possible; if not, through or beneath the trochanter major, because of the shortening which is liable to ensue.

A nearthrosis is best secured when the section passes through the neck near the head, yet subtrochanteric sections have given as good results in the restoration of the joint. Such cases are seen in the autopsy shown by J. Israel (German Surgical Congress, 1883) and in the collection made by Sach (*Deutsche Zeitschrift für Chir.*, xxxii.). In some of these cases a newly formed head covered with fibro-cartilage, a new trochanter, and synovial membrane were reproduced to a considerable extent. To obtain the best results, one must operate early in the disease, early in life (three to fifteen years), and subperiosteally, and must preserve as much of the bones as possible, so as to diminish the shortening.

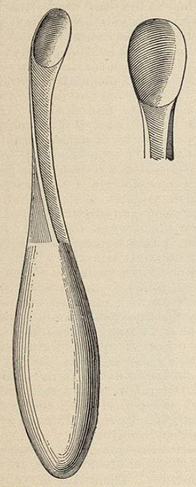

FIG. 4092.—Löbker's Spoon-Elevator. (About ½ natural size.)

When a nearthrosis is not attainable or is inadvisable, the after-treatment should secure the retention of the limb in abduction with the slightest flexion. This gives a very good and useful limb.

2. *Operation by the Anterior Incision.*—The only incisions here considered are those which are longitudinal. The transverse are too destructive of the soft parts.

According to Lücke and Schede, the incision commences one finger's breadth below and to the inner side

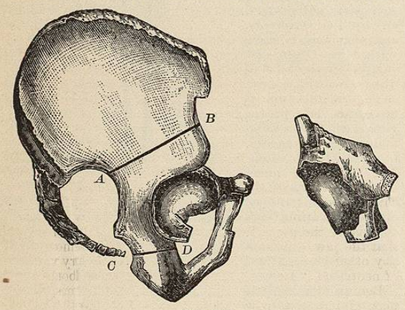

FIG. 4093.

of the anterior spine and descends in the long axis of the femur for a distance of 10 to 12 cm. (Fig. 4091, *BB*). As it is deepened it passes to the inner side of the sartorius and the rectus muscles and to the outer side of the iliopsoas muscle. The crural nerve and the external circumflex artery are avoided. The assistant flexes, abducts, and rotates outward the thigh. The sartorius and rectus muscles are drawn outward, the ilio-psoas muscle and the crural nerve inward. The capsule of the joint is exposed and is divided by a crossed incision, the transverse portion parallel to the neck passing from the acetabulum over to the anterior intertrochanteric line, while the vertical portion crosses this line at a right angle. The neck is now sawn with a Gigli saw and the head is extracted after dividing the ligamentum teres by Löbker's spoon-elevator (Fig. 4092) or by a lion-toothed forceps. For the extraction of the head alone this incision may suffice, but if we wish

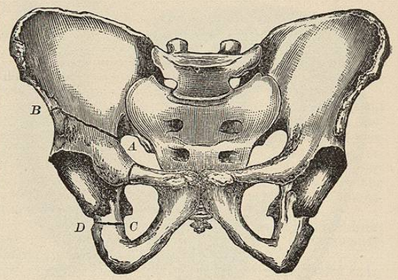

FIG. 4094.

to reach the trochanter in addition we must advocate the incision of Hueter which has been much used and strongly advocated by Barker. In this latter method, the patient rests supine with the thighs extended; the surgeon makes an incision which, according to Hueter, passes from the middle of a line drawn from the anterior superior iliac spine to the trochanter major, downward and slightly inward along the outer border of the sartorius. In children the incision is 6 to 8 cm., in adults 10 to 15 cm. in length. According to Barker, the incision commences in the anterior surface of the thigh, one-half inch below the anterior superior spine of the ilium, and runs downward and inward for three inches (Fig. 4091, *AA*). With either incision, the dissection is carried in the space between the sartorius, anteriorly, and the tensor vaginæ femoris and the gluteus medius behind. The incision is deepened to the bone and some fibres of the vastus externus are divided. In the lower angle of the wound is seen the external circumflex artery, which may be divided. These muscles are retracted, the joint capsule is seen and is incised by the same cross incision mentioned in the Schede-Lücke method. After this exposure of the head and neck, the spoon-elevator may be used and the trochanter freed of its muscles sufficiently to allow an easy exposure of the joint. The diseased head is now removed after encircling the neck and dividing it with the Gigli saw. The removal of the head is often difficult unless it be much diseased. With the lion-toothed forceps the removal is often very difficult and the soft parts and the head are often crushed. The easier method is to pry the head out of the acetabulum by introducing a strong, gently curved elevator or Löbker's spoon in the space between the head and the acetabulum, and after the ligamentum teres has been divided the head is then easily removed.

