chlorophyll; but they differ from these again in their mode of reproduction, being reproduced by division or simple fission. Hence bacteria have been called *schizomycetes* or fission fungi. A few varieties of unicellular organisms have also been found resembling bacteria in all points, except that they possess chlorophyll or some pigment substance similar to it. Other organisms, again, have been observed which, though they are without chlorophyll, are able to build up organic compounds synthetically and even in the absence of light. Some bacteria, moreover, especially the motile forms, are closely allied to certain micro-organisms belonging to the animal kingdom. It is therefore difficult to classify or define bacteria scientifically, under our existing knowledge of them. Excluding the micro-organisms, however, which contain chlorophyll, bacteria may be defined accurately enough for all practical purposes as *extremely minute living vegetable organisms, without chlorophyll, which are reproduced by division, consisting of single spherical, rod-shaped, or corkscrew-like cells or aggregation of such cells, between whose protoplasm and nucleus it has not been possible to differentiate with certainty.*

Bacteria, then, belong to the family of mycetes or fungi, of which there are four groups:

1. *Hyphomycetes*, or *mould fungi.*
2. *Blastomycetes*, or *yeast fungi.*
3. *Streptothrices.*
4. *Schizomycetes* or *bacteria.*

But besides this classification of bacteria it becomes necessary to divide them into *saprophytes* or refuse-eaters, and *parasites.* Saprophytic micro organisms are such as commonly exist independently of a living host, obtaining their supply of nutriment from soluble food stuffs in dead organic matter. Parasitic micro-organisms, on the contrary, live on or in some other living organism, from which they derive their nourishment for the whole or a part of their existence. Those micro-organisms which depend entirely upon a living host for their existence are known as *strict* or *obligatory parasites;* those which can lead a saprophytic existence, but also thrive within the body of a living animal, are called *facultative parasites.* The saprophytes strictly so called, which represent the larger number of micro-organisms, are not only harmless but perform the useful function of the destruction of dead organic matter through fermentation and putrefaction. The parasites, on the other hand, though some of them may multiply in the secretions or on the surface of the body without injury to the animal upon which they exist, are usually harmful invaders, giving rise, through the lesions brought about in the body by their growth and products, to various acute and chronic infectious diseases.

Numerous attempts have been made by various authors to classify bacteria systematically, but usually with the proviso that the system was only a temporary one. As a rule, the genera are based upon morphological characters and the species upon biochemical, physiological, or pathogenic properties. While the form, size, and method of division are the most permanent characteristics of micro-organisms, and so are naturally utilized for classifications, nevertheless on this basis of arrangement there are decided difficulties. Thus while the form and size of bacteria are fairly constant under the same conditions, they are in many quite different under diverse conditions. Another serious drawback is that these morphological characteristics give no indication whatever of the relation of bacteria to disease, etc.—the very characteristics for which as physicians we study them. Other properties of bacteria which are fairly constant under uniform conditions are those of spore formation, motility, reaction to staining agents, relation to temperature, to oxygen or other food materials, and finally their relation to disease, fermentation, and pigmentation (pathogenic, zymogenic, and chromogenic bacteria).

Taking any one of these properties of bacteria as a basis, we can classify them; but even here there will be groups which under certain conditions would be placed in one class and under other conditions in another. Thus the power to produce spores may be totally lost or held in abeyance for a time. The relation to oxygen may be gradually altered, so that an anaërobic species grows in the presence of oxygen. Parasitic bacteria may be so cultivated as to become saprophytic varieties, and those which have no power to grow in the living body given pathogenic properties. The possibility of making any thoroughly satisfactory classification is rendered still more difficult by the fact that many necessarily imperfect attempts have already been made, so that there is a great deal of confusion, which is steadily increased as new varieties are found or old ones re-investigated and classified differently in the various systems. We shall, therefore, simply use the commonly accepted nomenclature, without any attempt at classification, except to consider together as far as practicable certain groups of bacteria whose members are closely allied to one another in some one or more important features.

Morphology.—There are three basic forms of the individual bacterial cells: the sphere, the rod, and the segment of a spiral. Although under different conditions the form of any one species may vary considerably, yet these three main divisions under similar conditions are permanent; and so far as we know, it is never possible by any means to bring about changes in the organisms that will result in the conversion of the morphology of the members of one group into that of another,—that is, cocci always, under suitable conditions, produce cocci, bacilli produce bacilli, and spirilla produce spirilla.

