodenum and in cæcum, duodenum and stomach. It is thus seen to be present especially in the lower portions of the bowel, but also to appear in the stomach and duodenum as well.

Serum Reactions: Does not agglutinate with the blood serum of patients suffering from dysentery.

3. BACILLUS ALCALESCENS, Ford, 1903, (n. sp.)

Literature: Ford, W. W., 1903, A Classification of Intestinal Bacteria, Journ. of Medical Research, Vol. 1, p. 211.

First isolated from intestinal contents and described by Ford.

Morphology: Bacilli measuring 0.5 by 1.0 to 2.0 mic., usually appearing as single individuals, but occasionally growing in long chains.

Motility: Actively motile.

Spores: Not formed.

Agar Slant: White translucent growth with rather limited line of inoculation or spreading rapidly from this line within 18 hours covering the whole agar slant and sloping to the bottom of the tube.

Agar Colonies: Deep colonies round, regular, opaque; superficial colonies have opaque white centres with spreading translucent peripheries.

Broth: Turbidity and sediment, no formation of pellicle.

Gelatine stab: Abundant growth along line of inoculation and on the surface of the gelatine. *No liquefaction.*

Gelatine colonies: Deep colonies, round, regular; superficial colonies have dark opaque centres and spreading peripheries.

Potato: Growth varies from a scanty yellowish-white to an abundant dark brown mass.

Fermentation Tube—Dextrose Broth: Abundant growth in bulk with the formation of a heavy sediment. *Reaction* in bulk, *acid.* Growth in closed arm with the evolution of gas and the production of *acidity.*

Saccharose and *Lactose* also fermented with the production of acid and gas.

Blood Serum: Abundant opaque white growth. *No liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Rarely produced.

Fecal Odour: Rarely produced.

Litmus Milk: Preliminary acidity yielding in 48 hours to an intense alkali production; *no coagulation* of the milk; *no peptonization* of the casein.

Occurrence and Distribution: Found in three cases from which it was isolated from the cæcum alone in one case and from the duodenum and cæcum together in two cases. A number of transplantations from original plates later proved identical.

4. BACILLUS SUBALCALESCENS, Ford, 1903 (n. sp.)

Literature:

Ford, 1903, Classification of Intestinal Bacteria, Journ. of Medical Research, Vol. 1, p. 211.

Isolated from intestinal contents and described by Ford. This organism differs from the preceding only in its failure to ferment saccharose, dextrose and lactose alike being broken up with the production of acid and gas. In its colony formation and in its cultural features it is identical with the organism described above. Several cultures were obtained from four cases where it appeared twice in the rectum, once in the cæcum and once in the duodenum.

5. BACILLUS ENTERITIDIS, Gartner, 1888.

Literature:

Gärtner, 1888, Ueber die Fleischvergiftung in Frankenhausen am Kyffhäuser und den Erreger derselben. Corresp. d. allg. Ärztl. Vereins Thüring. [illegible] c. 9.

Migula, 1900, System der Bakterien, p. 744.

Chester, 1901, Manual of Determinative Bacteriology, p. 207.

First isolated and described by Gärtner in epidemics of meat poisoning. Identical culturally with,

Bacillus paracolon, Widal, 1897, La Semaine Medicale, August 4th.

Bacillus paracolon, Gwynn, 1898, Johns Hopkins Hospital Bulletin, March, p. 54.

Bacillus O., Cushing, 1900, ibid., July, August, p. 157.

Bacillus icteroides, Sanarelli, 1897, British Medical Journal, July 3rd; 1898, Centralblatt für Bakteriologie, 24, p. 376.

Bacillus paratyphoid, Schottmüller, 1901. Zeitschrift für Hygiene, vol. 36, p. 368.

Morphology: Bacillus measuring 0.5 by 1.5 to 2 microns, appearing either as single elements, as pairs, or as short chains.

Motility: Actively motile.

Spores: Not formed.

Agar Slant: Greyish-white growth along line of inoculation without tendency to spread or slope.

Agar Colonies: Deep colonies, round, regular, uniform and opaque; superficial colonies, round, translucent, with dark nucleus not spreading.

Broth: Turbidity, no scum.

Gelatine Stab: Abundant growth, *no liquefaction.*

Gelatine Colonies: Deep colonies regular brown, superficial colonies, round, grey, translucent, granular.

Potato: Abundant brown or yellowish-brown growth.

Fermentation Tube: Dextrose Broth: Abundant growth in bulb with heavy sediment; *reaction acid.* Growth in closed arm, abundant evolution of gas; reaction of closed arm *acid.*

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant dirty-white growth; *no liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: Preliminary acidity yielding to alkali-production within 48 hours; *no coagulation.* No peptonization of casein.

Occurrence and Distribution: Isolated from the cæcum in two cases, a number of cultures from the original plates giving identical reactions.

6. BACTERIUM GALACTOPHILUM, Ford, 1903 (n. sp.)

Literature:

Ford, 1903, Classification of Intestinal Bacteria. Journ. of Medical Research, vol. 9, p. 211.

First isolated from intestinal tract and described by Ford.

Morphology: Bacteria measuring 0.75 by 1.5 microns, appearing in single elements.

Motility: Non-motile.

Spores: Not formed.

Agar Slant: Raised, viscid, sweaty growth, spreading along line of inoculation, but not sloping to bottom of tube. When touched with platinum needle long threads are brought away.

Agar Colonies: Colonies vary in size, are usually round, project from the surface, are dull-white in color, appearing not unlike drops of sweat.

Broth: Turbidity, scum on the surface and an abundant sediment.

Gelatine Stab: Abundant growth, *no liquefaction*

Gelatine Colonies: Deep colonies, round and regular; superficial colonies irregular, skein-like with spreading processes.

Potato: Abundant dull white growth.

Fermentation Tube: Dextrose Broth: Thick scum and heavy sediment in fulls, no growth in closed arm; *reaction* in fulls *alkaline*. Dextrose not broken up.

Saccharose and *Lactose* both fermented with the production of *acid* and *gas*.

Blood Serum: Abundant white growth, *no liquefaction*.

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fecal Odor: Not produced.

Litmus Milk: Preliminary acidity followed by intense alkali-production. No coagulation. No peptonization of the casein.

Occurrence and Distribution: Obtained in several cultures from the stomach of one case.

7, BACILLUS ENTERICUS, Ford, 1903, (n. sp.)

Literature:

Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

First isolated from intestinal contents and described by Ford.

Morphology: Bacilli measuring 0.5 by 1.5 3.0 microns, often growing out into long chains.

Motility: Actively motile.

Spores: Not formed.

Agar Slant: White, glistening growth, spreading over the surface of agar, and when specially luxuriant sloping to the bottom of the tube, where it forms a thick heavy mass.

Agar Colonies: Deep colonies round, regular, opaque; superficial colonies have white opaque centres and slightly spreading peripheries. Colonies never spread as much as those of *Bacillus vulgaris* and are easily distinguished from them

Broth: Marked turbidity, no scum.

Gelatine: Rapid *liquefaction* from surface downward; within 24 hours a thick rim of liquefied gelatine is produced and by the end of the fifth day the entire mass of gelatine is transformed to a thin fluid.

Gelatine Colonies: Small, round, regular, translucent colonies often in rouleaux and giving a "broken glass" appearance.

Potato: Luxuriant dirty-brown growth spreading rapidly over the surface of the potato.

Fermentation Tube: Dextrose Broth: Turbidity in bulb; heavy sediment; *acid reaction; growth* in *closed arm; acid reaction* and evolution of *gas.*

Saccharose and *Lactose* also split up into *acid* and *gas.*

Blood Serum: Thick white growth, *no liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Produced, often in large quantity.

Fecal Odour: Rarely produced.

Litmus Milk: Preliminary acidity followed by intense alkali-production. *No liquefaction.* Upon neutralization casein found undissolved

Occurrence and Distribution: Isolated from nine cases; from rectum alone in three cases, from stomach alone in two cases, from caecum alone in one case, from stomach and caecum together in one case, and from stomach, caecum and rectum in one case.

8, BACILLUS SUBENTERICUS, Ford, 1903 (n. sp.)

Literature:

Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

Organism similar to *Bacillus enterieus* in the majority of their reactions but failing to ferment *Saccharose* were isolated in two cases. They represent a sub-species of this microorganism. They were present in the stomach of one case and in the caecum of another.

9. BACILLUS PLEBEIUS, Ford, 1903 (n. sp.)

Literature:
Ford, 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

Morphology: Bacilli 0.5 by 1.5–3.0 microns appearing in pairs or in long chains.

Motility: Actively motile, especially in old cultures.

Spores: Not formed.

Agar Slant: White glistening abundant layer spreading over the surface of agar and sloping to bottom of tube.

Agar Colonies: Deep colonies round or oval, brown in color; superficial colonies have opaque white centres and spreading translucent peripheries with frequent branching threads. Colonies may assume various bizarre shapes.

Broth: Marked turbidity. Rarely the production of a delicate film on the surface.

Gelatine: Abundant growth along line of inoculation; rapid and complete *liquefaction* of gelatine beginning at the surface and proceeding downward.

Gelatine Colonies: Spreading colonies with dark opaque centres and lighter periphery. Rapid *liquefaction* about the individual colonies.

Potato: Abundant yellowish white or creamy white growth turning brown or red in old cultures.

Fermentation Tube: Dextrose Broth: Marked turbidity and sediment in open bulb; rapid growth in closed arm with production of a large quantity of *gas. Reaction* in *bulb* and *closed arm acid.*

Gas and acid also from *Saccharose* and *Lactose.*

Blood Serum: Abundant growth; slow but complete *liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Rarely produced.

Fæcal Odour: Not produced. Odor of putrefaction common to this group.

Litmus Milk: Preliminary acidity followed by intense alkali-production. No coagulation of the milk. Slow digestion of the casein which after 8 to 10 days is completely dissolved. Reduction of the litmus takes place at the same time, the resulting fluid being clear, transparent, soapy, with small drops of oil floating on the surface. Neutralization shows the complete *peptonization* of the casein.

Occurrence and Distribution: This microorganism was isolated from twenty-three different cases, thus being present in nearly half of the cases examined. It was found in the rectum alone in four cases, in cæcum alone in two cases, in duodenum alone in seven cases, and in the stomach alone in one case.

Found in combination, in stomach and duodenum, in stomach and duodenum, in stomach and cæcum, and in duodenum, cæcum and rectum. In three cases obtained from stomach, duodenum and cæcum, and in one case isolated from every portion of the intestines examined, stomach, duodenum, cæcum and rectum.

This bacillus occupies relatively the upper portion of the intestinal canal, appearing most frequently in the stomach and duodenum, and becoming less frequent in the lower portion of the bowel.

10. BACILLUS INFREQUENS, Ford, 1903 (n. sp.)

Literature:

Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

Organisms differing from the preceding form in their failing to ferment *Saccharose*, but agreeing with it in their main cultural features may conveniently be grouped together under the name *Bacillus infrequens*.

This form was obtained in nine different cases, in rectum once, in cæcum once, in duodenum three times and in combination in rectum and cæcum once, in rectum and stomach twice, and in duodenum and stomach once. It is thus more frequently met with in the upper portions of the alimentary canal, being especially common to the duodenum.

11. BACILLUS VULGARIS (Hauser, 1885), Migula, 1900.

Literature and Synonyms:

Proteus vulgaris, Hauser, 1885, Ueber Fäulniss-bacterien, Leipzig.
Bacillus proteus, Trevisan, 1889, Genera.
Bacillus vulgaris (Hauser) Migula, 1900, System der Bakterien, p. 797.
Bacillus vulgaris (Hauser), Chester, 1900, Manual of Determinative Bacteriology, p. 244. First isolated from putrefying masses by Hauser.

Morphology: Bacilli 0.5–1.0 by 1.0–3.0 microns in dimensions, appearing in pairs but frequently in long chains. Great diversity in morphological appearance, the individual elements frequently looking like micrococci, or very stumpy bacilli.

Motility: Young cultures show sluggish motility, old cultures often show active motility.

Spores: Not formed.

Agar Slant: Thin bluish-grey growth, spreading rapidly over the surface of the agar and sloping to the bottom of the tube.

Agar Colonies: Typical spreading colonies with opaque white centres and outlying bluish-grey periphery. Deep colonies, round or oval, brown in color.

Broth: Turbidity marked, rarely a scum.

Gelatine: Abundant growth; rapid and complete *liquefaction*, beginning at the surface and extending downwards along line of inoculation.

Gelatine Colonies: Irregular spreading colonies with rapid *liquefaction* of the gelatine about them.

Potato: Abundant yellowish-white, or creamy-white growth, turning brown in old cultures.

Fermentation Tube: *Dextrose Broth*: Rapid growth with production of a heavy sediment. Growth in closed arm. *Abundant gas*. *Acid reaction* in bulb and branch.

Saccharose broken up into *acid* and *gas*.

Lactose not affected by this bacillus.

Blood Serum: Abundant growth. *Slow and complete liquefaction*.

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced. Putrefactive odor common.

Litmus Milk: Preliminary acidity followed by intense alkali-production with *peptonization* of the casein and reduction of the litmus. Usually a soft coagulum is produced. After ten days milk transformed to a thin curdless liquid with a few oil drops floating on the surface.

Occurrence and Distribution: Found in four different cases from each of which several different cultures were obtained. Obtained from rectum once, cæcum twice and from stomach and cæcum in combination once.

12, BACILLUS RECTI, Ford, 1903 (n. sp.)

Literature :
Ford, W. W., 1911, Classification of Intestinal Bacteria, Journal of Medical Research, vol. 1, p. 211.

First obtained from intestinal contents and described by Ford.

Morphology : Bacilli measuring 0.5 by 1.5–2.0 microns, occurring usually in pairs and chains.

Motility : Actively motile.

