through. In grafting extensors upon flexors, or the reverse, the tendon may in the forearm and leg be carried through the interosseous space instead of around the limb.

The suture should be made under a certain amount of tension, and should be capable of withstanding considerable force. This is best accomplished, ordinarily, by passing the end of the divided tendon through one or even two buttonholes in the other tendon and securing it by a number of sutures. When two divided ends are to be joined, this is done, as above described, under tendon suture. Silk is by all means the best material to use for the suture, as it can be made truly aseptic, and will retain its strength sufficiently long. In a small proportion of cases sutures will afterward work their way out without jeopardizing the result of the operation.

In order to satisfy the two rules, that the tendon suture should be under tension and that it should be done under slight overcorrection of any pre-existing deformity, it will often be necessary to do tendon lengthening on some contractured muscle, such as the tendo Achillis, and tendon shortening on others. Lengthening is done by means of the plastic tenotomy above described (Fig. 4635), while shortening is usually best accomplished by taking a fold in the tendon and maintaining it by sutures.

The proposals of Lange and Wolff to fasten the end of the active tendon into periosteum or bone, instead of into the paralyzed tendon, would seem to involve unnecessary complication, and the more so since the results of these procedures have not been shown to surpass those of the older ones. Lange's plan of using silk strands to connect a sound tendon with a bony insertion in order to avoid the necessity of incising or splitting the tendon has been proved by him to be perfectly feasible. It might be employed with advantage where the tendon graft cannot be made of sufficient length.

The operation upon the tendons having been completed, it is well to attempt to bring the wounds in the sheaths together, or at least to sew the fascia over them. In closing the skin wound drainage had best be dispensed with if possible. The part should be fixed in a plaster-of-Paris dressing, applied over the aseptic bandage; this should hold the joint in a neutral position, *e.g.*, midway between flexion and extension. In the absence of wound infection, the original dressing should be allowed to remain for from six to eight weeks. Suppuration will usually place the result in great doubt. It is not, however, incompatible with a successful issue. It is best to maintain the patient in complete recumbency for at least one month.

After the removal of the fixation dressing, warm baths, massage, passive and active, as well as resistive movements, must be employed with energy and skill if fullest success is to be obtained. In many cases a light brace should be worn during the first few months, so that the act of walking may not tax the muscles too greatly. This is especially true of cases in which a deformity had been corrected.

The number of combinations which may be made in the performance of tendon transplantations is so great that space forbids mention of them in detail. For this reason only a few of the commoner ones are given as examples.

Paralysis of Tibialis Anticus and Tibialis Posticus.—The foot is in position of equino-valgus. The extensor hallucis is cut through and the proximal end is sewed to the tibialis anticus. A slip is taken from the extensor communis and sewed to the tibialis anticus. The distal end of the extensor hallucis is attached to the extensor communis. The tendo Achillis is lengthened, and the peroneus longus is grafted upon the tibialis posticus.

Paralysis of Gastrocnemius.—The foot is in position of calcaneo-valgus. The proximal ends of peroneus longus, flexor digitorum, and a slip from the tibialis posticus are implanted upon the tendo Achillis, which itself requires to be shortened. The distal end of the peroneus longus may be attached to the tendon of the peroneus brevis.

Paralysis of Extensor Communis and Peronei.—The foot is in position of equino-varus. Redressement of the deformity. Extensor hallucis sewed to extensor communis digitorum. Tibialis posticus severed and proximal end attached to peroneus brevis. A slip from tendo Achillis is attached to the peroneus longus.

While tendon transplantation is by all means to be considered a very great advance in the treatment of partial paralysis and of paralytic deformities, unreasonable things should not be expected of it. The most satisfactory results by far are obtained when only one or two muscles are paralyzed, and here the cure may under favorable conditions be practically perfect. When a number of important muscles must be substituted for, much less is usually accomplished. A better position of the limb, making the wearing of apparatus easier, because of simpler needs for it, is all that is frequently accomplished, and it is likely that in some cases arthrodesis would be of more beneficent effect. The success of transplantation depends, however, not only upon the selection of the proper muscles for grafting and a correct operative technique, but in no less degree upon attention to even the minor details of the after-treatment. The full benefit of the operation is usually not to be observed until some months afterward, and the total improvement is sometimes not gained until a period of as much as two years has expired. Sometimes benefit from the operation is found to be transitory; a few months afterward the patient is found to be in the old condition. In this case careful investigation will sometimes disclose the cause of failure in improper selection of energizing muscles, and one may with hope of success resort to secondary operations.

Albert H. Freiberg.

