the subject only that supports him, without the need of any other point of support than the two chairs (Fig. 2).

Usually, there are plenty of persons ingenuous enough to think that Mr. David is actually in a cataleptic sleep, one of the characters of which is cadaveric rigidity.

As Mr. David's neck is entirely bare, it is not possible to suppose that the simulator of catalepsy wears an iron corset concealed beneath his clothing. He has performed a feat of strength and skill rendered easy by the exercise that he has given to the muscles occupying the *collicite* of his vertebral column. This part of the muscular system is greatly developed in the weakest and least hardy persons. In fact, in order that man may keep a vertical position and execute an infinite multitude of motions in which stability is involved, nature has had to give him a large number of different organs. The muscles of the back are arranged upon several superposed layers, the vertebral column is doubly recurved in order that it may have more strength, and, finally, rachidian nerves issue from each

FIG. 1.—CATALEPTIC RIGIDITY.

vertebra in order to regulate the contraction of each muscular fasciculus according to the requirements of equilibrium. The trick is so easy that we have seen youths belonging to the Ligue d'Education Physique immediately imitate Mr. David after seeing him operate but once.

For the sake of those who would like to perform it, we shall add that Mr. David takes care to bend his body in the form of an arch in such a way that the convexity shall be beneath. As Mr. Harrington never fails to place himself in the center of the line that joins Mr. David's head and heels, his weight is divided into two parts, that is to say, 88 pounds on each side of the point of support. The result is that the stress necessary is less than that of a strong man of the Halle lifting a bag of wheat to his shoulder or of an athlete supporting a human pyramid. The force of contraction of the muscular fibers brought into play in this experiment is much greater than is commonly believed. In his lectures on physiology, Milne-Edwards cites some facts that prove that it may exceed 600 pounds per square inch of section.

The experiment on cadaveric rigidity is followed by others in insensibility. Mr. David, without wincing, allows a poignard to be thrust into his arm, which Mr. Harrington has previously "cataleptized" (Fig. 3). This trick is performed by means of a blade divided into two parts that are connected by a semicircle. This process is well known to prestidigitators, but it might be executed in a genuine manner. In fact, on replacing the poignard by one of the gold needles used by physicians for acupuncture, it would be possible to dispense with prestidigitation. Under such conditions it is possible to transpierce a person's arm. The pain is supportable, and consists in the sensation of a prick produced in the passage of the needle

thousand years in Chinese medicine, for opening a passage for the bad spirits that produce diseases. For some years past, a much more serious use has been made of it in European medicine for introducing electric currents into the interior of the organism. In this case the perimeter of the needle is insulated, and the electricity flows into the organism through the point. We have several times had these operations performed upon ourselves, and this permits us to assert that the above mentioned facts are absolutely true.—*Lq Nature*.

NEWER PHYSIOLOGY AND PATHOLOGY.

By Prof. SAMUEL BELL, M.D.

PHYSIOLOGY has for many decades been a science founded on experiment, and pathology has been rapidly pressing forward in the same direction. To read the accounts of how certain conclusions have been arrived at in the laboratory, by ingenious devices and by skillful manipulations, is as fascinating as any tale of adventure.

When the microscope began its work, how discouraging was the vastness and complexity of the discoveries which it brought to light; how many years has it been

FIG. 4.—AN ARM TRANSPIERCED BY A NEEDLE.

diligently used, and how uncertain are we still about many of its revelations! But what a happy conjecture of man, and as proper environment takes place we may reach better results! Let me give an illustration:

Some thirty years ago, Virchow began his studies and lectures upon cellular pathology. The enthusiasm which he awakened spread over the whole medical world. The wonderful attention to detail, the broad philosophy which signaled his observations, were alike remarkable. His class room was packed with students from every country, who thought it no hardship to struggle for a seat at eight o'clock in the morning. With his blackboard behind him and specimens of pathology before him, and microscopes coursing upon railway tracks around the tables which filled the room, he was the embodiment of the teacher; his highest honor was as discoverer. The life and importance of the cell, both in health and disease, it has been his work to discover and to teach. The point of view from which he has classified tumors is founded on this basis, and remains the accepted method. The light which he cast upon the nature of inflammation has not yet been obscured, and while other phenomena appear, the multiplication of cells and nuclei and the formation of connective tissue in the process of inflammation will always call to mind his labors.

