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## Medical, Surgical and Physical Science.

## ORIGINAL COMMUNICATIONS.

ART. LX.—*The Hip-joint—Considerations on its injuries and diseases,, deduced from the Anatomy, by* S. J. STRATFORD, M.R.C.S., Eng., Toronto.

TREATMENT OF FRACTURE OF THE NECK OF THE THIGH-BONE.

*(Continued.)*

When we were considering the nature and varieties of fractures of the neck of the thigh-bone, we pointed out that there often happened two distinct characters in the varieties of these injuries; that they were both produced by the action of direct force; that the one was produced by the action of that force proceeding from without inwards, while the other was caused by the influence propagated from above downwards; that the direction in which the force proceeded clearly indicated these differences, and was a mark in the nature of the accident that plainly pointed out; that a variety of treatment was applicable in each case; that when the force was shown to proceed from without inwards, the accident was always attended with a far greater amount of local injury and irritation to the surrounding parts; that the muscles were always influenced with a far greater amount of spasm, swelling and contraction, than when the direction of the force proceeded from above downwards; hence the treatment demanded in this variety was perfect rest and relaxation of the parts, by means of the double inclined plane. But when the injury was caused by a force proceeding from above downwards, that there was always far less irritation and spasms; consequently the straight splint of Desault might be employed from the first, preserving the fractured bones in a state of constant apposition, and maintaining the limb in a condition of continual extension, until the cure was more or less perfectly accomplished.

Sir Astley Cooper has advised that we leave these cases of fracture of the neck of the thigh-bone almost entirely to nature, as we cannot hope for union of the fractured bone; but we must ever remember, that union ever so imperfect would in these cases be a marked advantage; consequently we think that every patient is entitled to a chance of such benefit. It must be clear to all that Sir Astley Cooper's advice can extend only to the last-named variety of these fractures of the neck of the thigh-bone, caused by force proceeding from above downwards—the accident which especially occurs in old people; but when fracture has happened external to the capsular ligament, we need not despair of bony union and the future usefulness of the limb, unless some constitutional disability intervene to prevent it. From the opinions expressed by Sir Astley Cooper, and the deductions we have endeavored to establish from the varying nature of the forces which produce these accidents, it must be evident that we may expect a vast difference in the results: first, in the nature of the fracture; second in the possibility of a cure. The first has been already fully explained. The second remains to be considered, and we believe may be readily explained by the anatomical peculiarities of the part. Thus, when fracture of the neck of the thigh-bone happens, caused by force proceeding from without inwards, it is always attended with considerable laceration of the capillary blood vessels; not only of the fractured bone and its periosteum, but also of the muscular and fibrous structures in their immediate neighborhood; from this results effusion of blood, and swelling of the part. As soon as the hœmorrhage has been arrested, and the tone of the capillaries and absorbent vessels has been re-established, the thinner portions of the blood—now separated into serum and clot—begin to be absorbed; it is taken up by endosmotic influence, through the thin and transparent coats of these vessels; this process constantly progresses until almost all the constituent principles of the blood, excepting the fibrine and corpuscles, are removed. These latter now at rest, are broken up, and their coloring matter, which tinges the various structures around with a great variety of tints, is also slowly absorbed; at last scarcely more than the fibrine is left in the part, and this is generally placed under the most favorable circumstances to become organized. New blood vessels are formed in the effused substance, it becomes fibrous tissue; the variety of this tissue will be always dependant upon the law of *analagous formations* which exists in the animal economy; hence, agreeably to the nutritive apparatus of the structure from which the blood is effused, shall we have a corresponding development; be it areola tissue, be a periosteum, or be it cartillage; all may be presented from the same injury. As the serum is absorbed, the pain and swelling subsides; still a certain amount of heat and increased vascular activity may be observed in all the injured structures. The influence of this vascular activity upon the bone is to cause a softening of the extremities of the fractured portions. The increased supply of blood to the haversian canals, the true capillaries of bone, is to yield a larger amount of serous fluid to the lacunæ and canaliculi—the true nutritive apparatus of bone. By means of this inordinate supply of fluid to the fibrous intercellular element of the bone, it is softened, the earthy matter is dissolved, and being absorbed into the capillary vessels is removed from the structure, while after a time the animal matter, the fibrous element of the bone, is itself softened and dissolved by similar means. At this period we find the ends of the fractured bone not only softened but rounded off, so that all points and spiculæ are gradually removed, and the extremities of the bone are prepared for the true reparative process about to take place.

About the period at which the fractured bone has arrived at this condition, we find that the fibrine effused around the broken extremities of the bone, between the lacerated periosteum, and in the surrounding areola tissue, has become organized. The fibrous element constituting the new periosteum becomes hardened with a deposit of the salts of bone; these are incorporated into its structure and constitute the formation of bone in ligament. This becomes the *provisional callus*, as it is called. The extent of this callus will be proportioned to the exigencies of the case—the power of motion left to the fractured extremities of the bone, and the ability in the surrounding structures to supply the necessary pabulum, will regulate its amount. In the case of fracture of the neck of the thigh-bone without the capsular ligament this is often very great, and not unfrequently forms a very large and hard swelling around the hip. This callus by degrees becomes bone, but it is only a temporary expedient, a splint formed by nature to preserve the broken fragments immoveable and in close apposition until more perfect union by true bone shall occur. The amount of the formation of this provisional callus seems to be proportioned to the latitude of motion to which the fractured portions of the bone are liable, if this is but little, either from the nature of the location, or the perfection with which the surgeon applies his splints, then the amount is small; but should the liability to movement be considerable, or the restraining power insufficient, then the amount of this callus will be considerable. The amount of provisional callus that generally forms around the trochanters and neck of the thigh-bone outside the capsular ligament is often considerable; the extended limb in all these cases forms a powerful lever, by which the smallest amount of motion in the foot is readily impressed upon the fractured neck, hence the necessity for the great amount of provisional callus in this instance. The callus fully formed, the ends of the fractured bone are firmly bound together and in preparation for the final union. During the progress of this condition, fibrine has been effused from the haversian canals, the capillary blood vessels of the bone—nodules of cartillage are developed; in these true cartillage cells are formed, they increase in numbers, and then gradually assume a longitudinal arrangement; when this condition is perfected the intercellular fibrous structure receives a deposit of the earthly salts, this deposit goes on with more or less regularity until the cartilage cells are enclosed in a bony wall, constituting a tube, continual layers of earthy matter are deposited in the fibrous element, until after a time the cartillage cells disappear and the space is occupied by a blood vessel in a true haversian canal. When this condition has been arrived at, the cartillage cells may be observed arranged in circles around the main group, and now the deposition of earthy matter progresses, until all the intercellular fibrous element is fully saturated with calcareous matter; the cartillage cells gradually disappear, and their positions are supplied by lacunæ and canaliculi, around which the earthy salts of the bone have been deposited—this is the true nutritive apparatus of fully developed bone. Heretofore, when the cartillage cell existed, no blood was supplied to this structure; but now red fluid blood enters into the bone, and traverses the capillaries, while the thinner parts, serum with the salts of the bone in solution, transude the coats of the vessel and are distributed to the canaliculi and lacunæ, to supply the earthy salts, and to moisten and nourish the fibrous element. This is the *definitive callus* of bone, the source of true bony union between the fractured extremities. Now the provisional callus begins to be removed, the earthy matter is taken up, the fibrous element becomes atrophied, and after a very considerable period of time will be entirely removed, leaving the fractured bone strong and perfect in its union and composition, if the fragments have been duly adjusted and maintained in proper apposition. When this condition has been fully accomplished in fracture of the neck of the thigh-bone, perfect union and a serviceable limb may be expected as the result, and this for the most part readily takes effect when the fracture is external to the capsular ligament.

When the force has proceeded from above downwards and the neck of the thigh-bone has been fractured within the capsular ligament, the result is seldom so favourable as in the variety which we have just detailed. When fracture takes place within the capsular ligament, if the fibrous envelope has not been lacerated—the retinaculæ of Weitbrecht—we believe that this structure may act as nature's splint, will retain the broken bone in contact, true definitive callus will be readily formed and bony union be the result; and this may account for the specimens of bony union of the neck of the thigh-bone within the capsular ligament which are occasionally presented to us in the various museums. When, however, the fracture has extended through the fibrous envelope and the broken neck is free in the joint, the want of the necessary support, the deficiency of fibrous tissue around the fracture, the impossibility of the formation of a provisional callus will render it improbable that any definitive callus will result; hence a deficiency of bony union is more than probable, and this is the reason why all these cases have been set down as incurable. When fracture of the neck of the thigh-bone has been complicated, with laceration of the capsular ligament, the anticipations of perfect union are still more improbable, the extremities of the bones will be rounded off, but seldom any perfect union will occur. The want of the provisional callus is considerably influenced by the great deficiency of the capillary apparatus supplied to the neck of the bone, as well as to the want of the surrounding fibrous structures. It must be evident that the only supply of blood which is yielded to the head and neck of the thigh-bone after complete fracture has occurred must be through the round ligament; were this structure injured or deficient, the fractured neck must necessarily die; when dead, it would be sure to cause great irritation of the joint, matter would form, complete disorganization and death of the part, in all probability, be the result. From this cause results the chief danger in separation of the epiphesis, which might otherwise unite without our being fully aware of the nature of the injury.

### FRACTURE OF THE COTYLOID CAVITY.

Fracture of the bones of the pelvis is commonly the result of very severe injury, and this always influences more or less extensively the viscera contained within its cavity. Fracture of the bones of the pelvis may implicate the cotyloid cavity; but as displacement does not often occur, it may be difficult to form a correct diagnosis, unless we can trace the fracture from the more superficial parts, feel or hear a crepitus upon the movement of the body, as upon a person being turned in bed. In all these cases, the injury to the viscera contained within the pelvis, and that of the surrounding soft parts, is generally of the most pressing importance, and demand our first and most careful consideration. Should the person withstand the first shock of the injury and its immediate consequences—upon the subsidence of the swelling and inflammation, the employment of a good broad belt applied as tightly as possible over the hips, should be adapted to the parts, so as to keep the bones perfectly steady, and prevent movement of one part upon the other, and so promote bony union. The severity of an injury that is sufficient to cause fracture of the bones of the pelvis, when that fracture extends through the cotyloid cavity and implicates the hip-joint is most commonly fatal, or it is certain that it will give rise to such grave consequences that recovery is an exception to the rule. When life is spared it usually happens that extensive sinuses and large collections of matter occur around the hip-joint and within the pelvis, that eventually lead to the patient's destruction.