The bleeding by this anterior incision is small in amount if one avoids the anterior circumflex artery. Drainage of the wound will require not infrequently a posterior opening, but in many cases operated early all necessary drainage can be secured through the anterior incision.

In neither of these methods by the anterior incision are muscles cut. Neither nerves nor vessels are injured. In both methods the route to the joint is a direct one. The advantage of the Hueter incision over the Lücke-Schede

incision is that the trochanter, as well as the head and neck, can be reached.

When the acetabulum is primarily involved, or the *x*-ray and the clinical symptoms show that the disease which affects it must be especially attacked, the methods introduced by Bardenheuer (*loc. cit.*) and Schmid (*loc. cit.*) give the best chances for radical cure. As usual methods, these procedures are considered at present too extensive. In Bardenheuer's hands, the mortality due to the operation alone was 4.3 per cent. In Schmid's hands, the recurrences were not lessened by the procedure, two of the four cases dying of continued tuberculosis. In the large majority of cases the Kocher incision will give sufficient exposure to enable us to chisel or gouge away the diseased acetabulum; and as this method is less extensive and more easily accomplished it should be preferred.

Operation by the Superior Incision.—In a few cases, Kocher's operation is not sufficient, and we recommend for these the suggestion of Sprengel ("Zur operativen Nachbehandlung alter Hüftresectionen," *Festschrift*, 1898), which consists in making an extensive incision along the crest of the ilium from the posterior superior spine of the ilium to the anterior superior spine of the same. This incision divides the muscles and the periosteum. At the border of the gluteus medius and the tensor vaginæ femoris this incision descends to the trochanter major. (Fig. 4088, *ABC*.) This quadrilateral flap is removed subperiosteally from the ilium until the joint is opened and the head and neck of the femur are exposed. As the nerves and vessels are avoided by this, the muscular paralysis and hemorrhage are practically nil. If the disease is well forward in the acetabulum and pubis, especially if a flexion-contracture exists, the incision is made in front of the tensor vaginæ femoris, sartorius and rectus, and these muscles are separated with the rest (Fig. 4088, *ABD*). After exposing the head of the femur, it is rotated inward or outward, as occasion demands, and adducted strongly. If the acetabulum alone is to be removed, this can be easily accomplished with the chisel or gouge through the incision first recommended (*ABC*). If the disease requires a resection of the acetabulum and the surrounding bone, the second incision is used (*ABD*). In this latter case the outer surfaces of the ilium, the acetabulum, and the outer margin of the great sciatic notch are bared of their periosteum. In like manner the internal surface of the ilium, the iliac fossa, is freed from the pelvic fascia and muscles until the great sciatic notch is reached. A Gigli saw is then inserted through the sciatic notch beneath the iliac muscles and over the anterior inferior spine of the ilium and the bone is sawn (Figs. 4093 and 4094, *AB*). The horizontal ramus of the pubis is next cleared of its periosteum, carrying with it the vessels, which are displaced from 1 to 2 cm. internally. An aneurism needle now carries a Gigli saw around the ramus and out of the obturator foramen (Fig. 4094, *CD*). The bone is sawn. As the bone is now cut upon two sides, it can be displaced outward somewhat. The periosteum is next removed from the descending ramus of the ischium from above downward with great care to avoid injuring the vessels and nerves as they pass out of the pelvis. The Gigli saw is again passed around this ramus at a point one finger's breadth beneath the acetabulum (Figs. 4093 and 4094, *EF*). The bone is sawn. The acetabulum and surrounding bone can now be quite easily removed with the heavy lion-toothed forceps. If the head of the femur is to be removed with the acetabulum, it is best removed before we attempt the resection of the acetabulum.

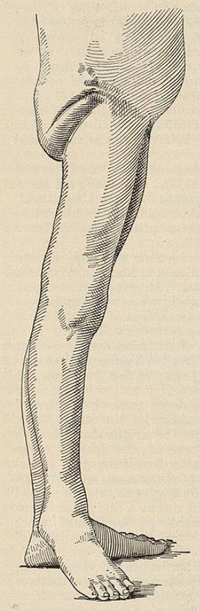

FIG. 4095.—A Patient Three and a Half Years After Removal of One-Half the Pelvis and the Head of the Femur. (Kocher.)

After the hemorrhage has been controlled the wound is closed with sutures except in some portion where the packing emerges. It is best in all cases to pack the large wounds for from twenty-four to forty-eight hours, in order to control hemorrhage completely. After this, that portion from which the gauze emerges can be left for drainage or it may be sutured at this time.