TERATOLOGY—derived from the Greek word τερατολογια (τερας, monster + λογια, tell)—in its broadest application is that department of biology which treats of the malformations or abnormal growths in both the animal and the vegetal kingdom. In the more restricted and usual sense of the term, as suggested by the elder Saint-Hilaire, in 1822, teratology includes the consideration of the graver malformations resulting from deviations in the normal development of man and other animals occurring at some period before birth.

It is evident that no sharp demarcation can be drawn between the many slight developmental variations giving rise to the numerous anomalies, or *hemiterata*, affecting various parts of the body and the more serious defects appropriately classed as malformations; with the latter, however, is associated the existence of disturbances of form and function which more or less profoundly affect the well-being of the organism.

Malformations may be grouped as *primary* and *secondary;* the former include those produced by arrest or deviation of the fundamental processes of development by which the animal body, or its parts, originates; the latter embrace those that result from disturbances of organs or parts, the early development of which has progressed normally until adversely impressed by some secondary influence.

Malformations presenting marked change or distortion from the normal appearance of the embryo or fœtus are termed *monsters*. In these the external characteristics are usually associated with structural defects of such gravity that the organism is incapable of maintaining an independent existence after separation from the sources of maternal nutrition. A conspicuous exception to such inability is seen in double monsters, which, notwithstanding their striking peculiarities, sometimes, as in the case of the famous Siamese twins, live, grow, and even thrive for years.

History.—An intelligent interpretation of malformations is so dependent upon an adequate knowledge of the processes of normal development that the evolution of teratology from the crude and fanciful speculations of the past into a recognized department of biology, founded upon a sound and rational basis, is largely the record of the progress of embryology itself.

The appearance, in 1759, of the epoch-making *Theoria generationis* of Caspar Friedrich Wolff marks the beginning not only of a true conception of normal development, as a progressive differentiation and specialization of a primarily simple germ-mass, but likewise of a just appreciation of the causes leading to abnormal formations.

From the earliest times the occurrence of congenital malformations may well be imagined as having arrested the attention and exacted the speculation of philosophers of all ages; objects of such deep general interest could not escape the keen scrutiny of Aristotle (384–332 B.C.), and to him we are indebted for the earliest discussions of the causes and the manner of production of such abnormalities.

Notwithstanding the interest with which these defective beings were regarded, over two thousand years elapsed before their true nature began to be suspected during the early half of the eighteenth century. Previous explanations of the production of monstrosities consisted of confused and fanciful assumptions, often grotesque in their absurdity, in which supernatural influences, the benign or baneful exercise of divine power, the impressions wrought by heavenly bodies, the blighting influences cast by unholy spirits and by witches, sexual congress with the lower animals or with Satan himself—"coitus cum diabolo" being an accepted factor even as late as Martin Luther and Ambrose Paré—all found accredited place in the category of potent causes of monstrous births. A detailed consideration of such idle speculation need not here detain us; the reader interested in a fuller account of these curiosities of medical literature may be referred to the interesting *résumé* of past theories contained in Ballantyne's paper on "Teratogenesis."[1]

Following, although tardily, the more accurate trend of anatomical investigation inaugurated by the genius of Vesalius and the enthusiasm of his pupils, the progress of teratology during the seventeenth and eighteenth centuries is marked by the passing of old traditions and the dawn of a rational conception of the significance of malformations as evidenced by the increasing number of accurate descriptions of these variations by competent observers. An adequate interpretation of malformations was manifestly impossible at a time when the fundamental facts concerning normal development were still to be recognized.

The discovery of the mammalian ovum by de Graaf, in 1672, and of the spermatozoa by Hamm, three years later, supplied the basis for the bitterly contested discussions of the two factions—the "ovists" and the "animalculists"—which, however, met on common ground in the acceptance of the doctrine of "evolution" which assumed that gestation resulted in the expansion and unfolding of the perfectly developed body, preformed but of infinitesimal size. These principles when directly applied to the explanation of malformations, as they were by many, led to the conclusion that such defects must result from malformed germs—an admission irreconcilable with the generally conceded adaptability to purpose of nature and a divine Wisdom. In order to meet these objections, the influence of mechanical disturbances, as well as of external pathological conditions, upon the unfolding germ was assumed by the more conservative. Even the philosophical Haller failed to appreciate the importance of the views advanced by Wolff, who, recognizing the fundamental truth that each new being is formed by individual development and differentiation of the primary simple germ, declared malformations to be the results of abnormal variations of the formative energy which under favorable conditions produced the perfect being. While in the main accepting the correctness of the then current doctrine of preformation, Haller presented for the first time a critical analysis of the relation of the known causes of abnormal development to the facts established by observation as gleaned from his own rich experience; he must be regarded, therefore, as one of the founders of scientific teratology.