Fracture of the brim of the acetabulum may occasionally happen; it is commonly the result of direct force applied from above downwards, which instead of fracturing the neck of the thigh-bone, carries away a portion of the upper lip or supercilium of the cotyloid cavity. A person alighting from a height suddenly rests upon his feet, and from some peculiarity in the position of the head of the thigh-bone at the time of the accident, the weight comes upon the margin of the cotyloid cavity, this yields to the impulse, and fracture of the hip-joint is the consequence—the result is that when displacement of the head of the bone occurs, the femur is drawn upwards and backwards upon the dorsum of the ilium; and when we examine the patient, we find all the symptoms that characterise dislocation of the femur in this location—such as shortening of the limb and permanent inversion of the toe, so much so, that the surgeon frequently resorts from the first view of the case to the means that were formerly employed to reduce the dislocation—this is easily accomplished by the old method of extension, and we have perhaps prided ourselves on the facility and tact with which we have accomplished the operation; when, behold, upon any great movement or exertion of the patient, we are surprised to find that the thigh-bone has again assumed its abnormal position—if during our attempt at reduction, or if we have been particularly careful in our examinations, we may perhaps have discovered a crepitus in the parts, which with the unusual facility of displacement of the head of the thigh-bone after it has been reduced to its proper situation, will form the most correct diagnostic signs of this variety of accident. If also we reflect upon the nature of the force that produced the accident, that it was direct force—that it proceeded from above downwards—hence that it was a fracture rather than a dislocation, which is always caused by indirect force acting upon the extended limb as upon a lever, so that the mode in which the accident is caused at once indicates that dislocation could not have been produced; and when the above mentioned symptoms present themselves, the shortened, permanently flexed limb and fixed inversion of the toe, will surely indicate that fracture of the brim of the acetabulum had been produced. After all, however, it must be confessed that to distinguish this variety of accident from fracture of the neck of the thigh-bone, when the neck has been left of very considerable length, is extremely difficult, for in this case we have all the indications presented in the before-mentioned variety. It appears to me impossible accurately to mark the distinction, unless we can discover the fractured lip elevated from its normal position, or discover a crepitus that is produced independent of any movement of the femur; should such symptoms present themselves we may then be fully confirmed in our diagnosis and could not possibly mistake it for any other variety of accident to which the hip-joint is liable. The treatment, as soon as the most severe inflammatory symptoms have subsided, and we shall have returned the head of the bone into the cotyloid cavity, should consist in the employment of a broad strong band firmly buckled round the pelvis and well padded where it passes over the fractured portion,—this will in all probability keep the fractured lip in its true position, provided we can prevent the retractile power of the muscles operating upon the shaft of the femur. To accomplish this indication, we should employ the straight splint as in fracture of the neck of the thigh-bone, so as to keep the limb extended, obviate any retraction which would necessarily cause a separation of the fractured parts, and prevent the bones growing together.

We have seen that fracture of the lip of the acetabulum may be caused by force proceeding from above downwards.

so may fracture of the bottom of the cotyloid cavity be produced by a force proceeding from without inwards—by a blow or fall upon the trochanter major which drives the head of the bone down into the acetabulum; this being abnormally thin, or not possessing sufficient strength to withstand this force, which comes in the direct line of the neck of the thigh-bone—yields to the influence, and permits the head of the femur to pass through the bone into the cavity of the pelvis. From the nature of the application of the direct force from without inwards, we commonly find great swelling and effusion into the soft parts; by accurate admeasurement we find the injured limb considerably shorter than its fellow; the limb lies in its normal position—the trochanter major is not quite so protuberant, but from the swelling this indication is not very striking; rotation of the limb, if permitted at all, is but slight in degree, it is evidently peculiarly confined, while the extended circle during such movement commonly performed by the trochanter major is greatly diminished. It is difficult to distinguish the character of this accident from fracture of the neck of the thigh-bone, when the neck of the thigh-bone is driven deep into the cancellated structure of the shaft of the femur, and firmly impacted in this position. When we examine a patient who has met with this accident, and make extension of the limb, we may be able readily to bring it to the length of its fellow, but as soon as the retractile power ceases, the limb becomes shortened as before; when this extension can be accomplished and its return readily recognized without the shaft of the femur becoming elevated upon the dorsum of the ilium, it will become a clear diagnostic of the nature of the accident—but when the head of the femur is immoveably wedged in the pelvis, the direction of the force, attended with shortening and immobility of the limb, the severity of the accident and the attendant injury and irritation of the pelvic viscera, will alone remain to throw light upon the nature of the accident. Inflammation of the pelvis viscera will be commonly a marked attendant upon this variety of fracture, and will produce the most grave and dangerous symptoms we shall have to combat; so that, after having withdrawn the head of the femur into the cotyloid cavity and maintained it in due position, we must give our most strenuous attention to this point. To maintain the bone in its proper position, the application of the long splint placed upon the opposite side of the body, so as not to irritate the injured limb, may be employed—this should extend from the armpit to the foot, and some four or five inches beyond it, and be firmly attached to the thigh, to the body, and to the foot; a transverse piece of iron nicely padded should be fixed to the lower extremity of the splint, and passing under the foot of the injured limb; this should be extended to the length of its fellow, and be firmly fixed to the iron by a bandage, so as to keep it extended exactly of the same length. To prevent intrusion of the head of the femur into the cotyloid cavity, we may place a firm pillow between the upper part of the thighs, so as to keep them well asunder; this should be made to act as a fulcrum, that on bringing the feet together will have the effect of drawing out the head of the femur to its full extent from the bottom of the cotyloid cavity. Should symptoms of pelvic or abdominal inflammation supervene, free and repeated blood-letting must be employed, assisted with the constant use of warm fomentations, the exhibition of calomel and opium, and occasional doses of castor oil if required, should be employed; these means may perhaps allay the inflammatory symptoms, but from the character of the accident it must be sufficiently evident that the fears for the safety of our patient must commonly be continuous and extreme.

### COMPOUND FRACTURE OF THE NECK OF THE THIGH BONE.

Having fully described every variety of simple fracture of the neck of the thigh-bone, it still remains for us to consider the causes and consequences of fracture attended with a wound or opening, extending into the coxo-femoral articulation—as it is called, a compound fracture of the neck of the thigh-bone. The force that shall be able to produce a compound fracture of this articulation must proceed from without inwards and be the result, either of great violence, in all probability producing great and extensive injury of the soft parts—not only to the thigh but also to the pelvis, or be caused by a gun-shot wound. If the result of the former, the amount of the attendant laceration and contusion of the soft parts must guide our judgment as to the course to be pursued. Should the injury, although a penetrating wound, be unattended with severe contusion, the result of a pointed instrument, for example, thrust into the joint, the patient with a good constitution, we may bring the parts together and hope for union by the first intention, and by treating the injury after the manner recommended in simple fracture hope to preserve to our patient a comparatively useful limb. Such however can seldom be the rule—it most commonly will be the exception to it; for an opening into so large a joint, and the fracture of the bone, surrounded as it is by the various structures, integral parts of the joint, it is very improbable that the patient can escape intense inflammation and all its attendant consequences. In such case, when we feel convinced the irritation will proceed to this condition, either from the extent of the wound or the character of the constitution, it will be well to proceed to excision of the head and neck of the thigh-bone as soon as possible after the accident; we shall by these means convert a dangerous compound fracture into a comparatively simple wound, and avoid to a certain extent the inflammation and suppuration of the limb, which will be almost sure to follow such an accident if left to itself.

In cases of fracture of the neck of the thigh-bone, when the bone has been greatly comminuted and the neighbouring soft parts have been vastly contused and lacerated, it has been recommended to remove the limb at the hip-joint; but the propriety of this operation in these cases must be very problematical, nay often positively improper when the soft parts have participated extensively in the injury. It certainly is contrary to all just rules of surgery during an amputation to cut through bruised and injured parts. How could this be avoided in such a case, and how could we hope for a proper union of the parts, or expect to save the life of our patient, with a large suppurating wound so near to the trunk, which would necessarily result from such an operation? In all these cases, we must be guided by the concomitant injury which has been inflicted upon the rest of the limb, and should the operation be clearly indicated, on our ability to save sufficient sound parts to make a flap and cover the wound with uninjured muscle and integuments—such a possibility could alone warrant the removal of the thigh at the hip-joint, for in all cases of fracture of the neck of the thigh-bone complicated with external injury, and not otherwise extensively implicating the limb so as to demand the operations, in my opinion excision of the head and neck of the thigh-bone should always be preferred to amputation of the limb.

When the fracture of the head and neck of the thigh-bone is the result of a gun-shot, the certainty of attendant injury will readily guide our practice—should a musket ball strike the bone and produce a comminuted fracture, or should a spent ball lodge in the neck of the thigh-bone, I fully concur with the judicious advice given by Mr. Guthrie, that a removal of the head and neck of the thigh-bone would be far preferable to amputation of the limb; if this speedily followed the injury the case would be greatly simplified and in all probability shorn of its worst symptoms; while the cause of the mischief having been removed, we might reasonably hope for the complete and speedy restoration of our patient to health, and that with a comparatively useful member, which in all probability would not be the case were the injury left to the unaided powers of nature.

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ART. LXI.—*On some Compounds of Urea, and on a new method for the determination of Chloride of Sodium and of Urea in Urine. By* JUSTUS LIEBIG, M.D., Ph.D., F.R.S., M.R.I.A.; Professor of Chemistry in the University of Giessen; Knight of the Hessian Order, and of the Imperial Order of St. Anne; Member of the Royal Academy of Science of Stockholm; Corresponding Member of the Royal Academies of Science of Berlin and Munich, of the Imperial Academy of St. Petersburg, of the Royal Institution of Amsterdam, &c. &c. &c.

*Concluded.*

METHOD FOR THE DETERMINATION OF UREA IN URINE.

The methods just described for the determination of chloride of sodium and of mercury are mainly calculated for the determination of chloride of sodium and urea in urine, and are, perhaps, of particular value for this purpose only.

I will now proceed to describe a new method of determining urea in urine, which equals those now in use, in point of accuracy, but has this advantage, that it far excels them as regards rapidity of execution, and that its application does not require any particular skill, so that it is particularly applicable, as I think, for medical purposes, as a means of assisting the diagnosis of certain states of disease. This method is based on the fact that urea is precipitated by nitrate of protoxide of mercury.

On gradually adding to a dilute solution of urea an equally dilute solution of nitrate of protoxide of mercury, and neutralizing the free acid of the mixture from time to time by baryta-water or dilute carbonate of soda, a flocculent snow-white precipitate is obtained, which is insoluble in water. If the addition of the salt of mercury and of carbonate of soda be continued alternately, as long as this precipitate is formed, a point is arrived at when, by the addition of the carbonate of soda, the mixture, or the spot with which the drop comes in contact, assumes a yellow colour of hydrated oxide of mercury, or basic nitrate of protoxide of mercury. When filtered at this point the liquor no longer contains any appreciable quantity of urea; all the urea is precipitated. I have subjected to analysis this precipitate, which differs by its amorphous condition from the above described compounds of urea and nitrate of protoxide of mercury, and I found it in every instance to contain 4 eq. of protoxide of mercury for 1 eq. of urea.

