ment. Tuberculous ulcers are far less common than the former; they are usually superficial; they often give rise to extreme pain, and they coexist with well-marked disease of the lungs, and generally with other manifestations of ulceration in the pharynx. The differentiation of lupus from syphilis of the soft palate is sometimes difficult, especially if the patient be also suffering from general syphilis. The chief characteristics of lupus are that the normal sensitiveness of the part is maintained; or, if altered, there is anæsthesia. The tubercles are multiple, which distinguishes the disease from carcinoma; they are rounded, their surface is smooth and glistening, and their color is bright red. They are firm in consistence, but less firm than epithelioma. The diagnosis may be confirmed by the presence of external manifestations of the disease. Lesions of the mucous membranes, common in leprosy, never occur until the disease has clearly manifested itself in other parts of the body. As a rule, therefore, little doubt can arise as to the true nature of the pharyngeal disease. Here, as elsewhere, the course of lepra is one of active and widespread destruction.

Syphilis of the Velum Palati.—The occurrence of the primary lesion of syphilis, although now and then observed upon the tonsil, is, upon the velum, almost unknown.

In the secondary manifestations of the disease, however, the soft palate and uvula are frequently involved. The conditions presented are those commonly seen in the adjacent parts of the oral cavity, and include simple erythema or congestive patches symmetrically disposed, submucous infiltration, mucous tubercles, followed by mucous patches, or by the formation of condylomata. A peculiar feature of these manifestations is their symmetry, which, as is often seen upon the uvula, is so well marked as to attract the attention of the observer. Early in the disease the congestion may be so indistinct as to escape observation. Gentle irritation, however, will often cause the distinctive character to be intensified. Considerable rise of temperature often accompanies the first appearance of this form of sore throat.

The tertiary form of syphilis may occur in the soft palate at any period of time beyond two years after the primary infection. It is characterized by true ulceration or loss of tissue, and is the result of the degeneration of gummatous deposit.

The effects upon the velum palati of tertiary syphilis are often most disastrous. A frequent seat of gummatous infiltration, its exposed situation and delicate texture render it liable to serious injury as the result of tertiary ulcerative processes. These are often characterized by extensive loss of substance, and are followed by marked cicatricial contraction and the formation of adhesions between the remaining tissue and the neighboring soft parts, which not only destroy the velum itself and abolish its functions, but result in a closure or a shutting off of the upper pharynx from the lower. This closure is more or less complete in proportion to the extent of adhesion present, and may vary from a slight narrowing of the aperture, due to adhesions at the outside angles of the velum, up to a degree of occlusion which seems absolute. Two varieties of cases may be described: (1) Those in which simple ulceration has taken place, at or near the margins of the velum, without material loss of substance. In such cases, the adhesions being limited to a somewhat narrow band of union between the edge of the velum and the pharynx, and the greater part of the velum itself being intact, the prognosis is good. (2) When the loss of substance has been considerable, and when the soft palate has become extensively adherent to the pharynx, relief becomes a matter of extreme difficulty, and, in many cases, is next to impossible by any known plan of treatment. In the worst cases the whole posterior surface of the velum, and the superior surface of the soft palate, seem to be firmly incorporated with the posterior pharyngeal wall. In these cases the roof of the mouth and the posterior wall of the pharynx seem to be continuous, the line of adhesion not being traceable in the confused mass of cicatricial bands which represent the original structures, and which are sometimes disposed in the shape of irregular vertical digitations, between which there may be one or more places in which the adhesion is incomplete, and through which a probe may be passed. Cases, however, in which complete occlusion has actually taken place are rare. Should the opening be invisible upon inspection of the pharynx, it may generally be demonstrated by forcing air into the nasal cavities by means of a Politzer inflator. If an opening exists, its presence will be indicated by the appearance of bubbles in the pharynx, when the air is forced through the opening.

The results of extensive adhesion of the velum to the pharynx are most distressing, and may be summed up as follows: (1) Mouth-breathing, with all of its attendant evil results; (2) impairment of the quality and tone of the voice; (3) interference with drainage from the nasal cavities and nasopharynx; (4) consequent upon this, loss of hearing from irritation of the Eustachian tube, and from the almost inevitable occurrence of serious middle-ear disease; (5) loss of the sense of olfaction, owing to the lack of a current of air through the nasal passages, such a current being necessary to bring the odoriferous particles in contact with the olfactory membrane. When the passage to the lower part of the pharynx is contracted, there is sometimes dysphagia as well as dyspnœa.

