As a matter of fact, some epithelial tumors may originate from any one of the three embryonic germ layers. In like manner the term connective-tissue tumors, as generally employed, refers to tumors derived from the mesoderm, when it should include only a part of those derived from the mesenchyma. Moreover, many writers include gliomata under the connective-tissue tumors.

A few writers attempt no classification of tumors, while others believe that they should be divided according to the organ or tissue from which they arise.

Unquestionably, the proper classification of tumors must be like that of normal tissues. It must be

1. *Embryological*, based on the origin of the various cells from the three primitive germ layers and the various structures to which they give rise, and

2. *Histological*, based on the differentiation of the cells and their intercellular substances.

For this reason a list is given of the three embryonic germ layers and of the tissues and organs derived from them.

The Three Embryonic Germ Layers.

A. Ectodermal.

1. *Epidermis*, including:
(*a*) Epidermal appendages.
(*b*) Lens of eye.
2. *Epithelium* of:
(*a*) Cornea.
(*b*) Olfactory chamber.
(*c*) Auditory organ.
(*d*) Mouth, including oral glands, enamel organ, hypophysis.
(*e*) Anus.
(*f*) Chorion, fœtal placenta.
(*g*) Amnion.
3. *Central Nervous System:*
(*a*) Brain, optic nerve, retina.
(*b*) Spinal cord.
(*c*) Ganglia.
(*d*) Peripheral nerves.
(*e*) Ependymal cells of ventricles and neural canal.
(*f*) Neuroglia cells.
4. *Sympathetic Nervous System*, including part of the adrenal glands.

B. Mesodermal.

1. *Mesothelium.*
(*a*) Epithelium of peritoneum, pericardium, pleura, urogenital organs (Wolffian body, kidney, ovary, oviduct, uterus, vagina, epididymis, testicle).
(*b*) Striated skeletal and cardiac muscle cells.
2. *Mesenchyma.* (The primitive type of mesenchymal cell is preserved with slight modifications in the lymph nodes, and in the mucous membranes of the intestine and uterus).
(*a*) Connective-tissue cells (with fibrillar, reticular, and elastic intercellular substances).
(*b*) Supporting tissues (cartilage and bone).
(*c*) Smooth muscle cells.
(*d*) Fat cells.
(*e*) The so-called endothelium of the blood-vessels and lymphatics, and of the arachnoid, synovial, bursal, and corneal spaces.
(*f*) Pigment cells.
(*g*) The epithelium of the adrenal.
(*h*) Nerve sheaths.
3. *Mesamœboids.*
(*a*) Red blood corpuscles.
(*b*) Leucocytes.
(*c*) Myelocytes.

C. Entodermal.

1. *Notochord.*
2. *Epithelium* of:
(*a*) Digestive tract, viz.: œsophagus, stomach, liver, pancreas, small intestine, yolk sac, large intestine, cæcum, vermix, rectum, bladder (from allantois).
(*b*) Pharynx, Eustachian tube, tonsils, thymus, parathyroids, thyroid.
(*c*) Respiratory tract (larynx, trachea, lungs).

From the embryological point of view the principal types of tumors can be classified as follows:

A. Tumors Derived from the Ectodermal Germ Layer.

1. Adenoma, including cysts and other tumors from epithelium of tooth papillæ.
2. Carcinoma.
3. Syncytioma from fœtal placenta.
4. Neuroma.
5. Glioma.
6. Epidermoids (cholesteatoma) and simple dermoids due to inclusions of epidermal cells.

B. Tumors Derived from the Mesodermal Germ Layer.

(*a*) *From the Mesothelium.*
1. Adenoma, adenocystoma.
2. Carcinoma.
3. Rhabdomyoma.
4. Teratoid tumors (ovary, testicle).
5. Congenital tumors of urogenital tract.
6. Tumors of testicle with embryonic type of cells.
(*b*) *From the Mesenchyma.*
1. Fibroma, fibrosarcoma, spindle-cell sarcoma.
2. Myxoma, myxosarcoma.
3. Chondroma, chondrosarcoma.
4. Osteoma, osteosarcoma.
5. Leiomyoma, malignant leiomyoma.
6. Lipoma.
7. Melanoma.
8. Hypernephroma.
9. Angioma, angioendothelioma.
(*c*) *From the Mesamœboids.*
1. Lymphosarcoma.
2. Chloroma.
3. Myeloma.
4. Leukæmia (lymphatic, myelogenous).