By mixing a solution of urea with a solution of mercury, both of known strength, it can easily be demonstrated that a precipitation of yellow oxide, by the addition of carbonate of soda to the mixture, is not produced until a volume of the nitric solution of mercury is added, which contains 77 parts of protoxide of mercury for 10 parts of urea in the solution of urea; this, however, amounts to 4 eq. of protoxide of mercury to 1 eq. of urea.

On adding nitrate of protoxide of mercury to a solution of urea, as long as a precipitate is formed, the mixture remains white on addition of carbonate of soda; if, however, the original mixture be left quietly for some hours, the precipitate is changed—it becomes crystalline; the six-sided tablets of the compound with 3 eq. of protoxide of mercury are easily recognized in it, and the clear liquid standing above the crystals, which was previously precipitated white, produces now a *yellow* precipitate with alkalies. The compound with 4 atoms of protoxide of mercury is reduced in the acid liquor into a compound containing less oxide—that is to say, part of the oxide is redissolved.

In order to ascertain whether the exact quantity of the salt of mercury has been added, necessary for the formation of the urea compound with 4 atoms of protoxide of mercury, it is requisite to neutralize the liquor with carbonate of soda, after the mercurial solution has been added. If the mixture—for instance, a drop of it on a watch-glass, mixed with a drop of solution of carbonate of soda remain white, it may be assumed with certainty that free urea is present in the liquor; only when on mixing the two drops, a yellow skin appears on the surface, the limit is attained, or rather a little exceeded; but a very slight excess of the mercurial solution is required to indicate that the requisite quantity for the precipitation of the urea has been added. From this it is evident that if the amount of mercury in the solution be known, the quantity of urea in a liquid containing it may be estimated by the amount of solution used in the described manner for the precipitation of the urea.

Or, if for the precipitation of a *known* quantity of urea, say 100 milligrammes, a certain volume of solution of mercury be necessary, an equal volume of it will indicate the same amount of urea in a liquor, the amount of urea in which is unknown. From the volume of this solution, used for the precipitation, the quantity of urea present may be calculated; the consumption of half the volume indicates half as much; that of double the quantity twice as much urea in the liquor.

On this point also my experiments have yielded perfectly concordant results, as the following numbers will show:

The first series indicates the amount of urea obtained from 10 cubic centimeters of the solution by simple evaporation. The second series exhibits the amount of urea in the same volume of the same solution, as found by the determination with the graduated solution of nitrate of protoxide of mercury.

For 10 cubic centimeters of solution of urea were obtained—

| | I. | II. | III. | IV. | V. | |
|---|---|---|---|---|---|---|
| I. Urea by evaporation . . | 371.5 | 412 | 117 | 98 | 512 | milligrammes. |
| II. „ by nitrate of merc. | 472.5 | 412 | 116.8 | 98 | 512.75 | „ |

The methods for the determination of urea, up to the present time acknowledged as the best, are those of Ragski and Bunsen; both are based upon the same principle, viz., upon the transformation of the urea into carbonate of ammonia. Ragski determines the ammonia in the form of ammonia chloride of platinum; Bunsen determines the carbonic acid in the form of carbonate of baryta. Both methods give very trustworthy results, if in Ragski's method the potassio chloride of platinum, precipitated simultaneously, be taken into account.

The following series of experiments, in which the amount of urea in urine of man was determined according to Ragski's method, and by means of nitrate of protoxide of mercury, may prove that the latter method is not inferior to the former.

20 cubic centimeters of urine of different individuals contained of urea—

| | I. | II. | III. | IV. | |
|---|---|---|---|---|---|
| Determined by means of nitrate of mercury | 450 | 360 | 450 | 508 | milligr. |
| Determined by Ragski's method.............. | 446 | 350 | 457 | 508 | „ |

I have found, on precipitating urine with a mixture of nitrate of baryta and baryta-water, filtering off the phosphate and sulphate of baryta, evaporating the liquid, extracting the residue with alcohol, evaporating the alcoholic extract to dryness, and again exhausting it with absolute alcohol, that this alcoholic solution contains tolerably pure urea, crystallizing from it in colourless needles. This method may be used to prepare urea directly from the urine, without precipitating with nitric acid; and this mode of proceeding may even be used for the quantitative determination, as the following experiments will show, for which the same urine was used as in the above determinations of urea:

| | In 20 c. c. of urine. | | | | In 10 c. c. of urine. | | | |
|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | IV. | V. | VI. | VII. | |
| Urea by alcohol ...... | 428 | 326 | 439 | 503 | 223 | 219 | 198.5 | milligr. |
| By nitrate of Hg O ... | 450 | 360 | 450 | 508 | 225 | 220 | 200 | " |

The solubility of chloride of sodium in alcohol is, however, somewhat increased by urea. According to an experiment made on this point, alcohol dissolved from a mixture of chloride of sodium and urea 1.0085 grammes, consisting of 0.9785 urea, and 0.030 chloride of sodium. 100 parts of the dissolved substance contained accordingly 2.97 of chloride of sodium, and 9.703 of urea.

Finally I determined urea by means of nitrate of protoxide of mercury in the urine of different persons, and then, in order to test the influence of the other constituents of urine, I mixed the same urine with weighed quantities of urea (pure), and determined the latter again: the following results will show that these other constituents exert an influence in the determination:—

10 cubic centimeters of urine gave

| | I. | | II. | | III. | | |
|---|---|---|---|---|---|---|---|
| Urea ......... | 272 | 372 | 212 | 462 | 170 | 195 | Millegrammes of urea. |
| After adding | 100 | | 350 | | 25 | | |
| The 2d determ. gave | | 373 | | 464 | | 196 | |

In all the experiments with the test liquor, the urine was previously precipitated with a mixture of baryta-water and nitrate of baryta, an operation which was omitted in the application of Ragski's method.

Preparation of the Solution of Mercury which serves for the precipitation of Urea in Urine.—4 grammes of pure urea are first dissolved in water, and diluted with water until the volume of the solution amounts to exactly 200 cubic centimeters (by dissolving 4 grammes of urea, 200 cubic centimeters of water, 201.75 cubic centimeters of liquor, would be obtained an excess of 1.75 cubic centimeters).

20 cubic centimeters of the solution of nitrate of protoxide of mercury, to be used for the determination of urea in urine, should exactly suffice to indicate with precision the urea in 10 cubic centimeters of the solution of urea just described, containing 200 milligrammes of urea: 1 cubic centimeter of it should correspond to 10 milligrammes of urea. For this purpose the solution of urea should contain a quantity of oxide sufficient to form, with 100 milli-

grammes of urea, the nitrate with 4 eq. of protoxide of mercury, besides a small excess of protoxide of mercury, for the purpose of indicating the complete precipitation of the urea; so that on adding the last drop of the 10 cubic centimeters of solution of mercury to the solution of urea, a distinct yellow colour is perceptible, when a few drops of the mixture are mixed with the solution of carbonate of soda. I have found by a series of experiments that for 100 milligrammes of urea, which require according to calculation 720 milligrammes of protoxide of mercury (in the form of nitrate) 10 cubic centimeters of the solution of mercury should contain 772 milligrammes of protoxide of mercury, in order to produce a distinct reaction of protoxide of mercury in dilute liquids. Every cubic centimeter of the liquid should, therefore, contain an excess of 5.2 milligrammes of protoxide of mercury.

The test liquor is best obtained by dissolving pure metallic mercury in pure nitric acid in a beaker, keeping the mixture heated, with frequent addition of some nitric acid, until no longer any trace of nitrous vapours escape; then evaporating to the consistence of a syrup in the same vessel, or a water bath, and lastly diluting with water, until 100 cubic centimeters of the dilute liquor contain exactly 7.140 grammes of mercury. This is the case when for 100 grammes of mercury (converted into nitrate of the protoxide) as much water is added as will bring the volume of the liquor to 1400 cubic centimeters.

When for the preparation of the nitrate of the protoxide crystallized nitrate of the suboxide is used, which may be obtained with greater facility in a state of purity and free from other metals than metallic mercury, and a concentrated solution of the salt of the protoxide of unknown strength is thus produced, the amount contained in it has to be determined, and the solution reduced by water to the proper degree. This is done by means of the method described (Determination of Protoxide of Mercury in a solution of Nitrate of Mercury, p. 496); or a known volume of the concentrated solution is diluted with ten times its bulk of water, and the amount of protoxide of mercury determined in 10 cubic centimeters of it, by precipitation with potassa, or in the form of sulphide of mercury, by mixing the solution with a solution of sulphate of soda and passing sulphuretted hydrogen through it till the precipitated basic sulphate of protoxide of mercury is decomposed.

Previous to its application for determining the urea in urine, the dilute solution of mercury must be tested as to its correctness by means of a solution of pure urea; for this purpose we may use the solution of urea, mentioned above, containing in 10 cubic centimeters 200 milligrammes of urea. It is advisable, in diluting the concentrated solution of mercury, not to reduce it by the addition of water at once to the calculated degree; but to add rather less water at first, then test it with the solution of urea, and complete the process.

The best mode of proceeding is to dilute 10 cubic centimeters of the concentrated solution of mercury with 5 or 10 times its volume of water, according to concentration, and to determine approximately the amount of protoxide in 10 cubic centimeters of this dilute solution by means of phosphate of soda and the graduated solution of chloride of sodium.

Suppose for 10 cubic centimeters of the five times diluted solution of mercury, 18.5 cubic centimeters of solution of chloride of sodium have been used; the amount of water to be added may then be easily calculated.

For 10 cubic centimeters of the concentrated solution should be used 38.5 cubic centimeters of solution of chloride of sodium (corresponding to 772 milligrammes of protoxide of mercury), there have been actually used 5 × 18.5 = 92.5 cubic centimeters of the solution of chloride of sodium. If then 92.5 cubic centimeters solution of chloride of sodium be used for 10 cubic centimeters of the concentrated solution of mercury, then exactly 4.16 cubic centimeters of it are necessary for 38.5 of solution of chloride of sodium. If, therefore, 416 volumes of the concentrated solution of mercury be mixed with 584 volumes, 1000 volumes of a dilute solution are obtained, 10 cubic centimeters of which correspond exactly to 38.5 cubic centimeters of solution of chloride of sodium.