After-Treatment.—The after-treatment in resection of the hip is important. An aseptic dressing, equable compression and rest for the wound are the first desiderata. The position to be maintained is that of extension and abduction of the thigh, with the neck or the trochanter closely applied to the acetabulum or ilium. During the first three weeks, since these wounds are packed with gauze and require secondary suture or dressings, a Buck's or Volkmann's extension apparatus with plaster-of-Paris spica passing to the knee is most frequently used. After this period, when the packing is removed or the wound is healed in great part, a Thomas splint or the plaster-of-Paris dressing may be used for the next three weeks. If the patient is up and about upon crutches (children), a Thomas splint is very inexpensive and satisfactory. If the patient is confined to bed, a plaster-of-Paris splint which can be readily removed for the active exercise of the joint is the more useful form of splint. During this period of three weeks, active exercise in the new joint is made every two or three days.

During the following three to six weeks patients are allowed to walk with their splints, and during this time the Taylor hip splint or some modification of it is substituted for the former apparatus. These splints allow flexion, extension, and abduction when applied, and the surgeon must continue the extension and abduction of the limb for a long time to overcome the constant tendency to flexion and adduction. It is only by this careful after-treatment that a good functional result can be obtained. *Frank Hartley.*

RESECTION OF THE SUPERIOR MAXILLA.—History.—Partial removal of the superior maxilla for alveolar growths, necrosis, disease of the antrum of Highmore, etc., has probably been practised for a very long time, but the complete, formal resection of this bone appears to have been first proposed by Lizars in 1826.

In the following year Gensoul, quite independently of Lizars' suggestion, performed the operation, and therefore seems entitled to the credit of having first executed this procedure.

The indication for resection of the upper jaw is almost invariably the presence of a new growth. Hueter states that the jaws are more frequently the seat of tumors than any other bones of the skeleton. Almost every variety of neoplasm is found in connection with these bones.

Benign tumors such as cysts, epulis, adenomas, fibromas, chondromas, osteomas, etc., require partial resections only; merely enough of the bone being removed to give access to the tumor or to effect the complete removal of the latter.

Complete resection of the superior maxilla is usually done for malignant growths, *i.e.*, carcinomas and sarcomas, affecting the bone. They occur with about equal frequency. The majority of the former begin in the alveolus.

ANATOMY.—The superior maxilla is the largest bone of the face, the lower jaw (mandible) excepted, and with its fellow forms the whole of the upper jaw. Each bone forms a part of the wall of three cavities: the mouth, the nasal fossæ, and the orbit. It is hollow, its cavity being known as the antrum of Highmore, which communicates by an aperture with the middle meatus of the nasal fossa. Either of these cavities may be the seat of new growths which involve the maxilla; the mouth and the antrum being most frequently affected. The mucous membrane of the antrum is frequently the seat of a catarrhal or purulent inflammation, giving rise to an excessive discharge through the nose, or if the fluid is prevented from escaping, the thin walls of the bone yield, and protrude toward the cheek, toward the mouth, or in both directions, the appearances then simulating those observed in solid growths of the bone.

Instruments Required.—Mouth gag, sponge holders, scalpels, toothed dissecting forceps, hæmostatic forceps, scissors, keyhole saw, Hey's saw, tooth forceps, bone-cutting forceps of different angles, chisels and mallet, lion-jaw forceps, sequestrum forceps, Paquelin cautery, tracheotomy tube, needles, straight and curved, ligatures, sutures, marine sponges.

Partial resection for alveolar tumors and necrosis may be carried out through the mouth in most instances, without making any external incisions. The removal of other benign growths must be carried out on general surgical principles. The affected part is approached by incisions designed to avoid important structures and to give the best exposure with the minimum resulting deformity, and the neoplasm, together with the bone to which it is attached, is then removed.

If the tumor is open to the suspicion of being malignant, a generous portion of the adjacent bone in all directions should be removed, or the complete resection may be advisable.

The dangers of resection of the superior maxilla are: hemorrhage, the entrance of blood into the air passages, and septic pneumonia.

Various means have been adopted by different operators with the view of controlling the hemorrhage. The internal maxillary and temporal arteries, and the external carotid artery have been ligated as a preliminary step in the resection. The common carotid has been compressed and subjected to temporary and permanent ligation. Crile has devised a clamp to be applied to one or both common carotids, as may be necessary, for the temporary control of bleeding during operations on the head and face if serious hemorrhage is probable.

With the view of preventing the blood from flowing into the air passages, Rose advises that the patient's head be allowed to project beyond the end of the table, and to drop well down so that the vertex points vertically to the floor. In this position the mouth and nose are on a lower level than the larynx and the blood would escape from them before it would enter the latter.