C. Tumors Derived from the Entodermal Germ Layer.

1. Chordoma (from notochord).
2. Adenoma.
3. Carcinoma.
4. Thyroid and parathyroid tumors.

From an examination of the above classification it is evident that certain tumors, such as adenomata and carcinomata, can arise from all three of the germ layers, while many other tumors, such as gliomata and myomata, can arise only from differentiated parts of single germ layers. It is possible that the epithelial growths derived from the different germ layers may eventually show some differences in structure or in chemical properties, but at present no marked differences are recognizable. Therefore, for the sake of convenience, it is customary to consider all epithelial tumors of a similar structure—as, for example, carcinomata—under a single heading, and to distinguish only those of which the cells or cell products are so characteristic that they can be readily recognized, as, for example, adenomata of the thyroid or carcinomata of the adrenal.

In taking up tumors in detail it is customary, as in dealing with normal tissues, to group together, largely for practical purposes, those that in the character and arrangement of the cells, and in the production or non-production of intercellular substances, are morphologically most closely related. Just as carcinomata are considered together without reference to the germ layer from which they arise, so other tumors are grouped together—as, for example, the gliomata—with certain new-growths of mesenchymal origin, because of the production of fibrillar intercellular substances.

One fault at present universally made is the grouping together of certain rapidly growing tumors and the separation of them from the slower-growing forms to which they are related. I refer particularly to the sarcomata.

A carcinoma is treated as an entity; it represents a certain type of tumor. The two extremes in its rapidity of growth are distinguished as scirrhous and medullary carcinomata: all intermediate stages occur.

A glioma is a definite tumor of which the extremes in rate of growth are represented by the dense fibrous and the soft cellular forms, while all intermediate forms occur.

The same method should be adopted in the discussion of tumors arising from smooth muscle cells (leiomyoma, malignant leiomyoma), from connective-tissue cells (fibroma, fibrosarcoma, spindle-cell sarcoma), from endothelium (hemangioma, hemangio-endothelioma), etc.

Unquestionably, the reasons for grouping the rapidly growing tumors of different origins together have been at least three: First, the common properties of rapid growth and of malignancy, due partly to infiltration of surrounding tissues and partly to giving rise to metastases; second, the difficulty of determining the origin of certain sarcomata owing to the lack of differentiation of the cells; and third, the fact that several of the tissues are very closely related (connective tissue, cartilage, bone) and are often present together in a single tumor. The two latter difficulties have not yet been entirely overcome, but it is believed that with better histological technique and more careful observation they may be.

It does not matter much in what order tumors are studied, but as a rule those most closely resembling simple normal tissues are taken up first because most easily understood by beginners.

It is not claimed that the following list of tumors is complete, but it includes the most characteristic types and permits of the insertion of others as their distinguishing characteristics become recognized and generally accepted.

1. Non-epithelial Tumors.

A. Tumors of which the Cells Secrete an Intercellular Substance.—(*a*) *Fibroma, Fibro-sarcoma, Spindle-cell Sarcoma.* These names are applied to tumors originating from connective-tissue cells, and represent the three rates in the rapidity of growth under which they are all grouped. These cells produce two kinds of fibrils which are chemically and morphologically different (see *Sarcoma* for staining methods). One variety is intercellular and corresponds to white fibrous tissue. The other variety of fibrils bear the same relation to the cell that neuroglia fibrils bear to neuroglia cells; they touch the surface of the protoplasm and continue indefinitely in two directions. They are numerous in the cellular forms of tumors and very scarce in the fibrous forms.

(*b*) *Myxoma, Myxosarcoma.* Myxomatous tissue consists of connective-tissue cells with branching protoplasmic processes: between the cells are numerous intercellular fibrils more or less separated from each other by a fluid containing an excess of mucin. The term myxoma is applied to a slow-growing tumor composed of myxomatous tissue, and the term myxosarcoma to a rapidly growing one.

(*c*) *Chondroma, Chondrosarcoma.* The first name is applied to the slow-growing, the other to the rapidly growing tumors which produce the homogeneous substance characteristic of cartilage. Connective-tissue fibrils may occur in any of these tumors, but elastic fibrils are found only in the more slowly growing ones.