It is, as before stated, advisable not to add the calculated quantity at once, but rather less. 10 cubic centimeters of the normal solution of urea are now measured off, and then from a burette the approximatively diluted solution is added, until a few drops on a watch-glass produce a distinct yellow colour with carbonate of soda. Suppose 19.25 cubic centimeters of the solution of mercury were used for this purpose; then for 192.5 cubic centimeters of the solution, 7.5 cubic centimeters of water have to be added, and with this solution another trial experiment is made. When after the addition of 20 cubic centimeters the appearance of the yellow colour is distinct, the solution of mercury may then be used for determining the urea in urine. Every possible care must be bestowed on the correctness of the test liquor, inasmuch as it replaces a balance with which, when defective, the weighings made are the more incorrect, the smaller the difference in the weights which have to be determined. In the case of an incorrect balance, the error may be met at each weighing; accurate weighings may be made with it; but in the case of a graduated liquid, the corrections must be made before it is used.

The volume of the liquor does not add to the trouble, and it is therefore advisable to prepare as large quantities as possible at one time. The slight excess of the protoxide of mercury in the test liquor is like the index of the balance; the yellow colour is its deflection, the amount of which must be carefully noted.

The test liquor is graduated with a solution of urea containing 2 per cent. of this substance; 15 cubic centimeters of this solution of urea require for the precipitation of the urea, and for indicating its termination, 30 cubic centimeters of solution of mercury; 45 cubic centimeters mixture are obtained, containing in the whole $30 \times 5.2 = 156$ milligrammes of free protoxide of mercury; every cubic centimeter contains therefore 3.47 millegrammes of protoxide of mercury.

If the 15 cubic centimeters of solution of urea contain 4 per cent. of urea, and to 15 cubic centimeters of it 60 cubic centimeters of solution of mercury be added, a mixture of 75 cubic centimeters is obtained, containing 312 milligrammes of protoxide of mercury; in every cubic centimeter 4.16 milligrammes; there is therefore an excess of 0.69 millegramme of protoxide of mercury required to produce the original colour.

Careful experiments have proved that, in analyses of urine, when the amount of urea is increasing, an error is committed tending to diminish the amount of urea; in the case just mentioned, only 59.37 cubic centimeters, instead of 60 cubic centimeters, of solution of mercury would be added to make the original colouring appear. In order to remove this error, an addition has to be made—for 15 cubic centimeters of urine, and before the test is applied—of ½ cubic centimeter of water for every cubic centimeter of solution of mercury which has been used over and above 30 cubic centimeters; if, for instance, 20 cubic centimeters more than the 30 cubic centimeters be required, we have to add 10 cubic centimeters of water. It will always be found that, after the addition of water, a few drops of the solution of mercury have to be added in order to produce the proper indication.

For the same reasons, when the quantity of urea in urine amounts to 1 per cent. only, 15.3 cubic centimeters, and not 15 cubic centimeters, of the solution of mercury must be added to 15 cubic centimeters of urine, in order to obtain the test; to remove this error, which increases the amount of urea, a deduction has to be made, in the more dilute urines, of 0.1 cubic centimeters for every 5 cubic centimeters of solution of mercury used less than 30 cubic centimeters. If therefore 25 cubic centimeters of solution of mercury have been used for 15 cubic centimeters of urine, the amount, 249 millegrammes, is expressed by 24.9 cubic centimeters of solution of mercury, &c.

For the purpose of determining the urea in urine, a mixture of two volumes of baryta-water and 1 volume of solution of nitrate of baryta, both saturated whilst cold, is first prepared, and 1 volume of this alkaline liquor mixed with 2 volumes of urine. Here a small glass cylinder of optional capacity is conveniently used, which is first twice filled with urine to overflowing. The aperture of the cylinder is each time covered with a glass plate, causing the excess to flow off; the same cylinder is then filled once with the solution of baryta, and this added to the urine in a beaker. On mixing both liquors a precipitate is formed, which is filtered off. 15 cubic centimeters of the filtered liquor are measured off for each analysis, corresponding to 10 cubic centimeters of urine.

To this volume of urine, without previously neutralizing, the graduated solution of the nitrate of protoxide of mercury is added from a burette, the liquor being constantly stirred, and the test applied when no further precipitate is formed—viz., no further thickening of the liquor.

To this end, a few drops of the liquor with the precipitate are put into a watch-glass, and then a few drops of solution of carbonate of soda added, proceeding from the rim of the watch-glass; this is best done by means of a pipette of indian rubber. If after some minutes the mixture retains its white colour, a further quantity of solution of mercury is to be added, and this process is continued till a fresh sample from the glass exhibits plainly the yellow colour after the addition of carbonate of soda. The number of cubic centimeters is then read off, and the figure obtained corrected as described above, according to the contents of the urine.

Method of determining Urea in Urine containing Chloride of Sodium.—A series of experiments have proved that the amount of chloride of sodium in urine, when it reaches 1 to $1\frac{1}{2}$ per cent., exercises an influence on the determination of urea by means of nitrate of protoxide of mercury. When 20 cubic centimeters of the graduated solution of mercury are added to 10 cubic centimeters of the solution of pure urea, carbonate of soda produces in this mixture a distinct yellow colour of precipitated protoxide of mercury; if now 100 to 200 millegrammes of chloride of sodium be added to the mixture, and the test again applied, the yellow colour does not make its appearance on the addition of carbonate of soda; and in order to reproduce it, 1½ to 2½ cubic centimeters of the solution of mercury have to be added. The determination shows therefore 15 to 25 millegrammes of urea too much.

Just the same occurs with urine. Of the many experiments which I have made on this point, I select the following in order to show plainly this influence. In one portion of urine the amount of chloride of sodium was first determined; then in an equal quantity, the urea by means of nitrate of protoxide of mercury. This determination was repeated with an equal volume of urine, after the chlorine had been removed by nitrate of silver; finally the urea was determined by Ragski's method in the same quantity of urine.

10 cubic centimeters of urine contained millegrammes of urea—

| | Chloride Sodium. | Before removing Chlorine. | After removing Chlorine. | According to Ragski's method. |
|---|---|---|---|---|
| I. | 145 | 245 | 225 | 223 |
| II. | 155 | 210 | 180 | 175 |
| III. | 136 | 245 | 225 | 235.5 |

In experiment I. the test indicated, before the chlorine was removed, 20; in II., 30; in III., 20 millegrammes of urea more than was actually contained in it. When the quantity of chloride of sodium amounts to more than 2 per cent. this error does not proportionally increase, but remains constant within certain limits.

It has been seen, from the method of determining chloride of sodium by means of nitrate of protoxide of mercury, that a solution of urea containing chloride of sodium is not precipitated by nitrate of protoxide of mercury, until the chloride of sodium is completely transformed into corrosive sublimate. In a solution of 200 millegrammes of urea and 10 millegrammes of chloride of sodium in 10 cubic centimeters of water, to which have been added 20 cubic centimeters of the solution of mercury, the excess of the salt of mercury (which would have produced the yellow colour on addition of carbonate of soda) is not contained in form of nitrate, but of corrosive sublimate, and it is evident that the change in the indication is effected by the formation and presence of the corrosive sublimate. Instead of 3.46

millegrammes of protoxide of mercury in the form of nitrate, the mixture contains the same amount of oxide in the form of corrosive sublimate.

On diluting a solution of corrosive sublimate with water until it yields with carbonate of soda a distinct brownish yellow precipitate of oxychloride of mercury; then mixing the same solution of sublimate with a drop of nitric acid, and adding it to the carbonate of soda, the mixture of both remains clear; no precipitate is formed, or at most only a slight whitish cloudiness, from which after long standing single brownish-yellow tablets are deposited. In this condition, however, the excess of corrosive sublimate is contained in the mixture of the solutions of urea and mercury; it contains the greater portion of the nitric acid of the latter in an uncombined state.

By this nitric acid part of the carbonate of soda is converted into bicarbonate, which does not precipitate corrosive sublimate. When the mixture contains a larger amount of corrosive sublimate, in consequence of a larger amount of chloride of sodium in urine, the liberated carbonic acid is not sufficient to prevent the precipitation of all the protoxide of mercury; a brownish-yellow precipitate is now formed. This appears to me to be the cause why the indication of the complete precipitation of the urea is deferred, by the presence of a certain quantity of chloride of sodium, and why the limit of the reaction is not still further removed, when the amount of chloride of sodium is increased.

With urine containing 1 to 1½ per cent. of chloride of sodium the correct number of millegrammes of urea in 10 cubic centimeters of urine may be obtained at once by subtracting 2 cubic centimeters from the number of cubic centimeters used for the solution of mercury; and even when the amount of chloride of sodium in the urine of different individuals varies within certain limits, the differences obtained in the amount of urea are still correct, and comparable with each other; only in the absolute quantity there is an error, which, uncorrected, amounts to from 15 to 20 millegrammes for 10 cubic centimeters of urine. In determinations in which the absolute quantity of urea in urine is of importance, the chlorine in the urine must be removed, and the chloride of sodium converted into the nitrate: this is done by means of nitrate of silver. For this purpose a solution of silver is prepared from 11.691 grammes of fused nitrate of silver, which are dissolved in water and diluted until the volume of the solution amounts to 400 cubic centimeters; 1 cubic centimeter contains 29.01 millegrammes of nitrate of silver, corresponding to 10 millegrammes of chloride of sodium.

The solution of mercury, the preparation of which has been already described (ante page 452), corresponds with this solution of silver; both indicate, when used in equal volumes, the same amount of chloride of sodium. If, therefore, 12.5 cubic centimeters of the solution of mercury had to be added to 10 cubic centimeters of urine until the appearance of the cloudiness, the chlorine in the same volume of urine will be completely separated by 12.5 cubic centimeters of the silver solution, whilst no silver remains dissolved.

Since the quantity of silver solution to be added to the urine containing chloride of sodium, for the removal of the chlorine, may be ascertained in a few seconds by means of the solution of mercury, this operation loses all inconvenience; whilst otherwise it would be inconvenient and require much time. Suppose for 15 cubic centimeters of the urine precipitated by the solution of baryta (containing 10 cubic centimeters of urine) 17.5 of solution of mercury has been used; then with the pipette, 30 cubic centimeters of the same urine are measured off, and 35 cubic centimeters of the solution of silver are added; the liquor is then at once filtered, and of the filtrate always one-half of the sum of the mixed liquors taken for the test; in this instance, therefore, 32.5 cubic centimeters contain 10 cubic centimeters of urine. These are now mixed with the graduated solution of mercury, and the amount of urea ascertained in the manner described, taking into consideration the dilution in consequence of the solution of silver added.

