heifers or in human vaccination; but the former, collected when the vesicles are from seven to nine days old, is, for obvious reasons, greatly to be preferred.

Vaccinia may be produced in the cow by inoculation with lymph from animals affected with the disease, with humanized virus, and with the lymph of variola.

The essential features are the same by whatever method produced, but vary in intensity.

At one time retrovaccination, or the inoculation of heifers with humanized lymph, was extensively practised, especially in Italy, in the belief that the supposed deterioration of human vaccine virus could in this way be prevented and all contaminations removed. The practice is now justly abandoned.

The true nature of cowpox has given rise to much discussion in professional circles and this discussion cannot yet be considered closed. It is questionable whether the disease ever originates spontaneously. The weight of opinion tends strongly to support the view originally advanced by Jenner, that the vaccine disease is variola modified by transmission through the system of the cow. The French school still indorses the conclusion of the well-known Lyon Commission (1865) as to the dual nature of the two diseases. It is, however, very difficult to produce the disease by inoculation with smallpox virus. But few of the many experimenters have succeeded, and at times very lamentable results have followed the attempt. In several instances widespread and fatal epidemics of genuine smallpox have been kindled by the use of virus obtained from bovine variolation. In confirmation of this statement we may cite the experiences of Martin in Attleboro, Mass. (1836), Reiter in Munich (1839), and the Lyon Commission (1865). In determining questions of this kind, one successful experiment rebuts the negative testimony of many failures. Mr. Ceely, of England, than whom there is no higher authority, Hime (1892), Voigt, Simpson of Calcutta (1892), and others have succeeded in cultivating a stock of virus which afforded perfect protection from subsequent inoculations of variolous matter. It may be stated, then, in summing up our present knowledge, that while vaccinia is very probably variola modified in some mysterious manner by its passage through the system of the cow, the difficulties of inoculation and the sad results which attend the use of spurious virus render bovine variolation impracticable as a source of vaccine supply. It is but right to add, however, that the experiments of Dr. Voigt,[2] Superintendent of the Vaccine Institute of Hamburg, lead to a different conclusion. He has experimentally demonstrated that where bovine variolation is practised the product of the first inoculation retains nearly all of the virulence of the original seed, but by successive transmissions from one animal to another it is so modified and reduced in activity as to correspond perfectly in its effects upon the human economy with lymph obtained from spontaneous cowpox. According to Voigt, true smallpox virus must be passed through not less than six heifers before it becomes properly transmuted and safe for human vaccination. The undue violence, both local and constitutional, induced not only by original cowpox virus, but by the earlier human removes from it, seems to offer some confirmation of the above statement. This theory is also strongly supported by the more recent researches of King, of Madras, Hime, of England, and of Haccius and Eternod, of Switzerland (1892). The latter deduce as one of their conclusions: "Smallpox inoculated in the heifer becomes transformed into vaccine in the course of several generations by transmission through the animal."

W. J. Conklin.

[1] The Medical News, vol. xl., p. 498.
[2] The Medical Times and Gazette, September, 1882.

COXA VARA.—(Synonym: Incurvation or depression of the neck of the femur.)

In the normal femur the neck projects slightly forward, and upward to form an angle of about 125° with the shaft. In childhood this angle is generally somewhat greater, and in later years it may be somewhat less than this; in fact, a variation between 110° and 140° may be within the normal limit.

When the neck of the femur is depressed to a degree that causes disability, the affection is called coxa vara. Coxa vara, like genu varum and genu valgum, is one of

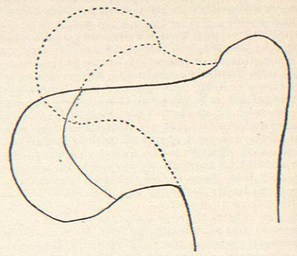

Fig. 1528.—Outline of the Depressed Neck of the Femur in Müller's Specimen, Contrasted with the Normal Position shown by the Dotted Line.

the group of so-called static deformities of the lower extremity, that more often appear at two periods of life: in early childhood, as a direct result of rhachitis; and in adolescence, when, with the weakness and the increased weight incident to this period of rapid growth, is combined, in many instances, the strain of laborious occupation (Fig. 1528).