(*d*) *Osteoma, Osteosarcoma.* Tumors of which the cells produce a homogeneous intercellular substance in which lime salts are deposited are classed according to their rapidity of growth as osteomata or osteosarcomata. An *osteoid sarcoma* is one in which the ground substance of bone is formed without the deposition of lime salts in it taking place. The *giant-cell sarcoma* probably represents, in the majority of cases at least, a further differentiation of the cells of this type of tumor in an attempt to form osteoclasts.

(*e*) *Lipoma.* This is a tumor composed of fat tissue. Two forms occur: in the common form each fat cell is enormously distended by a single drop of fat, the protoplasm is reduced to a thin envelope, the nucleus is flattened and pressed to the periphery of the cell. In the rarer form the fat occurs in numerous large and small droplets scattered fairly uniformly in the protoplasm, and the nucleus remains in the centre of the cell. This type of fat cell occurs to some extent in normal human fat tissue and is quite common in some of the lower animals. The fat cells in lipomata are held together by intercellular connective-tissue fibrils which possibly are produced by the fat cells.

(*f*) *Leiomyoma, Malignant Leiomyoma.* Smooth muscle cells have two sets of fibrils: the coarse or myoglia fibrils are situated at the periphery of the protoplasm, run from cell to cell, and can easily be stained differentially; the fine contractile fibrils are situated between the nucleus and the periphery of the cell. Between the muscle cells and surrounding them closely is a network of intercellular fibrils probably produced by the smooth muscle cells. In the ordinary leiomyoma, all three kinds of fibrils are produced. In the more rapidly growing malignant leiomyomata the intercellular fibrils are formed in great abundance and so far as my experience goes many or practically all of the smooth muscle cells are sufficiently differentiated to produce the coarse myoglia fibrils.

(*g*) *Glioma.* The neuroglia is the connecting and supporting tissue of the central nervous system and is of ectodermal origin. It is composed of cells and of fibrils. The fibrils are in intimate contact for a part of their course with the cell from which they arise and then continue away from the cell in two directions running between the other cells. The fibrils of neuroglia cells have characteristic chemical properties which permit of their being stained by certain differential methods. A glioma is a tumor composed of neuroglia tissue. All gradations occur between dense fibrous forms containing few cells and many fibrils, and soft cellular forms with few fibrils.

Chordoma. This is a tumor derived from remains of the notochord. It consists of large pale cells surrounded by a homogeneous intercellular substance and containing vacuoles in the protoplasm.

B. Tumors of which the Cells are Embedded in a Reticulum.—(*a*) *Malignant Lymphoma.* This term is applied to a series of tumors derived from the lymphocyte series. The cells vary from undifferentiated lymphocytes such as fill the germinative centres of Flemming to the typical differentiated lymphoid cell found in the circulation. The cells vary not only in histological differentiation but also in size. They lie in the meshes of a connective-tissue reticulum which is furnished by the tissue in which the tumor cells grow. Tumors of this series vary much in rate of growth.

(*b*) *Chloroma.* This tumor is closely related to the malignant lymphoma, but is distinguished by the fact that some or all of the nodules of new growth are, for some reason yet unknown, of a greenish color. The tumor arises from cells in the bone marrow.

(*c*) *Myeloma.* This is a tumor which likewise arises from cells of the bone marrow, and which is closely related to the malignant lymphoma. The cells are characterized by having basophilic protoplasm. They resemble plasma cells except that they possess distinct nucleoli.

(*d*) *Leukæmia.* It is not impossible that both forms of leukæmia are true tumors, of which the cells find the conditions in the blood favorable for growth and multiplication.

C. Non-Epithelial Tumors Having an Alveolar Structure.—(*a*) *Melanoma.* Chromatophores or pigment cells are certain differentiated cells of mesenchymal origin which occur normally in the choroid and iris of the eye, and in certain situations in the pia and in the skin. They are also present more or less abundantly in the congenital soft warts or nævi (abnormalities, not true tumors) of the skin. Tumors arising from these pigmented cells are called melanomata or melanotic sarcomata. The cells do not produce an intercellular substance, but like the cells of the carcinomata are arranged in alveoli more

or less separated by a connective-tissue stroma containing blood-vessels.