The closing years of the eighteenth century, and the opening decade of the next, witnessed further advances in the study of malformations in the accurate investigations into the anatomical peculiarities of many abnormalities by Sömmering, Autenrieth, Tiedemann, Blumenbach, and others; Sömmering in particular was fortunate in recognizing the fact that congenital defects were not capricious aberrations, but that in their production they followed definite laws.

The services of Meckel to embryology in securing to Wolff's later papers their merited recognition, by translation into German, were also shared by teratology, since his keen appreciation of the truth of Wolff's "Epigenesis," as opposed to the long-accepted evolution theory, enabled Meckel to regard the production of malformations from an advanced standpoint. As an ardent believer in the dynamic causes of malformations, Meckel sought to explain the majority of defects as the result of disturbances of formative energy, attributing to an early arrest of development the prominence which his own researches suggested.

In 1822, four years after the completion of Meckel's "Handbuch der pathologischen Anatomie," the name of Saint Hilaire appears which, represented by father and son, has become inseparably associated with the study of congenital defects. The "Traité de Teratologie" of the younger, Isidor Geoffroy, Saint Hilaire, published in 1837, presented a most elaborate and systematic consideration of malformations in which the various forms of deviation are described and grouped with such completeness that even at the present day many of the features and names of St. Hilaire's classification find recognition by the latest writers. Although influenced by the opinions of his father to regard mechanical influences as the most potent cause in producing malformations, the fuller appreciation and the emphatic statement of the truth that certain typical forms of variation are continually repeated are among the benefits derived from the teachings of this eminent French teratologist.

Among the immediate results of the establishment of the cell doctrine by Schleiden and Schwann, in 1837, were not only renewed investigations and rapid advances pertaining to normal development, but also more searching inquiries into the mode of production of malformations in the light of these newer views. The contributions of Bischoff (1842), Vrolik (1849), Panum (1860), and Förster (1865) mark the beginning of a new era in teratological literature; the last-named author, in particular, proposed a classification upon an embryological basis which, in a modified form, may serve the purposes of today. Among the more recent systematic works on teratology may be mentioned those of Ahlfeld (1880), Taruffi (1881–95), Hirst and Piersol (1891), Guinard (1893), and Marchand (1897).

The deep interest which the causation of malformation has always excited could not fail to suggest attempts to produce artificially monstrosities as aids in solving the problems connected with the mode of production of these variations. Even before the appreciation of the fundamental truth that malformations arise as disturbances and deviations of the normal processes of development, the elder Saint Hilaire succeeded in producing abnormalities by incubating hens' eggs placed in unusual positions, thus meriting the distinction of being the founder of experimental teratology, to the results of which we are indebted to many most suggestive and important data. Liharzik, Panum, Dareste, Schrohe, Koch, Gerlach, O. and R. Hertwig, and Richter are among the investigators whose experimental studies yielded positive proofs of the disturbing effects of mechanical, chemical, thermal, and other influences. Within the last ten years the important experimental studies of Roux, Born, Driesch, Wilson, O. Schultze, Windle, Morgan, Schaper, and others have added much valuable information relating to embryological mechanics and to the formation of developmental variations.

It will be seen from the foregoing brief historical sketch that the advancement of teratology as a science may be divided (according to the predominating influences) into three periods:

1. The descriptive—embracing the last half of the eighteenth and the first third of the nineteenth century, when the systematic grouping of the various malformations was based upon the apparent relationship, as exhibited by the characteristics of the completed defects.

2. The morphological—during which the anatomico-embryological details chiefly claimed attention.

3. The experimental—including the last ten years, during which the causation and the mode of production have been the subjects of inquiry rather than the structural peculiarities of the malformations. It is to the further achievements along the lines of experimental investigation that we must look for the advances in accurate knowledge necessary to place teratology upon a satisfactory plane as a department of biology.

In the limited space alloted to this article it will be impossible to present more than a brief account of the more important malformations occurring in the human subject. For a more detailed consideration of the particular defects, the reader must be referred to the special papers to be found in the publications noted at the end of this article.

Causation.—The etiology of malformations in many cases is still a matter of uncertainty; the causes, however, may be divided in general into two groups—*external* and *internal*. The latter, in contrast to external causes, may be held responsible for the production of spontaneous malformations in which influences acting from without are excluded; they comprise the defective constitution of the germ-plasm, whether the latter be modified by the inherent peculiarities of one or both parent cells, by pathological changes affecting the embryonic organism, or by impressions due to heredity or atavism.