Genu varum and valgum are common in childhood, but rarely develop in adolescence; coxa vara, in comparison, is not only an infrequent deformity, but it differs also in that it more often attracts attention in later childhood or adolescence than at an earlier period, doubtless because the neck of the femur is, at the age when rhachitic distortions are common, very short and is relatively stronger than the shaft, while in adolescence the conditions may be reversed. The distortions at the knee are self-evident, but the neck of the femur is concealed from view so that the diagnosis of its depression may be somewhat difficult, and, in fact, it is only in very recent years that its symptoms have been recognized.

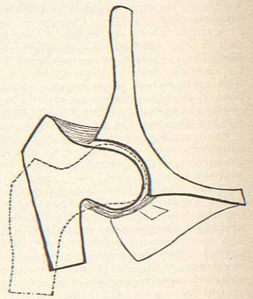

Fig. 1529.—Cross Section of the Pelvis and the Deformed Femur. A scheme to show the effect of the deformity in limiting abduction of the limb. The dotted outline shows the normal relation.

Fiorani first described the deformity as it had been observed by him in childhood (*Gazetta degli Ospitali*, Nos. 16, 17, 1881), but E. Müller first called attention to the affection as one of the deformities of adolescence which, until that time, had been mistaken for hip disease (*Beiträge zur klin. Chir.*, 1889, Bd. iv.).

Physical Signs and Symptoms.—The nature of the symptoms is explained by the physical effects of the deformity. The neck of the femur is depressed, and it is usually twisted somewhat backward in its relation to

the shaft, following the line of least resistance. Thus the limb is actually shortened and is rotated outward; the trochanter is elevated above Nélaton's line, its prominence is increased, and it is displaced somewhat forward toward the anterior superior spine in compensation for the loss of the normal forward projection of its neck.

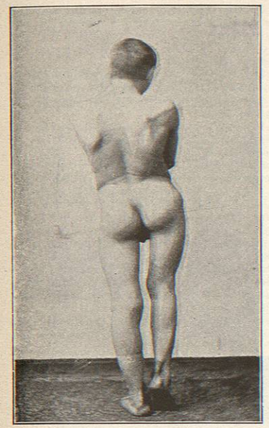

Fig. 1530.—Unilateral Coxa Vara of an Extreme Degree. Showing great apparent shortening due to the adduction of the limb.

A secondary effect of the distortion is limitation of the normal range of motion. Abduction is checked by the tension upon the lower border of the capsule, by the adaptive shortening of the adductor muscles, and by the direct contact of the neck of the femur with the upper border of the acetabulum (Fig. 1529). Inward rotation and flexion are limited because of the backward displacement of the neck, but the range of extension is not restricted and it may be increased even.

In rare instances the depression of the neck of the femur may be directly downward, in which case the range of motion is but little affected except in abduction; or the distortion may be downward and forward, when extension and outward rotation are limited in the place of flexion and inward rotation. These cases are, however, exceptional, and they are practically never seen in the adolescent type of deformity.

The most noticeable symptom of coxa vara is a persistent limp, due primarily to the shortening of the limb caused by the depression of the neck of the femur. The actual shortening, which is not often more than an inch, is, in well-marked cases, increased by an upward tilting of the pelvis on the affected side, in compensation for the restriction of abduction, similar to the so-called practical shortening of hip disease. This practical shortening may be from one to three inches (Fig. 1530). Thus, as in genu varum and genu valgum, the direct effects of the deformity are the most characteristic symptoms, although in coxa vara there is usually greater discomfort than in the latter affections, because the interference with the function of the joint is more marked. The patient usually complains of sensations of weakness and discomfort after long standing or walking, and of stiffness on changing from a position of rest to one of activity. This discomfort, usually referred to the thigh and the neighborhood of the joint, may be increased to actual pain by overexertion or injury; in such instances there may be attendant muscular spasm which disappears with the subsidence of the acute symptoms.

Diagnosis.—On physical examination, the shortening is apparent and its cause is explained by the elevation of the trochanter. There is the characteristic limitation of motion that has been described, but as a rule pain on manipulation and muscular spasm are absent. There are slight atrophy, more marked in the thigh than in the leg, and in most cases persistent outward rotation of the limb also is present.

There are but three affections with which coxa vara is likely to be confounded. These are:

1. Fracture of the neck of the femur.
2. Congenital dislocation of the hip.
3. Hip disease.

1. *Impacted fracture of the neck of the femur*, or simple united fracture, causes deformity practically identical with coxa vara. It must therefore be distinguished from it by the history of injury and subsequent disability.