The objection to this position is that the surgeon is obliged to work at a great disadvantage, and the hemorrhage is greater when the head is dependent than when it is elevated.

Some surgeons perform a preliminary tracheotomy, introducing a tube, and continue the anæsthesia through this, so that the pharynx may be packed with marine sponges to which stout strings have been attached to assist in their withdrawal. The sponges absorb the blood that finds its way to the pharynx and prevent any from flowing into the trachea.

Of this procedure it may be said that while a carefully performed tracheotomy that is well cared for afterward does not add much to the dangers of the operation, it is an additional complication, and is usually unnecessary.

The use of Trendelenburg's tampon cannula for the trachea answers the same purpose as the tracheotomy, and is open to none of its objections.

The methods which are employed in preventing the entrance of blood into the lungs do not diminish in the least the amount of blood lost. By having the patient only partially anæsthetized, he will be able to spit out the blood and thus keep his air passages free. In this way the necessity for adopting the measures spoken of will be avoided, and if the operation be expeditiously performed, the amount of blood lost will not be great.

To summarize, it may be said: (1) That Rose's position is not to be recommended. (2) If no complications are to be expected, the operation may be done with the patient but partially anæsthetized. If this plan be adopted, everything that may be needed should be at hand, and there should be an ample number of assistants, so that not an unnecessary moment shall be lost after the operation has actually begun. (3) In performing the operation for vascular tumors affecting the bone, or when for any other reason unusually free bleeding may be expected, it will be advisable to pass a loop of silk about the external or common carotid, traction upon which will occlude the vessel, or, if at hand, one of Crile's clamps may be applied. In either case, especial care must be exercised to prevent infection of the wound exposing the artery, as such an occurrence may readily be more serious than the resection of the bone. (4) If there is no reason to expect serious hemorrhage, these precautions become unnecessary. On the other hand, if a more deliberate operation is required, as in cases in which tumors have passed the limits of the maxilla and must be followed in whatever direction they have taken, the advantage of having a dry wound, so that every portion may be inspected without being obscured by blood, cannot be overestimated. In these instances some method of controlling the circulation is of inestimable value.

Septic pneumonia is best prevented by having the nasopharynx treated before the operation by cleansing sprays, douches, and gargles, and by keeping the cavity sweet and clean after the operation.

Operation.—A number of methods have been devised for resecting the superior maxilla, and many of them have been named after the operator who devised them. The chief variation is in the skin incisions employed to expose the bone, the mode of actually removing the latter being essentially the same in all.

In the classical resection the incision variously known as the median, Fergusson's, Nélaton's, Liston's, Weber's, etc., is beyond question the best. It gives ample exposure and is followed by less disfigurement than is any other incision. For partial resections and special cases some of the other incisions may be more suitable.

The incision from the angle of the mouth to the malar bone has been ascribed to Lizars and to Velpeau. Langenbeck exposed the bone by a U-shaped flap, beginning at the side of the nose, at the point of junction of the nasal cartilage and bone, and carried downward, outward, and upward, terminating at the middle of the malar bone. Liston's incision extended from the angle of the mouth to the external angular process of the frontal bone. Gensoul made three incisions: the first from just below the inner canthus, down the side of the nose, and through the upper lip; a second at right angles to this, on a level with the floor of the nose, as far out as a line perpendicular to the external angular process of the frontal bone; and a third, from the termination of the second to the external angular process.

The anæsthetic may be either ether or chloroform, according to the custom of the surgeon. If the thermo-cautery is to be employed to control bleeding, chloroform should be administered on account of the inflammable character of the vapor of ether.

The patient should be placed on his back, with the head and shoulders raised on pillows, the affected side being uppermost. His face should have been cleanly shaven.

The median incision is made in the following manner: The knife should enter the skin about half an inch below the inner canthus, and the incision should then be carried downward in the line of junction of the nose and cheek to the ala nasi, around and close to the latter, and it should stop just short of the middle line of the lip, from which point it should be extended vertically through the lip to its free border. The incision should be carried down to

the bone at once, all bleeding points being caught by pressure forceps. Finally, a second incision is to be carried along the lower border of the orbit from the beginning of the first to the malar bone.

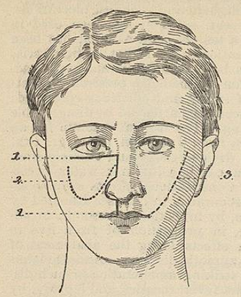

FIG. 4096.—Resection of the Superior Maxilla. 1, The median incision (also called Fergusson's, Nélaton's, Liston's, and Weber's); 2, Langenbeck's incision; 3, Lizars' or Velpeau's incision.