Spores : Not formed.

Agar Slant : Greyish-white growth limited to line of inoculation, not spreading or sloping.

Agar Colonies : Deep colonies, round, regular, uniform; superficial colonies very large, have opaque centres and very slightly spreading edges without branching.

Broth : Turbidity ; no scum.

Gelatine : Rapid and complete *liquefaction* along line of inoculation.

Gelatine Colonies : Round or oval colonies, brown in color with great variations in size and shape.

Potato : Luxuriant brownish-red growth.

Fermentation Tube : *Dextrose Broth* : Turbidity in open bulb to which the growth is limited ; no growth in closed arm. *Reaction* of bulb *alkaline*.

Saccharose and *Lactose* not fermented.

Blood Serum : Abundant white glistening growth *without liquefaction*.

Nitrates : Reduced to nitrites.

Indol : Not produced.

Fæcal Odour : Not produced.

Litmus Milk : No preliminary acidity. Immediate alkali-production. No *coagulation* of the milk. No *peptonization* of the casein.

Occurrence and Distribution : Found but once in the intestinal contents when several cultures were obtained from the cæcum and rectum of one case.

13, BACILLUS PYLORI, Ford, 1903 (n. sp.)

Literature:

Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

First obtained from intestinal contents by Ford.

Morphology: Large bacilli measuring 1.0 by 3.0 4.0 microns, never appearing in chains.

Motility: Very actively motile. Bacilli shoot rapidly from one portion of the field to another with the velocity of a cholera vibrio.

Spores: Not formed.

Agar Slant: Spreading white translucent growth.

Agar Colonies: Deep colonies round and regular; superficial colonies spread over the surface with opaque white centres and outlying edges.

Broth: Turbidity, no scum.

Gelatine Stab: Abundant growth. *Rapid liquefaction* from surface downward.

Gelatine Colonies: Deep colonies round and regular; superficial colonies greyish with dark opaque centres and outlying translucent ring not spreading.

Potato: Luxuriant dull white growth.

Fermentation Tube: *Dextrose Broth*: Growth limited to open bulb where a heavy sediment is produced. No growth in closed arm. *Reaction* of *bulb alkaline.*

Saccharose and *Lactose* not broken up.

Blood Serum: Abundant white growth, *no liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: Preliminary acidity followed by alkali-production. *No coagulation* of the milk. *Rapid peptonization* of the *casein* and *reduction* of the *litmus.*

Occurrence and Distribution: Found but once in the intestinal contents, being isolated from the stomach of one case.

14, BACILLUS CÆCI, Ford, 1903 (n. sp.)

Literature:
Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, Vol. 1, p. 211.

First obtained from intestinal contents by Ford.

Morphology: Long thick bacilli measuring 0.75 by 2.0 - 4.0 microns, usually growing in long chains.

Motility: Very sluggishly motile.

Spores: Not formed.

Agar Shake: Brown sweaty growth along line of inoculation without spreading or sloping.

Agar Colonies: Opaque, round, non-spreading colonies.

Broth: Turbidity and rarely the production of a scum.

Gelatine Stab: Abundant growth along line of inoculation. Rapid and complete liquefaction.

Gelatine Colonies: Irregular brown colonies, often associated in long rouleaux and cork-screws.

Potato: Luxuriant yellowish-white growth.

Fermentation Tube: *Dextrose Broth*: Growth limited to open bulb where a great turbidity is produced. No growth in closed arm; *reaction alkaline*.

Saccharose and *Lactose* not broken up

Blood Serum: Abundant yellowish-white growth and a slow but complete liquefaction.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: No preliminary acidity. Intense alkali production. No coagulation. Rapid liquefaction of casein.

Occurrence and Distribution: Found in one case from which it was obtained from the stomach and rectum.

15. BACILLUS BOOKERI, Ford, 1903.

Literature and Synonym:

Bacillus A. Booker.

Sternberg, 1896, Manual of Bacteriology, p. 402.

First isolated from alvine discharges of children suffering with cholera infantum, by Booker.

Morphology: Small bacilli measuring ½ x 1½ to 2 mikrons.

Motility: Actively motile.

Spores: Not formed.

Agar Slant: Abundant yellowish or yellowish-brown growth along line of inoculation, not spreading or sloping.

Agar Colonies: Deep colonies, round, regular, opaque; superficial colonies have opaque centres and transparent thin film in periphery, which gradually merges with surrounding agar giving an indistinct bluish look.

Broth: Marked turbidity, no scum.

Gelatine: Abundant growth along line of inoculation; slow but complete liquefaction along line of puncture.

Gelatine Colonies: Round brown colonies of various sizes.

Potato: Luxuriant yellowish white growth.

Fermentation Tube: Dextrose Broth: Abundant growth in open bulb with the production of a heavy sediment. *No growth in closed arm. Alkaline reaction in bulb.*

Saccharose and Lactose also not broken up.

Blood Serum: Yellowish-brown growth. Gradual liquefaction.

Nitrates: Not reduced to nitrites.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: No preliminary acidity. Intense alkali-production. No coagulation. Slow and complete *liquefaction* of the casein with reduction of the litmus.

Occurrence and Distribution: Isolated from one case, the stomach of a foundling.

16. BACTERIUM OXYGENES, Ford, 1903 (n. sp.)

Literature:
Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

First isolated from intestinal contents by Ford.

Morphology: Bacteria measuring 0.5 by 2.0 - 3.0 microns.

Motility: Non-motile.

Spores: Not formed.

Agar Slant: Thick white glistening growth, limited to line of inoculation.

Agar Colonies: Deep colonies small brown and regular; superficial colonies large, round, translucent, spreading over the surface of the agar and assuming a bluish look.

Broth: Turbidity, no scum.

Gelatine Stab: Growth along line of inoculation, *no liquefaction*.

Gelatine Colonies: Irregular brownish colonies of various sizes and shapes, usually round or oval, not characteristic.

Potato: Very abundant yellowish-white or yellowish-brown growth, rapidly covering cut surface of potato.

Fermentation Tube: *Dextrose Broth*: Abundant growth in bulb with production of a turbidity and sediment. *Reaction alkaline*. *No growth* in *closed arm*.

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant white growth *without liquefaction*.

Nitrates: Not reduced to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: Intense acid-production. Coagulation of the milk to a dense hard mass. *No liquefaction of the casein*.

Occurrence and Distribution: Found in one case from which several cultures were obtained from the duodenum and cæcum, and from the cæcum of another case.

17. BACTERIUM BIENSTOCKII, Schröter, 1886.

Literature and Synonyms:

Bacillus ans fæces, No. iii, Bienstock,
Bienstock, Ueber die Bakterien der Fæces, Zeitschrift für klin. Med., Bd. VIII Heft 1.

Bacterium Bienstockii, Schröter.
Schroter, 1886, Pilze Schlesien, p. 163.

Bacillus coprogenes parvus, Bienstock,
Flügge, 1886, Die Mikroorganismen, 2nd edition, p. 269, 1896, 3rd edition, vol. 2, p. 423.

Bacterium Bienstockii, Schröter,
Migula, 1900, System der Bakterien, p. 393.

Bacterium Bienstockii, Schroter.
Chester, 1901, Manual of Determinative Bacteriology, p. 144.

First obtained by Bienstock from human fæces.

Morphology: Very short fine bacteria measuring 0.5 by 0.75 microns, in stained preparations barely to be distinguished from micrococci.

Motility: Non-motile.

Spores: Not formed.

Agar Slant: Growth very slow; after 48 to 72 hours only a faint film produced on agar.

Agar Colonies: Small, fine, brown, non-spreading colonies.

Broth: Turbidity, no scum.

Gelatine Stab: Slow growth along line of inoculation. *No liquefaction.*

Gelatine Colonies: Small fine regular pale brown colonies.

Potato: Hardly perceptible, greyish-white growth.

Fermentation Tube: *Dextrose Broth*: Growth in bulb, where faint turbidity is produced. *Reaction alkaline*: *No growth* in *closed arm.*

Saccharose and Lactose not fermented.

Blood Serum: Faint white film, *No liquefaction.*

Nitrates: Not reduced to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: Acid production, slow coagulation, eventual production of a dense firm mass *No liquefaction of the casein.*

Occurrence and Distribution: Isolated from the cæcum of one case.

18. BACILLUS OXYPHILUS, Ford, 1903, (n. sp.)

Literature:
Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

Isolated from intestinal contents by Ford.

Morphology: Bacilli measuring 0.75 by 2.0 microns.

Motility: Actively motile.

Spores: Not formed.

Agar Slant Abundant thick white growth.

Agar Colonies: Deep colonies round, regular and greyish; superficial colonies usually have opaque white centres and slightly radiating branches.

Broth: Turbidity and rarely a slight scum.

Gelatine Stab: Growth along line of inoculation. *No liquefaction.*

Gelatine Colonies: Irregular, round or oval colonies, presenting "broken glass" appearance.

Potato: Luxuriant brownish growth.

Fermentation Tube: *Dextrose Broth:* Growth in open bulb with the production of turbidity and sediment. *Reaction acid.* Growth in closed arm. *Reaction acid.* *No gas.*

Saccharose and Lactose not fermented.

Blood Serum: Luxuriant greyish-white growth. *No liquefaction.*

Nitrates: Reduced to nitrites

Indol: Not produced.

Fecal Odor: Not produced.

Litmus Milk: Acid-production and coagulation of the milk within 24 hours. *No peptonization of the casein.*

Occurrence and Distribution: Isolated from four cases, once from the stomach and three times from the cæcum.

19. BACTERIUM ACIDOFORMANS, Sternberg, 1892.

Literature and Synonyms:
Bacillus acidoformans:
Sternberg, 1892, Manual of Bacteriology, p. 499.
Bact. Acidoformans, Sternberg:
Chester, 1901, Manual of Determinative Bacteriology, p. 150.

Isolated from the liver of a Yellow Fever cadaver by Sternberg.

Morphology: Thick stumpy bacilli measuring 0.75 by 1.0–1.5 microns, often associated in long chains.

Motility: Non motile.

Spores: Not formed.

Agar Slant: Abundant thick white growth spreading over the surface of agar and turning brown in old cultures.

Agar Colonies: Deep colonies, minute and brownish; superficial colonies large, opaque and circumscribed.

Broth: Turbidity, without scum.

Gelatine Stab: Growth along line of inoculation. *No liquefaction.*

Gelatine Colonies: Deep colonies fine, opaque; superficial, irregular, translucent, non-spreading.

Potato: Luxuriant yellowish-white or yellowish brown growth.

Fermentation Tube: Dextrose Broth: Abundant growth in bulb with the production of a turbidity and sediment. *Reaction acid.* Abundant growth in closed arm. *Reaction acid. No gas formed.**

Saccharose and Lactose not fermented.

Blood Serum: Heavy white growth *without liquefaction.*

Nitrates: Not reduced to nitrites.

Indol: Not produced.

Fecal Odour: Not produced.

Litmus Milk: Acid reaction within 24 hours. Coagulation of the milk to a hard firm mass. *No peptonization of the curd.*

Occurrence and Distribution: Found in two cases, in the cæcum in one case and in the stomach, duodenum and cæcum alike in the other.

*I have never found that this organism produces any gas bubbles with the carbohydrates. It produces only an acidity.

20. BACTERIUM MINUTISSIMUM, Migula, 1900.

Literature and Synonyms:
Bacillus pyogenes minutissimus, Krause,
Flügge, Mikroorganismen, 1896, Bd. II, p. 447.
Bacterium minutissimum, Migula, 1900,
Migula, 1900, System der Bacterien, p. 418

Isolated by Krause from a brain abscess.

Morphology: Fine short bacilli measuring ½ by 1 micron, appearing usually as diplo-bacilli which when stained look like diplococci.

Motility: Non-motile.

Spores: Not formed.

Agar Slant: Faint transparent film visible on the surface only in 24 hour cultures, after 48 hours sinking into the depths of the medium and distinguished with difficulty.

Agar Colonies: Deep colonies not characteristic; superficial colonies pale grey, round or oval, appearing only after 48 hours.

Broth: Slow growth, with the production of a turbidity but no scum.

Gelatine Stab: Faint slow growth along line of puncture. *No liquefaction.*

Gelatine Colonies: Small round regular pale-brown or pale-yellow colonies.

Potato: Faint, white glistening growth developing after several days.

Fermentation Tube: *Dextrose Broth*: Faint turbidity in bulb with scanty sediment. *Reaction acid.* Slow growth in closed arm. *Reaction acid, no gas.*

Saccharose and Lactose not fermented.

Blood Serum: Faint white growth. *No liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: Reaction acid. Coagulation of milk after 48 hours. *No peptonization of casein.*

Occurrence and Distribution: Isolated from the rectum of one case where it was obtained in two pure cultures.

21. BACILLUS COLI, Migula, 1900.*

Literature and Synonyms:

Bacterium coli commune.
Escherich, 1886, Darmbakterien des Säuglings, Stuttgart.

Neapeler Bacillus.
Emmerich, 1884, Deutsche med Wochenschrift, No. 50.

Bacillus Neapolitanus.
Fraenkel, 1887, Grundriss der Bakterienkunde.

Emmerich's Bacillus.
Eisenberg, 1886, Bakteriologische Diagnostik.

Bacillus pyogenes-fœtidus.
Passet, 1885, Ätiol citerigen Phlegmon des Menschen, Berlin.

Bacillus coli. (Escherich.)
Migula, 1900, System der Bakterien, p. 734.

Bacillus coli communis verus.
Durham, 1900-1901, Journal of Experimental Medicine, vol. V, p. 353.

Bacillus coli (Escherich).
Chester, 1901, Manual of Determinative Bacteriology, p. 205.

First isolated by Escherich from the intestinal contents of infants.