2. *Congenital dislocation of the hip* is a disability that is apparent when the child begins to walk, while coxa vara does not, except in very rare instances, develop until a later period. In congenital dislocation the head and neck of the bone may be palpated beneath the gluteal muscles when the thigh is flexed and adducted, while in coxa vara only the prominent trochanter can be felt. There is also an absence of the abnormal mobility that characterizes the former affection.

3. *Hip Disease.*—In hip disease there are discomfort on manipulation, muscular spasm, and limitation of motion in all directions; while in coxa vara muscular spasm is usually absent and the limitation of motion is irregular. In hip disease shortening is a late symptom, in coxa vara it is present from the first; and finally, in hip disease there is usually some evidence of the local destructive process, in swelling, sensitiveness, and the like, symptoms that are of course absent in coxa vara.

Bilateral Coxa Vara.—Bilateral coxa vara is far less common than the unilateral form. The limp is replaced by a waddle or swaying of the body from side to side, resembling the gait of knock-knees. The awkwardness and weakness are of course correspondingly increased, and in the extreme cases, in which the thighs are adducted, the limbs may be crossed so that walking is extremely difficult. The pelvis appears to be abnormally broad because of the elevated and prominent trochanters, and the lumbar lordosis is diminished (Fig. 1531) because of the loss of the normal inclination of the pelvis due to the forward displacement of the supporting femora. In the rare cases in which the femoral necks are displaced forward as well as downward, the lumbar lordosis is increased and the appearances are somewhat similar to those of congenital dislocation of the hips (Fig. 1532). Bilateral coxa vara is not

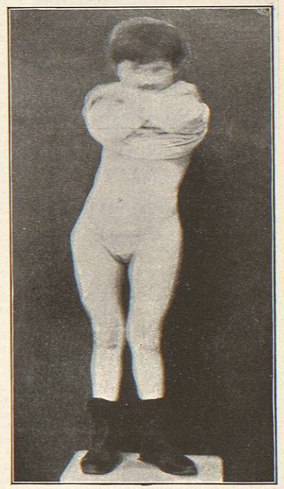

Fig. 1531.—Bilateral Coxa Vara, more Marked on the Right Side. Complete loss of abduction on both sides.

infrequently accompanied by other evidences of weakness, for example by knock-knees or by flat feet.

Statistics.—About 75 per cent. of the cases of coxa vara are in males, and in a similar proportion of cases the affection is unilateral. In 42 cases treated by the writer, the first symptoms were noted in adolescence (twelve to seventeen years of age) in 22. In later childhood (five to eleven years of age) in 14; in early childhood (less than five years) in 5; unknown, 1. In 37 instances the neck of the femur was depressed downward and backward, in 3 downward and forward, in 2 directly downward. The deformity was unilateral in 35, bilateral in 7 cases. Thirty-one of the patients were males, 11 were females.

Fig. 1532.—Bilateral Coxa Vara, of the Anterior Form, Showing the Lordosis. An uncommon type that resembles congenital dislocation of the hips.

Etiology. — It is evident that depression of the neck of the femur may be caused by local disease, such as tuberculosis, infectious osteomyelitis, rheumatoid arthritis, and the like. Deformity from such causes should be classified, however, as incidental to the disease of which it is a result, while the term coxa vara should be reserved for those cases of simple deformity which are caused by local weakness rather than by actual disease. The physical signs of unilateral coxa vara are, as has been stated, practically identical with those of impacted fracture of the neck of the femur, and in childhood, but for the history of injury and of the immediate disability that followed it, it would be impossible to distinguish between the two. Fracture of the neck of the femur is, as the writer has demonstrated, comparatively common in childhood, and for practical purposes it may be classified as the traumatic form of coxa vara.

The Etiology of Simple Coxa Vara.—In very many instances coxa vara may be explained by an acquired or an inherited predisposition to the deformity. The normal inclination of the neck of the femur protects it from strain; if the angle is diminished the strain upon the part is proportionately increased. This is proved by the fact that simple traumatic depression predisposes to further deformity long after the repair of the injury. Thus, one may assume that in many instances a slight depression is acquired in childhood as a result of rhachitis, of which there was a clear history in more than a third of the cases examined by the writer, including all of the bilateral form. Such depression may remain latent, or under favoring circumstances it may become exaggerated to noticeable deformity. These favoring circumstances are, as has been stated, more likely to occur during adolescence, when to the instability of rapid growth is added the increase of the weight of the body, and in some instances the over-strain of laborious occupation.