The form of the bacterial cells at their stage of complete development must be distinguished from that which they possess just after or before they have divided. As the spherical cell develops preparatory to its division into two cells, it becomes elongated and appears as a short oval rod at the moment of its division; on the contrary, the transverse diameter of each of its two halves is greater than their long diameter. A short rod becomes in the same way, at the moment of its division, two cells, the long diameter of each of which may be even a trifle less than its short diameter, and thus they appear on superficial examination as spheres.

As bacteria multiply the cells produced from the parent cell have a greater or less tendency to remain attached. In some varieties this tendency is extremely marked, in others it is slight. This union may appear simply as an aggregation of separate bacteria or so close that the group presents the appearance of a single cell. According to the method of the cell division and the tenacity with which the cells hold together we get different groupings of bacteria, which aid us in their identification and differentiation. Thus whether the bacterial cell divides in one, two, or three planes, we get forms built in one, two, or three dimensions. If we group bacteria according to the characteristic forms of the cells, and then subdivide according to the manner of their division in reproduction and the tenacity with which the newly developed cells cling to one another, we shall have the following varieties:

1. *Coccus or Micrococcus.*—Spherical or subspherical forms.

(*a*) *Single coccus*, grouped irregularly.
(*b*) *Diplococcus*, forming pairs.
(*c*) *Streptococcus*, forming chains, often showing paired cocci.
(*d*) *Tetracoccus*, forming fours by division through two planes of space.
(*e*) *Sarcina*, forming packets of eight by division through three planes of space.
(*f*) *Staphylococcus*, forming irregularly shaped, grape-like bunches by division apparently in any axis.

2. *Bacillus.*—Oblong or cylindrical forms, having one dimension greater than any other, more or less straight, and never forming spirals, dividing only in one plane perpendicular to its long axis.

(*a*) *Single bacillus.*
(*b*) *Diplobacillus* and *streptobacillus*, forming twos or longer chains, the bacilli attached end to end.
(*c*) *Filaments* or thread-like growths, in which division into bacilli of the normal length are not apparent, or

occur irregularly and transversely to the long axis of the growth.

3. *Spirillum.*—Cylindrical and curved forms, constituting complete spirals or portions of spirals. Spirilla, like bacilli, divide only in one direction. A single cell, a pair, or the union of two or more elements may thus present the appearance of a short segment of a spiral or a comma-shaped form, an S-shaped form, or a complete spiral or corkscrew-like form.

The term *bacterium* has also been used by some authors for *bacilli* or rod-shaped organisms; while to *spirilla* the terms *vibrio* and *spirochaëte* have sometimes been applied. But as there is no uniformity among bacteriologists as to the exact meaning of these terms, we shall employ only the terms *bacillus* and *spirillum* to denote these different groups.

Structure of Bacterial Cells.—A bacterial cell consists of protoplasm enveloped in a cell membrane; the cells as a rule being homogeneous and without visible nucleus. The cell is generally colorless, though in some species it contains chlorophyll or other similar coloring matter. The protoplasm may at times also contain minute granules of sulphur and occasionally refractive oily particles or colorless spaces in stained specimens, which have been mistaken for spores, but are supposed to be due to the shrinkage of the protoplasm with partial dissolution of the cell wall caused by abstraction of water, known as *plasmolysis.* In many species of bacteria, as in the diphtheria bacillus, there is observed in the interior of the cells, on suitable staining, a peculiar granular appearance, to which has been given the names *metachromatic bodies* or *sporagenous granules.* The cell membrane is sometimes colored, and sometimes surrounded by a gelatinous envelope or capsule, which can be occasionally brought out by staining. The demonstration of this capsule may be of assistance in differentiating between certain bacteria, as, for example, some forms of the streptococcus and pneumococcus. A peculiarity of the capsule bacteria is that, except very rarely, they exhibit this envelope only when grown in the animal body or in special culture media, such as liquid blood serum, bronchial mucus, etc. The outer surface of bacteria when occurring in the form of spheres and short rods is almost always smooth and devoid of appendages; but the larger rods and spirals are usually provided with fine hair-like cilia or *flagella*, which are their organs of motility. These flagella, either singly or in numbers, are sometimes distributed over the entire body of the cell, or they may form a tuft at one end of the rod, or only one polar flagellum is found. The polar flagella appear in the cells shortly before division. They are believed to be formed of protoplasmic material, which penetrates the cell membrane, and probably to have the property of protrusion and retraction; but their nature is imperfectly understood. So far as we know, the flagella are the only means of locomotion of bacteria. They are not readily stained, special mordants being required for this purpose. Bacteria may lose their power of producing flagella for several generations, whether permanently or not is not known.