Morphology: Short stumpy bacilli measuring 0.5 by 1.0 2.0 microns. Occurs usually in single elements but frequently in pairs and short or long chains. When unstained the long chains are seen to be made up of 15 to 20 separate bacilli linked together. May appear as a diplobacillus which when stained looks like a diplococcus. The diplococcoid forms are common in young cultures, or, as Adami has pointed out, are frequently seen in attenuated cultures from the tissues or from the gall bladder.

Motility: *Bacillus coli* always possesses a well defined motility which, while not especially active, is always sufficient to differentiate it from any bacteria. In the 200 cultures of this bacillus which were obtained at various intervals, unquestioned motility was demonstrated in every culture. The motility is usually less than that of *Bacillus typhosus* or that of *Ps. aeruginosa (Bacillus pyocyaneus)* but occasionally cultures are encountered where the bacilli move across the field with the velocity of a *cholera vibrio*. Usually a *moderate motility*.

Spores: At no time observed. The diplococcoid form is considered by Adami to represent an attempt on the part of the bacillus, when grown under unfavorable conditions, to assume a more resistant state, but one distinct from spore formation.

Agar Slant: Glistening white or yellowish white growth extending rapidly along the line of inoculation, spreading and sloping to the bottom of the tube, where it developes luxuriantly. In old cultures the growth becomes dirty brown, especially after drying. Attenuated forms grow as a faint white film on the surface of agar.

Agar Colonies: Deep colonies, round or oval, regular, sharply cut edges, slightly brown in color, nail-form growth often seen; superficial colonies are slightly opaque, brownish, either circumscribed or spreading over the surface of the agar and assuming diverse forms, sometimes occupying the whole plate.

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*The correct name of this organism is probably *Bacillus Neapolitanus*, which was the first use of a binominal species name. It seems better, however, to retain Migula's name.

Broth: Turbidity and heavy sediment settling to the bottom of the tube. Slight filmy scum on the surface sticking to the sides of the tube, easily broken up and sinking to the bottom. Slight movements such as handling the broth tube when transferring it from one place to another, are sufficient to dislodge the film. At no time is a scum like that of *Ps. aeruginosa (B. pyocyaneus)* with its firm glistening surface or that of *Bacillus subtilis* with its hard leathery look, formed by *Bacillus coli*.

Gelatine Stab: Abundant growth along line of inoculation and spreading over the surface of the gelatine. *No liquefaction.*

Gelatine Colonies: Deep colonies regular, round or oval, brownish in color; superficial colonies, opaque, brownish, slightly spreading.

Potato: Growth varies from faint white glistening barely perceptible film to an abundant yellowish brown or even reddish brown mass covering the entire cut surface of the potato.

The variations in the growth depend more on the nature and composition of the potato than upon any variations in the bacillus itself, as a number of potato tubes inoculated with the same culture will show every conceivable gradation in extent and character of growth.

Fermentation Tube: *Dextrose Broth*: Abundant growth in bulb with the production of a turbidity and heavy sediment. Rarely, a faint film on the surface. *Reaction* in bulb *acid*. Abundant growth in closed arm with rapid evolution of *gas*. *Reaction* in closed arm *acid*.

The amount of gas from the dextrose broth varies considerably in quantity, this quantity depending somewhat on the temperature at which the growth takes place, and somewhat upon the character of the culture itself. The first evolution of gas is deceptive, as the fermentation tubes when kept for a number of days allow approximately the same quantity of gas to collect.

Saccharose not broken up to either *acid* or *gas*.

Lactose split up with the production of *acid* and *gas*. The quantity of gas from lactose varies considerably, but if the lactose tubes be observed for some time the amount of gas in the different tubes will be found to reach nearly the same level.

Blood Serum: Abundant white growth over the surface. *No liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Usually produced abundantly. The amount is greater in old cultures and also in cultures freshly isolated from the lower portion of the intestinal tract. At times cultures from the stomach give positive indol reactions. Again, cultures of organisms which are undoubtedly *Bacillus coli* fail to produce indol.

Fecal Odour: Usually produced. Not to be regarded as necessary for the identification of *Bacillus coli* as many cultures fail to exhibit it.

Litmus Milk: Abundant acidity invariably produced within 48 hours. Amount of acid constantly increasing, milk usually coagulated on the second day. When the coagulation of milk takes place early, the coagulum is dense and firm but white or pink in color. The amount of acid constantly increases and the coagulum assumes a pink color which is increased in the presence of oxygen. Shaking the tube and breaking up the coagulum produces a deep pink. In other cases an acidity is produced early but the coagulation is delayed for some days, sometimes for a period of three weeks. *Coagulation always eventually* takes place even though delayed for some time.

Frequently the transfer of the milk tubes from a lower to a higher temperature, as from that of the room to that of the thermostat, will induce coagulation in specimens in which the coagulation has failed to appear. Heating in the gas flame also throws down the casein. The time at which coagulation ensues depends somewhat on the quality of the milk used, as freshly inoculated tubes will occasionly reveal an immediate coagulation with the same bacillus which originally failed to coagulate for days. In two instances cultures were encountered which coagulated milk within 18 hours,

the coagulum remaining white and colorless. In all other respects this organism corresponded to a typical *Bacillus coli*. Booker, 1889, has also referred to this variety.

Under all circumstances the production of acidity and the coagulation of milk must be regarded as essential to the diagnosis of Bacillus coli. No production of alkali at any period. No peptonization of the casein.

Occurrence and Distribution: Found in twenty-seven different cases, *i.e.*, in over 50% of the cases examined, and thus is slightly more frequent than *Bacillus communior* of Durham.

Isolated from the rectum alone in five cases, from the cæcum alone in four cases, from the duodenum alone in two cases and from the stomach alone in one case.

Isolated from two portions of the intestinal tract in ten cases; from cæcum and rectum in six cases, rectum and duodenum once, rectum and stomach once, and stomach and duodenum twice.

It was obtained from three portions of the intestinal tract in four cases; from stomach, duodenum and cæcum twice; from stomach, duodenum and rectum once, and from duodenum, cæcum and rectum once. In one case found in the stomach, duodenum, cæcum and rectum.

It is thus seen to be one of the most common inhabitants of the intestinal tract, appearing in all its regions, but especially favouring a location in the cæcum and rectum, although wandering frequently to the duodenum and stomach, where it grows abundantly and where its cultures produce characteristic reactions on culture media.

22. BACILLUS COMMUNIOR, Ford, 1903.

Literature and Synonymy:

Bacillus coli communior.

Durham, 1900-1901, Journal of Experimental Medicine, vol. V, p. 353.

Ford, W.W., 1900, Classification of Intestinal Bacteria, Journ. of Medical Research, vol. I, p. 211.

As already stated, Durham has called attention to the fact that the variety of *Bacillus coli*, which was originally described by Escherich, is not endowed with the property of fermenting Saccharose, and that this variety is not as common in the intestinal tract as the organism fermenting the three sugars. Our observations on the intestinal flora substantiate Durham's conclusions in their main details. There are two great groups of *Bacillus coli* to be separated by their capacity of splitting up Saccharose, as has already been mentioned, to one of which the name, *Bacillus coli, Escherich*, is exactly applicable, while for the other the name, *Bacillus communior*, may be utilized, reserving as a synonym the term originally proposed by Durham, *Bacillus coli communior*.

In regard to the frequency with which these two microorganisms are present in the intestinal contents, we were unable to confirm Durham's work. The *Bacillus coli* fermenting Saccharose is somewhat less common than the true *Bacillus coli* of Escherich, and thus the name *Bacillus communior* may not be interpreted numerically although it be retained as a specific name.

The cultures of *Bacillus communior* agree in all important respects with the pure type of this species, in morphology, motility, non-liquefaction, acid-production and in their reactions with dextrose broth in the fermentation tube. *Saccharose* is fermented, however, with the production of *acidity* and much *gas*.

Occurrence and Distribution: Obtained in twenty-six cases out of fifty examined, as compared with twenty-seven for the *verus*; and in forty-four portions of the intestinal tract as compared with forty-seven for the verus.

Found in one portion of intestinal tract alone in fourteen cases, in eight of which it was isolated from the rectum, in two from the cæcum, in one from the duodenum and in three from the stomach. In seven cases it appeared in two regions in the combinations, rectum and cæcum three times, rectum and duodenum once, cæcum and duodenum once, and duodenum and cæcum twice.

In four cases it was obtained from three portions: rectum, cæcum and stomach twice, cæcum, stomach and duodenum twice. In one case it was obtained from all the different regions of the intestine examined, appearing concurrently in the stomach, duodenum, cæcum and rectum. It thus is present in all portions of the bowel, especially towards the lower end, but is able to occupy the duodenum and stomach as well.

23. BACTERIUM AEROGENES, Migula, 1900.

Literature and Synonyms:

Bacterium lactis aerogenes.
Escherich, 1886, Die Darmbacterien des Säuglings, Stuttgart, p. 57

Bacterium acidi.
Babinsky, 1888, Zeitschrift f. Phys. Chemie, 12, p. 434.

Bacillus aerogenes.
Kruse, 1896, Flügge, Die Microorganismen, p. 340.

Bacterium aerogenes. (Escherich.) Migula.
Migula, 1900, System der Bakterien, p. 396.

Bacterium aerogenes. Escherich.
Chester, 1901, Manual of Determinative Bacteriology, p. 128.

First isolated by Escherich from the intestinal contents of infants.

Morphology: Short stubby bacteria usually measuring 0.75 by 1.0 microns. When stained these forms resemble large cocci. When unstained are seen to be short bacteria. Longer bacteria of the same diameter as the typical forms are frequently met with, their length approximating 2.0 microns, the diameter, however, being identical with that of the short stubby forms. Milk cultures show the development of a capsule the presence of which contributes to the peculiar thick form of the micro-organism.

The morphology of *Bacterium aerogenes* is always characteristic and is of prime importance in its identification.

Motility: Motility cannot be demonstrated at any time either in agar and broth cultures, or in old cultures.

Spores: Not formed.

Agar Shake: Abundant thick white glistening growth, usually heaped up at the edges and along the line of inoculation. It often spreads over the surface and slopes to the bottom of the tube. It rarely penetrates deeply beneath the surface of the agar, and it recovers its typical appearance after several inoculations.

Agar Colonies: Deep colonies round and regular; superficial colonies thick, opaque, raised slightly from the surface and circumscribed in outline.

Broth: Great turbidity, abundant sediment and usual production of scum.

Gelatine: Thick growth along line of inoculation and spreading over the surface of the gelatine. *No liquefaction.*

Gelatine Colonies: Deep colonies, round, regular, greyish brown; superficial colonies, thick, opaque, porcelain white.

Potato: Thick, yellowish-white or yellowish-brown growth with peculiar wart-like elevations along the edges and upon the surface.

Fermentation Tube: *Dextrose Broth*: Turbidity and sediment in bulb. *Reaction acid in bulb.* Abundant growth in closed arm with the production of an *acid reaction* and much *gas.*

Saccharose and *Lactose* also fermented with the production of *gas* and *acid.*

Blood Serum: Abundant glistening white growth. *No liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Usually not produced. Occasionally typical cultures of *Bacterium aerogenes* give characteristic and positive reactions for indol.

Litmus Milk: Acidity produced within 18 hours. Coagulation of the milk usually within the first 24 hours, the coagulum being a pale pink in color. The color deepens with the production of acidity and by the free access of oxygen to the coagulum. The coagulation may be delayed 15-20 days, but always eventually

develops. It may frequently be hastened by rapid changes of temperature. Bacteria which, with some specimens of milk coagulate only at a late date, will coagulate other samples within 48 hours. Occasionally a perfectly white coagulum is produced in the first day, only a faint acidity developing, analogous to certain cultures of *Bacillus coli*. *No peptonization of casein.*

Production of acidity and coagulation of milk essential in the identification of *Bacterium aerogenes.*

Occurrence and Distribution: Isolated from thirty-one different cases, thus being the most frequent microorganism in the intestinal tract. In the thirty-one cases it was found in fifty-six different regions.

In twelve cases it was obtained from one region of the bowel alone, from the stomach in five cases, from the duodenum in three cases, from the cæcum in three and from the rectum in one case. It was found in combination in two regions in fifteen cases; in stomach and duodenum four times, in stomach and cæcum four times, in stomach and rectum twice, in duodenum and cæcum four times and in the cæcum and rectum once.

Three times it was seen in three different portions of the intestinal tract, stomach, duodenum and cæcum, once; stomach, cæcum and rectum, once; and in the duodenum, cæcum and rectum, once. It was obtained from all four regions of the intestines examined in one case, stomach, duodenum, cæcum and rectum.

The *Bacterium aerogenes* thus enjoys a very wide distribution in the intestinal contents, being most frequently seen in the stomach and duodenum, but also being carried down to the cæcum and rectum where it dwells side by side with *Bacillus coli.*

NOTE. If the code of botanical nomenclature be adhered to the name of this organism is probably *Bacterium aerogenes*, Bulevsky, 1895. For the sake of uniformity I have retained Migula's name here as in the case of *B. coli.*

24, BACTERIUM DUODENALE, Ford, 1903 (n. sp.)

Besides the typical *Bacterium aerogenes*, capable of fermenting three sugars, a micro-organism corresponding in its main cultural features to *Bacterium aerogenes* but differing in regard to its inability to ferment Saccharose, is a common inhabitant of the intestines. To this organism the name *Bacterium duodenale* may be given, indicating its more frequent habitat, the duodenum.

In morphology, lack of motility, non-liquefaction and reactions with the fermentation tube, it agrees with *Bacterium aerogenes.*

It was isolated from twenty-eight different cases and from forty-five different regions. It was found in one region alone in eighteen cases, in the stomach in five, in the duodenum in three, in the cæcum in six and in the rectum in four cases; in stomach and duodenum once; in stomach and rectum once and in the cæcum and rectum twice. In five cases it was seen in three regions, stomach, duodenum and cæcum three times, and stomach, duodenum and rectum twice. In one case it was found in stomach, duodenum, cæcum and rectum.