(*b*) *Alveolar Sarcoma.* This group of tumors must be regarded with suspicion. Some included in it may have been slightly pigmented melanomata; others were unquestionably carcinomata. Possibly rapidly growing tumors, arising from striated muscle cells, possess an alveolar arrangement and may have been included under this heading.

D. Tumors Arising from Endothelial Cells.—(*a*) *Hæmangioma, Hæmangio-endothelioma.* The congenital vascular nævi of the skin and the cavernomata of the liver are abnormalities, not true tumors, but they may give rise to autonomous vascular tumors. A hæmangioma is a slow-growing tumor composed of blood-vessels, which exhibits the characteristics of true tumors. The vessels often dilate and become cavernous in type. Rarely the tumors are multiple. The term hæmangio-endothelioma is applied to rapidly growing tumors arising from the endothelium of blood-vessels. As the lumina of the new-formed capillaries often become occluded by intravascular proliferation or by rupture of continuity, rows of anastomosing cells and concentric cell masses are usually formed in parts, at least, of the tumors. There is a gradual growth of connective tissue between the cells separating them from each other.

(*b*) *Lymphangioma, Lymphangio-endothelioma.* These names are applied to the slowly and rapidly growing tumors arising from the endothelium of lymph vessels.

(*c*) *Dural Endothelioma.* Tumors distinguished by this title arise from the endothelium lining the arachnoid space. They vary in rate of growth from slow to rapid. The structure of the tumors varies greatly; it may be cellular like a sarcoma or more or less fibrous like a cellular fibroma. The cells may have an alveolar arrangement with the cells often grouped in whorls, or the cells may be more or less uniformly distributed in the stroma.

E. Tumors Arising from Nerve Cells.—(*a*) *Neuroma.* This term is often applied to a tumor-like mass which follows amputation of a limb, and is due to an attempt at regeneration made by the axis cylinders of a cut nerve. As an axis cylinder is only a process of a cell it cannot give rise to a true tumor. A true neuroma is a tumor composed, in large part at least, of ganglion cells which may produce medullated or non-medullated nerve fibres. Neuromata are rare, and arise chiefly from the sympathetic nervous system.

2. Epithelial Tumors.

In this group of tumors epithelial cells play as a rule the more important part. Like the cells in the tumors already described they cannot exist by themselves, but are always accompanied by a certain amount of connective tissue and blood-vessels on which they depend for support and nutrition. In some of the tumors the stroma is slight in amount; in others it is abundant, rapidly growing, and suggests active inflammatory tissue; in still others the connective tissue accompanying the epithelium is very abundant, and cannot be regarded as stroma but as part of the tumor formation.

A. From surfaces covered with epithelium tumors arise which are divided into two groups, according as they are elevated above the lining epithelium or invade the tissues below it.

(*a*) *Papillary fibroma*, a tumor composed of papillary outgrowths of connective tissue and blood-vessels, covered externally with a single layer of epithelium, or with a pavement epithelium. Sometimes the connective tissue is very slight in amount, sometimes very abundant.

(*b*) *Carcinoma*, a tumor composed of branching and anastomosing columns and masses of epithelial cells which invade the tissue beneath the lining epithelium, from which the tumor arises and which give rise to metastases.

B. From the epithelium lining glands, two general types of tumors arise.

(*a*) *Adenoma*, a tumor composed of new-formed glands which do not invade the surrounding tissue. Closely related to the adenoma are on the one hand the *adenocystoma*, an adenoma in which some of the glands dilate to form cysts, and the *papillary adenocystoma*, an adenocystoma with papillary projections from the wall. This latter tumor sometimes approaches the carcinoma in malignancy, and is even classed by Ribbert as one form of it. On the other hand, the connective tissue surrounding the glands may play an equal or even more important part than the epithelium, and then we get the *adenofibroma*, or, if papillary ingrowths occur, the *intracanalicular papillary adenofibroma.*

(*b*) *Malignant adenoma, adenocarcinoma, carcinoma.* A closely related group of tumors, morphologically somewhat different, biologically alike, which are often included under the term carcinoma. They also correspond biologically with the carcinoma of the first group of epithelial tumors.

The term carcinoma is unfortunately employed in two ways—biologically as a designation for all malignant epithelial tumors, and morphologically to distinguish in malignant epithelial new growths the epithelium growing in solid masses from that which grows in the form of glands or cysts.