The flap thus outlined should be rapidly dissected from the bone, all bleeding points being secured by forceps or by sponge pressure.

At this stage it is well to tie off such forceps as interfere with the subsequent steps, and to arrest all bleeding as far as possible. The malar bone is next divided at about its middle by Hey's saw. If it is proper to leave the orbital plate a second saw cut is made in the line of the second incision, beneath the orbit as far as the nasal process. If the orbital plate is to be removed, the periosteum is incised along the lower border of the orbit and carefully separated from the bone as far back as necessary, and the floor of the orbit divided at the proper line with a chisel and mallet; or if it is necessary to remove the orbital plate entire, the periosteum is fully separated and it is wrenched from its connections at the time of removing the maxilla.

The nasal bone and nasal cartilage are next separated from the maxilla by means of a saw or chisel. The upper central incisor tooth in the affected maxilla must now be extracted and the mucoperiosteum covering the hard palate divided near the middle line from before backward; the soft palate should also be separated by a transverse incision along the posterior border of the hard palate on the diseased side. By means of a keyhole saw introduced into the nostril the hard palate is divided in the line of the incision in the mucoperiosteum as rapidly as possible. The bone is then grasped by lion-jaw forceps and wrenched from its remaining attachments, the principal one being the pterygoid process. At this stage the use of the bone-cutting forceps bent at an angle may be required to sever any firm connections. Sponges should be instantly thrust into the cavity and pressure exerted to check the bleeding, and the patient's throat should be cleared of any collection of blood. The sponges may now be removed one by one, and the bleeding points dealt with by ligation or by the thermo-cautery. Usually the hemorrhage will cease after a few moments' pressure.

It will be necessary to pack the wound with gauze which will effectually arrest oozing, but it must not be depended upon to control spurting vessels. Each piece of gauze introduced should have firmly attached a strong thread to assist in its removal. After the operator has assured himself that the hemorrhage is controlled, he should replace the flap and should suture it in position by means of silkworm gut. Especial care should be observed in adjusting the free margin of the lip.

If the bone is much diseased it is apt to break, and must then be removed in fragments. In such cases every portion should be examined for evidences of remaining disease and all such tissue removed.

The advantage in leaving the floor of the orbit when possible is that the eye is not disturbed. When it is removed, the eye drops somewhat, and the lower lid is apt to remain red, swollen, and distorted.

The removal of both superior maxillæ becomes necessary in rare instances. The technique is the same as that described above save that it is duplicated on the opposite side.

After-Treatment.—The gauze tampon should be removed on the day following the operation unless there is reason to expect free hemorrhage, when it may be allowed to remain another twenty-four hours. The mouth must be kept as clean as possible by the frequent use of washes, douches, and sprays. These should consist of mild antiseptics like solutions of boric acid, salicylic acid, etc.

Nourishment during the first few days is maintained preferably by nutrient enemata, and later by milk, broths, and other liquid foods given by the mouth.

Mortality.—This varies in different collections of cases. Butlin in 1887 found the mortality to be about 30 per cent. Bryant's collection (1890) showed 14 per cent. of deaths. Of 66 more or less complete unilateral and 5 bilateral resections, collected by White and Wood (1896), but 6 per cent. died as a result of the operation. The records of St. Bartholomew's, St. Thomas', and University Hospitals, London, have been examined by Butlin (1900), who found 127 cases of resection for malignant disease with 16 deaths (12.6 per cent.). Martens (quoted by Butlin) reports from the Clinic of König, in Göttingen, 74 total resections, from 1875 to 1896, with nearly 30 per cent. mortality.

Osteoplastic resection of the superior maxilla is occasionally performed for the purpose of removing nasopharyngeal tumors. Nélaton's method consists in the division of the soft palate antero-posteriorly, and the removal of the posterior half of the hard palate after the mucous membrane and periosteum have been separated from the middle line toward the alveolus on either side. After the removal of the polyp the palate is closed by sutures.

Chalot separated the upper lip from the superior maxilla until the nasal fossæ were opened, then extracted the two upper canine teeth and made an incision through the mucoperiosteum of the hard palate from the point occupied by the extracted teeth, along the alveoli, to the posterior border of the hard palate. The alveolus and palate were next divided by a mallet and chisel and the fragment was separated from the vomer and turned down into the mouth, being attached only to the soft palate. After the removal of the tumor the bone should be replaced and held by sutures.

Several methods have been proposed by different surgeons for reaching these tumors by temporary resection of portions or all of the nose, the most useful perhaps being that of Rouge. This consists in separating the upper lip from the maxillæ by dividing the mucous membrane close to the bone; the septum and the alæ are also detached from their attachments to the bone and turned upward by inverting the upper lip and making traction. After the removal of the tumor the parts fall naturally into place.