The occurrence of defective conditions of the parental germ-cells, whether of father or mother or of both, is more a matter of *a priori* assumption than of positive demonstration, since it is impossible to detect structural variations which account for the often far-reaching impressions produced on the embryo.

The influence of heredity—whatever the limitations of our intimate understanding of the phenomena—in the production of malformations has long been recognized in those cases in which particular defects, as supernumerary fingers and toes, harelip and skin pigmentation, occur in certain families through successive generations. Even graver abnormalities, including hypospadias, imperforate anus, spina bifida, microcephaly, and partial absence of limbs, seem influenced by transmitted predisposition. An unbroken sequence of generations may be wanting, since the defects may be absent in one generation and again appear in the next, or a "reversion" may occur to an abnormality presented by some ancestor several generations removed.

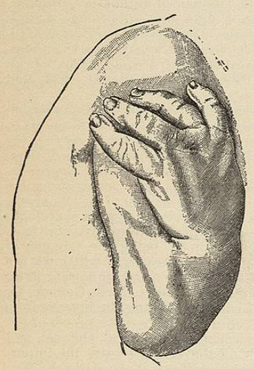

Fig. 4643.—Distortion of Upper Extremity Resulting from Amniotic Pressure. (Ziegler.)

The responsibility of one parent for the inherited defect has been repeatedly shown in families where the children of one father by two or more wives, or, conversely, those of one mother by different husbands, have presented similar malformations. A remarkable case in point is recorded by Meckel,[2] in which two children of a man by his first wife had harelip; of four children by his second mate, two had the same deformity, while a third had cleft palate. Two relations of the father also had harelip. Gade[3] reported the case of a woman who had given birth to three anencephalic monsters.

Notwithstanding the important investigations of recent years relating to the details of the union of the chromatin contributed by the male and female germ-nuclei that have given to our knowledge of fertilization an almost mathematical precision and supplied an accurate morphological basis for our understanding of heredity, the inscrutable variations in the ultimate constitution of the chromatin upon which depend the transmission of inherited characteristics must still remain subjects of speculation.

Pathological changes affecting the early embryo are sometimes indistinguishable, in their consequences at least, from true formative disturbances, since both may result in the arrested development and death of the embryo. Defective nutrition, whether due to diseased conditions of the maternal tissues or to defective development of the early circulatory system of the embryo itself, is responsible for the loss of many products of conception—probably of a far larger number than is usually appreciated, since these may be thrown off in the earlier weeks of gestation without attracting attention. The aborted "moles" so frequently encountered are the malformed and partly absorbed embryos of later, but still early, stages; the disproportion between the size of the embryo and the duration of pregnancy, so conspicuous in many cases, is accounted for by the fact that the death of the embryo takes place some time prior to its expulsion. In not a few instances, in which death occurs at a very early period, absorption has been so complete that even the most careful examination fails to locate the embryo within the enveloping sac.

We are indebted to His[4,5] for the first comprehensive study of these defective forms which, according to this authority, constitute at least forty per cent. of all early abortions. Giacomini[6] regards this estimate as too low, and declares that in less than twenty-five per cent. of abortions during the first month the embryo presents normal development. The last-named writer divides these abortive products into two chief groups: 1, the embyro is present; 2, the embryo is absent. When present, the embryo is represented by (*a*) atrophic forms, or (*b*) nodular malformations. When absent, the disappearance of the embryo may be due (*a*) to absorption, either with or without the retention of the fetal appendages, or (*b*) to complete or partial escape from its enclosing sac.

Mall[7] has also contributed an instructive paper relating to early malformed embryos. In all described, some fifty in number, he regards the abnormality as either primarily of the embryo or of the chorion. The term "vesicular" is suggested instead of His' nodular forms, all of which are earlier than the second week. Mall concludes that the cells which so conspicuously infiltrate the tissues of such malformed embryos are the blood cells that migrate from the vessels, which latter are left enlarged and empty. After the early formation of the amnion, the embryo may die while the amnion, chorion, and umbilical cord continue to grow for a time, thus accounting for the discrepancy between the development of the membranes and of the product of conception which may undergo partial or complete destruction. In certain cases the supposed vesicular embryo is really the remains of the yolk sac.