To one of Virchow's pupils, Prof. Recklinghausen, we chiefly owe our knowledge of the phenomena of diapedesis as a part of the inflammatory activity. How incredible it seems that masses of living matter can make their way through the walls of blood vessels which do not rupture and which have no visible apertures!

Virchow fixed his attention upon the forms and activities of the cells, their multiplication and degrada-

tion, and how they build up tissues, both healthy and morbid.

To another matter with which, both literally and metaphorically, the air is filled, we must also make allusion. The existence of micro-organisms in countless numbers is no new fact, but the influence they may exert over living tissues has only lately become the subject of earnest attention. So long as they were not known to have any practical bearing upon human welfare, they interested almost nobody, but when, however, it was shown that putrefaction of meat is due to the agency of the *bacterium termo*, and the decom-

position of albumen to the *bacillus subtilis*; when anthrax in cattle and sheep was found to depend on the *bacillus anthracis*, and that in human beings it caused malignant pustules; when suppuration of wounds was found to be associated with micrococci; and when it was announced that by a process of inoculation cattle could be protected against anthrax, and that by carbolic spray and other well known precautions the suppuration of wounds could be prevented—all the world lent its ears and investigation at once began.

Because labors in bacteriology promised to be fruitful in practical results, the workers speedily became innumerable, and we are accumulating a wondrous store of facts. How long now is the list of diseases in which germs make their appearance—in pneumonia, in endocarditis, in erysipelas, in pyæmia, in tuberculosis, and so on and so on. One of the most striking illustrations is the gonococcus of gonorrhœa, whose presence in and around gives to the pus cells their virulent properties, and when transferred to the eye works such lamentable mischief. Without their existence the inoculation of pus in the healthy eye is harmless; pus bearing the gonococci excites the most intense inflammation. Similar suppurative action in the cornea is often caused by infection of cocci. The proof of causation may be found in the fact that the most effective cure now practiced for such suppuration is to sterilize them by the actual cautery. Rosenbach says that he knows six distinct microbes which are capable of exciting suppuration in man. Their activity may be productive of a poison, or putrefactive alkaloid, which is absorbed.

There are at present two prominent theories in regard to the infections which produce disease. The first is based upon chemical processes, the second upon the multiplication of living organisms. The chemical theory maintains that after the infectious element has been received into the body it acts as a ferment, and gives rise to certain morbid processes, upon the principle of catalysis. The theory of organisms, or the germ theory, maintains that the infectious elements are living organisms, which, being received into the system, are reproduced indefinitely, and excite morbid processes which are characteristic of certain types of disease. This latter theory so readily explains many of the facts connected with the development and reproduction of infectious diseases, that it has been unqualifiedly adopted by a large number of investigators. The proofs of this theory had not, however, advanced beyond the demonstrations of the presence of certain forms of bacteria in the pathological changes of a very limited number of infectious diseases, until February, 1882, when Koch announced his discovery of the tubercle bacillus, since which time nearly every disease has its supposed microbe, and the race is, indeed, swift in which the would-be discoverers press forward with new germs for public favor.

The term bacteria or microbe refers to particles of matter, microscopic in size, which belong to the vegetable kingdom, where they are known as fungi. If we examine a drop of stagnant water under the microscope, amplifying say four hundred diameters, we see it loaded with minute bodies, some mere points, others slightly elongated into rods, all actively in motion and in various positions, a countless confusion. If evaporation now takes place, all is still. If we now apply moisture, the dried-up granules will show activity, as though they had not been disturbed.

All these different organisms have become familiar to us under the generic term bacteria, which is a very unfortunate application, as it really applies to only a single class of fungi. Cohn calls them schizomycetes, and makes the following classifications:

1. *Sphero-bacteria*, or microbes.
2. *Micro-bacteria*, or bacteria.
3. *Desmo-bacteria*, or bacilli.
4. *Spiro-teriu*, or spirilla.