Vegetative Reproduction.—The process of vegetative reproduction of bacteria, which is to be distinguished from spore formation, takes place by division, and may go on, under favorable conditions, indefinitely. When development is in progress a single cell will be seen to elongate in one direction. Over the centre of the long axis thus formed there appears a slight indentation in the outer envelope of the cell; this indentation increases until there exist two distinct cells. As a rule, the cells separate soon after division, but occasionally they remain together for a time, forming pairs and chains, or under certain conditions of nutrition long threads or filaments, which break up into fragments, however, when placed under other conditions. Although elongation in one direction and transverse division is the rule for most bacteria, there are certain groups (as the sarcina, for example) which divide more or less regularly in three directions. Division in two directions results, as already mentioned, in the formation of tetrads; while division irregularly in all directions produces grape-like clusters. Bacilli and spirilla, as far as we know, never divide longitudinally.

Spore Formation.—This is the process by which bacteria are enabled to enter a stage in which they resist deleterious influences to a much higher degree than is possible for them in the growing or vegetative condition. It is not a process of multiplication of bacteria, but only one of reproduction for the preservation of the species under conditions unfavorable to their growth, and occurs when the organism has nearly exhausted its supply of nutrition or poisoned it with products of its growth, etc. The fungi, on the other hand, form spores under the most favorable conditions, even requiring an abundant supply of nutrition for their production, the life history of the fungi, indeed, being incomplete without the formation spores. But in bacteria the process is comparatively rare, and all the conditions which tend to bring it about are not yet known.

Two kinds of spores have been described in bacteria:

1. *Endospores*, which are strongly refractile and glistening in appearance, oval or round in shape, and developed within the interior of the cell. They are characterized by the power of resisting to a considerable extent the injurious influences of heat, desiccation, and chemical disinfectants, which would kill vegetative cells. 2. *Arthrospores* or jointed spores, developed, not within the cell, but as a sprout-like projection from one of its extremities. These jointed bodies are believed by Hueppe to have also more or less greater power of resistance to desiccation, etc., than the ordinary cells, though less than endospores; but they have been but little studied, and their existence in bacteria is still an open question. In describing the biological characters, therefore, of the various species, whenever their property of spore formation is mentioned it will be understood that endogenous spores are meant.

The production of endospores in the different bacterial species, though not identical, is very similar. Spores represent a state of suspended activity, and motile organisms always come to a state of rest or immobility previous to spore formation. The following description of the method of spore formation in the anthrax bacillus may serve as an illustration of the process: Under suitable conditions of temperature, moisture, etc., the cell is elongated and at first the protoplasm is clear and homogeneous, but after a time it becomes turbid and finely granular. These fine granules are then replaced by a smaller number of coarser granules, which are finally amalgamated into a spherical or ovoid refractile body. This is the spore. As soon as the process is completed there appears between two spores a delicate partition wall. For a time the spores are retained in a linear position by the cell membrane of the rod, but this later is dissolved or disintegrated and the spores are set free.

The following types have been observed: (*a*) Spores lying in the interior of a short, undistended cell; (*b*) spores lying in the interior of a short, undistended cell, forming one of the elements of a long filament; (*c*) the spores lying at the extremity of an undistended cell much enlarged at that end—the so-called "head spores"; and (*d*) the spores lying in the interior of a much enlarged cell in its central portion, giving it a spindle shape.

The *germination of spores* takes place as follows: By the absorption of water the spores become swollen and paler in color, losing their shining, refractile appearance. Later a little protuberance is seen to project from one side or at the extremity of the spore; this rapidly grows out to form a new rod, which consists of soft protoplasm enclosed in a membrane formed of the inner layer of the cellular envelope, or *endosporum.* The outer envelope, or *exosporum*, is then cast off, and may often be seen in the vicinity of the newly formed rod. In some species the vegetative cell emerges from one end of the oval spore, and in other species the exosporum is ruptured and the bacillus emerges from the side.