The *Bacterium duodenale* is thus most frequently found in the stomach and duodenum, but may be carried down to the cæcum and rectum. Like *Bacterium aerogenes* it prefers, however, a location in the upper portion of the intestines.

25. BACILLUS GASTRICUS, Ford, 1902 (n. sp.)

Literature:

Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

First obtained from the intestinal contents by Ford.

Morphology: Small bacilli measuring 0.5 by 2 – 3.0 microns, appearing as single elements or rarely in short chains.

Motility: Active motility; bacilli move rapidly from one portion of the field to another.

Spores: Not formed.

Agar Slant: Glistening white or yellowish white abundant growth, usually limited to line of inoculation.

Agar Colonies: Deep colonies round and regular; superficial colonies thick, opaque, non-spreading.

Broth: Turbidity, no scum.

Gelatine Stab: Rapid and complete liquefaction from surface downward, the fluid gelatine forming a thick layer above the solid within 24 hours.

Gelatine Colonies: Deep colonies round and regular; superficial colonies of various dimensions, opaque with dark centres and slightly spreading periphery.

Potato: Luxuriant brownish or brownish-red growth.

Fermentation Tube: *Dextrose Broth*: Abundant growth in open bulb with the production of turbidity and a heavy sediment. *Reaction acid* in bulb. Growth in closed arm with the evolution of *gas* and an *acid reaction*.

Saccharose and Lactose also fermented with the production of *acidity* and *gas*.

Blood Serum: Abundant dark-yellow or greenish-brown growth. *No liquefaction*.

Nitrates: Reduced to nitrites.

Indol: Usually produced.

Fæcal Odour: Usually produced.

Litmus Milk: Rapid production of acidity, coagulation of the milk, coagulum dense and firm. No *peptonization of the casein*.

Occurrence and Distribution: Found in seven different cases, from which it was isolated twice from the stomach, twice from the cæcum, twice from the rectum and once from the stomach, cæcum and rectum together.

26. BACILLUS SUBGASTRICUS, Ford, 1902 (n. sp.)

Literature:

Ford, W. W., 1901, Classification of Intestinal Bacteria. Journal of Medical Research, vol. 1, p. 211.

An organism differing from *Bacillus gastricus* in not fermenting Saccharose, but in agreeing with it in its general cultural features was isolated from two cases.

To this bacillus the name *Bacillus subgastricus* may be given. It was obtained from the stomach and duodenum in one case, and from the duodenum and cæcum in another.

27. BACTERIUM LIQUEFACIENS (Eisenberg, 1892) Ford, 1902.

Literature and Synonym:
Bacillus liquefaciens.
Eisenberg, 1892, Bakt. Diagnostik, p. 13.

Originally obtained by Eisenberg from feces, later from water.

Morphology: Broad thick bacteria, measuring 0.75 by 2.0 in dimensions.

*Motility**: Non-motile.

Spores: Not formed.

Agar Slant: White glistening abundant growth, thick and heaped up along line of inoculation, but not spreading or sloping.

Agar Colonies: Deep colonies, round and regular; superficial colonies, large, round, opaque, circumscribed, varying greatly in size.

Broth: Turbidity, no scum.

Gelatine Stab: Slow growth along line of inoculation; cone-like liquefaction appearing on the 5th or 6th day and progressing slowly; no surface growth.

Gelatine Colonies: Deep colonies, round and regular; superficial colonies, slightly spreading, greyish, looking like broken glass when thickly sown.

Potato: Luxuriant dirty-brown growth.

Fermentation Tube: *Dextrose Broth*: Abundant growth in bulb with turbidity and sediment. *Reaction* in bulb *acid*. Growth in closed arm with the evolution of *gas* and the production of an *acid reaction*.

Saccharose and *Lactose* also fermented to *acid* and *gas*.

Blood Serum: Abundant yellowish growth. *No liquefaction*.

Nitrates: Reduced to nitrites.

Indol: Abundant.

Fecal Odour: Frequently present.

Litmus Milk: Acidification and coagulation of the milk within 48 hours. *No peptonization* of the casein.

Occurrence and Distribution: Found in two cases, once in the stomach and once in the duodenum.

28. BACTERIUM SUBLIQUEFACIENS, Ford, 1902 (n. sp.)

Organisms agreeing in their main cultural features with the preceding, but failing to ferment *Saccharose*, are more frequently present in the intestines than are the typical form. To them the name *Bacterium subliquefaciens* may be given. They were met with in three cases, once in the duodenum, once in the cæcum, and once in combination in the stomach and rectum.

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*For the Motility of this organism our observations agree with those of Fuller and Johnson, 1900, who consider it non-motile, and therefore a bacterium and not a bacillus.

29. BACILLUS CLOACÆ, Jordan, 1890.

Literature:
Jordan, 1890, Report of the State Board of Health of Massachusetts, Part II, p. 836.
Migula, 1900, System der Bakterien, p. 722.
Chester, 1901, Manual of Determinative Bacteriology, p. 232.

First obtained by Jordan from sewage.

Morphology: Short thin bacilli, measuring 0.5 – 1.0 by 1 – 2.0 microns.

Motility: Actively motile.

Spores: Not formed.

Agar Slant: Porcelain-white glistening growth, spreading over the surface of the agar.

Agar Colonies: Deep colonies, round and regular; surface colonies thick, opaque, round or with opaque white centres with thin outlying periphery.

Broth: Turbidity and frequently a thin scum.

Gelatin Stab: Complete, usually rapid liquefaction, fluid gelatine lying above the solid medium. In certain cultures the liquefaction is very slow.

Gelatine Colonies: Deep colonies, round, regular, yellowish; superficial colonies, thin, bluish, translucent.

Potato: Luxuriant dull-white or yellowish-white growth.

Fermentation Tube: *Dextrose Broth*: Sediment and turbidity in bulb; *reaction acid*. Abundant growth in closed arm. Evolution of *gas* and an *acid reaction*.

Saccharose and Lactose alike fermented to *acid* and *gas*.

Blood Serum: Abundant growth, *liquefaction slow, but complete* after 10 to 12 days.

Nitrates: Reduced to nitrites.

Indol: Usually produced.

Fæcal Odour: Usually present.

Litmus Milk: Slow development of acidity and eventual coagulation of the milk. Gradual *peptonization* of the casein.

Occurrence and Distribution: Found in nine different cases from which it was isolated, four times from the stomach, once from the duodenum, twice from the cæcum, once from the stomach and cæcum together, and once from the cæcum and rectum together.

30. BACILLUS SUBCLOACÆ, [illegible], 1902 (n. sp.)

Organisms corresponding to *Bacillus cloacæ* in all respects except in their fermentation of Saccharose may conveniently be grouped together under the name *Bacillus subcloacæ*. They were isolated from the intestinal contents in five cases, from stomach, duodenum, cæcum and rectum separately once, and from the duodenum, cæcum and rectum together once.

31. BACILLUS ILIACUS, Ford, 1903 (n. sp.)

Literature:
Ford, W. W., 1903, Classification of Intestinal Bacteria. Journal of Medical Research, Vol. 1, p. 211.

Morphology: Very large bacilli measuring 0.75 by 3–4.0 microns, appearing invariably as single elements.

Motility: Actively motile, the bacilli shooting rapidly from one portion of the field to another.

Spores: Not formed.

Agar Slant: White glistening growth spreading over the whole surface of the agar.

Agar Colonies: Deep colonies, round and regular; superficial colonies opaque spreading rapidly over the surface, with thick opaque centres and thin translucent margins.

Broth: Turbidity and thick scum.

Gelatine Stab: Rapid growth along line of inoculation with complete liquefaction of the gelatine from the surface downward.

Gelatine Colonies: Deep colonies regular, slightly brown; superficial colonies large, translucent and spreading.

Potato: Abundant yellowish-brown growth.

Fermentation Tube: *Dextrose Broth*: Rapid growth in bulb with the production of a scum and turbidity. *Reaction in tube.* Growth in closed arm with the evolution of *gas* and the formation of *acid.*

Saccharose also fermented with the production of *gas* and *acidity.*

Lactose not broken up to either *acid* or *acid* and *gas.*

Blood Serum: Abundant dull-brown growth with a rapid and complete liquefaction.

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: Rapid acidification and coagulation with an early *peptonization* of the casein and a reduction of the litmus.

Occurrence and Distribution: Found in the duodenum of one case and the cæcum of another. A large number of different cultures at first giving anomalous reactions later proved to be identical.

32, BACILLUS CHYLOGENES, Ford, 1903 (n. sp.)

Literature:
Ford, W. W., 1901. Classification of Intestinal Bacteria, Journal of Medical Research, vol. 1, p. 211.

First obtained from intestinal contents by Ford.

Morphology: Small, fine bacilli, measuring about 0.5 by 1.0 microns, appearing as diplo-bacilli which, when stained, look like diplo cocci.

Motility: Actively motile.

Spores: Not formed.

Agar Slant: Pale, almost transparent film, almost invisible even after the lapse of 48 hours.

Agar Colonies: Deep colonies, very fine pale brown; superficial colonies, oblong or nail-shaped, very small, pale brown in color; growth very slow.

Broth: Marked turbidity after 48 to 72 hours. No scum.

Gelatine Stab: Slow growth along line of inoculation, with beginning *liquefaction*, which is completed only after 6-8 days.

Gelatine Colonies: Small, round, regular, non-characteristic, deep and superficial colonies.

Potato: Growth varies from a scanty white to a pale yellow brown appearing after 48 hours

Fermentation Tube: *Dextrose Broth*: Turbidity in bulb with a scanty sediment. *Reaction acid* in *bulb*. Slow growth in closed arm. *Reaction* in *arm acid*. *No gas.*

Saccharose and *Lactose* not fermented to *acid* alone nor to *acid* and *gas*.

Blood Serum: Abundant pale white growth developing very slowly, but not producing any liquefaction.

Nitrates: No reduction to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: Within 48 hours production of a slight acidity which constantly increases till the milk is coagulated, and a pink color is eventually produced *No peptonization of casein.*

Occurrence and Distribution: Found in one case where it was isolated in two pure cultures from the stomach.

33. BACTERIUM CHYMOGENES, Ford, 1903 (n. sp.)

Literature:

Ford, W. W., 1903, Classification of Intestinal Bacteria, Journal of Medical Research, vol. 1, p. 211.

First obtained by Ford from intestinal contents.

Morphology: Bacteria measuring 0.5 by 2.0 microns in dimensions.

Motility: Non-motile.

Spores: Not formed.

Agar Slant: Abundant white glistening growth, heaped up above line of inoculation.

Agar Colonies: Deep colonies, round and regular; surface colonies, large, opaque, round, circumscribed, varying greatly in size.

Broth: Turbidity, no scum.

Gelatine Stab: Slow growth along line of inoculation; slow *liquefaction* complete after 7-8 days.

Gelatine Colonies: Deep colonies, round regular; superficial colonies, large regular, refractile, non-characteristic.

Potato: Luxuriant dirty brown growth.

Fermentation Tube: Dextrose Broth. Turbidity and sediment in bulb. *Reaction* in bulb *acid.* Growth in closed arm with the production of *acidity*, but no *gas.*

Saccharose and *Lactose* not fermented, to either *acid* or *acid* and *gas.*

Blood Serum: Abundant growth, yellowish-white. *No liquefaction.*

Nitrates: Not reduced to nitrites.

Indol: Not produced.

Fecal Odor: Not produced.

Litmus Milk: Acidification and coagulation within 48 hours. No *digestion* of the casein.

Occurrence and Distribution: Found in two cases, from one of which it was isolated from the duodenum, and from the other from the duodenum and rectum.

34. BACILLUS LEPORIS, Migula, 1900

Literature and Synonyms:

Bacillus leporis lethalis.
Sternberg, 1892, Textbook of Bacteriology, p. 478.

Bacillus leporis (Sternberg) Migula.
Migula, 1900, System der Bakterien, p. 631.

Bacillus leporis (Sternberg).
Chester, 1901, Manual of Determinative Bacteriology, p. 243.

Isolated first by Gibier and later by Sternberg from the contents of the intestine in yellow fever.

Morphology: Very long, thin bacilli measuring 0.5 by 4–6.0 microns, always made up of long single elements and never appearing in chains.

Motility: Bacilli are very actively motile, shooting rapidly from one portion of the field to another with the velocity of a culture of *Ps. aeruginosa* (*B. pyocyaneus*).

Spores: Not formed.

Agar Shake: Abundant white glistening growth in young cultures, but rapidly drying and turning brown in old cultures.

Agar Colonies: Deep colonies round and uniform; surface colonies round, slightly spreading, with serrated edges, greyish in color.

Broth: Turbidity. No scum.

Gelatine Stab: Abundant growth, rapid and complete liquefaction, beginning at the surface and proceeding downwards.

Gelatine Colonies: Deep colonies, round, translucent, light-yellow; surface colonies transparent, spreading, with broken-glass appearance.

Potato: Luxuriant yellowish-brown growth within 3-4 days.

Fermentation Tube: Dextrose Broth: Turbidity and sediment in bulk. *Acid reaction.* Growth in closed arm with the production of an *acid reaction* but no *gas*.

Saccharose and Lactose alike fermented to *acid* but no *gas*.

Blood Serum. Abundant growth in 24 hours. Rapid and complete *liquefaction* of the blood serum.

Nitrates: Reduced to nitrites.

Indol: Usually produced.

Fecal Odor: Rarely produced.

Litmus Milk: Rapid acidification and coagulation of the milk. No *peptonization* of the casein or reduction of the litmus.

Occurrence and Distribution:
Found in one case in which it was isolated from the rectum.