The *spiro-bacteria*, or micrococci, are the simplest of the fungi, and appear as minute organisms of spherical form. They multiply by fission, a single coccus forming two, these two producing four, and so on. They present a variety of appearances under the microscope. From single isolated specimens (which under the highest magnifying power present nothing beyond minute points) you will observe them in pairs,

FIG. 2.—EXPERIMENT ON THE SAME SUBJECT.

through the skin. As for the muscular flesh, that is of itself perfectly insensible. The needle, upon the necessary antiseptic precautions being taken, may traverse the veins and arteries with impunity, provided that it is not allowed to remain long enough to bring about the formation of a clot of coagulated blood (Fig. 4).

We think it of interest to add that it is necessary that the experiment be performed by a practitioner if one desires to demonstrate upon himself a very curious physiological fact that has been known from the remotest antiquity. It has been employed for several

again in fours, or in clusters of hundreds (forming zoëglea) and still adhering together, forming chains. When a given specimen is about to divide, it is seen to elongate slightly, then a constriction is formed, which deepens until complete fission ensues.

Micrococci possess no visible structure. They consist of a minute droplet of protoplasm (mycroprotein) surrounded by a delicate cell membrane. Certain forms are embedded in a capsule (diameter 0.0008 to 0.0001 millimeter). These little organisms, when observed in a fluid like blood, sputum, etc., are found to present very active

FIG. 3.—THE PERFORATE ARM

movements, although provided with no organs of locomotion.

This Brownian motion is possessed by almost every minute particle of matter, organic and inorganic, and is not due to any inherent power of the individual. They are almost omnipresent, abounding in the air, the earth, the water, are always found in millions where moist organic matter is undergoing decomposition, and are associated with the processes of fermentation—in fact, they are essential to it. The souring of milk succeeds the multiplication of these germs. Certain varieties are pigmented, and we observe colonies of chromogenic cocci multiplying upon slices of boiled potato, eggs, etc., presenting all the colors of the rainbow. All of these germs are not the cause of disease. Certain species, however (termed pathogenic), are always associated with certain diseased conditions.

The *bacteria-terro*—micro-bacteria—are slightly elongated, and inasmuch as they multiply by division, frequently appear coupled together, linked in pairs, and in chains. They are generally found in putrefying liquids, especially infusions of vegetable matter. They possess mobility to a remarkable degree. Observing a field of bacteria-terro under the microscope, they may be seen actively engaged in twining and twisting. A flagellum has been demonstrated as attached to one or both extremities. This is too minute to be generally resolved, even if it is a common appendage.

Desmo-bacteria (or bacilli) are rod-like organisms, occurring of various lengths and different thicknesses. In a slide of the bacillus of tuberculosis and anthrax, we notice at intervals dots which represent the spores from which, as the rods break up, future bacilli are developed.

Then we have *spiro-bacteria*, the spirilla and the spirochetæ; the former having short open spirals, the latter long and closely wound spirals. The *spirillum volutans* is often found in drinking water, and in common with some other specimens of this class is provided with flagellæ, sometimes at both extremities, which furnish the means of rapid locomotion. The spiro-bacteria multiply by spores, although little is at present known of their life history. They frequently are attached together at their extremities, forming zigzag chains.

We have seen that bacteria differ greatly in appearance from the elongated dot of the bacterium proper, to the elongated rod or cylinder of the bacillus, and the long spirals of spiro-bacteria. It is unfortunate that they are not sufficiently constant in habit to always attach themselves to one or the other of these genera. The micrococcus has a habit of elongating at times until it is impossible to recognize him except as a bacterium; while bacilli, again, break up until their particles exactly resemble micrococci.

Bacteria cannot exist without water; certain forms require oxygen, while others thrive equally well without it; some thrive in solution of simple salts, while others require albuminoid material.

Bacteriology, with its relation to the science of medicine, is of importance to every investigating physician; it covers our knowledge of the relation of these minute organisms to the ætiology of disease. What has been gained as to practical application in the treatment of disease? This question is not infrequently asked in a sneering manner. We can, in reply, say that the results are not all in the future. It is encouraging that results have been attained which have had a very important practical bearing, and that these complaints come generally from individuals least acquainted with scientific investigations in bacteriology.