There is a certain tendency to give a special name to all epithelial tumors coming from a certain organ, such as malignant hypernephroma for epithelial tumors of adrenal origin, provided the cells or their secretions are very characteristic.

In the above classification those tumors in which epithelium and connective tissue play an essentially equal part are often separately considered under the heading fibro-epithelial tumors. This would include papillary fibromata of the skin and the adenofibromata of the breast.

It is to be noted, however, that adenomata of any organ imitate that organ not only in regard to the glands, but also in regard to the amount and character of connective tissue which is between the glands. In the liver and adrenal there is very little connective tissue and adenomata of these organs exhibit the same condition. But in the mammary gland, where there is always a great amount of dense connective tissue between the glands, the adenomata arising there have much connective tissue associated with them. It would seem as if the two tissues worked together in an attempt to form mammary-gland tissue.

C. Cysts Lined with Pavement Epithelium.—Cysts lined with a single layer of epithelium belong in one of two classes. The first are due to dilatation of pre-existing glands or cavities under the influence of retained secretions. The second are true tumor formations and begin as adenomata, of which some of the glands dilate and fuse to form cysts.

There is another class of cysts which are lined with epidermis. Those due to the dilatation of the ducts of sebaceous glands (wen, atheroma) are certainly not tumors. There is another group, however, which is usually included among the new growths. These are the simple dermoids occurring chiefly along the lines of closure of the embryonic fissures and the cholesteatomata which are found almost exclusively in connection with the central nervous system. They are probably both to be regarded not as true tumors, but as embryonic inclusions and displacements. The dermoid cysts enlarge as sebaceous cysts do under the influence of retained secretions. If the secretions could escape they would not enlarge any more than do the fistulæ originating from branchial clefts.

The cholesteatoma is due to the inclusion within the central nervous system of ectodermal cells, which would normally form epidermis. The apparent tumor is due to the gradual accumulation of dead desquamated epidermal cells.

The simple dermoids and the cholesteatoma belong in the same class with aberrant adrenal rests. They are unquestionably under the physiological control of the body. They can give rise to tumors, but are not themselves true tumors. They have been classed with the tumors largely because under the influence of retained secretions they often attain a considerable size.

3. Mixed Tumors.

There are three principal groups of mixed tumors which require attention. It is possible, however, that the fibro-epithelial tumors should be added to them as the simplest type of mixed tumors.

A. *Mixed Tumors of the Salivary Glands.*—They develop most commonly in or near the parotid. They are nodular tumors of varying size which are usually benign, but may become malignant. They are composed of tissue elements derived in part from the ectoderm, in part from the mesoderm. The latter germ layer may give rise not only to connective tissue, but often to cartilage and more rarely to bone, fat, and lymphoid tissues, and even to striated muscle cells. The epithelium of ectodermal origin may occur in the form of glands or in solid masses as in a carcinoma.

These tumors probably arise from embryonic displacements of cells of the ectoderm and mesoderm during the formation of the branchial arches and of the parotid and submaxillary glands.

B. Mixed Tumors of the Genito-Urinary Tract.—They occur most commonly in the kidney, but arise sometimes in the uterus and vagina, and even in the wall of the bladder. They are congenital tumors which are always malignant, and may give rise to metastases. They are composed of rapidly growing connective tissue which resembles sarcomatous tissue, of embryonic striated muscle cells, of tubular structures lined with epithelium, and occasionally of fat tissue and cartilage. These tumors unquestionably arise from the displacement, at an early stage of embryonic development, of undifferentiated cells, which under normal conditions are capable of giving rise to differentiated cells such as occur in the tumors.

C. Teratoma.—This group of tumors can be divided into two subdivisions.

(*a*) *Embryoma.* In the ovary and to a less extent in the testicle tumors occur which vary from a simple to a very complex structure. They may contain practically all the different tissues present in the body, *i.e.*, all three embryonic germ layers are represented. It is probable that these tumors arise from undifferentiated cells which under normal conditions are capable of giving rise to embryos, *i.e.*, from ova or more probably from cells which give rise to ova.

(*b*) *Fœtus in Fœtu.* Very complicated tumors, more or less similar in structure to those occurring in the ovary and testicle, sometimes occur in other parts of the body. They are probably due to the inclusion in a fœtus of an ovum or of cells developed from an ovum, which under normal conditions would give rise to another fœtus.