35. BACILLUS DUBIUS, Kruse, 1896.

Literature:

Bleisch, 1894, Zeitschrift für Hygiene, vol. 13, p. 31.
Flügge, 1896, Die Mikroorganismen.
Chester, 1901, Manual of Determinative Bacteriology, p. 237.

First isolated from faeces by Bleisch.

Morphology: Short, thin bacilli measuring 0.75 by 2.0 microns, sometimes appearing in pairs.

Motility: Actively motile.

Spores: Not formed.

Agar Stab: Moderate filiform growth, yellowish growth, turning brown in old cultures.

Agar Colonies: Deep colonies round and regular, opaque; superficial colonies grey, spreading over surface, corrugated or skein-like in appearance.

Broth: Turbid. No pellicle.

Gelatine Stab: Abundant growth along line of inoculation. Rapid and complete liquefaction, usually within three days.

Gelatine Colonies: Deep colonies round and regular; superficial colonies fine, irregularly spreading, greyish brown.

Potato: Abundant grey-brown glistening mass.

Fermentation Tube: Dextrose Broth: Abundant growth in broth with a heavy sediment. *Reaction to both acid.* Abundant growth in closed tube with an *acid reaction* but no gas.

Saccharose and *Lactose* not fermented to acid or gas.

Blood Serum: Yellowish growth and is slow but complete [illegible].

Nitrates: Reduced to nitrites.

Indol: Produced in small quantities.

Fecal Odour: Produced in small amount.

Litmus Milk: Acidification and coagulation within 48 hours [illegible] peptonization of the casein with a reduction of the litmus.

Occurrence and Distribution: Isolated from the faeces of [illegible] was obtained in three pure cultures.

36, BACILLUS JEJUNALIS, Ford, 1902 (n. sp.)

Literature:
Ford, W. W., 1901, Classification of Intestinal Bacteria, Journal of Medical Research, vol. 1, p. 211.

First isolated from intestinal contents by Ford.

Morphology: Short bacilli measuring 0.5 by 2.0 microns, appearing as single elements or as long chains.

Motility: Actively motile.

Spores: Not formed.

Agar Slant: Abundant thick white growth within 48 hours.

Agar Colonies: Deep colonies, round regular, dark brown; superficial colonies, may be large, translucent, pale blue, or spreading, with opaque centres and filmy transparent margins, assuming star shapes or bizarre shapes.

Broth: Turbidity but no scum.

Gelatine Stab: Abundant growth. Rapid and complete liquefaction.

Gelatine Colonies: Deep colonies, fine, brown, regular; superficial colonies are large, irregular, slightly spreading, dark brown in color.

Potato: Luxuriant glistening white growth.

Fermentation Tube: *Dextrose Broth*: Turbidity and sediment in bulb.

Reaction in bulb *acid*. Abundant growth in closed arm with the production of *acidity* but no *gas*.

Saccharose and *Lactose* not fermented to acid or gas.

Blood Serum: Slow white growth, becoming very luxuriant after 8-10 days, and causing a complete liquefaction of the medium.

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: Acidification and coagulation within 48 hours. Slow peptonization of the casein but no reduction of the litmus.

Occurrence and Distribution: Found in one case from which it was obtained in several cultures from the stomach.

37. PSEUDOMONAS AERUGINOSA (Schröter, 1872), Migula, 1900.

Literature and Synonyms:

Bacterium aeruginosum.

Schröter, 1872, Ueber einige durch Bakterien gebildete Pigmente, Cohn's Beitrage zur Biologie, Bd. I, p. 126.

Bacillus aeruginosus, Schroter, 1872.

Schröter, 1886, Kryptog. Flora von Schlesien, Bd. 3, p. 157.

Bacillus pyocyaneus.

Gessard, 1882, De la pyocyanine et de son microbe, Thèse de Paris.

Pseudomonas pyocyanea.

Migula, 1896, Die Natürlichen Pflanzenfam.

Pseudomonas pyocyanea (Gessard) Migula.

Chester, 1901, Manual of Determinative Bacteriology, p. 321.

Migula, 1896, System der Bakterien, p. 884.

First accurately described by Gessard in 1882. Found frequently on the surface of the body, in the mouth, intestines, and in many pathological conditions.

Morphology: Fine bacilli measuring 0.5 by 2.0 microns, appearing as single elements, pairs and short chains.

Motility: Actively motile, bacilli shooting rapidly from one portion of the field to another.

Spores: Not formed.

Agar Stab: Abundant glistening white growth within 24 hours, rapidly producing a bright green pigment which is imparted to the medium. The growth itself rapidly turns dark brown.

Agar Colonies: Deep colonies, round and regular, yellowish; superficial colonies large, spreading with darker centres and translucent edges, assuming various bizarre formations and producing a green color in the surrounding agar.

Broth: Great turbidity and heavy tenacious scum rapidly formed. Bright green fluorescence produced.

Gelatine Stab: Abundant growth along line of inoculation and on the surface. Rapid liquefaction of the gelatine which assumes a bright green color.

Gelatine Colonies: Deep colonies round and regular, yellowish; superficial colonies, yellowish or greenish yellow, fringed, irregular, producing a skein-like formation.

Potato: Luxuriant dirty brown growth, the potato assuming a greenish color.

Fermentation Tube; *Dextrose Broth*: Abundant turbidity with the formation of a thick scum. *Reaction* of bulb *alkaline*. *No growth* in *closed arm*. Dextrose broth assumes a bright green color.

Saccharose and *Lactose* also show a heavy scum and assume a bright green color.

Blood Serum: Rapid growth, the serum turning bright green and rapidly being liquefied.

Nitrates: Not reduced to nitrites.

Indol: Not produced.

Fecal Odour: Not produced, in its place a characteristic odour of trimethylamin.

Litmus Milk: Reaction of Litmus unchanged; no acid production, no alkali production, no coagulation. Rapid digestion of the casein and reduction of the litmus.

Fluorescence and *Chromogenesis*: Greenish.

Occurrence and Distribution: Frequently present in the intestinal contents. Found in nine cases, being isolated from one portion of the intestines alone in five cases, four times from the rectum and once from the cæcum. In one case found in the duodenum and rectum. In three cases it was isolated from every portion of the intestines, appearing simultaneously in stomach, duodenum, cæcum and rectum.

38. PSEUDOMONAS OVALIS (Ravenel, 1896). Chester. 1901.

Literature and Synonym:

Bacillus fluorescens ovalis.

Ravenel, 1896, Memoirs National Academy of Sciences, No. 9.

Pseudomonas ovalis.

Chester, 1901, Manual of Determinative Bacteriology, p. 345.

First obtained from the soil by Ravenel.

Morphology: Very fine bacilli measuring 0.5 by 2.0 microns, appearing usually as single elements.

Motility: Actively motile. Bacilli shoot rapidly from one portion of the field to another.

Spores: Not formed.

Agar Slant: Thick, white abundant growth. No pigment production. Green fluorescence produced only in 6-8 days.

Agar Colonies: Deep colonies fine, colorless; superficial colonies round, regular, circumscribed, opaque, gradually producing a greenish fluorescence.

Broth: Scum and turbidity.

Potato: Luxuriant dirty brown growth.

Fermentation Tube: *Dextrose Broth*: Turbidity in bulb. Scum on surface of broth. *Reaction* in bulb *alkaline*. No growth in closed arm. Abundant green fluorescence.

Saccharose and *Lactose* show a green fluorescence, scum on surface but no fermentation.

Gelatine Stab: Abundant growth along line of puncture. *No liquefaction.*

Gelatine Colonies: Deep colonies, fine, regular, colorless; superficial colonies irregular, with faint prolongations, which give a granular appearance like broken glass.

Blood Serum: Abundant growth without liquefaction.

Nitrates: Reduced to Nitrites.

Indol: Not produced.

Fæcal Odour: Not produced.

Litmus Milk: No preliminary acidity. Alkali production immediate. No coagulation of the milk. No digestion of the casein. No reduction of the litmus.

Fluorescence: Green in all fluid cultures and in old agar tubes. No chromogenesis.

Occurrence and Distribution: Found in the cæcum of one case.

39. BACTERIUM HAVANIENSE (Sternberg, 1892), Chester, 1901.

Literature and Synonym:

Bacillus Havaniensis.

Sternberg, 1892, Manual of Bacteriology, p. 718.

(Not *Bacillus Havaniensis* of Migula, 1900.)

Bacterium Havaniense (Sternberg.)

Chester, 1901, Manual of Determinative Bacteriology, p. 178.

First isolated by Sternberg from the intestinal contents of yellow fever cadavers.

Morphology: Short line bacteria measuring 0.5 by 0.75 microns, in stained preparations looking like micrococci or diplococci. In unstained preparations seem to be true bacteria.

Motility: Non-motile.

Spores: Not formed.

Agar Slant: Bacteria grow rapidly on agar, forming a dull, thick, white growth. Occasionally a carmine red growth is produced at the temperature of the body within 24 hours, but usually the pigment production is delayed for 48 to 72 hours. Pigment is formed at the edge of the growth which after 6-8 days is completely colored. Cultures freshly isolated from the intestine show a much more rapid pigment production. Growth never tenacious. *No fluorescence.*

Agar Colonies: Deep colonies round and regular, colorless; superficial colonies may be white, opaque or carmine red, with other colonies showing gradations between the two. The colonies are usually white with reddish margins. In the same plate all the varieties of colonies may be seen. After the lapse of 48 or 72 hours the colonies all became carmine red.

Broth: Turbidity and heavy scum. No fluorescence.

Gelatine Stab: Rapid growth and complete liquefaction. Gelatine turned a brilliant red.

Gelatine Colonies: *Characteristic appearance.* Gelatine is liquefied within 24 hours and assumes a bright red color. Floating about in the liquefied gelatine are numerous small colonies with dark red centres and lighter peripheries. No odor from gelatine plate.

Potato: Luxuriant growth, at first white but rapidly becoming a dark red.

Fermentation Tube: *Dextrose Broth*: Heavy scum and great turbidity.

Reaction acid. Growth in closed arm. *Acid reaction. No gas.*

Saccharose fermented to *acid* and *gas.*

Lactose not fermented to *acid* or *gas.*

Blood Serum: Abundant carmine red growth. *No liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fecal Odor: Not produced.

Litmus Milk: Reaction of milk remains unchanged. No demonstrable production of acid or alkali. Coagulation of the milk with digestion of the casein and reduction of the litmus.

Occurrence and Distribution: Found in one case in which it was isolated from the rectum.

40, BACTERIUM LUTESCENS, Migula, 1900.

Literature and Synonym:

Der Gelbe Bacillus.

Migula, 1900, System der Bakterien, p. 476.

Lustig, 1893, Diagnostik der Bakterien des Wassers, p. 78.

First isolated by Lustig from water.

Morphology: Short bacteria measuring 0.5 by 0.75 microns, appearing like cocci and diplococci in stained preparations.

Motility: Non-motile.

Agar Slant: Growth slow. Pale yellow at first, later turning to a golden yellow. *No fluorescence.*

Agar Colonies: Deep colonies round, regular and pale yellow; superficial colonies circumscribed, white colonies later becoming golden yellow.

Broth: Turbidity. No scum. No fluorescence.

Gelatine Stab: Slow growth. Gradual complete liquefaction.

Gelatine Colonies: Deep colonies round, circumscribed; superficial colonies fine, round, with slight peripheral extensions, gradually becoming golden yellow.

Potato: Luxuriant golden yellow growth.

Fermentation Tube Dextrose Broth: Turbidity and sediment in bulb. *Reaction alkaline.* No growth in closed arm.

Saccharose and *Lactose* also not fermented.

Blood Serum: Abundant yellowish growth; *no liquefaction.*

Nitrates: Reduced to Nitrites.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: No preliminary acidity. Alkali production immediate. No coagulation of the milk. No digestion of the casein.

Chromogenesis, yellow. *No fluorescence.*

Occurrence and Distribution: Found in one case from which it was isolated from the stomach.

41, BACTERIUM ANTHRACOIDES. (Hueppe and Wood, 1889), Migula, 1900.

Literature and Synonym :

Bacillus anthracoides,
Hueppe and Wood, 1889, Berliner Klin. Wochen. No. 16.

Bacterium anthracoides,
Migula, 1900, System der Bakterien, p. 281.

Bacillus anthracoides (Kruse),
Chester, 1901, Manual of Determinative Bacteriology, p. 191.
First isolated by Hueppe and Wood from soil and water.

Morphology : Long thick heavy bacteria appearing as single elements or in long chains, measuring 1.5 by 2 — 4.0 microns. The individual bacteria show granules at either end which when stained form bipolar bodies

Spores : Formed rapidly in all media.

Motility : Non-motile.

Agar Slant : Dull white, non-glistening growth, drying rapidly along upper portions of the agar, and becoming thickly wrinkled after 6-8 days.

Agar Colonies : Deep colonies small, round, regular and opaque ; superficial colonies spread over the surface of the agar, assuming diverse shapes and coalescing, forming a dense felt-work which appears grey to the naked eye.

Broth : Turbidity and wrinkled scum after 48 hours.

Gelatine Stab : Rapid and complete liquefaction.

Gelatine Colonies : Deep colonies round and regular ; superficial colonies opaque, grey, spreading irregular, forming a skein-like network. Plate rapidly liquefied.

Potato : Abundant greyish-white, or rarely, reddish-white, growth, never becoming wrinkled.

Fermentation Tube. Dextrose Broth : Turbidity in bulb. Wrinkled scum. *Reaction* in bulb *alkaline*. No growth in closed arm. *Saccharose* and *Lactose* also not fermented by this organism.

Blood Serum : Abundant white or reddish-white growth. *No liquefaction.*

Nitrates : Reduced to nitrites.

Indol : Not produced.

Fæcal Odor : Not produced.

Litmus Milk : Acidification and coagulation within 48 hours followed by rapid digestion of the casein and reduction of the litmus.