In other instances there may be a congenital predisposition to the deformity, caused either by a lessened angle or by abnormal weakness of structure, and one case of congenital coxa vara has been reported by Kredel (*Cent. für Chir.*, October 17th, 1896). In none of the cases in later childhood or adolescnce examined by the writer has there been evidence of active or "late" rickets, and the presence of so-called local rickets, as accounting for the deformity, is at present unproved.

In a small percentage of the cases the early symptoms appear to have been induced or aggravated by over-strain or injury, but as a rule the symptoms appear insidiously and without assignable cause.

Pathology.—In ordinary cases the neck of the femur is depressed to a right angle with the shaft, but in certain instances the deformity may be greater. Usually the entire neck is involved in the distortion. Less often the deformity is greatest at the epiphyseal junction.

In the specimens that have been examined during the progressive stage, the internal structure has shown congestion and softening, changes that would almost inevitably appear in a bone bending and breaking under strain, but no other evidences of disease have appeared that would justify a diagnosis of so-called local rickets or osteomalacia. As has been stated, coxa vara may occur in early childhood as one of the distortions of rhachitis; but in the adolescent type of deformity, evidence of general weakness of this character is unusual.

Prognosis.—In the adolescent type of coxa vara the duration of what may be termed the active stage of the affection is from one to three years. The deformity then ceases to progress, the symptoms of discomfort disappear, the restriction of motion becomes less marked and the disability less noticeable.

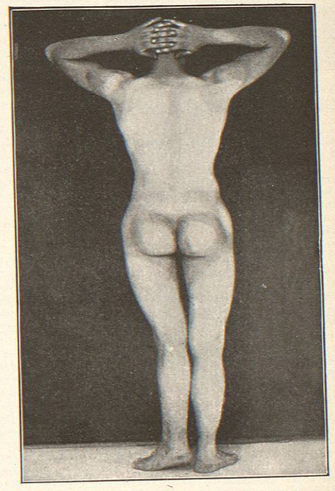

Fig. 1533.—Unilateral Coxa Vara of the Ordinary Form. A final result. The elevated and prominent trochanter, the shortening, and the outward rotation are shown.

In the unilateral form a moderate limp remains, and in the bilateral type a degree of disability and awkwardness, in proportion to the final restriction of the range of abduction. If the affection first appears in childhood, the progress of the deformity is slower, and it is often intermittent, increasing usually during adolescence. In this regard the affection resembles closely other distortions of similar origin (Fig. 1533).

Treatment.—Deformity of the neck of the femur cannot be remedied by braces. The part can be relieved, however, from strain by restricting the burden of occupation, and distortion may be checked by the use of a support, similar to that employed in the treatment of hip disease, by which the weight is borne upon the perineum.

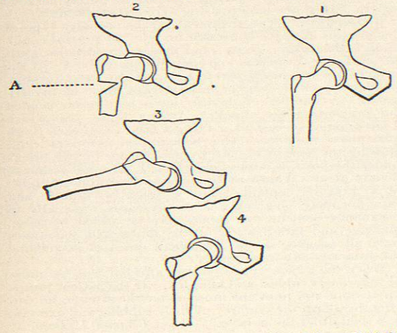

Fig. 1534.—1, The Normal Femur; 2, depression of the neck of the femur—coxa vara (at A a wedge of bone has been removed); 3, abduction of the limb first fixes the upper segment by contact with the rim of the acetabulum, then closes the opening in the bone; 4, replacement of the limb after union is completed elevates the neck to its former position.

Massage and exercises to improve the nutrition of the part, and manipulation with the aim of overcoming restriction of motion, may be of service also, and general therapeutic treatment may be indicated in suitable cases.