Origin of Tumors.—A certain number of tumors unquestionably arise from cells which during embryonic development are displaced from the site where they belong. Some of these cells are displaced at an early stage of cell differentiation, and hence are capable of producing tumors of a complex nature, containing a variety of tissues, as for example the mixed tumors of the kidney. Other cells are displaced at a later period of development when they are more or less completely differentiated, and in consequence they give rise to tumors consisting essentially of a single kind of cell, as for example the tumors of adrenal origin.

Of these displacements of embryonic cells the commonest and most easily recognized are the aberrant adrenals or hypernephromata. Their size probably corresponds to the amount of gland tissue which they would have produced if they had remained in their proper situation. Small, misplaced spleens are not at all uncommon. Displaced bits of pancreatic tissue are less frequent. The so-called cholesteatomata found in connection with the central nervous system, the remains of branchial clefts and of the lower end of the neural canal, and the gland-like structures so common in the wall of the oviduct are all examples of cells or groups of cells displaced during embryonic development. Pigmented and vascular nævi are still other examples which should, however, probably be classed as abnormalities rather than as displacements. Some of these "fœtal rests" become so large in consequence of the accumulation of retained secretions (the cholesteatoma and the simple dermoid) that they are usually classed as tumors.

It is probable that all of these displaced tissues are under the normal physiological control of the body. They can give rise to tumors, but are not themselves new growths.

Certain displacements of embryonic tissue are recognized only by the tumors to which they give rise, as for example those from which come the mixed tumors of the genito-urinary tract and of the salivary glands.

The adenofibromata of the breast may be derived from displacements in post-embryonic life, at the time when the mammary gland is developing. They certainly suggest an attempt at the formation of mammary-gland tissue.

The important point to bear in mind in regard to these tumors which unquestionably arise from embryonic displacements of tissue, such as the malignant hypernephromata, and the mixed tumors of the urogenital tract, is this, that they are as malignant as any tumors which exist, and that they give rise to metastases.

Etiology of Tumors.—In regard to the cause of tumors we know absolutely nothing. Bacteria, protozoa, and blastomycetes have been claimed to be the active agents in the production of some of them, particularly of carcinoma. It must be acknowledged that blastomycetes produce a curious form of tissue proliferation containing great numbers of endothelial cells, which to an unskilled observer might suggest an epithelial growth, but the result is granulation tissue, not a true tumor. It has been claimed that trauma (acute injury and chronic irritation) may so stimulate the cells of a part that a tumor formation is the result, but it is impossible to regard this as a general cause, although in certain cases it is possible that it is the exciting cause.

We thus come back to displaced cells as a possible solution of the question. In many cases, certainly, tumors arise from them, but the reason for it we are unable to understand, because most of these tissue displacements persist throughout life without leading to anything abnormal. Possibly a series of experiments with displaced tissues of various sorts might throw some light on the subject. Certainly at present such experimentation is the most promising field for investigation.

F. B. Mallory.

TUNNELLING, DANGERS OF.—The scope of this article is to deal with such explosives as are generally used in public or private works of improvement, the effects of the explosion upon the workingmen employed, and the way in which accidents with such explosives frequently occur.

I. Explosives Used in Blasting.—There are numerous kinds of explosives: Gunpowder, guncotton, nitroglycerin, dynamites, picrates, fulminates, etc. It is not the purpose of this article to deal with all of the different kinds of explosives, but simply with those which come into common use.

The principal ingredients of the various explosives are potassium nitrate, sodium nitrate, ammonium nitrate, potassium chlorate, nitric acid, sulphuric acid, sulphur, the hydrocarbons, benzene, toluene, naphthalin, carbohydrates, cellulose, alcohols, glycerin, ethers, acetone, camphor, vaseline, paraffin, kieselguhr, randanite, tripoli, coal dust, and the alkaline carbonates.

Gunpowder is of two kinds—nitrate and chlorate. Ordinary black gunpowder belongs to the *nitrate* class, and is composed of potassium nitrate, 75 parts; charcoal, 15 parts; sulphur, 10 parts. There are many special powders of this class which vary, not so much in their composition as in their shape, size of the grain, density,