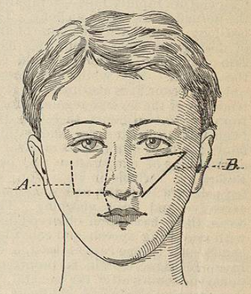

FIG. 4097.—Resection of the Superior Maxilla. *A*, Gensoul's incision; *B*, Langenbeck's incision for osteoplastic resection.

This procedure is suitable for tumors situated anteriorly chiefly. Some means must be adopted for preventing the blood from getting into the larynx. Langenbeck makes two incisions: one from below the inner canthus to the malar bone, and another from the nostril to join the outer extremity of the first. The bone is sawn through in the lines of the incisions. The bone still attached to the soft parts is then raised

and thrown over on the opposite cheek. The parts are restored and sutured in place after the tumor is removed.
Alfred C. Wood.

RESINS. See *Active Principles.*

RESOPYRIN. See *Antipyrin.*

RESORBIN is a readily absorbable ointment base made by emulsifying expressed oil of almond with yellow wax, soap, gelatin, and water, and adding lanolin to give it a proper consistency. It was introduced by Lebermann, who used it as a vehicle for mercury, as more readily absorbed and less greasy than blue ointment. He also employed it in various skin diseases. In course of time it tends to become rancid. *W. A. Bastedo.*

RESORCIN: RESORCINOL.—Resorcin, chemically *metadioxybenzene*, $C_6H_4(OH)_2$, is one of a trio of isomeric diatomic phenols, of which pyrocatechin and hydroquinone are the other two members. It is official in the United States Pharmacopœia under the title *Resorcinum*, Resorcin.

Resorcin occurs in colorless, needle-shaped crystals, having a peculiar smell, resembling that of carbolic acid, and a bitter-sweetish taste. Resorcin dissolves readily in water, and still more readily in alcohol and in ether. In its effects resorcin resembles its congener, carbolic acid, but is, in general, less active than that substance, and, in particular, very much indeed less poisonous, constitutionally. Resorcin inhibits bacterial growth, but probably less potently than carbolic acid. Locally, the drug is without effect upon the sound skin, but applied, undiluted, to a moist mucous membrane, it is mildly caustic, while at the same time anæsthetic and healing. By reason of the anæsthesia it produces, resorcin may be applied even to such sensitive parts as the mucous membrane of the larynx (Andeer). Internally, resorcin may be given in very considerable doses, as compared with carbolic acid, and such doses, administered to a fevered subject, will show to a marked degree the peculiar antipyretic effect so characteristic of the phenols. After a dosage of from 2 to 3 gm. (from gr. xxx. to gr. xlv.) there set in, in a few minutes, quickening of heart action and of breathing, reddening of the face, and buzzing in the ears, with giddiness. Within fifteen minutes sweating begins, speedily becoming active, whereupon the antecedent derangements abate, and at the same time the pyrexial temperature rapidly falls—so rapidly as perhaps to reach the normal point within an hour. The sweating does not last long, so that after the lapse of an hour from the time of dosing, the fever patient may have a naturally moist skin only, with temperature and pulse rate reduced to the normal. But while defervescence by resorcin is quick to occur, it is also quick to give way to the natural tendency of the fever to regain its former height. Within from two to four hours, therefore, the temperature often begins its succeeding rise, and within a single additional hour may have attained its original height. Such rapid after-risings of temperature may be attended by a chill. Resorcin is variable in its action; sometimes the fall of temperature is slight, and sometimes the by-effects are excessive and even alarming. Thus, after medicinal doses, there have been observed delirium and illusions, with muttering speech and convulsive trembling of the hands, and, in one case at least, a deep comatose sleep. In overdosage resorcin is competent to induce constitutional poisoning after the general type of poisoning by the phenols—producing giddiness, insensibility, profuse sweating, great reduction of temperature, and general collapse, with olive green coloration of the urine. Such alarming condition has followed a succession of doses increased from half a drachm to two drachms. Therapeutically, resorcin has been used for both local and constitutional medication. Locally, resorcin is possibly available for a simple "antiseptic" effect, but is surpassed in this therapeusis by so many other agents as to be little used for the purpose. But for a combined antizymotic and *healing* effect the local application of resorcin may be quite serviceable. Thus injections of a five-per-cent. aqueous solution have been made into the bladder, in cystitis, and into suppurating cavities, with good effect, and salves of resorcin have abated malignant and syphilitic ulcerations. A spray of a two-per-cent. solution has been used in whooping-cough; and a ten-per-cent. solution has been praised for local application to the throat in diphtheria. Internally, resorcin has been used for its antipyretic action, in which application the medicine presents the feature of a fair degree of safety and efficiency combined; but the action is evanescent and attended by disagreeable excitement and sweating. The dose of resorcin for an antipyretic effect ranges from 2 to 4 gm. (from gr. xxx. to xlv.), best given in divided doses and administered, dry, in a wafer or capsule, or in solution in water, sweetened and aromatized. Constitutional effects are also asserted (Andeer) to be procurable, in diseases attended by an affection of the skin, by inunction of resorcin in admixture with vaseline, in proportion of from five to eighty per cent., such effects being the abatement of symptoms in so-called zymotic diseases. Andeer claims thus to have produced striking amelioration in such diseases as smallpox, scarlet fever, measles, and leprosy, by inunctions, over the whole body, of resorcin vaseline. Resorcin has been used as an intestinal antiseptic, under a variety of conditions, in doses of one or two grains every two hours. *Edward Curtis.*