Involution Forms.—In old cultures of bacteria in which deleterious substances have been produced or the supply of nutriment has been exhausted, there are frequently found irregular or distorted forms, which are thought to be due to abnormal development of the bacterial cells under unfavorable conditions. These are generally spoken of as *involution* or *degenerated* forms, though sometimes the terms *pleomorphism* and *polymorphism* are applied to them. Placed under suitable conditions these irregular or deformed cells again produce normally shaped organisms.

Chemical Composition.—Qualitatively considered bacterial cells consist of carbon, hydrogen, oxygen, and nitrogen, for the most part in the form of water, salts, fats, and albuminous substances. There are also present, in smaller quantities, extractive substances soluble in alcohol. Glucose has not been found in any bacteria, but many species contain starchy substances which give a reaction with iodine. Cellulose has also been detected in certain species, as the bacillus subtilis, some of the colon group, and the tubercle bacillus. The neuclein bases, xanthin, guanin, and adenin, moreover, have been found in considerable amounts. There is also a group of bacteria, the *Beggiatoa*, which contain sulphur, and another group, the *Cladothrix*, has the power of separating ferric oxide from water containing iron, as in iron and sulphur springs. But very little is known about the chemical composition of bacteria quantitatively, only few species having been completely analyzed; but the percentage composition would appear to depend largely upon the character and constituents of the culture media in which they are grown.

Conditions of Growth.—Although there are some pathogenic bacteria which grow only in the bodies of living animals and plants, and are therefore apparently strict parasites, yet the majority of pathogenic micro-organisms can be cultivated more or less readily in artificial culture media, and are thus facultative parasites. The saprophytic bacteria, as a rule, are easily cultivated artificially, though some of these, as certain organisms met with in the saliva and in water, are very difficult or impossible to cultivate.

The essential condition for the cultivation of all bacteria is water; salts are also indispensable, and organic matter for the supply of carbon and nitrogen. Most of the important bacteria and all the pathogenic species thrive best in media containing albumin and of a neutral or slightly alkaline reaction. The demands of bacteria, however, with regard to nutrition are various. Some water bacteria, for instance, require so little organic food that they will grow in water that has been twice distilled, and in which no nutritive material can be chemically demonstrated. But the pathogenic bacteria are seldom so easily satisfied, though there are several species which will develop in comparatively simple culture media and without albumin.

Considering more in detail the source of the important chemical ingredients of bacteria, we find that their nitrogen is most readily obtained from diffusible albuminous material and less easily from ammonium compounds. Their carbon they derive from carbohydrates, albumin, peptone, sugars, glycerin, fats, and other organic substances. Some bacteria grow best in special culture media, such as bouillon, gelatin, agar, blood serum, potato, milk, etc. The majority of bacteria absolutely require the presence of free oxygen for their growth, although a considerable number fail to develop at all unless oxygen be excluded. Between these two groups of aërobic and anaërobic bacteria, we have those which grow either with or without oxygen. Some of the strictly anaërobic species require for their full development the presence of fermentible substances, such as sugars, from which they obtain their oxygen. In so far as the amount of oxygen present acts unfavorably upon bacteria, there will be more or less restriction in certain of their life processes, such as pigment and toxin production, spore formation, etc. Some aërobic bacteria, however, can be accustomed to grow without oxygen, while certain of the anaërobes can be gradually made to develop in its presence. Among other food stuffs required by bacteria are sulphur and phosphorus; calcium or magnesium and sodium or potassium are also usually needed. Very few species require iron.

With regard to the more complex culture media, whether naturally existing, such as blood serum, ascitic fluid, etc., or artificially made, as bouillon, glycerin, and agar, beyond the necessary amount of soluble nutrition present, the points of greatest importance are the relative proportion of each form of food and its total concentration. Very wide differences, however, may exist in the composition of the culture media with but slight effect upon the development of bacteria, the growth usually ceasing on account of the accumulation of deleterious substances in the media rather than from exhaustion of the food supply.

The reaction of culture media is of great importance. Most bacteria grow best in neutral or slightly alkaline media, very few requiring an acid medium, and none of the parasitic species. An amount of acid or alkali insufficient to prevent the development of bacteria may yet suffice to rob them of some of their most important functions, as the production of toxins.