Occurrence and Distribution : Found in nine cases ; four times in the stomach, once in the cæcum and twice in the rectum ; found once in stomach, duodenum, cæcum and rectum together, and once in stomach, duodenum and cæcum.

42. BACTERIUM IMPLECTANS, Burchard, 1898.

Literature: Burchard, 1897, Beitrage zur Morphologie und Entwickelungsgeschichte der Bakterien, Inaugural Dissertation.

Burchard, 1898, Arbeiten aus dem bakt. Inst. d. Techn. Hochschule zu Karlsruhe, Bd. 2, p. 29.

Migula, 1900, System der Bakterien, p. 284.

First isolated by Burchard from drinking water.

Morphology: Bacteria measuring 0.5–0.75 by 3–4.0 microns, growing in long chains and showing polar granules.

Motility: Non-motile.

Spores: Formed rapidly on all media.

Agar Slant: Dull greyish-white growth wrinkling in old cultures.

Agar Colonies: Deep colonies round and regular, yellowish; superficial colonies spread over the surface of agar with white opaque centres, and greyish filmy irregular margins, often assuming bizarre shapes.

Broth: Turbidity without scum.

Gelatine Stab: Rapid and complete liquefaction with the formation of a heavy scum on the surface.

Gelatine Colonies: Deep colonies small, round and brownish; superficial colonies spreading, greyish, skein-like, rapidly liquefying the gelatine plate.

Potato: Luxuriant white growth, rarely becoming yellowish brown.

Fermentation Tube: *Dextrose Broth*: Turbidity and sediment in bulb. *Reaction* in bulb *acid*. Growth in closed arm with the production of *acid*, but *no gas*.

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant white growth, without liquefaction.

Nitrates: Reduced to nitrites.

Indol: Produced in small quantities.

Fecal Odor: Not produced.

Litmus Milk: Acidity and coagulation within 48 hours with digestion of the casein and reduction of the litmus.

Occurrence and Distribution: Found in six cases; twice in the stomach, once in the rectum, once in the duodenum and cæcum, and twice in the stomach, duodenum, cæcum and rectum alike.

43. BACILLUS CEREUS. Frankland. 1887.

Literature: Grace A Percy Frankland, 1887, Studies on some new Micro-organisms obtained from Air. Philosophical Trans. of the Royal Society of London, Vol. 178 B., p. 259.

Migula, 1900, System der Bakterien, p. 537.

Chester, 1901, Manual of Determinative Bacteriology, p. 278.

First isolated from the air by the Franklands

Morphology: Long thick bacilli, measuring 1·75 by 3·4·0 microns in dimensions, not showing polar staining. Frequently grows in long chains.

Motility: Actively motile.

Spores: Formed rapidly on all media

Agar Slant: Abundant growth, at first white and glistening, later becoming a dirty brown. Not dull or wrinkled.

Agar Colonies: Deep colonies round, regular and greyish; superficial colonies spread over the surface of the agar, showing dark centres and outlying grey peripheries, and assuming diverse bizarre shapes.

Broth: Turbidity and scum.

Gelatine Stab: Abundant growth. Rapid and complete liquefaction.

Gelatine Colonies: Deep colonies small, round and regular; superficial colonies have dark centres and spreading peripheries made up of long thin threads.

Potato: Faint, scanty white growth.

Fermentation Tube: *Dextrose Broth*: Turbidity and heavy scum in bulb.

Reaction alkaline. No growth in closed arm.

Saccharose and *Lactose* not fermented. Abundant scum on all sugar media.

Blood Serum: Abundant white, moist growth with rapid liquefaction.

Nitrates: Not reduced to nitrites.

Indol: Not produced.

Fecal Odor: Not produced

Litmus Milk: No preliminary acidity. Alkaline reaction. No coagulation.

Digestion of the casein and reduction of the litmus.

Occurrence and Distribution: Isolated in two cases; once from the duodenum and once from the cæcum.

44, BACILLUS MYCOIDES. Flugge, 1886.

Literature:

Flügge, 1886, Mikroorganismen, 2 Aufl.

Migula, 1900, System der Bakterien, p. 538.

Isolated from water and soil by Flügge.

Morphology: Bacilli measuring 1 – 1¼ by 3 – 4 microns in dimensions, occurring in pairs and chains.

Motility: Actively motile.

Spores: Formed rapidly on all media.

Agar Slant: Growth along line of inoculation dull, wrinkled and tenacious, with difficulty raised from the surface of the agar, into which it sinks for a considerable depth.

Agar Colonies: Deep colonies round, regular and opaque; superficial colonies spread over the surface of the agar assuming diverse sizes and shapes, but gradually fusing and forming a thick network.

Broth: Turbidity and wrinkled scum.

Gelatine Stab: Rapid and complete liquefaction with a heavy scum on the surface.

Gelatine Colonies: Deep colonies round, regular and opaque; superficial colonies bluish-grey with light opaque centres and dark spreading peripheries. As colonies become older they coalesce forming a skein-like mycelium.

Potato: Thick white abundant growth.

Fermentation Tube: *Dextrose Broth*: Turbidity in bulb with a heavy scum on the surface. *Reaction acid.* Growth in closed arm with the production of acid but no gas.

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant white growth. *No liquefaction.*

Nitrates: Reduced to nitrites. Heavy scum on nitrate broth.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: Preliminary acidity followed by an alkaline reaction. No coagulation. Digestion of the casein and reduction of the litmus.

Occurrence and Distribution: Isolated from two cases, from one from the stomach, and from one from the cæcum.

45. BACTERIUM LACTICOLA. Migula, 1900.

Literature and Synonym:

Flügge, 1894, Die Aufgaben und Leistungen der Milchsterilisierung gegenüber die Darmbakterien des Säuglings, Zeitschr. f. Hygiene, Bd. 17, p. 294.

Bacillus lactis, No. 17.

Kruse, 1896. Flügge, Microorganismen, 3 Aufl. Bd. 2, p. 28.

Migula, 1900, System der Bakterien p. 305.

First obtained by Flügge from milk.

Morphology: Long thin bacteria measuring 1.0 by .3 — 5.0 microns, occurring in short chains and showing polar staining.

Motility: Non-motile.

Spores: Formed quickly on all media.

Agar Slant: Dull wrinkled growth in young cultures, rapidly spreading over whole surface of the agar.

Agar Colonies: Deep colonies regular and opaque; superficial colonies spread over the surface of the agar assuming diverse shapes and producing a greyish coloration.

Broth: Turbidity and a wrinkled scum.

Gelatine Stab: Rapid and complete liquefaction.

Gelatine Colonies: Greyish-brown colonies with many spreading processes producing a rapid liquefaction of gelatine.

Potato: Abundant creamy-white or reddish-white growth.

Fermentation Tube: *Dextrose Broth*: Turbidity in bulb with a wrinkled scum. *Reaction* in bulb *alkaline*. No growth in closed arm.

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant white growth. *Rapid* and *complete* liquefaction.

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: Acidification and coagulation. Peptonization of the casein and reduction of the litmus.

Occurrence and Distribution: Found in one case, from which it was isolated from stomach, cæcum and rectum.

46. BACTERIUM VERMICULARE (Frankland, 1889), Migula, 1900.

Literature and Synonym:

Bacillus vermicularis,
Frankland, Grasce and Percy, 1889. Ueber einige typische Microorganismen in Wasser und Boden, Zeitschr. f. Hygiene, vol. 6, p. 384.
Migula, 1900, System der Bakterien, p. 302.

Bacterium vermicalare (Frankland, 1889).
Chester, 1901, Manual of Determinative Bacteriology, p. 193.
Obtained from air by Frankland.

Morphology: Bacteria very long and thin, measuring 0.5 by 6 — 8.0 microns, often growing in long chains.

Motility: Non-motile.

Spores: Formed rapidly on the usual media.

Agar Slant: Greyish-white and glistening dull growth, never becoming wrinkled.

Agar Colonies: Deep colonies, round, regular, opaque; superficial colonies greyish, spreading, various shapes and sizes.

Broth: Turbidity, no scum.

Gelatine Stab: Rapid and complete liquefaction.

Gelatine Colonies: Grey, spreading irregular colonies forming a felt-work on the surface.

Potato: Luxuriant reddish or flesh-colored growth.

Fermentation Tube: *Dextrose Broth*: Turbidity and sediment in bulb. *Reaction* in bulb *acid*. Growth in closed arm with the production of gas.

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant reddish growth, causing a complete liquefaction of the blood serum.

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: Rapid acidification and coagulation of the milk, peptonization of the casein and reduction of the litmus. With some cultures the amount of acidity is not great, the milk turning red, later to a deep purple after which coagulation sets in.

Occurrence and Distribution: Found in one case from which it was isolated from the stomach.

47. BACILLUS VULGATUS. Trevisan, 1889.

Literature and Synonym :

Bacillus mesentericus vulgatus.

Flügge, 1886, Mikroorganismen, 2 Aufl.

Eisenberg, 1891, Bakteriol. Diagnostik, 3 Aufl.

Bacillus vulgatus.

Trevisan, 1889, Genera, p. 19.

Bacillus vulgatus (Flügge Mig.

Migula, 1900, System der Bakterien, p. 550.

Bacillus vulgatus, Trevisan.

Chester, 1901, Manual of Determinative Bacteriology, p. 271.

Potato Bacillus of various authors.

Morphology : Bacilli measuring 0.5 by 3 4.0 microns, appearing as single elements without polar staining.

Motility : Actively motile.

Spores : Formed quickly on all media

Agar Slant : Abundant, thick, moist growth, in old cultures becoming greyish and crumpled

Agar Colonies : Deep colonies round and regular ; superficial colonies, greyish, irregular, forming thick centres and thin irregular prolongations.

Broth : Turbidity and thick wrinkled scum.

Gelatine Stab : Rapid liquefaction with the formation of a surface membrane.

Gelatine Colonies : Deep colonies round and regular ; superficial colonies have white opaque centres and curling prolongations which form a thick skein.

Potato : *Characteristic appearance* : Luxuriant heaped-up, pink growth made up of long processes, which cover the entire surface of the potato with a corrugated mass.

Fermentation Tube : *Dextrose Broth* : Turbidity and membrane in bulb. *Alkaline reaction* in *bulb*. No growth in closed arm.

Saccharose and *Lactose* not fermented.

Blood Serum : Abundant growth. Complete liquefaction.

Nitrates : Reduced to nitrites.

Indol : Not produced.

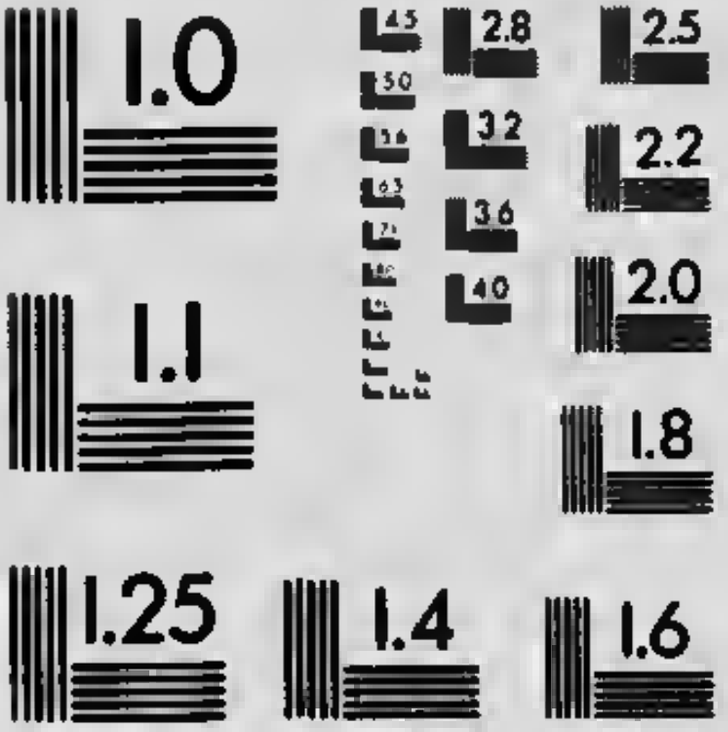
Fæcal Odor : Not produced.

Litmus Milk : No preliminary acidity. Rapid production of alkali. No coagulation. Peptonization of the casein and reduction of the litmus.

Occurrence and Distribution : Isolated from two cases, in one of which it was found in the duodenum, and in the other in the stomach and duodenum.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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48, BACILLUS BREVIS, Migula, 1900.

Literature and Synonym:

(*Bacillus* No. 1.)

Flügge, 1894, Die Aufgaben und Leistungen der Milchsterilisirung. Zeitschrift für Hygiene, Bd. 17, p. 294.

Migula, 1900, System der Bakterien, p. 583
First obtained by Flügge from milk.

Morphology: Long thin bacilli measuring 0.5 by 3.0 microns, often appearing in long chains.

Motility: Actively motile.

Spores: Rapidly formed on the usual media.

Agar Slant: Abundant soft glistening brown growth covering whole surface and not becoming dull or wrinkled.

Agar Colonies: Deep colonies round and regular; superficial colonies round, opaque, non-spreading.

Broth: Turbidity without scum.

Gelatine Stab: Slow but complete liquefaction.

Gelatine Colonies: Round irregular brown colonies often forming a network of fine threads.

Potato: Little or no growth.

Fermentation Tube: *Dextrose Broth*: Turbidity and sediment in bulb.

Reaction alkaline. No growth in closed arm.

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant growth with complete liquefaction.

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: Slight acidity without coagulation, followed by digestion of the casein and reduction of the litmus.

Occurrence and Distribution: Found in the rectum of one case.

49, BACILLUS SUBTILIS. (Ehrenberg, 1838), Cohn, 1872.