RESPIRATION, PHYSIOLOGY OF.—Respiration is the function by which living cells obtain oxygen and get rid of carbonic-acid gas. It is an essential factor in the existence of both animals and plants, being a necessary accompaniment of the chemical processes underlying life. In the higher animals respiration is a very complicated process, consisting of many stages, but in lower forms it is comparatively simple and may be studied to advantage.

Comparative.—*Protozoa.*—Simple one-celled organisms like the amœba, live in a fluid medium, water, which surrounds them on all sides. From this surrounding medium the dissolved oxygen is absorbed by the general surface of the body, and distributed to all parts by diffusion or by currents set up by the contracting vacuoles, or by some unknown form of cell activity. The carbon dioxide is got rid of by a reverse process. This simple form of respiration is probably very similar to the process by which the cells of the higher animals obtain their supply of oxygen and return their carbon dioxide to the surrounding lymph, constituting the so-called "internal or tissue respiration."

Cœlenterata.—In this group each animal consists of a central cavity surrounded by two layers of cells (see Fig. 4098). Oxygen is taken in to some extent by the external surface, but also by the central body cavity, which serves the double purpose of food absorption and respiration. This prepares us to find the lungs of higher animals having a common embryological origin with the organs of digestion, and suggests the close relationship of the two processes. The currents set up to and from the central cavity by the movements of the body wall and of the tentacles facilitate the respiratory processes by bringing fresh fluid with a new supply of oxygen within reach of the absorbing cells.

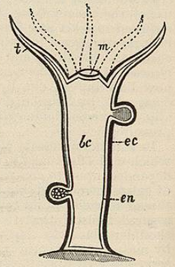

Fig. 4098.—Hydra, diagrammatic, showing Body Cavity *bc*, body wall in two layers *en* and *ec*, tentacles *t*, and mouth *m*. (After Bell.)

Worms.—In this heterogeneous division of the animal kingdom we find a circulating fluid or blood capable of

carrying the oxygen from the surface of the body where it is absorbed, to the cells in the interior which have need of it. In some cases the blood contains a special substance, hæmoglobin, with which the oxygen can enter

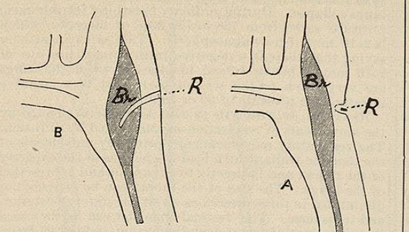

Fig. 4099.—Two Types of Nemertinea showing Rudimentary Respiratory Organs, *R*. Leading in toward the Brain, *Br*. In *A*, *R* is a simple pit and in *B* it is a duct ending blindly among the cells of the brain. (After Bell.)

into loose combination while being carried about. In the worms we find for the first time special organs of respiration. Sometimes these are little more than grooves or pits supplied with cilia to favor the renewal of the oxygen-containing medium. In other cases we find these pits becoming deeper so as to form ciliated ducts (Fig. 4099).

Insects.—In insects we find a system of tubes (tracheæ) adapted for air breathing. These are distributed through the body, and the renewal of the air within them is favored by movements of the legs and wings.

Higher Animals.—As we ascend the scale we find further developments of the organs of respiration, such as to offer the greatest respiratory surface in the smallest possible space. This is seen both in the gills of fishes and the lungs of air-breathing animals. The arrangements for the renewal of the oxygen-containing medium are elaborated and reach their highest development in the bony thorax of the higher vertebrates with their costal and diaphragmatic breathing. The blood-vascular system also becomes better adapted for taking up oxygen and carrying it rapidly all over the body.