The numerous experiments made by Professors Dr. Vogel and Dr. Bischoff, at whose instigation this method has been devised, leave no doubt as to its applicability and correctness. In describing such a proceeding, numerous difficulties present themselves, which in practice prove to be insignificant; indeed the description is much more complicated than the execution.

The remarkable simplicity which this mode of determining urea and chlorine has attained, is mainly owing to the deep interest which my two excellent friends have bestowed upon my experiments; it is the result of a whole series of methods, which one after the other were rejected, not so much for want of accuracy, but on account of the greater difficulty of execution; and on this occasion I have very plainly seen how important and requisite it is for the purpose in view, when the chemist is solving a physiological problem, does not work by himself alone, but in conjunction with a pathologist and a physiologist. Chemists will observe that by this determination of urea, mercury, and chloride of sodium, another very interesting problem has been solved—viz., the determination by weight of chloride of sodium, mercury, and urea, without having recourse to a balance. The paradox of a determination by weight without weighing disappears by the consideration that a solution of chloride of sodium, saturated at the ordinary temperature, contains a definite, unchanging weight of chloride of sodium, and that in 10 cubic centimeters exactly 3.184 grammes of chloride of sodium are obtained; by dilution with the proper quantity of water, a solution of chloride of sodium is obtained containing 1 cubic centimeter 10 or 10.852 millegrammes of chloride of sodium. With these solutions nitrate of protoxide of mercury may be graduated for the determination of chlorine, mercury, and urea, without the necessity of using other instruments than a burette and a pipette.

## BOOKS RECEIVED FOR REVIEW.

*Auscultation and Percussion.* By Dr. Joseph Skoda. Translated from the fourth edition by W. O. Markham, M.D.; Assistant Physician to St. Mary's Hospital. Philadelphia: Lindsay and Blakiston. 1854. H. Rowsell, Toronto.—This appears to be a most valuable manual, and its contents shall receive our earliest attention.

*The Half-Yearly Abstract of the Medical Sciences;* being a Practical and Analytical Digest of the Contents of the principal British and Continental Medical Works published in the preceding six months; together with a series of Critical Reports on the Progress of Medicine and the collateral Sciences during the same period. Edited by W. H. Ranking, M. D., Cantab, Physician to the Norfolk and Norwich Hospital; and C. B. Radcliffe, M. D., London, L. R. C. P., Assistant Physician to and Lecturer on Materia Medica at the Westminster Hospital. No. XIX.; January—June, 1854. Philadelphia: Lindsay and Blakiston, No. 25, South Sixth-st. H. Rowsell, Toronto.—An admirable digest of current medical literature—a *multum in parvo.*

*The British and Foreign Medico-Chirurgical Review, or Quarterly Journal of Practical Medicine and Surgery.* No. VII.; July, 1854. New York: Re-published by S. S. and W. Wood, No. 251, Pearl-street. Price $3 per annum, payable in advance. H. Rowsell, Toronto.—This famous old Review fully maintains its just celebrity, and should be on the table of every enlightened medical man.

# REVIEW.

CLINICAL LECTURES ON PULMONARY CONSUMPTION. —By Theophilus Thompson, M.D., F.R.S., *Fellow of the Royal College of Physicians, London; Physician to the Hospital for Consumption and Diseases of the Chest; author of Annals of Influenza. Prepared for the Sydenham Society, &c.* Philadelphia: Lindsay & Blakiston, 1854; H. Rowsell, Toronto.

(*Concluded.*)

The second lecture is dedicated to the further illustration of the *bruit de pot fêlé* as a diagnostic symptom of cavity in the lungs, at the same time the special advantage in the administration of cod-liver oil is fully demonstrated by the decided improvement of the patient, and is instanced as proof that we should persevere in its use, even in apparently hopeless cases. Dr. Thompson then demonstrates the truth of the deductions that the peculiar sound above alluded to is dependant upon cavity in the lungs, by the morbid examination of a patient, who had gangrene of the hand and arm, complicating the consumptive disease. The gangrene was clearly traced to the formation of coagula which interfered with the circulation of the subclavian artery, at the same time there were evident demonstrations of arterial disease in other parts of the circulating system. Hœmoptosis as an alarming symptom in consumption is then passed in review; upon the whole, Dr. Thompson looks upon this symptom as favourable to the slow progress of the complaint, and points out that it should not be too hastily arrested, but should be treated by determination of blood to other organs, by means of sulphate of magnesia and dilute sulphuric acid, rather than to check it by more powerful astringents.

The cause of hœmoptosis, in a great majority of cases, is shown to depend upon the compression of the pulmonary veins by the tubercular deposit, so that the return of the blood is prevented or delayed in its course to the left side of the heart, and consequently that it exudes into the neighbouring bronchial tubes—hence it is shown that hœmoptosis may relieve pressing symptoms; at the same time it must ever be looked upon as of very serious import, as it indicates the great amount of tubercular deposit in the texture of the lungs. Exceptional cases sometimes occur, in which hœmorrhage may result from the rupture of a large blood-vessel; such cases are rare, for we find that when surrounded with an amount of tubercular deposit, that is sufficient to destroy the smaller vessels and bronchial tubes, that the blood will coagulate in the vessel, the walls will become thickened by the deposit of fibrine as conservative material around them, while they become completely plugged with fibrine, and are at last transformed into solid cords; as such we may often find them passing, comparatively isolated, across a vomica of long standing. This process completely closes up the blood-vessel, so that when it is ultimately destroyed it does not bleed; hence hœmorrhage from the patulous mouth of a large vessel is an exception, not the rule.

The third lecture is dedicated to the consideration of expectoration as a means of diagnosis in consumptive cases. The presence of pus was once considered a pretty certain indication of phthisis; but the inaccuracy of such an opinion is now pretty certain. At page 63 we find the following judicious remarks as to the value of this consideration. "There are certain general rules worthy of regard in connection with this subject. Thus, if a person has some severe chest complaint, coughs frequently, and expectorates only frothy, salivary-looking fluid, you suspect pleurisy; if another patient expectorates a glary fluid resembling white of egg, you suspect bronchitis; if the expectoration have a rusty tinge and resembles thick gum-water coloured with blood, you are not likely to err in recording pneumonia; if you are toldof a sudden gush of pus in considerable quantity, especially if it be fœtid, you may expect to find matter, accumulated in the cavity of the pleura, had found its way into the bronchial tubes;" or it might be a chronic abscess of the lung, or a large tubercle which has softened and opened into a bronchial tube.

The character of expectoration presented in consumption isin the first place dependent upon pulmonary congestion; it is thin and frothy, produced by the escape of a thin serous fluid from the pulmonary capillaries, and an amount of epithelial structures, shed from the surface of the bronchial tubes, having atmospheric air entangled within it. The second variety consists of a somewhat similar material, but in this we have an increased amount of mucus. The mucus corpuscles are rapidly developed, mucine is freely liberated; instead of the thin transparent fluid it is far more glary; runs from the cup with much less facility; sometimes is particularly tough and tenacious, and the mucus corpuscles may be distinguished abounding in the fluid. Sometimes in this expectoration you find a little blackish matter; if you test it, this is evidently not the carbonaceous matter of smoke, for the colour fades upon the application of nitric acid; it is true-formed pigment, in all probability from the bronchial mucous membrane. Under the microscope, crystals of the triple phosphates may be seen in this mucous expectoration. Dr. Garrod maintains that the greater the proportion of these salts, the more marked is the diagnostic sign of the decrease of the inflammatory action in the bronchial membrane. The third variety of this expectoration is characterized by a mixture of the two former varieties united with pus—the appearance presented to the eye is that of viscid transparent mucus, consisting of mucine and saline ingredients mixed with the pus corpuscle. The pus corpuscle in this instance being a diseased condition of the mucus corpuscle, in which the organ that naturally secretes mucus is plainly deranged in its formative powers, and now we find the cell filled with minute globules of olein, the cell-wall more opaque and more readily undergoing disintegration; in it one or more nuclei may be commonly distinguished, which in some degree serves to distinguish it from the inflammation corpuscle formed from the red corpuscle of the blood. The fourth example is pure pus unmixed with either of the other varieties, or only in very minute quantities. Under the microscope this is plainly distinguished as the inflammation corpuscle of Gluge, derived for the most part from the red corpuscle of the blood, which has lost its hœmatin, and may be seen filled with minute corpuscles of olein or granular matter, but without any nucleus; this expectoration is generally the production of a cavity, while the variety previously described is the secretion of a diseased mucous membrane. A point that very particularly distinguishes the expectoration of pus from a vomica, is that the matter takes a peculiar shape—when spit into water it looks like balls of cotton or wool—when spit upon a hard surface, is round and flattened, and in distinct patches not unlike pieces of money. A singular fact that the microscope discloses is, that it not unfrequently happens that we find vegetable growths in the expectoration. Dr. Thompson found a variety of conferva not unlike the pencillium glaucum of Link, showing the spores arranged like little beads placed at the extremity of dichotomously branched and jointed tubes. These vegetable growths are said to inhabit pulmonary excavations. Sometimes the microscope will indicate the peculiar granular matter of tubercle; such expectoration, however, is frequently mixed with other materials. Every one of the varieties of expectoration above indicated may be commingled with it and serve to disguise it; to the eye it commonly bears a flocculent aspect, but is not to be recognized without the microscope. The mixture of materials in the matter of expectoration is often a source of embarrassment to the microscopist, for he not unfrequently finds in his specimen epithelium from the mouth chloride of sodium, muscular and vegetable fibres, and tartar from the teeth, besides the materials above referred to; commonly much practice is required in these investigations to enable us to arrive at just conclusions, and is in some degree a drawback to their value as a means of diagnosis: nevertheless practice and experience will overcome these difficulties. Portions of fibrine will occasionally be found in the expectoration; it commonly appears as casts of the bronchial tubes, and is dependent upon local inflammatory action of portions of these structures.

The fourth lecture is dedicated to the consideration of the pulse. It is an established fact that in a state of health the pulse gives a considerable number of beats in a change from the horizontal to the erect position—the average in a table indicates a variation of 18 pulsations. The fact which it is endeavoured to establish is, that such a condition is lacking in cases of consumption, and that the difference is seldom more than 2 or 3 beats in cases of tubercular deposits in the structure of the lungs. The reason of this peculiarity is not very clear; it is thought to depend upon the lesser influence which trivial exciting causes produce upon the nervous and muscular structures of the arteries in this state of disease, or by its increasing the size and power of the heart; the impediment to the circulation through the lungs being a cause of this increase. Dr. Graves observed this fact in cases of hypertrophy of the heart, and Dr. Clendinning has investigated its truth in phthisis, and finds the coincidence is sufficiently remarkable to form a characteristic of the complaint.