In the study of the relation of a given bacterium to a certain disease, it becomes necessary to attend carefully to three different operations: First, the organism supposed to cause the disease must be found and isolated. Second, it must be cultivated through several generations in order that absolute purity may be secured. Lastly, the germ must be again introduced into a healthy living being. If the preceding steps be carried out, and the original disease be communicated by inoculation, and the germs be again found in the diseased body, we have no alternative; we must conclude that we have ascertained the cause of the disease. The importance of being familiar with the ætiology of the disease before we can expect to combat it with any well-grounded hope of success is evident.

If the sputum of a phthisical patient be submitted to the skilled microscopist, he is nearly always able to demonstrate bacilli, but this goes for very little. Because bacilli are found in phthisis, it is no more certain that they are the cause of phthisis than it is certain that cheese mites are the cause of cheese. Well, suppose we were to inject sputum from a phthisical person into the lower animal and tuberculosis follows, and then announce to the profession that we have demonstrated the relation of the cause and effect between bacilli and phthisis? Why we would start such an uproar of objections as would speedily convince us that there was much work yet in the domain of bacteriology.

The scientific investigators would say you have injected with the sputum into the blood of your unfortunate patient, pus, morphological elements, and perhaps half a dozen other forms of bacteria, any one of which is just as likely to produce the disease as the bacillus you have selected.

The first important step is, first isolate your bacillus. If I were to take a glass plate, one side of which is coated with a thick solution of peptonized gelatin, and allow the water to collect, the gelatinous matter will become solid. If now, with a wire dipped in some tuberculous matter, I draw a line along the gelatin, I have deposited at intervals along this line, specimens of tubercle bacilli. If this plate be now kept at a proper temperature, after a few days, wherever the bacilli have been caught, a grayish spot will appear, which, easily seen with the naked eye, gradually spreads and becomes larger. These spots are colonies containing thousands of bacilli. Let us return to our gelatin plate.

We find a spot which answers to the description of a colony of tubercle bacilli. We now take a minute particle from this colony on a wire and convey it to the surface of some hardened blood serum in a test tube. We plug the tube so that no air germs may drop in, and place it in an incubator at the proper temperature. After several days, if no contamination be present, a colony of bacilli will appear around the spot where we sowed the spores. Let us repeat the process.

Take a particle from this colony, and transfer it to another tube. This is our second culture. This must be repeated until we are satisfied that we have secured a pure culture. If this be carried to the twenty-fifth generation, we may be assured that there remains no pus, no ptomaines, nothing but the desired bacilli.

It is a proper material now for inoculation, and if we inoculate some of the lower animals, for instance the monkey, we produce a disease identical with phthisis pulmonalis. Bacteria also afford peculiar chemical reactions. For example, nitric acid will discharge all the color from all bacilli artificially dyed with anilin, except those of tubercle and anthrax. One species is stained readily with a dye that leaves another unaltered. Thus we are enabled in the laboratory to determine whether the bacilli found in sputum, for example, are from tubercle or are the bacteria of decomposition.

From what I have said of the tubercle bacillus, it would seem thoroughly demonstrated that it is the cause of tubercle in these animals. But we must walk cautiously here. These are not human beings, who know that like results would follow their inoculation. The animals used by Koch are animals very subject to tubercle.

We must, from the very nature of our environment, be constantly inhaling these germs as we pass through the wards of our hospitals; yes, they are floating in the air of our streets and dwellings. It becomes necessary then for us to inquire: If bacteria cause disease, in what manner do they produce it? The healthy organism is always beset with a multitude of non-pathogenic bacteria. They occupy the natural cavities, especially the alimentary canal. They feed on the substances lying in their neighborhood, whether brought into the body or secreted by the tissues. In so doing they set up chemical changes in their substances. Where the organs are acting normally these fungi work no mischief. The products of decomposition thus set up are harmless, or are conveyed out of the body before they begin to be active.

If bacteria develop to an inordinate degree, if the contents of organs are not frequently discharged, fermentative processes may be set up, which result in disease. Bacteria must always multiply and exist at the expense of the body which they infest, and the more weakened the vital forces become, the more favorable is the soil for their development.