As a rule, however, the most effective treatment is the correction of the depression by operation. This is indicated as a prophylactic measure in the younger class, in which the deformity is slight. For as the depression of the neck of the femur increases, the strain upon it is greater and thus there is a tendency to progressive deformity, which one may hope to check by replacing the neck at its normal angle. This may be accomplished by the removal of a sufficient wedge of bone from the base of the trochanter. In this operation all resistance to abduction, other than that dependent upon the deformity of the bone, should be overcome by preliminary manipulation. The base of the wedge, about three-quarters of an inch in width, should be directly opposite the trochanter minor. The layer of cortical substance on the inner aspect of the bone should not be divided, but should serve to retain the two segments of the femur in proper relation to one another. When the wedge has been removed, the thigh should be gently abducted; the upper fragment is first fixed by contact with the acetabulum and the shaft is then bent outward upon it until the opening is closed by apposition. In this attitude of extreme abduction the limb is fixed by a plaster bandage. When union is complete, the neck of the femur is replaced in its normal relation to the shaft when the limb is in the normal attitude. As a rule, no apparatus is required in the after-treatment (Fig. 1534).

In the adolescent cases it is well to postpone the operation until a certain stability of tissue is assured, and in certain instances, particularly those in which there is marked antero-posterior distortion of the neck, a simple linear osteotomy may be indicated, as the distortion may be corrected by rotating the shaft on its long axis until the foot is brought to its normal position.

Royal Whitman.

Literature.

The more important articles on this subject, besides those mentioned in the text, are as follows:
Hofmeister: Beiträge zur klin. Chir., Bd. xxi., H. 2, 1894.
Whitman: N. Y. Med. Jour., June 23d, 1894, January 21st, 1899, and Annals of Surgery, February, 1900.
Frazier: Annals of Surgery, July, 1898.
Alsberg: Zeit. f. orthop. Chir., Bd. vi., H. i., 1898.

CRAB-ORCHARD SPRINGS.—Lincoln County, Kentucky.

Access.—Viâ Knoxville Branch of the Louisville and Nashville Railroad to Crab Orchard, 115 miles southeast of Louisville.

These waters are chiefly used in the manufacture of the famous Crab Orchard salts, which are used extensively in Kentucky and neighboring States as a cathartic. The following analyses were made by Dr. Robert Peter, State Geologist:

One United States Gallon Contains:

Solids.	Epsom or Foley Spring, grains.	Sowder's Spring, grains.
Magnesium carbonate	7.64	19.20
Iron carbonate	Trace.	Trace.
Calcium carbonate	53.18	29.51
Sodium chloride	17.72	58.32
Potassium sulphate	9.91	17.37
Sodium sulphate	59.07	23.20
Magnesium sulphate	205.28	174.31
Calcium sulphate	10.79	91.32
Bromine	.....	Trace.
Silica	3.26	1.22
Loss and moisture	34.58	Trace.
Total	401.43	414.45

Carbonic acid not estimated.

Crab-Orchard Salts.

100 Parts Contain:	Parts.
Magnesium sulphate	63.19
Sodium sulphate	4.20
Potassium sulphate	1.80
Calcium sulphate	2.54
Sodium chloride	4.77
Lime, magnesia, iron and silica (carbonates)	.89
Bromine	Trace.
Water of crystallization and loss	22.61
Total	100.00

Other springs at Crab Orchard are the "Field" and the "Grove" springs, which are but feebly impregnated with mineral ingredients. *James K. Crook.*

CRAMP BARK. See *Viburnum Opulus.*

CRAMPS.—Cramp is a term applied to denote a painful tonic muscular contraction of some moments' or minutes' duration. As several of these painful contractions generally occur successively, the term "cramps" is used to designate the attack. Cramps belong to the local spasmodic disorders; cramp is, in fact, technically a local tonic spasm, to which is added the element of pain. It is true that in tetanus there is a general cramp of almost the entire voluntary muscular system, and that in cholera cramps are widely diffused; nevertheless medical usage assigns the term cramps to the local spasmodic disorders.

Properly speaking, cramps may affect both the voluntary and the involuntary muscles. Writers sometimes speak of cramps of the heart, of the stomach, intestines, bladder, and uterus; but, as a rule, these cramps of the involuntary muscles are given the term colic. Cramps of the voluntary muscles are strictly analogous, therefore, to colic of the involuntary muscles.

The further relations of cramps to the other hyperkineses are shown in the article on *Convulsions*. In this description of cramps we shall limit the application of the term, as is usually done, to the voluntary muscles.