Literature and Synonym:

Vibrio subtilis,
Ehrenberg, 1838, Infusionsthierschen als volkommene Organismen, Leipzig.

Bacillus subtilis,
Cohn, 1872, Beiträge zur Biologie, bd. 1, p. 175.

Bacillus subtilis (Ehrenb.) Cohn.
Migula, 1900, System der Bakterien, p. 515.

Bacillus subtilis (Ehrenberg), Cohn.
Chester, 1901, Manual of Determinative Bacteriology, p. 276.

First obtained by Ehrenberg from air and water.

Morphology: Bacilli measuring 0.5 by 4 6.0 microns, without polar staining, appearing rarely in short chains.

Motility: Actively motile.

Spores: Formed rapidly, lying in the centres of the bacilli.

Agar Slant: Glistening, dull white, sticky, matted tenacious growth.

Agar Colonies: Deep colonies, round and regular; superficial colonies spread slightly, with opaque white centres assuming various bizarre shapes.

Broth: Turbidity and heavy scum.

Gelatine Stab: Abundant growth with a rapid liquefaction and a heavy scum on the surface.

Gelatine Colonies: *Characteristic appearance.* Deep colonies round, regular and opaque; superficial colonies spreading with dense black centres and greyish-outlying threads.

Potato: Luxuriant thick greyish or yellowish brown growth, which in old cultures forms a corrugated stringy mass covering the whole surface of the potato.

Fermentation Tube: *Dextrose Broth*: Turbidity and sediment in bulb. *Reaction* in bulb *acid.* Growth in closed arm with the production of an acid reaction but no gas.

Saccharose and *Lactose* not fermented.

Blood Serum: Abundant white growth. *Rapid liquefaction.*

Nitrates: Reduced to nitrites.

Indol: Not produced.

Fæcal Odor: Not produced.

Litmus Milk: Rapid acidification and coagulation of the milk; peptonization of the casein and reduction of the litmus.

Occurrence and Distribution: Found in one case where it was isolated from the stomach and duodenum.

50, BACILLUS ARACHNOIDEUS. Migula, 1900.

Literature and Synonym :
(Bacillus No. 111).
Flügge, 1894, Die Aufgaben und Leistungen der Milchsterilisierung. Zeitschr. fur Hygiene, Bd. 17, p. 294.
Migula, 1900, System der Bakterien, p. 583.
First isolated by Flügge from milk.

Morphology : Fine bacilli measuring 0.5 by 2.0 microns. No polar staining, often grows in short chains.

Motility : Actively motile.

Spores : Formed rapidly on the usual media.

Agar Slant : Dull wrinkled tenacious growth, sinking deeply beneath the surface of the agar.

Agar Colonies : Deep colonies round and regular ; superficial colonies, greyish, spreading, with white opaque centres.

Broth : Turbidity without scum.

Gelatine Stab : Rapid liquefaction.

Gelatine Colonies : Deep colonies, regular, uniform ; superficial colonies slightly spreading, greyish with opaque centres, somewhat resembling colonies of *Bacillus subtilis*.

Potato : Luxuriant yellowish-brown growth forming huge blebs.

Fermentation Tube : *Dextrose Broth* : Turbidity and sediment in bulb.

Reaction in bulb *acid*. Abundant growth in closed arm with the production of an *acid reaction* but *no gas*.

Saccharose fermented with the production of *acidity* and a small quantity of *gas*.

Lactose not fermented.

Blood Serum : Abundant white growth. *Rapid liquefaction.*

Nitrates : Reduced to nitrites.

Indol : Not produced.

Fæcal Odor : Not produced.

Litmus Milk : Acidity and coagulation of the milk within 48 hours. Peptonization of the casein and reduction of the litmus.

Occurrence and Distribution : Isolated from the stomach of one case.

Staphylococcus Albus and Staphylococcus Aureus.

The Staphylococci were isolated in a number of instances from the intestinal contents, but their cultural features did not differ in any respect from the ordinary varieties of these organisms. The *Staphylococcus aureus* was somewhat more numerous than the *Staphylococcus albus*. The "aureus" was obtained from ten cases, in six of which it appeared in the stomach, in one in the duodenum, and in three in the stomach and duodenum together. The "albus" was obtained from seven cases, three times from the stomach, twice from the cæcum, once from the cæcum and rectum, and once from the stomach, duodenum and cæcum, and from an additional culture taken from the mid-duodenum.

The Staphylococci are thus seen to occupy almost exclusively the upper portion of the intestinal tract, usually appearing in the stomach and rarely being carried down from the stomach to the duodenum and cæcum.

Sarcina Lutea.

Representations of the Sarcina group were observed in but one case when a culture of *Sarcina lutea* was isolated from the stomach.

Moulds.

Unknown varieties of moulds were seen in one case in the duodenum.

The Distribution of Intestinal Bacteria.

The phenomena of the distribution of the various species of intestinal bacteria in the different regions of the alimentary canal may be best explained and understood by a preliminary survey of the organisms found in the *Stomach*, and by a subsequent examination of the changes which these species undergo as the gastric contents are carried down through the duodenum and cæcum to the rectum.

Nearly forty different organisms were isolated at one time or another from this region, representing its usual bacteriology, but the frequency with which the different species occur is subject to the greatest variation. It is apparent at once that the bacteria in question belong to two categories, according as to whether they are essentially "intestinal bacteria" in their nature, finding their primary habitat in the alimentary canal but occasionally maintaining an existence outside it, or whether they are identical with the microorganisms belonging to the external world, the air, the soil or water whence they are introduced through the buccal cavity into the stomach and become "transitory inhabitants" of the bowel. The gastric flora is thus complex in its nature, made up of seven or eight different species living side by side, and in every case we find representatives of these two categories.

Thus, on the one hand, the "Lactis aerogenes" group—*Bacterium aerogenes* and *bacterium duodenale*—are found in practically every examination and may be considered the normal inhabitants of the stomach. Mingled with this group in a very considerable number of cases appears either *Bacillus coli* or *Bacillus communior*, organisms whose seat of election is the lower bowel, but which occasionally find the proper conditions for a luxuriant development in the stomach and duodenum.

Less frequent than these species, but in sufficient numbers to merit careful consideration, we find organisms which do not ordinarily enjoy an extra-corporeal development, but which appear in the intestines but seldom. Among these minor intestinal bacteria, *Bacillus alcaligenes* of Petruschky and *Bacillus pseudodysentericus* are encountered with some frequency, while the various liquefying organisms, *Bacillus*

gastricus and *Bacillus entericus*, seem to possess an especial predilection for the gastric contents. In rarer instances, various acid-producing bacteria like *Bacterium oxygenes*, *Bacterium acidoformans* of Sternberg and *Bacillus chylogenes*, are cultivated, bu, from their infrequency they can hardly be said to play any important part in the economy of the alimentary canal.

On the other hand, the "transitory inhabitants" of the bowel are constantly introduced in great numbers through the mouth and either find a proper soil for growth and multiplication or are destroyed by the intestinal secretions and the more resistant microorganisms. Thus *Staphylococcus albus* and *aureus* and a large number of spore-bearing bacteria are nearly always present in combination with the purely intestinal bacteria, while *Bacillus cloacæ*, *Bacillus pyocyaneus* and the members of the Proteus group, *Bacillus vulgaris*, *Bacillus plebeius*, are isolated from a considerable proportion of cases.

The stomach is thus seen to not only possess a certain number of characteristic inhabitants derived from the intestinal tract, but to serve as a great receptacle for the microorganisms of the external world, introduced with our food and drink, the various species meeting diverse fates in their passage downwards towards the rectum.

As the products of gastric digestion are poured into the *Duodenum* profound changes occur in the chemical constitution of the intestinal secretions, while the absorption of the chyle through the walls of the duodenum causes a considerable loss in the amount of material available for bacterial life. The result of these influences is two-fold. Primarily the actual number of bacteria present in the duodenum is much less than in the stomach, the culture plates being but sparsely filled with colonies. In rare instances, indeed, the duodenum is sterile, the post-mortem examinations thus bearing out the suggestions already made, that this region is free from bacteria at certain periods of digestion and secretion. Secondarily, marked alterations are visible in the species of bacteria which are cultivated. While "*Bacillus lactis aerogenes*" is still the predominant form, developing in almost the same profusion in the duodenum as above, *Bacillus coli* is considerably increased in frequency and appears in a large number of cases. The Petruschky bacillus is similarly increased. The

other species of intestinal bacteria, however, which were found occasionally in the stomach, are but rarely or never present in the duodenum, such organisms as *Bacillus gastricus* and *Bacillus entericus* being entirely absent. The greatest changes are seen with the "transient inhabitants" of the bowel which are either destroyed in the stomach or are unable to develop beyond the pyloric orifice.

The *Staphylococcus albus* and *aureus* and the many species of spore-bearing bacteria are cultivated in but few cases in comparison with their almost constant occurrence in the stomach, while *Bacillus cloacæ* is but rarely present in the duodenum. The alkali-producing bacteria, however, especially the members of the Proteus group, *Bacillus vulgaris* and *Bacillus plebeius*, find here more favorable conditions for their survival and develop in considerable numbers. The *Bacillus pyocyaneus (Pseudomonas aeruginosa)* is likewise more abundant. In general, the duodenal flora may be said to consist of the members of the "Bacillus lactis aerogenes" group in combination with either *Bacillus coli* or the Proteus Group.

The qualitative changes already outlined in the transition from the stomach to the duodenum, are continued in the *Cæcum* where the accumulation of intestinal contents favors a most vigorous development of organic life. The cæcum is constantly filled with bacteria, the culture plates which are made from its interior being always thickly strewn with colonies. Aside from this fact, however, the alterations in the species found, follow two perfectly distinct lines. The "Bacillus lactis aerogenes" is much diminished in frequency in comparison with the stomach and duodenum, yielding to the constantly increasing development of *Bacillus coli*, while the rarer species of intestinal bacteria which but seldom exist in the upper region of the alimentary canal, find in the cæcum a soil favourable for their multiplication. Consequently we find with some frequency *Bacillus alcaligenes*, *Bacillus pseudodysentericus*, *Bacillus entericus* and *Bacillus gastricus*, while such species as *Bacillus alcalescens*, *Bacillus enteritidis* of Gärtner, *Bacillus dubius* of Kruse, or *Bacillus cæci*—which in any event are cultivated from the alimentary tract—when they do occur, are practically always isolated from this locality.

At the same time the Staphylococci and the spore-bearing bacteria continue their previous diminution in the struggle against the more resistant species of the intestine, which gradually outgrow and overcome the "transient inhabitants" of the bowel, until in the constant passage downwards, their appearance in the cæcum is an event of some rarity. In some cases, however, the species of spore-bearing bacilli which have found their entrance into the stomach, developing luxuriantly there, multiply vigorously in the cæcum, being carried past the duodenum to this point. The Proteus Group, so luxuriant in the second portion of the bowel, is relatively less frequent in this region, and finally *Bacillus pyocyaneus* which found only a hardy existence in the stomach, steadily increases towards the cæcum, from which it is abundantly obtained.

The cæcal flora is thus somewhat complicated in its construction, a number of factors contributing to the development of a relatively large number of organisms.

The changes between the *Cæcum* and *Rectum* are only continuous with those which have already taken place between the small and large intestine. The "Lactis aerogenes" group is but rarely encountered in the terminal portion of the bowel, precedence being given to *Bacillus coli* which finds in the rectum its most favorable habitat. It is probably present indeed in every case. At the same time the Staphylococci are practically never found beyond the sigmoid flexure, and the spore-bearing bacteria are only present when carried down from the cæcum. The rectum, however, is the favorite seat for *Bacillus alcaligenes* and *Bacillus pseudodysentericus* while *Bacillus pyocyaneus* is more frequently present here than in any other region, as a result of its steady increase from the stomach downward. Finally both the Proteus and the Cloacæ Groups diminish in numbers in the traversal of the large intestine.

Summary.

From the survey of the different regions of the alimentary canal we see that the various species of intestinal bacteria undergo constant change in their passage from the stomach to the rectum, and that the bacteriological phenomena exhibited by the several regions are subject to more or less definite laws. On the one hand we find "Lactis aerogenes" inhabiting by preference the upper portion of the bowel, the stomach and the duodenum, but occasionally carried beyond the ileo-cæcal valve, where in contact with *Bacillus coli* it gradually but constantly disappears. On the other hand, *Bacillus coli* whose habitat is essentially the cæcum and rectum, at times finds favorable conditions for growth in the duodenum or stomach, and maintains an independent existence there. The minor intestinal species, while in exceptional cases showing decided preferences for particular localities (as in the case of *Bacillus gastricus* for the stomach and *Bacillus alcaligenes* for the rectum), in reality appear in those regions which furnish the greater nutrition, and thus are cultivated in the greatest abundance from the cæcum. On the other hand, the "transitory inhabitants" of the bowel, the Staphylococci and the spore-bearing bacilli, are most numerous in the stomach, constantly diminishing in frequency along the length of the intestine only to disappear completely in the rectum. Coincident with these changes the Cloacæ Group grows most luxuriantly in the stomach and in the cæcum, while the "Proteus" and the "Pyocyaneus" introduced from the buccal cavity find a favorable location beyond the pyloric orifice, the one in the duodenum and the other in the rectum.

Finally, under unknown conditions of digestion and secretion certain species of bacteria develop at times to the exclusion of all others and those anomalous cases are presented where either individual portions or the entire length of the intestinal tract are occupied by a single microorganism.

SUMMARY OF CASES.

CASE No. 1, M. 70, *Mitral Endocarditis.*

Stomach: Bact. aerogenes and B. infrequens.
Duodenum: B. alcaligenes and B. alcalescens.
Caecum: Bact. aerogenes, B. alcalescens and B. subalcalescens.
Rectum: B. alcaligenes, B. infrequens and B. pseudodysentericus.