External causes adversely affecting the development of the embryo include *mechanical influences*, as traumatism and pressure, *physico-chemical influences*, as variations of temperature, electricity, deficient oxygen, toxics, and *maternal influences*. External violence, when not too overwhelming in its immediate effects, may bring about arrest of development and subsequent malformation by causing an impaired nutrition in consequence of the separation between the ovum and the maternal tissues due to extravasation of blood. The results of such nutritive disturbances may be death and subsequent expulsion of the embryo, or a malformation which may be retained until the termination of gestation.

Pressure is a potent source of defective development; and even when of slight degree, if long continued and exerted at an early period, is capable of producing profound changes in the young fœtus. Conspicuous examples of malformations due to such causes are seen in abnormalities of the extremities, congenital luxations and club feet, in the production of which unusual relations of the amnion, or malposition of the fœtus in utero, must be assumed as common sources of the undue pressure. Joachimsthal[8] further refers certain examples of spinal curvature, deep constrictions on the head, and flattened nose to such influences. The pathological conditions of the fetal membranes, particularly of the amnion, may be responsible for pressure-defects in cases in which the available space for the developing fœtus is reduced by hemorrhages either within or between the membranes.

Many malformations may be properly attributed to arrested or disturbed development induced by pressure in consequence of failure of the amnion to keep pace in its expansion with the growth of the fœtus. The close relation between the tubular amniotic envelope and the young human embryo, especially at its cephalic end, renders abnormal diminution of the amniotic space in the early stages a serious matter for the delicate product of conception. Under such unfavorable conditions profound changes may occur, which, when involving the head, may lead to defective development of various segments of the brain, the eyes (*cyclopia*) or the parts normally formed from the visceral arches. Certain types of deformities of the skull (*cranioschisis*) and of the spine (*rachischisis*) are probably expressions of later influences due to amniotic pressure.

Likewise the development and differentiation of the caudal end of the embryo may suffer and the immature lower limbs may remain stunted (*phocomelus*) or unformed, or early be so blended that their future development gives rise to a composite member (*symelus*).

In certain cases there is evidence that the pressure has been only temporary, the amnion after a time assuming a normal relation to the fœtus. Rarely the obliteration of the amniotic sac is only local, the membrane being closely applied to the fœtus over portions of its surface, while in others the amnion is separated and removed by accumulations of the amniotic fluid. Where tightly applied the investing membrane sometimes undergoes atrophy to such extent that the embryo appears to, or actually does, lie partially uncovered.

Amniotic adhesions are productive sources of malformations, especially of those parts, as the head and the extremities, which present prominences favorable to the attachment of the investing membrane during the early period of gestation when the amnion lies closely related to the embryo. The fact that both the exterior of the latter and the inner surface of the amnion are covered by the same layer, the ectoblast, is favorable to union of these surfaces when brought into unusual intimacy. Such adhesions may remain limited, or, when favored by mechanical influences, may become more extensive and firm. When, on the other hand, the amnion is later removed from the embryo, the adhesions may be reduced to a few delicate and attenuated strands, as occasionally seen attached to the fingers and toes. Sometimes the constriction due to an encircling band of amniotic tissue leads to amputation and loss of a larger or smaller portion of one or more limbs. Ridlon[9] describes a case exhibiting congenital amputation of both legs at the knee and of the left arm at the elbow. In another he noted a constriction around the middle finger on one hand; on the other the corresponding finger beyond the proximal phalanx was represented by a mere thread. On both feet the distal phalanx of the great toe and the distal and middle phalanges of the second toe were amputated, the third digits being also imperfect. The fact that the separated parts are never found is explained by their maceration and disintegration after constriction, since such amputations occur at a time while the limbs are still small and immature. Not infrequently the amniotic adhesions may disappear as gestation advances, and at birth their former existence may be indicated only by

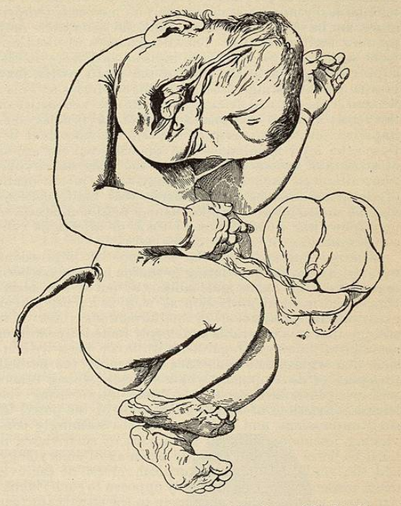

Fig. 4644.—Results of Amniotic Adhesions. (Marchand.)

scar-like markings. It is often difficult or impossible to distinguish between primary unions and the results of secondary adhesions due to inflammatory processes, although according to Tesdorpf[10] the blood-vessels so characteristic of the latter are wanting in the simple primary attachments.