Septicæmia is caused by the absorption of the products of putrefaction, induced before bacteria can multiply inside or outside the body. Bacteria must find a congenial soil. The so-called cholera bacillus must gain access to the intestinal tract before it finds conditions suitable to colonization. It does not seem to multiply in the stomach or in the blood, but once injected into the duodenum develops with astonishing rapidity, and the delicate epithelial cells of the villi become swollen, soften and break down, exposing the mucosa.

It has been shown that *bouillon* in which Loeffler's diphtheria bacillus has grown, and which has been passed through unglazed porcelain filters, shows the presence of a poison which is capable of producing the same results upon inoculation as the pure culture of the bacillus itself. Zarniko, working upon the same organism, obtained a number of positive results that led him to declare this bacillus is the cause of epidemic diphtheria, in spite of many assertions to the contrary. Chantemesse and Vidal record the results of their work as to what will most easily and effectively destroy the bacillus of diphtheria.

The only three substances that actually checked and destroyed its vitality were phenic acid (5 per cent.), camphor (20 per cent.), olive oil (25 per cent.), in combination. For the last I substitute glycerine, because this allows the mixture to penetrate farther into the mucous membrane than oil, the latter favoring a tendency to pass over the surface. This mixture when heated separates into two layers, the upper one viscid and forming a sort of "glycerol," the lower clear. The latter will completely sterilize a thread dipped in a pure culture of the diphtheria bacillus. Corrosive sublimate was not examined because in strong enough doses it would be dangerous and in weaker ones it would be useless.

The facts obtained in regards to the streptococcus of erysipelas are reported as follows: That both chemical and experimental evidence teach the extreme ease of a renewed attack of the disease; that it is possible to kill guinea pigs by an intoxication when they are immune to an inoculation of the culture in ordinary quantities. And this latter fact should warn experimenters trying to obtain immunity in man by the inoculation of non-pathogenic bacteria, because the same results may be reached.

A new theory in regard to fevers and the relation of micro-organisms is suggested by Roussy, viz.: That it is a fermentation produced by a diastase or soluble ferment found in all micro-organisms and cells, and which they use in attacking and transforming matter, either inside their substance or without it.

The resemblance of the malaria parasite to that of recurrent fever is noted in the work of Sacharoff. He states that there exists in the blood of those suffering from recurrent fever a hæmatozoon, which is most prominent after the fever has begun to fall, when it is of enormous proportions, twenty or more diameters of a red blood corpuscle, although smaller ones may still be found. The parasite consists of a delicate amœboid body containing a multitude of dark, round, uniform, sharply outlined, movable granules. Besides these, the protoplasm contains a generally grayish homogeneous nucleus as large as one or two red blood corpuscles. The protoplasm sends out pseudopodia (with granules), which sometimes separate and appear as small delicate pieces of protoplasm. They vary in size, and are often swallowed by the red blood corpuscles in which they grow, and finally develop into the above mentioned amœboid bodies.

Prof. J. Lewis Smith has made a great many autopsies of children dead from cholera infantum, and almost invariably found the stomach and liver in a comparatively healthy condition. Ganghen, who has given this subject considerable study, denies the existence of any specific germ in the summer diarrhea of infants, but claims to have found three different germs in the intestines of children suffering from cholera infantum, each producing a chemical poison which is capable of producing vomiting, purging, and even death. A great variety of germs are found in drinking

water, and no doubt countless numbers are taken into the digestive tract, and the principal reason why pathological conditions do not occur more frequently is on account of the germicidal qualities of the gastric juice.

The comma bacillus of Koch, and the typhoid fever germ of Eberth, are especially destroyed in normal gastric juice. When the germs are very numerous, they run the gauntlet of the stomach (as the gastric juice is secreted only during digestion); and once in the alkaline intestinal canal they are capable of setting up disease, other conditions contributing—ill health, deranged digestion, etc.

Mittman has made a study of bacteria beneath the nails, and reports, after examining persons following different occupations, having found numerous varieties of micro-organisms; which are interesting from a scientific standpoint relative to the importance of thoroughly cleansing the hands before undertaking any surgical procedure. He found, out of twenty-five experiments, 78 varieties of bacteria, of which 36 were classed as micrococci, 21 diplococci, 18 rods, 3 sarcinæ, and 1 yeast. Cooks, barbers, waiters, etc., were examined.