Clinical History.—The voluntary muscles oftenest affected by cramps are those of the extremities, and especially those of the lower extremities. The muscles most susceptible are the gastrocnemii and plantar muscles. The psoas muscle, and flexors of the thigh upon the abdomen, are also at times affected. In the upper extremities it is the muscles of the fingers that are most often attacked. In the special neurosis of which writer's cramp is a type, the muscles of the whole arm may also be involved. Of the trunk muscles, those forming the soft wall of the abdomen are not infrequently affected with slight cramps. After a violent sneeze, for example, part of the rectus may become knotted up in a cramp. In cholera the abdominal muscles are all involved. A sudden "stitch in the side," is due to a cramp of some of the intercostal muscles. A crampy condition of the sterno-cleido-mastoid and of part of the trapezius is observed in the clonic forms of wry-neck. The muscles of the face, of the eye, and of mastication, are not subject to cramps, except in very rare cases.

When the term cramp is used, without further special designation, it refers to painful spasms in the extremities, especially the lower extremities. Attacks of such spasms come on generally at night, or after some violent exertion, such especially as swimming, when the circulation in the extremities is disturbed by the cold water. The pain and contraction come on suddenly, as a rule, though sometimes slight premonitory twinges are felt. The muscle is contracted, and feels hard and knotty, the limb is drawn up, and attempts to straighten it or to relax the muscle give great pain. The patient often feels a sensation of nausea, depression, and even of faintness. Pressure on the affected part gives relief, and forcible rubbing or sudden extension of the muscle will often relax the spasm. No especial change in the electrical relations has been observed. The attack lasts only a few seconds or minutes, as a rule, but it may continue for hours. After one attack has gone, a second and third may succeed. A patient may have to get up half a dozen times a night on account of his seizures.

When the spasms have disappeared, the muscle is left sore and tender to the touch, owing to stretching of the muscle and the irritation and injury to the sensory nerves.

Etiology.—Cramps in the extremities occur as the result of organic disease of the brain and spinal cord, and as the result of certain functional morbid conditions. Pressure on, or irritation of, nerve trunks sometimes causes cramps. The cramps of organic disease I do not purpose to consider here. The causes of the functional cramps are various. In some persons there is an inherited or connate tendency to this trouble. Cramps occur more frequently in the aged and in growing children than at the middle period of life. Gouty and rheumatic conditions, and anæmia, predispose persons to them. In disordered states of the stomach and bowels nocturnal attacks of cramp occur. Cramps in the lower extremities are often an annoying disturbance of pregnancy. In the early months the gastrocnemii and plantar muscles are most affected; later the thighs are drawn up by painful contractions of the psoas and other flexors. These cramps of pregnancy are probably at first reflex in character; later they are due to the pressure of the gravid womb on the nerves which supply the lower limbs.

Cramps of a distressing character occur in Asiatic cholera and cholera nostras. They are also observed in persons of intemperate habits. Arterial sclerosis involving the vascular supply of the legs is a cause of leg cramps of elderly people.

Probably the most frequent of all the exciting causes of ordinary forms of cramps in the extremities is violent exercise, such as swimming, dancing, walking, running, and jumping.

Pathology.—In the ordinary type of cramps the muscle itself is at fault. Through deficient nutrition or over-use its fibres are irritated, an involuntary contraction results which is painful because it is so abnormally powerful that the sensory nerve fibres are pressed upon. Tonic spasms become painful and crampy in character, therefore, simply because of a quantitative excess in muscular contraction. No one can voluntarily knot up his calf muscles as is done in a cramp. The myopathic character of the contraction is shown by the fact that, by the pressure of bands and tourniquets, which alters the blood supply to the muscles, the cramps can often be relieved.

There are, however, certain forms of cramps, like wry-neck, or writer's cramp, that are of purely nervous origin. Here the cramp is due to overstimulation.

Treatment.—The treatment of the ordinary type of leg cramps must be addressed first to the general condition. Rheumatic, gouty, and anæmic tendencies must be corrected, dyspepsia and constipation relieved. If the attacks are unusually severe and obstinate, the question of diabetes or of some organic disease must be investigated. A number of devices have been recommended for preventing the attacks. Among these, one which I have found successful is tying a tape about each thigh just above the knee. This is done just before retiring. Raising the head of the bed by placing one or two bricks under the posts is a measure which I have not found to do any good. A dose of bromide with alkalies at night, or a mixture containing gr. v. each of lupulin and camphor, may be given. In severe cases, especially in pregnancy, codeine or opium may be added to these. Massage and faradization of the limbs will sometimes ward off attacks, and so will small doses of strychnine continuously administered.