The prominence and irregularity of surface presented by the head offer especially favorable localities for amniotic adhesions. These may lead to profound disturbances in the development of the skull and brain, as well as to the more common defects in the formation of the face due to interference with the closure of the various clefts between the processes and arches which normally take part in completing the face. The unusual traction exerted by an attached amniotic fold may give rise to extensive facial clefts, or if attached in the orbital region defects involving the palpebral opening, together with those of the eyelid or eye, may occur. The accompanying illustration from Marchand is a remarkable exhibition of the defects produced by amniotic adhesions, including partial exencephalus, oblique facial cleft, disturbed and imperfect development of the right eye. A firm band connects the head with the thorax in consequence of which attachment closure of the ventral body wall has been incomplete. Additional manifestations of amniotic adhesions are seen in the constricted condition of two fingers of the right hand and the tail-like appendage attached in the lumbar region.

Ahlfeld[11] has pointed out that the oval areas of defective integument occasionally seen on the head are attributable to limited amniotic adhesion of tubular form.

The effects of *physico-chemical influences* upon development have suggested important themes for the experimental investigator who has subjected the ova of the lower types, as birds, amphibians, and fishes, to variations of temperature and to the action of chemical substances and of electricity. Interesting as the results of such investigations may be in connection with experi-

mental teratology, it must be pointed out that our knowledge relating to the effect of these influences upon the human embryo is for the most part conjectural. The well-known adverse effects of certain febrile conditions of the mother in frequently producing abortions are attributable by no means exclusively to increased temperature, nor have we any evidence that the latter cause may produce malformations. The disturbances of development which follow artificially induced deficiency in the supply of oxygen in the case of the bird's ovum, may be assumed as taking place in the higher forms and man whenever the normal balance between the necessities of the fœtus and the maternal supply of oxygen becomes impaired, either by reason of imperfect connections between the fetal membranes and the maternal tissues, or of stasis and venous congestion of the maternal circulation; although such conditions may result in the death of the fœtus, we have no evidence that malformations may be so produced. In like manner fatal consequences may follow the introduction of toxic or infectious substances into the circulation of the fœtus.

Maternal Impressions.—The influence of impressions received by the mother during gestation has always been regarded by the laity, and, indeed, by not a few members of the medical profession as well, as a most potent cause in the production of malformations. Nor is it strange that this venerable and deeply rooted superstition should continue to be regarded with favor when we consider the widespread ignorance concerning the normal processes of development which prevails among otherwise well-informed persons. While appreciating the honest convictions of many in the belief of the power of such impressions, and in the sometimes seemingly convincing testimony adduced in support of such views, it must be borne in mind that the teaching of embryology and the verdict of unbiassed critical review of the evidence presented are irreconcilably opposed to such claims. Attention may be called once more to the significant fact that in a majority of cases the affected parts are well advanced in their development before the supposed impression occurs; in fact, not infrequently the developmental deviations necessary to produce the malformation attributed to the influence of the maternal impression take place before the existence of pregnancy is even suspected. Were the instances recorded in which no defective development follows the exposure of the mother to impressions to which malformations are attributed, the overwhelming majority of negative results would do much to lessen the effect now made on the popular mind by the carefully reported cases in which the real or imaginary coincidences are cited as positive proofs of the sufficiency of maternal impressions as a cause of deviations in embryogenesis.

Although, as again emphasized by Ballantyne,[12] it cannot be admitted that an unusual impression upon the mind of a pregnant woman is capable of producing defects in the fœtus closely resembling the object responsible for the impression, there are sufficient grounds for believing that the mental state of the mother may indirectly influence the development of the offspring by inducing changes in nutrition leading to congenital debility, retarded growth, and even death. Conceding that certain defects may result from nutritive changes arising in consequence of profound nervous impressions on the mother, nevertheless, to those familiar with the embryological significance of malformations, the basis of the popular belief in the potency of maternal impressions will appear as depending upon the very natural desire to find an explanation for unintelligible misfortunes in coincidental circumstances rather than upon well-established and accurately observed phenomena.

Frequency of Malformations.—The earlier attempts to determine the relative frequency of malformations resulted in widely differing estimates. The most trustworthy figures are those supplied by Winckel,[13] who found in Dresden, covering a period of eleven years, in 10,056 births 156 abnormalities, or 1:64; the same authority, however, records the occurrence of 232 malformations in 8,149 births, or 1:35, in Munich during ten years. The latter proportion agrees closely with the results of Förster, whose observations gave 1:36 based upon the examination of 1,000 cases.