The fifth lecture speaks of cod liver oil as a curative means of great value in consumption, and at page 98 Dr. Thompson endeavours to show the modus operandi of the medicine. "In scrofulous affections, if Dr. Hughes Bennett be correct in his hypothesis, there is probably undue acidity of stomach unfavorable to the solution of albuminous materials. The alkali of the salivary and pancreatic fluids, being neutralized, fails to fulfil its proper office. The lungs not having enough carbon to excrete, local congestions arise; the blood is overcharged with albumen, and the albuminous exudations being deficient in fat, elementary molecules are not formed so as to constitute nuclei into cells, and tubercular corpuscles are the natural result."

"Cod-liver oil probably tends to obviate the series of derangements thus described, by combining with the albuminous elements of chyme, so as to form the healthy chyle-granules which feed the blood; and, for the reason above named, is probably more advantageously introduced in scrofulous subjects when combined with an alkali." Whatsoever may be the rationale of the treatment, there is no doubt that cod-liver oil exercises a powerful influence in that state of constitution which predisposes to tubercular deposits, and has been a means of warding off many an attack of consumption.

In the sixth lecture an inquiry is instituted between the effects of cod-liver oil and other animal and vegetable oils. It has been recommended to add iodine and phosphorus to the vegetable oils, but a fair trial does not seem to countenance their employment or recommend them as substitutes for cod liver oil.

Many interesting facts still remain to be considered, but want of space reluctantly compels us to abridge our notice of this trite and excellent compendium; but we cannot terminate our labours without conscientiously recommending these lectures of Dr. Thompson to every student in medicine, and to every physician desirous of becoming practically acquainted with the disease of which they treat.

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## DEGRADATION OF THE MEDICAL PROFESSION.

*To the Editor of the Upper Canada Medical Journal.*

Sir,—I take the liberty of laying before you the following extract from the letter of a friend in reference to the character of a portion of the medical profession in one of the finest counties in this province. It is, indeed, a melancholy picture, and of its truth I am but too well assured by my own experience. I have the more freedom in laying the subject before you knowing, as I do, the interest you take in the profession generally, and the efforts you are making to elevate it to its proper position in this country—efforts which, however well directed, I fear cannot be completely successful so long as members of the profession continue to cover themselves with disgrace, and reflect their shame upon the body generally. The following is the extract referred to:—

"A sober, skilful physician is much needed in this village. There is no confidence at all by any class either in ——— or ———. The former is supposed to 'know nothing,' and the latter habitually renders himself unfit for practice by drunkenness and other vices. A. has had a regular 'spree,' and was almost dead for several days. After drinking seven pints in a day he fell into a stupor and slept soundly for almost the same length of time, despite the exertions of his neighbors to rouse him. B. is going down, *down*, as fast as a habitual course of intemperance can carry him; and old ———, of ———, may be seen when, occasionally, he visits our village, 'reeling to and fro like a drunken man;' while C., of ———, is a devoted worshipper of Bacchus. In fact, I am beginning to think that medical men, as a class, are a notch below others in the scale of moral rectitude, and I have concluded that their course of study and practice has a tendency to blunt the finer feelings of their nature and render them proof against the calls of humanity, reason, and religion."

Such is the testimony of an intelligent observer respecting these medical men in his own neighborhood, and all of them within a few miles of each other; and such are the physicians who are to minister in the hour of need to the afflicted among a population for integrity and intelligence second to none in this province. It is worthy of remark that these persons are, without exception, old countrymen, having received their education and imbibed their early principles in Britain. It is to be hoped that those who enter the medical profession in Canada will be too deeply impressed with the sacredness of their calling and the duty they owe to the public to trifle thus with themselves or others, and that in after years they may be found honorable and useful members of society and ornaments of the profession they have chosen. In the meantime it is hoped that exposing this great evil will have a tendency to check its further extension, and that while an act of incorporation and other great movements are being advocated for the elevation of the profession, these humbler matters, bearing a less conspicuous, though not less important part, in securing that great object, will not be overlooked.

Having every confidence in the sincerity of your motives and the disinterestedness of your zeal in furthering this great cause, I trust you will yet see your efforts crowned with success.

I remain, dear Sir,
Yours respectfully,

SCALPEL.

Toronto, July 15, 1854.

We have given insertion to this communication with considerable reluctance, and would willingly have thrown a veil over so terrible a description of human infirmity as here presented, but justice demands that we should give to all a fair hearing. The causes of this deep degradation are, we believe, dependent upon the want of that just and proper position which the science of medicine should occupy in the social condition of this province: it is a matter that requires from the legislature a searching inquiry as to its causes, and the national interest demands that a sufficient remedy should be found for its effect. If it is intended to insinuate that the practitioners educated in Britain are the only portion of the profession addicted to this bad vice, we must protest against it as slander; at the same time we can admit that they may more sensitively feel the causes which tend to produce this sad vice, from the greatly altered position in which they are placed while residing in Canada. Take the medical practitioners as a body in Britain, and you will find them the hardest worked, the most industrious, and the most practically learned of any of the professions. The vice of drunkenness, as a matter of necessity, could not be conjoined with such qualities. The mind of man always requires some incentive to action. In Britain it is certainly not the love of money—for the medical profession, with few exceptions, are about the worst paid of all the community in proportion to their mental and bodily exertions. No—it is a desire to excel and a possibility of distinguishing themselves that alone supports them in their daily toil and encourages them in their onward progress.' Their mode of education has led them to this point: "As the twig is bent so doth the tree incline." In after years this habit of study and exertion, which has become second nature, has to be continued, and the public reap the benefit of this condition; besides which there is a certain *status*, a certain honorable name and position, which the practice of medicine yields to its possessor, which is totally absent in this country. When a medical practitioner comes to this country and alights in the Canadian bush, he soon lacks most of the honorable incentives to exertion which prove a stimulus in the old country. In almost any part of the country he may locate himself in he may readily get an extensive practice—often, however, as rough as extensive; people are ever ready to employ a thoroughly educated medical man; but, alas! few are willing to pay him in proportion to his education and acquirements; and the way that they often remunerate him for his services is to give him a bad name, and to fight him ever afterwards. Placed in juxtaposition with the quack, who charges for his services whatsoever he can get—payment not being compulsory—he is generally preferred to the licensed practitioner on that very score. The consequence is that the professional medical man gets disappointed, disgusted, and quite out of heart; takes to the bottle to drown his cares—a fashionable remedy with all parties in this country. It is not improbable that if this same medical man had invested the principal which his education cost in Britain, and the money expended in his emigration, that he could have lived comfortably and respectably in Canada without any necessity for practice. His error has been in fancying that in serving the public he would be serving himself. In Canada we have a middle class of cash, but are generally devoid of a middle class of intellect; for most of the independent yeomen (and be it spoken to their credit) were extremely poor when they arrived in Canada and could not claim the position which we are now adverting to, but have since risen by their own hard labor to their present condition. Hence they have not the same sympathy for the well educated professional man as the same class in the old country—cannot understand the distinction between the physician and the quack, save it be in the license, which they are too apt to look upon as a monopoly; so that they are more inclined to pity the impostor and spite the physician, than to encourage his exertions. Again: there are but few opportunities to improve the mind, and no inducements to excel. Should such a course be attempted, the field is so extremely limited that professional jealousy and ill feeling throw every obstacle in the way and crush the faintest attempts. These are the reasons, we believe, that lead to the lamentable state of things which our correspondent has depicted. Such a condition spreads its baneful influence over the whole profession, as is evidenced by general disappointment and the want of due public appreciation. It can also be demonstrated in that absence of unanimity and good feeling so evident among the members of the medical profession. It causes them in many instances to descend to the lowest trickery to maintain power and influence, which sorely rebounds to the disgrace and deterioration of the professional character, until the value of the profession has sunk lower and lower in public estimation, and its complete extermination as a science bids fair to be speedily accomplished. Still the press and the public exclaim, "Free trade in physic." Such may make it cheaper, but it will not make it better. Is knowledge and science to be placed upon the same grade as labour? Is mind not to be exalted above muscle?—the power that gives the impulse, to the agent which produces the effect? This is surely going backwards in the world's progress, and must lead to lamentable results. The public and the press must in a considerable degree be answerable for this condition of things, for the effects of the degradation of the medical profession are now painfully evident. But who will be the loser if the science of physic is exterminated or degraded? Not the physician, for he can cease to study it; but the public will be deprived of one of the means that Providence has provided for the benefit of mankind It will be blotted out by their own stupidity in the misapprehension of the truth, or it will be so deteriorated that it will be worse than useless. Under such circumstances we would call upon the profession to arouse, leave party differences and private animosities, and, with a powerful and united effort (in which they would be readily sustained by the well informed and conscientious portion of the public), try and obtain an efficient act of incorporation, so as to place the profession upon a more sound and stable basis, more honorable to the practitioner and beneficial to the public than the present humiliating condition.

In the vast strides of material improvement now making in Canada, almost every individual, save those connected with the professions of physic and divinity, are advancing at no tardy rates. The professions alone appear to be deteriorating in public estimation. Many will instance the facts of our correspondent as pointing to the cause. We maintain they are only the effect—an effect produced by the unjust and insane treatment which the profession has long experienced at the hands of the legislature and of the public. We fear that this degradation of the professions is an evidence of the downward tendency of the Anglo-Saxon race,—this condition evincing itself most powerfully at the circumference of the empire, in the colonies. Such was the case with the ancient Roman Empire when it tottered to its fall. The Roman Empire was a kingdom established by military prowess and successful war; the Empire of Britain has been the fruit of the successful cultivation of science and the judicious application of knowledge. The first mark of weakness in the Roman power was the necessity for the withdrawal of her troops from the distant colonies, and the successful irruption of barbarian and undisciplined hordes. And we take it that one of the first marks of Britain's decline is a want of appreciation of the sciences, and a due estimate and encouragement of knowledge, which has ever been the source of her wealth and power. As far as Physic is concerned, take Canada for an example. Hence we confess we have our fears that the great mass of the public and the legislature will fail to see their error—will still endeavor to perpetuate a condition that only leads to public disadvantage and political degradation, while it stays the onward progress of science that might lead to more powerful and permanent results. Let, however, an effort be made to attain the position which is due to the noble science of Physic, and if it fail, the influence will rebound upon the public; it will be their misfortune, if it is the profession's loss.