The blood, defibrinated and freshly drawn, has marked germicidal action; for bacteria its action is decidedly deadly, even hours after it has been drawn from the body. Especially were anti-germic qualities noticed upon pathogenic bacteria. Buchner put the bacilli of anthrax in a quantity of blood, and in two hours the number was reduced from 4,800 to 56, and in three hours only 3 living bacteria remained. Other bacteria were experimented upon in blood with similar results, but the destruction of the organism from putrefaction was much less marked, and on some varieties the blood had little or no action.

It is not the object of these remarks to even give a *résumé* of the *status præsens* of bacteriology, but simply to stimulate thought in that direction. The claims of some of the ultra-bacteriologists may never be realized, but enough has been accomplished to revolutionize the treatment of certain diseases, and the observing student will do well to keep his eye on the microbe, as it seems from the latest investigations that its star is in the ascendant. And who can prognosticate but that in the next decade an entire revolution in the ætiology and treatment of many diseases may take place?

Detroit, Mich.

THE COMPOSITION OF KOCH'S LYMPH.

WHAT PROFESSOR KOCH SAYS IT IS, AND WHAT IT CAN DO.

(By Cable to the *Medical Record*.)

BERLIN, January 15, 1891.

THE curiosity to know the composition of the famous lymph has been gratified by the publication to-day of an article by Professor Koch on the subject. In the following, as will be seen, he reaffirms his original convictions and acknowledges the valuable assistance he has received from those who have used his fluid, and thus helped him in the accumulation of experience.

Professor Koch says: Two months ago I published the results of my experiments with the new remedy for tuberculosis, since which time many physicians who received the preparation have been enabled to become acquainted with its properties through their own experiments. So far as I have been able to review the statements published and the communications received by letter, my predictions have been fully and completely confirmed. The general consensus of opinion is that the remedy has a specific action upon tubercular tissues, and is, therefore, applicable as a very delicate and sure reagent for discovering latent and diagnosing doubtful tuberculous processes. Regarding the curative effects of the remedy, most reports agree that, despite the comparatively short duration of its application, many patients have shown more or less pronounced improvement. It has been affirmed that in not a few cases even a cure has been established. Standing quite by itself is the assertion that the remedy may not only be dangerous in cases which have advanced too far—a fact which may forthwith be conceded—but also that it actually promotes the tuberculous process, being therefore injurious.

During the past six weeks I myself have had opportunity to bring together further experiences touching the curative effects and diagnostic application of the remedy in the cases of about one hundred and fifty sufferers from tuberculosis of the most varied types in this city and in the Moabit Hospital.

I can only say that everything I have latterly seen accords with my previous observations. There has been nothing to modify in what I before reported. As long as it was only a question of proving the accuracy of my indications, it was needless for any one to know what the remedy contained or whence it was derived. On the contrary, subsequent testing would necessarily be more unbiased, the less people knew of the remedy itself. Now, after sufficient confirmatory testing, the importance of the remedy is proved, my next task is to extend my study of the remedy beyond the field where it has hitherto been applied, and if possible to apply the principle underlying the discovery to other diseases.

This task naturally demands a full knowledge of the remedy. I therefore consider that the time has arrived when the requisite indications in this direction shall be made. This is done in what follows.

Before going into the remedy itself, I deem it necessary for the better understanding of its mode of operation to state briefly the way by which I arrived at the discovery. If a healthy guinea pig be inoculated with the pure cultivation of German Kultur of tubercle bacilli, the wound caused by the inoculation mostly closes over with a sticky matter, and appears in its early days to heal. Only after ten to fourteen days a hard nodule presents itself, which, soon breaking, forms an ulcerating sore, which continues until the animal dies. Quite a different condition of things occurs when a guinea pig already suffering from tuberculosis is inoculated. An animal successfully inoculated from four to six weeks before is best adapted for this purpose. In such an animal the small-indentation assumes the same sticky covering at the beginning, but no nodules form. On the contrary, on the day following, or the second day after the inoculation, the place where the lymph is injected shows a strange change. It becomes hard and assumes a darker coloring, which