Classification.

All attempts to divide malformations into systematic groups must be regarded as more or less provisional in the present state of our knowledge concerning the mode of their production, since it is evident that an entirely competent classification must be based upon their origin and true nature rather than upon the external peculiarities of the abnormalities. The elaborate classification devised by the younger Saint Hilaire attempted to provide for all forms of variation, but notwithstanding its apparent completeness many incongruities became evident as an embryological foundation for teratology became more secure. The artificial divisions set up by many proposed classifications based upon external characteristics separate abnormalities which are closely related, and, on the other hand, place in intimate relation defects depending upon entirely different causes. The early attempt by Bischoff to formulate a division based upon the embryological significance of the variations was supplemented with greater success by the classification of Förster,[14] in which malformations are considered from the standpoint of their development. More recently Marchand[15] has adopted Förster's classification which, in a modified form, has been likewise followed in this article.

Abnormal Development Affecting the Entire Embryonic Area.—In addition to the disturbances due to pathological conditions of the amnion and the chorion which so often result in the defective development, early death, degeneration and partial or complete absorption of the embryo, already described in connection with the various forms of "moles," the changes affecting the entire embryonic area may be considered as (1) *abnormalities of size*, (2) *abnormalities of position*, (3) *duplicity*.

Congenital Abnormalities of Size. These may be either (*a*) *excessive* or (*b*) *defective*.

1. *Excessive size*, giant growth, or *macrosomia*, is characterized by a general increase of the entire organism which may be manifested at, or shortly after birth, or be developed later, especially about the time of puberty. True giantism is to be distinguished from the excessive size observed in consequence of pathological conditions (*acromegaly*). While slight manifestations from the normal average length (50.5 cm., or about 20 in.) and weight (3,250 gm., or about 7.2 lbs.) of the new-born infant constantly occur, well-substantiated instances in which these figures are exceeded to any marked extent are by no means frequent. Among the instances of new-born children of excessive weight is the case noted by Eddowes[16] of a male child weighing twenty pounds two ounces, and measuring twenty-three inches in length. Dickinson[17] reports the case of a woman whose first child weighed nine pounds, the second twenty, and the third sixteen. Rice[18] mentions a neonatus weighing twenty and a quarter pounds, Baldwin[19] one that weighed twenty-three.

It is worthy of note that children of extraordinary size are usually offspring of parents of average stature. A striking exception is presented in the case reported by Beach,[20] since the father measured seven feet two and one-half inches and the mother seven feet five and one-half inches. Their first child, immediately after birth, weighed eighteen pounds and measured twenty-four inches, while the second turned the scales at twenty-three and three-quarter pounds and was thirty inches long. The assumption of an excessive amount of formative material or genetic force, in an attempt to find an explanation of these instances of unusual growth, must be unsatisfactory, and it must be admitted that our knowledge is altogether conjectural as to the cause of these cases.

Equally uncertain is the etiology of the curious partial excessive growth limited to some particular part of the body, as where one-half of the body, one extremity, one hand, or even a single finger or toe, attains unusual dimensions without participation of the adjacent parts. As with a general giantism, so here, the affected parts may for some time after birth present no unusual characteristic, the tendency to extraordinary growth first becoming noticeable at a later day. These instances of hemihypertrophy must be carefully distinguished from enlargement, the result of inflammatory processes or other pathological conditions.

It may be of interest to note incidentally the excessive stature of a few famous "giants," although it must not be forgotten that in the majority of these individuals the undue proportions are expressions of pathological conditions (acromegaly) rather than true giantism, the conspicuous stature depending largely upon excessive growth of the lower limbs. The accounts of individuals over nine feet in height are to be regarded as apocryphal, very few well-authenticated cases exceeding eight feet. Measurements by Topinard on Austrian soldiers gave eight feet four and one-half inches as the extreme height. The giant Winckelmeyer is said to have attained a height of eight feet six inches. O'Brien, the famous "Irish Giant," whose skeleton was secured for the museum of the Royal College of Surgeons, London, by John Hunter, measured eight feet four inches at the age of twenty-four; his successor, Patrick Cotter, was of similar height.