The human embryo in its respiratory function, as in other things, passes through many of the stages represented in lower forms. The one-celled ovum, like the amœba, takes in oxygen by its general surface from the fluids which surround it in the uterus. As growth proceeds it develops a blood-vascular system, but for a time continues to take in its oxygen by the general surface of the surrounding membranes. When the placenta is formed, the fœtus has a special organ of respiration, but obtains its supply like a fish from a fluid medium, the mother's blood. At birth the tying of the cord shuts off the placenta, and the consequent deficiency of oxygen stimulates the centre in the medulla to initiate the first respiratory movements. The opening up of the lungs diminishes the pressure in the pulmonary vessels, and thus determines an increased blood supply to these organs. The foramen ovale closes and the adult condition is rapidly established.

The Organs of Respiration.—These include the *air passages* leading into the lungs from outside and comprising the nose, pharynx, larynx, trachea, and bronchi; the *lungs* which contain the respiratory surfaces (air sacs or alveoli) in which the interchange of gases takes place, the divisions and ramifications of the bronchi leading down to the alveoli, and the supporting connective tissue in which run the blood and lymph vessels and the nerves; the *pleuræ* which cover the lungs and line the thoracic walls with a smooth slippery membrane facilitating movement; the *thoracic walls* which enclose the lungs and which are strong enough to protect them and yet mobile enough to be the medium through which the expansion of the lungs is effected; the *muscles of respiration*, including the diaphragm and the muscles acting upon the ribs; the *nervous mechanism* through which all the respiratory processes are initiated and regulated.

The *nose* serves a useful purpose in warming the inspired air and thus protecting the other air passages from too sudden changes of temperature. The *larynx* is especially concerned in speech and voice production. It also plays an important part in preventing dust particles and noxious gases from entering the lungs by the cough and spasm which these substances excite when they come in contact with its mucous membrane. The *trachea* and *bronchi* consist of tubes of fibrous and elastic tissue supported at regular intervals by incomplete rings of cartilage. The portion behind, where the cartilage is absent, is supplied with plain muscle tissue by which the tubes can be somewhat constricted. The mucous membrane consists of loose lymphoid tissue. It is supplied with mucous glands, which keep the surface moist, and is lined with ciliated columnar epithelium. The cilia carry the mucous secretion and inhaled dust particles up toward the larynx. The *lungs*. As the bronchi enter the lungs they divide and subdivide, forming the bronchial tubes, to the smallest of which the name bronchioles is applied. The structure of the trachea and bronchi is continued into the bronchial tubes with certain modifications. The cartilaginous rings are replaced by irregular plates of cartilage distributed at intervals around the tubes, and even these are not found in the very smallest bronchioles. The unstriped muscle becomes relatively more abundant as the size of the tubes diminishes and it forms a continuous layer of circular fibres. The epithelium changes from columnar to cubical, and in the smallest tubes mucous glands are not found. The lungs may be seen to be divided into innumerable tiny sections known as lobules, of which each has a diameter of 1–3 cm. They are of pyramidal shape, and are divided from one another by a little fibrous tissue. A bronchial tube entering such a lobule divides several times, forming tiny bronchioles. If we follow the bronchiole along we will find the epithelium changing from cubical to pavement, and we will see an occasional air sac or alveolus opening out from the side. These tubes supplied with alveoli are known as respiratory bronchioles. Each respiratory bronchiole ends in a dilated passage called an alveolar duct, into which open a number of infundibula. An infundibulum is a cone-shaped expansion with the apex toward the duct. Extending out from it are numerous hemispherical expansions known as air sacs or alveoli which very greatly increase the total surface (see Fig. 4100).

The wall of an infundibulum consists of a thin basement membrane lined by epithelium, the so-called "respiratory epithelium." The cells composing this epithelium are of two kinds: non-nucleated platelets resting upon the blood capillaries and smaller nucleated cells between. Around the infundibula is spread out a network of capillaries so dense that the meshes are narrower than the vessels themselves. Between the air in the air sacs and the blood in the capillaries nothing intervenes but the two layers of epithelium belonging to the alveoli and the capillaries respectively. In some cases the capillary may be in contact with the epithelium of two contiguous alveoli (see Fig. 4101).

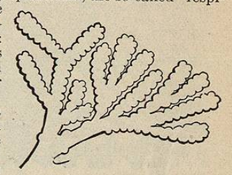
Fig. 4100.—Diagrammatic Representation of the Ending of a Bronchial Tube in Sacculated Infundibula. (After Schaefer.)

The capillaries distributed to the air sacs are from branches of the pulmonary artery. The walls of the bronchial tubes and the connective tissue of the lungs are supplied by the bronchial arteries belonging to the systemic circulation. The connective tissue which inter-