CASE No. 2, M. 29, *Septic Peritonitis and Pneumonia.*

Stomach: B. plebeius, Bact. duodenale, B. gastricus and B. cloacae.
Duodenum: Bact. aerogenes and B. plebeius.
Caecum: B. gastricus, Bact. aerogenes, B. alcaligenes and B. plebeius.
Rectum: B. gastricus, B. plebeius, Bact. duodenale and B. pseudodysentericus.

CASE No. 3, M. 30, *Railway Injury.*

Stomach: B. plebeius, B. cloacae, Bact. aerogenes and Bact. lutescens.
Duodenum: B. cereus, B. plebeius, Bact. duodenale and B. alcaligenes.
Caecum: B. plebeius and B. mycoides.
Rectum: B. pseudodysentericus and P. aeruginosa.

CASE No. 4, M. 48, *Scoliosis of Spine.*

S.: B. communior, B. coli, Bact. duodenale, B. subliquefaciens, B. pseudodysentericus, Bact. vermiculare and Sarcina lutea.
D.: Bact. oxygenes, B. liquefaciens.
C.: B. communor and Bact. oxygenes.
R.: B. communior and B. alcaligenes.

CASE No. 5, M. 31, *Septic Pneumonia and Empyema.*

S.: Pseudomonas aeruginosa.
D.: B. alcaligenes and P. aeruginosa.
C.: B. alcaligenes, B. pseudodysentericus and P. aeruginosa.
R.: P. aeruginosa.

CASE No. 6, F. 41, *Aortic and Mitral Endocarditis.*

S.: Bact. aerogenes, Bact. duodenale and Bact. implectans.

D.: Bact. aerogenes.

C.: B. cloacae and B. vulgaris.

R.: B. cloacae, B. plebeius, B. subcloacae, B. gastricus, B. enterieus and Bact. havaniense.

CASE No. 7, F. 44, *Mitral endocarditis.*

S.: Bact. aerogenes, B. cloacae, B. gastricus, B. plebeius and B. vulgatus.

D.: B. alcalescens, B. plebeius, B. infrequens, B. subalcalescens, B. vulgatus, Bact. implectans.

C.: B. cloacae, B. alcalescens, B. pseudodysentericus, Bact. aerogenes, Bact. oxygenes, B. oxyphilus, B. gastricus, B. subalcalescens, B. alcaligenes, Bact. implectans.

R.: B. pseudodysentericus and P. aeruginosa.

CASE NO. 8, F. 32, *Lobar Pneumonia.*

S. : B. plebeius, B. gastricus and B. subgastricus.
D. : Bact. aerogenes, B. infrequens, B. subgastricus and B. chymogenes.
C. : B. cloacae, Bact. duodenale, B. plebeius and B. vulgaris.
R. : Bact. chymogenes.

CASE NO. 9, M. 21, *Railway Injury.*

S. : Bact. aerogenes, B. plebeius, B. alcaligenes, B. pseudodysentericus, Bact. implectans, B. pylori.
D. : B. pseudodysentericus, Bact. implectans, B. infrequens, B. plebeius, B. alcaligenes, B. coli.
C. : B. plebeius, B. pseudodysentericus, B. entericus and Bact. implectans.
R. : Bact. implectans and P. aeruginosa.

CASE NO. 10, M. 47, *Empyema and Lobar Pneumonia.*

S. : Bact. aerogenes and P. aeruginosa.
D. : Bact. aerogenes and P. aeruginosa.
C. : B. cereus and P. aeruginosa.
R. : P. aeruginosa.

CASE NO. 11, M. 38, *Railway accident.*

S. : B. coli.
D. : Bact. aerogenes, infrequens and B. pseudodysentericus.
C. : B. pseudodysentericus, Bact. aerogenes, B. gastricus, B. caeci, and B. iliacus.
R. : Bact. duodenale, B. coli, B. brevis, B. caeci, B. subliquefaciens, B. communior.

CASE NO. 12, M. 76, *Cirrhosis of the Liver.*

S. : B. pseudodysentericus, B. coli and B. alcaligenes.
D. : B. coli.
C. : B. pseudodysentericus, P. aeruginosa and P. ovale.
R. : B. communior, Bact. duodenale, B. alcaligenes.

CASE NO. 13, F. 19, *Appendicitis, General Peritonitis.*

S. : B. subcloacae, B. plebeius, B. infrequens, Bact. anthracoides.
D. : Bact. aerogenes and Bact. duodenale.
C. : Bact. aerogenes.
R. : B. infrequens, Bact. aerogenes and B. leporis.

CASE NO. 14, M. 60, *Gangrene of Lung.*

S. : B. communior, Staph. aureus, Bact. anthracoides.
D. : B. communior and Bact. anthracoides.
C. : B. communior, B. plebeius, B. coli and Bact. anthracoides.
R. : B. coli.

CASE No. 15, M. 60, *Aortic and Mitral Endocarditis.*

S. : B. oxyphilus and B. subtilis.
D. : B. communior, Bact. aerogenes and B. subtilis.
C. : Bact. duodenale, B. coli, B. communior.
K. : B. coli.

CASE No. 16, *Fractured pelvis.*

S. : B. communior and Bact. aerogenes.
D. : B. communior and B. plebeius.
C. : Bact. aerogenes, Bact. duodenale and B. communior.
K. : B. coli and B. communior.

CASE No. 17, *Superficial burns.*

S. : B. plebeius and B. infrequens.
D. : B. infrequens and B. subcloacae.
C. : Bact. duodenale and B. subcloacae.
K. : B. coli, B. plebeius and B. subcloacae.

CASE No. 18, F. 34, *Abscess of Brain.*

S. : B. coli and Bact. duodenale.
D. : B. coli.
C. : B. communior and B. acidoformans.
K. : B. coli and B. communior

CASE No. 19, M. 38, *Fibroid Tuberculosis of Lungs.*

S. : B. chylogenes.
D. : B. coli.
C. : B. coli.
K. : B. coli.

CASE No. 20, F. 46, *Mitral endocarditis.*

S. : B. communior and Staph. albus.
D. : B. plebeius, B. cloacae and B. subcloacae.
C. : B. coli and B. enteritidis.
K. : B. coli.

CASE No. 21, F. 47, *Lobar Pneumonia.*

S. : Staph. aureus and B. communior.
D. : B. Communior.
C. : B. coli.
K. : B. coli.

CASE No. 22, *Tuberculosis of Lungs.*

S. : B. cloacae and B. communior.
D. : Bact. aerogenes and B. coli.
C. : B. infrequens and B. subcloacae.
R. : B. plebeius and B. infrequens.

CASE No. 23, F. 60, *Mitral Endocarditis.*

S. : Bact. aerogenes and Bact. duodenale.
D. : B. plebeius.
C. : B. coli.
R. : Bact. aerogenes.

CASE No. 24, F. 21, *General Peritonitis.*

S. : Bact. aerogenes and B. coli.
D. : Bact. aerogenes.
C. : B. coli,
R. : B. communior

CASE No. 25, F. 54, *Carcinoma of Stomach.*

S. : Bact. aerogenes.
D. : Bact. duodenale.
C. : Bact. duodenale.
R. : Bact. duodenale.

CASE No. 26, F. 85, *Mitral Endocarditis.*

S. : Bact. aerogenes, Staph. aureus, Staph. albus, Bact. galactophilum.
D. : B. iliacus, Staph. albus and B. plebeius.
C. : Staph. albus, B. communior, B. dubius and B. alcalescens.
R. : B. communior, B. pseudodysentericus, B. subalcalescens, B. gastricus and B. alcaligenes.

CASE No. 27, M. 67, *Mitral and Aortic Endocarditis.*

S. : Staph. albus, Bact. implectans and Bact. duodenale.
D. : B. alcaligenes and Mucor.
C. : B. coli, Bact. duodenale and B. oxyphilus.
R. : Bact. duodenale and B. coli.

CASE No. 28, F. 20, *Septic Peritonitis.*

S. : Bact. duodenale, Bact. anthracoides, B. vulgaris, B. coli.
D. : Bact. duodenale, B. coli and B alcaligenes.
C. : Bact. aerogenes, Bact. duodenale, vulgaris and B. plebeius.
R. : B. vulgaris, Bact. aerogenes, B. entericus and B. plebeius.

CASE No. 29, *Atrophic Cirrhosis of the Liver.*

S. : Bact. duodenale, Bact. implectans, B. communior, B. entericus, B. subentericus and Bact. aerogenes.
D. : B. communior and Bact. implectans.
C. : B. entericus, B communior, B. coli, Bact. implectans and Bact. aerogenes,
R. : B. entericus, Bact. implectans and Bact. aerogenes.

CASE NO. 30, M. 54, *Haemorrhagic Pancreatitis.*

S. : Bact. aerogenes and B. communior.
D. : B. vulgatus, B. plebeius, B. subliquefaciens, B. coli and B. subgastricus.
C. : B. subgastricus, Staph. albus, Bact. anthracoides, B. recti.
R. : Bact. anthracoides, Staph. albus, B. coli, B. recti and B. alcaligenes.

CASE NO. 31, F. 59, *Carcinoma of Rectum.*

S. : Bact. duodenale and Bacillus entericus.
D. : B. plebeius, Bact. duodenale.
C. : B. entericus, B. alcaligenes, B. plebeius, B. communior and B. cloacae.
R. : B. coli and B. plebeius.

CASE NO. 32, F. 33, *Peripheral Neuritis.*

(Cultures 1½ hours post-mortem.)

S. : Bact. aerogenes and Bact. lacticola.
D. : Sterile.
C. : Bact. lacticola, Bact. duodenale and Bact. aerogenes.
R. : Bact. minutissimum, P. aeruginosa and Bact. lacticola.

CASE 33, *Pernicious Anaemia.*

S. : B. acidoformans.
D. : B. acidoformans.
C. : B. acidoformans, Bact. duodenale and Staph. albus.
R. : Bact. duodenale and B. alcaligenes.

CASE NO. 34, M. 81, *Duodenal Ulcer.*

S. : Bact. Duodenale and Bact. anthracoides.
D. : Bact. duodenale and Bact. chymogenes.
C. : Bact. duodenale.
R. : B. plebeius and B. infrequens.

CASE NO. 35, F. 36, *Gangrenous cholecystitis.*

S. : Staph. aureus and Bact. anthracoides.
D. : Staph. aureus.
C. : B. oxyphilus and Bact. duodenale
R. : B. coli and Bact. duodenale.

CASE NO. 36, F. 30, *Osteo-sarcoma of Lumbar Vertebrae.*

S. : Staph. aurens.
D. : Staph. aureus.
S. : B. plebeius and B. coli.
R. : B. coli and B. communior.

CASE NO. 37, M. 14, *Appendicitis.*

S. : B. coli.
D. : B. coli and Bact. aerogenes.
C. : B. coli.
R. : B. coli and B. communior.

CASE NO. 38, F. 14. *Meningitis* (serous).

S. : B. coli.
D. : B. coli.
C. : B. coli.
R. : B. alcaligenes and Bact. aerogenes.

CASE NO. 38, F. 19 mo., *Laryngeal Diphtheria.*

S. : B. mycoides.
D. : Bact. aerogenes.
C. : Bact. aerogenes.
R. : B. communior.

CASE NO. 40.

S. : B. communior and Staph. aureus.
D. : Staph. aureus.
C. : B. communior.
R. : B. communior.

CASE NO. 41, *Foundling.*

S. : Staph. aureus, Bact. duodenale, B. arachnoides, B. entericus and B. Bonkeri.
D. : Bact. duodenale.
C. : Bact. duodenale, Bact. aerogenes and B. infrequens.
R. : B. communior and B. subalcalescens.

CASE NO. 42, *Foundling.*

S. : Staph. aureus and Bact. duodenale.
D. : P. aeruginosa, Bact. duodenale and B. communior.
C. : Bact. duodenale, B. coli and Bact. aerogenes.
R. : P. aeruginosa, B. coli, Bact. duodenale and B. communior.

CASE NO. 43, *Foundling.*

S. : B. communior and Bact. aerogenes.
D. : Bact. aerogenes and B. communior.
C. : Bact. aerogenes.
R. : B. coli and Bact. aerogenes.

CASE NO. 44, *Foundling.*

S. : Staph. aureus.
D. : Bact. aerogenes.
C. : B. communior.
R. : B. communior and B. plebeius.

CASE NO. 45, *Foundling.*

S. : B. gastricus, Bact. anthracoides, B. cloacae, B. liquefaciens and Staph. albus.
D. : Bact. aerogenes.
C. : Bact. aerogenes.
R. : Bact. anthracoides, Bact. duodenale, B. entericus.

CASE NO. 46, *Foundling.*

S. Staph. aureus, and Bact. aerogenes.
D. : B. plebeius and Staph. aureus.
C. : B. communior and Staph. albus.
R. : Bact. anthracoides and Bact. aerogenes.

CASE NO. 47, *Foundling.*

S. : B. duodenale, and P. aeruginosa.
D. P. aeruginosa.
C. : P. aeruginosa.
R. : P. aeruginosa.

CASE NO. 48, *Foundling.*

S. : Bact. aerogenes.
D. : Bact. aerogenes.
C. : B. enteritidis, Bact. duodenale and B. subliquefaciens.
R. : Bact. implectans.

CASE NO. 49, *Foundling.*

S. : B. plebeius, B. vulgaris, Bact. aerogenes and Bact. anthracoides.
D. : B. plebeius, Bact. aerogenes and B. coli.
C. : B. plebeius, B. vulgaris, Bact. aerogenes, Bact. anthracoides and B. infrequens.
R. : Bact. duodenale.

CASE 50, *Foundling.*

S. : B. coli.
D. : B. coli.
C. : B. coli, Bact. aerogenes and Bact. Bienstockii.
R. : B. communior.

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