When the attack comes on, the affected muscles must be vigorously rubbed and kneaded. If the patient jumps up at once and puts the muscles on the stretch, he can often break up the cramp. A little rubbing and exercise will then quiet the muscle. *Charles L. Dana.*

CRANIAL NERVES.—The Doctrine of Nerve Components.—The proper classification and morphological comprehension of the cranial nerves, human and comparative, have remained in an unsatisfactory state because of the difficulty of correlating the several anatomical and physiological data with each other and with the findings of the embryologists. That the arrangement and composition of the twelve pairs of cranial nerves as commonly enumerated have a profound morphological significance is evident from the remarkable constancy with which their main features are repeated throughout the vertebrate phylum. But we are still very far from a complete explanation of the individual peculiarities of the several pairs, and especially of the differences between the cranial and the spinal nerves. During the past decade, however, this field has been very diligently cultivated by the comparative anatomists and much progress has been made toward a better comprehension of the significance of the peripheral nervous system as a whole.

Starting from the undifferentiated nerve tube of the ancestral vertebrate or of the embryo, the morphologist who follows the series of forms presented by the central nervous systems of the animal types from Amphioxus to man will find the problems suggested by this progressively increasing complexity soluble largely in proportion as he realizes that every change in the centre is but the reflection of a corresponding change in the peripheral nervous system, especially the sense organs, which in turn rests upon a new point of contact with the outside environment.

This point of view—the correlation of changes in the centre with those in the periphery—lies at the basis of the recent work on nerve components. To Gaskell belongs the credit of having clearly separated the peripheral nervous system into two great categories: on the one hand, the visceral systems, sensory and motor, which effect the adjustments to the internal environment; and on the other hand, the somatic systems, sensory and

motor, which effect the adjustments to the external environment. With this as a foundation to build upon, Strong carried out the separation of these elements, especially the sensory ones of the cranial nerves, into other components.

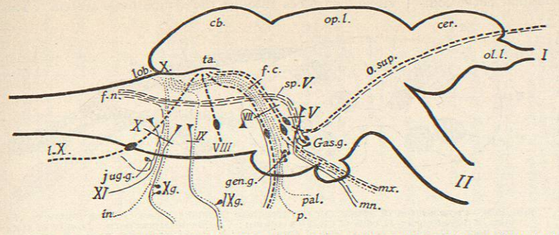

Fig. 1535.—The Cranial Nerves of *Menidia* as seen from the right side, illustrating the central convergence of the sensory components of the several nerves into functional systems. The eye-muscle nerves have been omitted, the superficial origins of the others being indicated by the Roman numerals at the transverse lines drawn across their roots. The viscero-motor roots are drawn as continuous lines, the general cutaneous roots as broken lines, the acustico-lateral system as heavier broken lines, and the communis system (visceral sensory) as dotted lines. The positions of the auditory and of the four lateral line ganglia are indicated, though no special designations are given them. This scheme can be applied with but slight modification to all of the fishes. The student of comparative anatomy will notice that some rami peculiar to the teleosts have been omitted, *e.g.*, the r. lateralis accessorius and the general cutaneous fibres in the hyomandibular trunk. Compare the detailed plot from which this diagram is drawn off, *Journal of Comp. Neurology*, vol. ix., plate xvi., and *Archives of Neurology and Psychopathology*, vol. ii., plate iii. The scheme can be adapted to higher vertebrates (including man) by the suppression of the lateral line roots of the facialis and vagus, leaving the VIII. nerve as the only representative of the acustico-lateral system.