During the last election no less than six of the medical profession have been honored by the choice of the people as their representatives in the Colonial Legislature of Canada West. To these individuals we would particularly present the terrible picture which is here exhibited. We would earnestly appeal to their patriotism, to their love of the medical profession, and entreat them to devise some efficient means that shall change this dreadful state of affairs. We have hopes that the coming session of the Legislature—which bids fair to be the most potent for good or for evil which Canada has yet witnessed—will see tardy justice rendered to the Science of Medicine. An act of incorporation that shall place in the hands of the profession the full management of all the medical affairs of this province—shall establish a college of physicians and surgeons second to none on this continent, in which each of the profession shall have a proper voice—shall endow the said college, of the funds set apart for university education, out of the £500,000 now lying comparatively idle in the hands of University College, Toronto, giving a fair proportion of those funds to the Science of Medicine for the establishment of a medical library and museum, &c.—shall place the appointment of the medical officers to the public hospitals in the hands of the profession, and also that of all health officers; in fact, shall make a full and efficient revise of the present degraded and depressed position of the medical profession, alike demanded for the public good and the honor of learning and of science.

## TORONTO GENERAL HOSPITAL.

Want of space alone forbids our offering a continuation of the detail illustrating the practice of the Toronto General Hospital. We have a mass of evidence to lay before the medical profession in proof of our assertion that certain of the gentlemen in medical charge are unworthy the position which they hold in that institution. In our next issue we may point out the way in which amputation of the thigh has been performed; how cancer has been opened for abscess, &c. &c.; and show the lamentable results that have flowed from such treatment; but we again declare that we would far rather cast a veil over such mismanagement than expose it to public view. Justice to ourselves and the rights of the medical profession alike demand of us this unpleasant task; should we find no evidence of a more generous spirit on the part of those gentlemen who have for base political purposes, and by false assertions, deprived us of an undoubted right, and the medical profession of one of its privileges. Before we take these steps we shall send a copy of our statement to the resident medical officer at the hospital, and again offer an honorable compromise.

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## DR. BEAUMONT'S CASE OF ANEURISM.

We have casually heard that a copy of Dr. Beaumont's clinical lecture on Traumatic Aneurism, published in the *Weekly London Lancet*, has been received in this city. It will be seen in our comments on the rough notes of this case (page 273), which excited so great an amount of ill feeling against us, that we stated, "*We understand that Dr. Beaumont means to publish a more full and complete history of the case than we are able to give; it will no doubt be found of the highest interest to the profession both in Europe and on this continent.*" We shall be well pleased to republish the lecture in question, to make amends for any unintentional inaccuracy that may have been made in our report of the case in question, as our only desire is to do Dr. Beaumont the full justice which the case deserves.

It appears that Dr. Beaumont sent a letter complaining of our conduct in publishing this case; but the editors have refused to insert it, remarking that they had little doubt but that the unseemly dispute had long since been arranged. *So says report.*

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INCORPORATION OF THE MEDICAL PROFESSION.—We have good authority for stating that a bill will be introduced into the next session of the Provincial Parliament for the incorporation of the profession.

# SELECTED MATTER.

## A COURSE OF LECTURES ON ORGANIC CHEMISTRY.

*Delivered in the Laboratory of the Royal Institution of Great Britain, by Dr A. W. Hofmann, F.R.S., Professor of the Royal College of Chemistry.*

### Lecture XI.—Fermentation of Sugar.

When describing to you the general properties of the substances which are called sugars, I have pointed out as one of their most salient characters, the faculty possessed by sugars of being, under certain circumstances, converted into alcohol and carbonic acid, of undergoing the metamorphosis called "alcoholic fermentation." This process of transformation necessarily claims our attention, equally interesting as it is from the scientific questions involved in its explanation, as on account of the immense scale on which it is carried out in practice.

Experiment has proved, that although all the sugars which I have enumerated,—namely, grape-sugar, unchrystallisable sugar, glucose, and milk-sugar,—are capable of alcoholic fermentation, they by no means undergo this change with the same facility. It is found, that of all the substances which I have named, glucose is most easily transformed, while cane-sugar and milk sugar undergo the same change more slowly. On this account, and also because it is in practice almost invariably glucose which is fermented, we will examine the transformation of that substance. You recollect that the composition of glucose is represented by the formula,

$$C_{12}\ H_{14}\ O_{14}$$

But that this expression includes two equivalents of water, which may be expelled at the temperature of boiling water. The dry substance, glucose, then, may be stated to be

$$C_{12}\ H_{12}\ O_{12}$$

If a solution of glucose, at a temperature which may vary between (40° and 90° F.) 4° and 32° C., be left in contact with substances in a state of decomposition, such as decaying albuminous principles, both of vegetable and animal origin, putrid blood, or urine, etc., we find that an evolution of carbonic acid soon begins, the rapidity of which depends to a certain extent upon the exact temperature at which the process is established. After twenty or thirty hours the liquid has ceased to contain any sugar; instead of this, we find several substances, among which invariably a peculiar volatile liquid is present, which may be separated by distillation, and which, as you all know, is called alcohol. The experiment succeeds best when the operation is performed between 18° and 21° C. (65° to 70° F.), and when, as the agent of transformation, a substance is employed which is called "ferment," and which is better known by the term of "yeast." In this case, almost the sole products of fermentation are carbonic acid and alcohol. It is by means of yeast that I have induced the fermentation of a portion of glucose contained in this small carboy. You observe the liquid is in a powerful agitation, and, as the carboy is provided with a delivery-tube, we have no difficulty in examining the gas which is evolved. The simple lime reaction tells us that it is carbonic acid; more accurate experiments have proved, that besides $C\ O_2$ no other gas is disengaged in this reaction. If the residuary solution be submitted to distillation, a liquid passes over, which is generally called spirits, and which consists of alcohol and water. By a series of manipulations, which I shall mention directly, the water may be entirely removed from this mixture, when the alcohol remains in the pure state. Analysis has proved alcohol to be represented by the formula,

$$C_4\ H_6\ O_2$$

And experiments made with the special object of ascertaining in what proportion the amount of alcohol generated stands to the quantity of carbonic acid which is disengaged, have shown that this transformation may be expressed by the following equations:—

$$\underbrace{C_{12}\ H_{12}\ O_{12}}_{\text{Glucose.}} = \underbrace{2C_4\ H_6\ O_2}_{\text{Alcohol.}} + 4CO_2$$

The transformation of glucose into alcohol and carbonic acid, takes place between the limits of temperature which I have mentioned,—1° and 32° C. (40° and 90° F.,)—but is most active between 21° and 26° C. (70° and 80° F.)

Cane-sugar and milk-sugar, submitted to the action of the ferment, undergo exactly the same transformation,—but the accomplishment of this process invariably requires more time. This becomes readily intelligible by the fact, long suspected, and lately established by a series of careful observations, that the several varieties of sugar, before undergoing alcoholic fermentation, are invariably first converted into glucose by the very ferment which effects the subsequent transformation into alcohol and carbonic acid. It is generally believed that this conversion is effected by the small quantity of free acid which is always found in yeast,—an opinion which appears to be supported by the observation, that the action of yeast, both on cane and milk-sugar, is remarkably retarded by the neutralization, or the removal by washing, of the free acid in the ferment.

The transformation of sugar into alcohol is a process of unusual interest, on account of the enormous scale on which it is carried out in practice, several trades and manufactures depending altogether on this curious metamorphosis. In the manufacture of wine, in the brewing of beer, in the distillation of spirits of every description, fabulous quantities of sugar undergo the process of fermentation. Even in the manufacture of vinegar, as we shall see by and by, the fermentation of sugar is largely concerned. Perhaps it may not be uninteresting to you to look at some statistical facts which are calculated to illustrate the importance of the subject of which we are treating. According to the experience of the Board of Inland Revenue and of the Customs, the average annual consumption of alcoholic liquids in the United Kingdom is as follows (*a*):—

*24 millions of gallons of proof spirit (b) is yearly manufactured in this country.*
4 millions of gallons in foreign spirits, (rum, Geneva, &c.)
44 millions of gallons in beer.
2 millions of gallons in wines.

—

74 millions of gallons of proof spirit. (*c*.)

This quantity would just twice fill Hanover-square up to the garrets.

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(*a*) I am indebted for these numbers to Adam Young, Esq., of the Chemical Department of the Inland Revenue Office.

(*b*) Composition of proof spirit by weight:—

| | |
|---|---|
| Alcohol | 49.24 |
| Water | 50.76 |
| | 100.00 |

(*c*) The details of these calculations are as follows:—

1—HOME-MADE.

*24 million gallons of plain spirits, proof strength.*
340 million gallons, or 15 million barrels of beer.

2—IMPORTED.

2½ million gallons rum (Colonial.)
1½ million gallons brandy, Geneva, etc.
*6 million gallons wine.*

The beer is assumed to contain, upon an average, only 8 1-5th per cent by measure of proof spirit, and the wine, 33⅓ per cent.

All these numbers are rather below than above the truth.

The usefulness of fermentation, which may be traced far beyond the production of wine, beer, and vinegar, into a great variety of trades and professions, has attracted, from a comparatively early period, the attention both of the practical man and of the scientific chemist. It may be said, that it has been studied with predilection, and these studies have elicited a great deal of useful information on the subject. The temperature at which fermentation proceeds most vigorously has been carefully ascertained. It is known, from experience, that many substances, such as certain acids, favour this process; while others, such as pyroligneous acid, sulphurous acid, corrosive sublimate, and volatile oil, retard or altogether interrupt it; and the best proportion in which the yeast is to be employed has been carefully established. But our knowledge regarding the causes of fermentation, and especially regarding the true nature of the ferment, such as yeast, &c., is still imperfect.

The origin of the ferment, its behaviour, and the views which the latest studies upon this subject have elicited, claim our attention for a moment. The juice of fruits, of grapes, for instance, which is rich in unchrystallisable sugar, gradually convertible into glucose, may be preserved for an almost unlimited period, if it be separated from the fruit in such a manner, as to exclude, during this operation, the access to it of atmospheric air. This tube contains a quantity of grape-juice obtained by squeezing the grape under mercury, and allowing the liquid to pass on into the tube. It has been preserved for about a month in a room, the temperature of which was very frequently between 21° and 26° C. (70° and 80° F.) the grape-juice has not undergone the slightest change. If, now, air or oxygen be admitted, we find, that in the course of half an hour active fermentation sets in, carbonic acid is evolved, and, after a short time, the sugar is converted into alcohol. Carbonic acid and alcohol are by no means the sole products of the fermentation of grape-juice. In addition to these, there is formed a grey insoluble body, which generally separates upon the surface of the liquid. This substance, the result of fermentation, is capable of again inducing fermentation when coming in contact with fresh liquids containing sugar. The result, however, varies considerably, according to the nature of the sugar-solution in which it causes fermentation. If this solution be one of pure cane-sugar or glucose, we find that its action is very soon exhausted. After a certain quantity of sugar has been transformed, this wine-ferment is converted into a white fibrous mass, possessing no longer the slightest action upon a fresh solution of sugar. A very different deportment, on the other hand, is observed, if the wine-ferment be introduced into such a solution of saccharine matter, as is obtained by the conversion of starch into sugar by means of diastase, if we ferment the saccharine solution, which the brewer calls sweet-wort. In this case, we find that after the completion of the process, a very considerable portion of new ferment is formed, sometimes ten or twenty times the original amount of the wine-ferment employed. The new ferment, which, for the sake of distinction, we will call beer-ferment, exhibits again the same behaviour as the ferment produced from wine; its fermentative action on pure sugar is rapidly destroyed; while it is capable of propagating fermentations, I might say, *ad infinitum* in solutions of glucose derived from barley or similar sources. In the manufacture of beer a much larger quantity of ferment of yeast is formed in each operation, than that which is necessary to start the following fermentation. The impossibility of producing ferment from pure sugar renders it obvious, that its formation in grape-juice or infusion of barley must be due to the presence of other substances. In addition to a great many mineral salts, it contains several organic acids—we shall see by-and-by, that it is the chief source of one of the most interesting organic acids—tartaric acid, and a large proportion of albuminous principles. These substances are the source of the wine-ferments; similar albuminous principles are present in sweet-wort, in fact, in all juices of plants, and hence, the invariable formation of ferment of yeast, when the sugar of such juices is submitted to fermentation.