The influence of one species of bacteria upon the growth of another, either when cultivated together or following one another, is very noticeable. The development of one species of bacteria in a medium causes that substance usually to become less suitable for the growth of other bacteria. This is due partly to the impoverishment of the medium, but also to the production of chemical substances or enzymes which are antagonistic not only to the growth of the bacteria producing them, but to many other species; very rarely are the changes produced by one species of bacteria in the media favorable to some other species.

A suitable temperature is also essential for the growth of bacteria. The most favorable or optimum temperature varies for different species, but for any bacteria a range of about 2.5° C. above or below the optimum covers the limits of their most vigorous growth. Few bacteria grow well under 10° C. or over 40° C.; 2° C. is about the lowest temperature at which any bacterial species has been known to grow, and 70° C. is the highest. In many cases the temperature of the natural medium in which the bacteria have been deposited is the controlling factor in deciding the temperature at which they will or will not grow under artificial conditions. Thus nearly all parasitic bacteria require a temperature near that of the body (36°–38° C.) for their development, while many saprophytic bacteria can grow only at much lower temperature. Bacteria when exposed to lower temperature than suffices for their growth, while having their activity inhibited, are not otherwise injured; but exposure to a higher temperature than that which permits growth destroys the life of bacteria.

VITAL PHENOMENA OF BACTERIA.—*Motility.*—Many bacteria when examined in the hanging drop are seen to exhibit active movements. This motility is produced by the fine hair-like *flagella* attached to all motile species. The movements are various—creeping, rotary, undulatory, etc., at one time being slow and sluggish and at another so rapid that no detailed observation is possible. The spontaneous movements of bacteria are to be distinguished from the so-called *Brownian* or molecular movements, which is a dancing, trembling, stationary motion possessed by all finely divided organic particles. Not all species of bacteria, however, which have flagella exhibit spontaneous motility invariably; in certain culture media and at too low or too high temperatures, and when there is an insufficient or excessive supply of oxygen, motility may be absent. The property of motility, therefore, evidently depends upon other factors than flagella. Some chemical substances apparently exert a peculiar attraction for bacteria, known as *positive chemotaxis*, while others repel them, *negative chemotaxis*; not all varieties, however, are affected alike, for the same substances may exert on some bacteria an attraction and on others a repulsion. Oxygen, for example, attracts aërobic and repels anaërobic species, and for each different species there is a definite amount of oxygen which

most strongly attracts or repels. Possibly these chemotaxic properties, which are as yet but little understood, may, under certain conditions, have something to do with the motility of bacteria, independently of their organs of locomotion, the flagella.

Production of Light.—Some bacteria have the property of emitting light; these are quite widely distributed in nature, particularly in sea water, salt fish, etc. The emission of light or phosphorescence is a property of the living protoplasm of bacteria, and is not usually due to the oxidation of any photogenic substance produced by them. Anything which is injurious to the life of the organism affects this property, as too cold or too high a temperature, chloroform, etc. But while the organism is unable to emit light except during life, it can live, as in an atmosphere of CO_2, without exerting this property. The power of phosphorescence is soon lost, unless the organism is constantly transplanted to fresh media, the presence of oxygen, carbon, and nitrogen being usually required to preserve the property.

Thermic Effects.—Most bacteria possess the power of producing heat, although this does not ordinarily attract attention because of the slight amount of heat produced in cultures. Careful tests, however, have shown that heat is produced. The increase of temperature in organic substances when stored in a moist condition, as tobacco, hay, manure, etc., is partly, at least, due to the action of bacteria. The high temperature thus exhibited may be caused, as Rabinowitsch suggests, to the so-called thermophilic bacteria.

Chemical Effects.—The processes which substances undergo in being decomposed depend, first, on the chemical composition of the substances involved and the conditions under which they exist, and, secondly, on the action of bacteria present. Bacteria are able to construct their body substance out of various kinds of nutritive materials and also to produce fermentative products and poisons, and they can do these things either analytically or synthetically with almost equal facility. In the chemical building up of their cell substance we may distinguish several groups of phenomena: polymerization, a sort of doubling up of a simple compound; synthesis, a union of different kinds of simple substances into one or more complex compounds; formation of anhydrides, by which new substances arise from a compound through loss of water; and reduction or loss of oxygen, which is brought about especially by the entrance of hydrogen into the molecule. The breaking down of organic bodies of complicated molecular structure into simpler combinations takes place, on the other hand, through the loosening of the bands of polymerization, by hydration or entrance of water into the molecule, or by oxidation.