cb., Cerebellum; *cer.*, cerebrum; *f.c.*, fasciculus communis (=fasc. solitarius); *f.n.*, funicular nucleus (terminal nucleus of spinal V. tract); *Gas.g.*, Gasserian ganglion; *gen.g.*, geniculate ganglion; *in.*, ramus intestinalis vagi; *IX.g.*, glossopharyngeal ganglion; *jug.g.*, jugular (gen. cutaneous) ganglion of the vagus; *lob.X.*, lobus vagi (sensory vagus nucleus); *l.X.*, ramus lateralis vagi; *mn.*, ramus mandibularis V; *mx.*, ramus maxillaris V; *ol.l.*, olfactory lobe; *op.l.*, optic lobe; *o.sup.*, superficial ophthalmic branches of the VII. and V. nerves (the latter = frontal nerve of man); *p.*, pretrematic branch of the facialis, corresponding in position with the chorda tympani of man, though not strictly homologous with it; *pal.*, ramus palatinus VII. (= great superficial petrosal); *sp.V.*, spinal V. tract; *ta.*, tuberculum acusticum (terminal nucleus for acustico-lateral system); *thm.*, hyomandibular trunk (=great facial trunk of man); *Xg.*, chief vagus ganglion; *XI.*, motor fibres for trapezius muscle, supposed to represent the accessory nerve.

Undoubtedly the morphological unit of structure in the peripheral, as in the central, nervous system is the neuromere, or neural segment. This is clearly seen in the peripheral (though not in the central) nervous system in the trunk region of the adult body, each spinal nerve repeating in a metameric way the morphological plan of its predecessors. Both embryology and comparative anatomy show that the head was also primitively segmented, and the present arrangement of the cranial nerves of man undoubtedly has a metameric basis; nevertheless so many disturbing factors have entered that it has thus far been impossible to determine what was the original segmentation of the head in general or of the cranial nerves in particular, so that it is not yet practicable to base a classification of the nerves upon this feature. On the other hand, the numerical designations of Sömmering now generally employed have little significance other than mere convenience in topographical description.

A descriptive unit which is much more generally useful is the functional *system*. Such a system has clearly definable morphological characters, easily demonstrable in the adult, and is immeasurably more useful in clinical neurology, and indeed in all pathological work. Each system may be defined as the sum of all the nerve fibres in the body, which possess certain physiological and morphological characters in common, so that they may react in a common mode. Morphologically, each system is defined by the terminal relations of its fibres—by the organs to which they are related peripherally and by the centres in which the fibres arise or terminate. The fibres of a single system may appear in a large number of nerves, repeated more or less uniformly in a metameric way (as in the general cutaneous system of the spinal nerves), or they may all be concentrated into a single nerve (as in the optic nerve). On the other hand, a single nerve may contain several components, *i.e.*, its fibres may belong to several of these systems. It becomes necessary, therefore, to analyze the root complex of each pair of cranial nerves into its components and to trace not only the central connections of these components within the brain, but also their peripheral courses as well. In other words, the description of any given nervous ramus is not complete when we have given its point of origin from the nerve trunk or ganglion, the details of its devious courses, and the exact points where the several ramuli terminate. In addition to this it is necessary to learn what systems are represented in the ramus, and the precise central and peripheral relations of each system.

The difficulty in determining this latter point is the chief obstacle in the way of researches on the nerve components; for, while the central connections of any nerve can be determined by the microscopical method, the peripheral courses are usually studied by gross methods which reveal nothing of the precise relations of the several components peripherally, and hence do not permit a knowledge of each system as a whole. To trace the components of the more complex cranial nerves continuously from their nuclei of origin or termination within the brain by means of serial sections to their ultimate peripheral termini has never been attempted in the human body. In a few of the lower vertebrates, however,

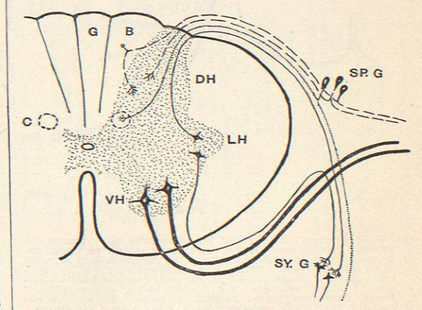

Fig. 1536.—Diagram illustrating the Composition of the Typical Spinal Nerve. The general cutaneous system is represented by broken lines, the visceral sensory by dotted lines, the somatic motor by the heavy continuous lines, the visceral motor by the lighter continuous lines. The visceral motor fibres of the dorsal root are found in lower vertebrates; their presence in the mammals is controverted.

B, Column of Burdach; *C*, Clarke's column; *DH*, dorsal horn; *G*, column of Goll; *LH*, lateral horn; *SP.G.* spinal ganglion; *SY.G.*, sympathetic ganglion; *VH*, ventral horn.