Thus it is evident that the saccharine juices of the vegetable kingdom contain within themselves this most powerful agent of their destruction,—an agent whose powers lie imperceptible and dormant, as it were, as long as the access of air is prevented, but which are called into action the very moment it is joined, under the necessary conditions, by its indispensable ally the oxygen of the atmosphere.

The recognition of the origin of the ferment forms but a first step in the investigation of this extraordinary substance. Admitting that the ferment is the product of the action of oxygen upon the albuminous principle of vegetable juices, the question arises. What kind of a body is produced in this manner? Is it an individual definite compound which is endowed with these wonderful properties? Is it a soluble compound, or, is it the insoluble amorphous substance which separates from the liquid? In what manner, lastly, does the ferment, whatever substance it may be, effect the metamorphosis of the sugar? Very different views have been brought forward on this subject in the course of time, and the opinions of chemists remain divided even at the present moment.

The deportment exhibited by ferment, by ordinary beer yeast for instance, with a solution of pure sugar in water, appears to furnish the key to these questions. I mentioned, that ferment is by no means capable of converting an unlimited quantity of pure sugar; the ferment when introduced into a large quantity of sugar-water excites a powerful fermentation, but during the progress of this action it undergoes itself a series of changes; the slimy matter is gradually converted into a white mass of fibres, resembling woody fibre, which are not further changed. The ferment thus transformed has entirely lost its action upon sugar water. And *thus we find that the ferment is capable of effecting the transformation of sugar only while it is itself in a state of transformation.* The above observations, which in a great measure are due to Colin and Thénard, have led Professor Liebig to a more general conception of fermentative processes. Far from attributing the ferment action to any individual body, (in fact, chemists had vainly endeavored to isolate such a body, both from the soluble and insoluble matter of yeast) Liebig is of opinion, that a ferment is essentially a substance which is undergoing a transformation, (which is itself in a state of decomposition,) and that the excitation of fermentation consists simply in a communication of the motion possessed by the molecules of the substance in a state of decomposition (the ferment) to the quiescent molecules of an undecomposed body. Fermentation thus becomes the transference of certain conditions of change from one body to another. Sugar, when exposed to the action of nitrogenous substances, in which the contact of atmospheric oxygen has induced a condition of change, splits into alcohol and carbonic acid, in consequence of the mechanical impulse which the quiescent elementary molecules of sugar have received from the motion of the molecules of the ferment.

The fermentation of sugar is by no means an isolated case; as we proceed in the study of organic compounds, we shall become acquainted with a considerable number of very analogous processes; but, even in chemistry, a variety of actions are met with, which evidently must be ascribed to similar causes. It is, in fact, from mineral chemistry that Liebig collects the most striking illustrations of his ideas upon this subject. He reminds us of the well-known fact, that platinum alone is not attacked by nitric acid, while an alloy of platinum and silver is oxidised with the greatest facility; that water is not decomposed by copper in the presence of dilute acids: while brass, an alloy of copper and zinc, effects this decomposition readily with formation of oxide of zinc and oxide of copper; and that binoxide of hydrogen, when losing its second equivalent of oxygen, in the presence of certain metallic oxides, such as binoxide of manganese, or lead, and protoxide of silver, gives rise to a partial or even to an entire reduction of the oxide.

The oxidability of silver and zinc is transferred in this case to platinum and copper, while the decomposition of binoxide of hydrogen is communicated to the metallic oxides, which alone, under these circumstances, would not be altered.

It has been stated, in the commencement of this lecture, that alcoholic fermentation takes place between certain rather extended limits of temperature, but that the action is most regular and vigorous between 18° and 21° C. (65° and 70° F.) Between these temperatures, glucose appears almost entirely converted into alcohol and carbonic acid; I say almost, because, even then, minute quantities of foreign substances are produced, or, perhaps, better expressed, a minute portion of sugar appears to undergo a transformation different from true alcoholic fermentation.

If, during the process, the temperature rise much above 21° C. (70 F.), the quantity of alcohol produced sensibly diminishes, and the character of the transformation gradually changes altogether. If the temperature rise to between 30° and 40° C. (86° to 104° F.,) the alcoholic fermentation ceases entirely, being replaced by what is called the *viscous fermentation.*

A saccharine liquid undergoing viscous fermentation does not present the same appearance which is exhibited by the liquid during the progress of alcoholic fermentation. The former process is usually attended with an evolution of carbonic acid; and, if the liquid be distilled after the action has terminated, a very trifling quantity of alcohol is obtained. The liquid is found to be strongly acid, and this acid reaction is due to the fermentation of a very important organic acid,—viz., of lactic acid, of which I may have to treat more in detail hereafter, since it has been lately produced by a very remarkable and interesting process. But carbonic and lactic acids are by no means the sole products; in addition, there are found two indifferent substances. The first, mannite, is a compound crystallising in beautiful needles; it is the chief constituent of manna, and is present, in smaller or larger proportion, in the juices exuding from many fruit-trees, in several varieties of fucus and mushroom. And, secondly, a gum-like substance, which is either gum (arabic,) or closely allied to it, possessing, in fact, all the properties, and also the composition of this substance. It is from the constant formation of this substance, which is precipitated in white curdy flakes from the solution on addition of alcohol, that the name of *viscous fermentation* has been derived. The nature of this fermentation is readily intelligible, if we examine the composition of the substances which are produced. The formula of gum is $C_{12}\,H_{10}\,O_{10}$, that of lactic acid $C_{12}\,H_{12}\,O_{12}$ (isomeric with anhydrous glucose); that of mannite lastly, $C_6\,H_7\,O_6$ or $C_{12}\,H_{14}\,O_{12}$ Gum and lactic acid are formed from glucose simply by an elimination of water.

$$\underbrace{C_{12}\,H_{14}\,O_{14}}_{\text{Glucose.}} = \underbrace{C_{12}\,H_{10}\,O_{10}}_{\text{Gum.}} + \underbrace{4\,HO}_{\text{Water.}}$$

$$\underbrace{C_{12}\,H_{14}\,O_{14}}_{\text{Glucose.}} = \underbrace{C_{12}\,H_{12}\,O_{12}}_{\text{Lactic acid.}} + \underbrace{2\,HO}_{\text{Water.}}$$

Mannite lastly contains the elements of glucose, minus 2 equivalents of oxygen.

$$\underbrace{C_{12}\,H_{14}\,O_{14}}_{\text{Glucose.}} = \underbrace{C_{12}\,H_{14}\,O_{12}}_{\text{Mannite.}} + O_2$$

It appears to be produced by the partial deoxidation of sugar, the oxygen of which may participate in the combustion of the ferment originally induced by atmospheric oxygen.

I have briefly to notice two other fermentative processes, which are not less interesting than the viscous fermentation. The character of fermentations, and of the products to which they give rise, is by no means exclusively dependent upon the temperature; the nature of the ferment exerts, likewise, a very decisive influence. Thus we find, that sugar, at the very temperature of alcoholic fermentation, when submitted to the action of cheese-ferment, instead of beer or wine-ferment, *i.e.*, to the action of casine, in that state of decomposition which is effected by protracted exposure to the atmosphere, furnishes no longer a trace of alcohol. Under these circumstances, only traces of carbonic acid are evolved, and the liquid becomes gradually so intensely acid, that the process of transformation is arrested unless the free acid be neutralised by some carbonate. After the lapse of some time the sugar is entirely converted into lactic acid, and hence the name of "lactic fermentation" which is given to this process. No mannite, and only traces of gum-like substances, are generated during the reaction. If the transformation of sugar be effected by casine at the temperature of the viscous fermentation (*i.e.*, between 30° and 40° C.—86° and 104° F.) instead of at the temperature of the alcoholic fermentation, another change sets in, which gives rise to perfectly different products. Between these temperatures the process becomes very tumultuous, abundance of gas is given off, which is no longer pure carbonic acid, but contains a large proportion of hydrogen. If the liquid remaining after all action has ceased, be examined, it is found to contain an acid differing in every respect from lactic acid. The acid thus produced is volatile; it has the composition and all the properties of one of the acid constituents of ordinary cow's milk-butter, in fact, it is butyric acid. The transformation of sugar into butyric acid is represented by the following equation:—

$$\underbrace{C_{12}\,H_{14}\,O_{14}}_{\text{Glucose.}} = \underbrace{C_8\,H_8\,O_4}_{\text{Butyric Acid.}} + 4CO_2 + 4H + 2HO$$

But this butyric fermentation is but a further stage of lactic fermentation, preceded, as the formation of butyric acid invariably is, by the formation of lactic acid. But lactic acid, you recollect, differs from glucose simply by containing 2 equivalents of water less. So that, the conversions require no further explanation.

The transformation of sugar into butyric acid was discovered about ten years ago by Messrs. Pelouse and Gelis. It is a process of particular interest, inasmuch as it furnished the first direct proof of the controvertibility of sugar into fats,—a change which at that period was contested by physiologists.

From the statement which I have brought under your notice, you perceive that sugar must be looked upon as a sort of magazine of carbon, hydrogen, and oxygen, from which, by the action of fermentation, a very considerable number of different substances may be compounded. It is probable, not to say certain, that this number is by no means completed with alcohol, mannite, gum, lactic, and butyric acids, but that a further examination of this process, especially that of fermentations accomplished at certain different temperatures and induced by a variety of ferments, will enable chemists to produce a vast series of bodies from sugar, which are at present obtained from perfectly different sources.