The chemical effects of bacteria are greatly influenced by the presence or absence of free oxygen. The access of pure atmospheric oxygen makes the life process of most bacteria more easy, but it is not indispensable when available substances are present which can be broken up with sufficient ease. Life processes carried on without oxygen do not effect any profound molecular changes in the organic material which is decomposed; but in order that the living organism may obtain the requisite amount of energy from this mode of life, a proportionately large quantity of material must be decomposed. Therein lies the power of a small amount of ferment to produce much alcohol or lactic acid, and of parasites which have invaded the living body to generate intensely poisonous substances out of the body proteids. In the presence of oxygen the decomposition products formed by the action of anaërobic bacteria are further decomposed and oxidized by the aërobes, being thus rendered inert, as a rule, and consequently harmless. Some bacteria have adapted themselves to the use of oxygen compounds, from which they are able to obtain their oxygen; and others—the obligatory or strict anaërobes—are able to live only in the presence of oxygen. The facts of anaërobiosis are of great importance to technical biology and pathology. Under strictly anaërobic conditions, secondary oxidation of the products of decomposition being impossible, the latter accumulate without the formation of by-products. Thus parasitic bacteria are often found to produce far more poison in the absence than in the presence of air.

Fermentation; the Production of Organized and Unorganized Ferments.—The chemical effects of bacteria are largely dependent upon the composition of the culture media. Thus many species which in albuminous media produce no visible changes, when sugar is added give rise to fermentation with the formation of gas. The term fermentation is differently applied by different authors. Some call every kind of decomposition due to bacteria a fermentation; others limit the term to the process when accompanied by the visible production of gas; while others again take fermentation to mean only the decomposition of carbohydrates, with or without gas production. Fermentation may be properly defined as a chemical decomposition of an organic compound, induced by living organisms or substances contained within them (organized ferments), or by chemical substances thrown off from the bacteria (unorganized ferments). In the first the action is due to the growth of the organisms producing the ferments, as in the formation of acetic acid from alcohol by the action of the vinegar plant, and in the second the enzyme causes a structural change without losing its identity, as in digestion. These ferments or enzymes, even when present in the most minute quantities, have the power of splitting up or decomposing complex organic compounds into simpler, more easily soluble or diffusible molecules. Ferments, like albuminoids, are not dialyzable. They withstand dry heat, but are destroyed in watery solution by a temperature of over 70° C. They are injured by acids, especially mineral acids, but are resistant to alkalies. All fermentation has for its object the acquisition by the organism of a store of energy. This storing up of energy is acquired in either of the ways above mentioned. The commonest example of fermentation by decomposition is that of sugar into alcohol and carbonic acid. Exactly opposite to this, and far less common, is fermentation by oxidation, as in the production of acetic acid from alcohol. Proteolytic or peptonizing ferments, which are similar to pepsin and trypsin, in that they decompose insoluble albuminoids into soluble or digestible substances, are very widely distributed. The liquefaction of gelatin, produced by many species of bacteria, is due to the presence of these peptonizing ferments. Diastatic ferments, which convert starch into sugar, like ptyalin, are also produced by bacteria. Other bacterial ferments are the invertive ferments, or those which convert cane sugar into grape sugar; and the rennet ferments having the power of coagulating milk.

The process of fermentation also gives rise to products that are destructive to the ferments; hence fermentation ceases when the nutriment is exhausted. Different kinds of fermentation are called by different names according to the products they yield. Thus, acetic acid fermentation, alcoholic or vinous fermentation, lactic acid fermentation, butyric acid fermentation, etc, are produced by different species of bacteria.

Putrefaction.—By putrefaction in the common acceptation of the term is understood the decomposition of animal or vegetable matter, accompanied by the generation of fetid odors. Scientifically considered it is a kind of fermentation or the decomposition of complex organic compounds, albuminous substances and the like, into simpler combinations, produced by micro-organisms called putrefactive ferments. Typical putrefaction occurs only when oxygen is absent or scanty. As putrefactive products we have peptone, ammonia, and the amines—leucin, tyrosin, and other amido-substances; oxyfatty acids, indol, skatol, phenol; and finally sulphuretted hydrogen, mercaptan, carbon dioxide, hydrogen, and possibly marsh gas.

Pigment Production.—Various bacteria form characteristic pigments as products of their growth. Some of these have been isolated and have been found to possess many of the properties of the aniline dyes. They have no known importance in connection with disease, but are