Women of unusual stature have become famous, from time to time, as "giantesses"; among the most noted of those accurately measured in recent years may be mentioned "Leah," an American, who at nineteen years of age measured seven feet two inches, and the giantess, Miss Marian, eighteen years old, who was exhibited in London as possessing a height of slightly over eight feet. The "Kentucky Giant," Captain Bates, and his wife, the "Nova Scotia Giantess," measuring seven feet two and one-half inches and seven feet five and one-half inches respectively, enjoyed the distinction of having a combined stature of fourteen feet eight inches and of being the tallest married couple known. The excessive size of the children springing from the union of these giant parents has been noted above in the case recorded by Beach. These giants themselves were the offspring, in both cases, of parents of usual stature.

2. The second group of abnormalities of size includes those exhibiting *defective growth*. These may be divided into (*a*) early defects arising from impaired nutrition, represented by the embryos whose arrested growth usually results in death and abortion during the first weeks of pregnancy; (*b*) fœtuses which complete their development, but in which growth has been defective so that at the close of gestation the new-born child is conspicuous for small size, constituting a congenital dwarf.

True dwarf growth, or *microsomia*, in which completed development is associated with insufficient growth, is to be distinguished from the not infrequent cases in which the diminutive size is due to the acquired influence of disease, as rachitis, caries, or inherited constitutional vice. True dwarfs of conspicuously diminished stature are extremely rare, their essential differential characteristic being that all parts of the body, including the head and the brain, are properly proportioned, although reduced in size. In the dwarfing due to pathological influences, on the contrary, the reduction in size is confined to certain parts, as exemplified in the shortened extremities of rachitic subjects. Such disproportion results in marked preponderance of the unaffected members, as often observed in the unduly large head of children affected with disease of the skeleton. Heredity plays an unimportant rôle in the production of dwarfs, since usually the parents are of normal size, and, further, frequently dwarfs during early infancy do not differ from other children of similar age, the diminutive size, which later renders them conspicuous, attracting attention only as age advances. The history of the celebrated dwarf, Gen. Tom Thumb, is an interesting case in point. At birth he weighed rather above the average, but ceased growing when about five months old and less than twenty-one inches in height. He lived until nearly sixty years of age, having had one child by his dwarf wife, Lavinia Warren. "Princess Paulina," described by Nagel,[21] measured nineteen inches in height at nineteen years of age, when she died. She was perfectly developed in every way, and very intelligent, speaking four languages. At birth she measured twelve inches.

Among the instances of full-term children of exceptional smallness may be cited the case, noted by Home,[22] of a living child which weighed one pound and measured less than eight inches in length. At the age of nine years, when it died, the child had attained a height of twenty-two inches. Mursick[23] mentions a living infant weighing one and three-quarter pounds at birth; Baker[24] another of the same weight and fourteen inches long when fifty days old. In 1874, at Kalamazoo, Mich., occurred the birth of twins, a boy and a girl, weighing one and a half and one and three-quarters pounds respectively, their combined weight reaching three and one-quarter pounds. They were perfectly formed and, while less than eight inches, unusually active. Another case of diminutive twins, both girls, twenty-two and one-half and twenty-four ounces in weight, is interesting from the fact that both lived to adolescence.

Abnormalities of Position.—Congenital deviations from the normal position present differing degrees of displacement, varying from involvement of a single organ, as a depressed kidney or an undescended testicle, to the complete transposition of all the thoracic and abdominal viscera, as sometimes seen in marked examples of *situs inversus viscerum*.

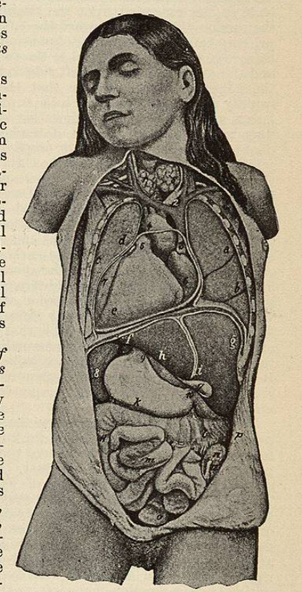

Fig. 4645.—Complete Transposition of Viscera. (Rüdinger.)

Since variations extensively involving the primary embryonic mass alone claim attention at this place, consideration of the minor deviations of position exhibited by organs, as well as the malpositions affecting the extremities, will be deferred until the description of the malformations of special parts.

Transposition of the organs (*situs transversus, inversio viscerum*) may be so complete that even the slight asymmetries which are usually observed on the two sides are all repeated, in reversed order, in the new arrangement, the functions of the organs remaining unimpaired. Complete situs transversus has been noted in about two hundred subjects, the two sexes being about equally represented. The case reported by Caton[25] presents a typical picture of this condition. The brain was normal, but the convolutions of the right Rolandic area were remarkably complex on the right side,