The treatment of this condition consists in the attempt to separate the adherent tissues, and to establish, more or less perfectly, communication between the upper and the lower pharynx. To carry out this design with success is one of the most difficult problems of surgery. Perforation of the velum through the breaking down of gummatous deposits is said to be a cause of serious danger to that organ, since, having thereby lost to a greater or less degree its muscular vigor and resiliency, it is liable to swing backward against the pharynx, instead of being held at a normal distance from it. Furthermore, a perforation renders it all the more liable to form adhesions subsequently with neighboring parts. The mechanism, however, by which adhesion commonly takes place, is the same as that which is observed in the cicatricial union of the fingers of the hand following burns. Despite all possible care, the cicatrizing surfaces begin to unite at the bottom of the angle between the members, and the process of adhesion continues until the denuded surfaces, throughout their whole extent, have become firmly joined to each other.

In the treatment of these unfortunate cases the first care should be to prevent adhesion, by checking with all possible diligence the appearance and spread of ulceration upon the parts. Not only should the iodide of potassium be freely administered, combined if necessary with mercury, but local applications should also be made to the ulcers: of nitrate of silver, or the acid nitrate of mercury, if they be spreading, or of a solution of sulphate of copper (gr. xv. ad ℥ i.) if they be indolent. If this treatment fails, means should be used to keep the ulcerated surfaces apart. For this purpose several methods have been proposed, but as they apply as well to the separation of the parts after operation, they will be described later.

The prognosis as to the results of operation must depend largely upon the extent of deformity present in a given case. Where the degree of adhesion is comparatively slight, the adherent surfaces may be separated by means of a small, flat knife. As, however, the separated parts have a very strong tendency to reunite, it will be necessary, after operation, to use means for preventing such a reunion. Of these the simplest is the application to the cut surfaces of monochloracetic acid. This forms an adherent eschar, under which the healing process seems to progress to such a degree that, when the eschar separates and comes away, the period in which adhesion would have taken place has passed, and the parts heal without uniting.

Few cases, however, are so simple as to render the above method possible. Perhaps the most valuable plan

of treatment yet suggested is to separate the united parts by means of the galvano-cautery, and then to use great diligence in keeping them apart, and in maintaining full dilatation of the passage. This may be done by repeatedly drawing forward the remnant of the velum by means of a palate hook—a procedure which the patient can carry out himself; or, as has been suggested, a piece of tape may be passed through each nostril and out at the corresponding angle of the mouth, the velum being thus drawn away from the posterior pharyngeal wall; or, finally, given the best results, a piece of metal shaped to fit the space between the velum and the pharynx may be suspended from two stout threads passed forward through the nose, and tied so as to hold the plate in position. This, worn constantly, serves as a permanent dilator.

Since readhesion after operation is due to granulation and union at the external angles of the wound, as in web finger, Nichols has devised the following excellent operation: Before attempting the separation of the velum from the posterior wall of the pharynx, openings should be made through the adhesions and at their extreme outer angle, one on each side. These openings should be kept packed until their surfaces have healed. Thus the granulating angle will have been destroyed, and in favorable cases the remaining adhesions can be separated and kept apart with success.

In cases in which the degree of deformity is excessive, the best that has hitherto been accomplished has been to widen the channel of communication between the upper and lower pharynx sufficiently to allow the nasal secretions to be drained away. This has been done by applications of the galvano-caustic knife, followed by persistent dilatation, practised by the patient himself by means of some form of sound. It is highly probable that by the last-mentioned method an opening of considerable size may be maintained. Preliminary to operating upon such a case, much aid may be secured by passing a sound backward through the nose, and demonstrating the lowest and most superficial point of the pharyngeal pouch. By cutting against the point of the sound used as a guide, an entrance may easily be effected.

Finally, it must be said that, although the prognosis as to relief of adhesion of the soft palate to the pharynx is often most unpromising, much may be done to help the sufferer by skill, ingenuity, and unremitting patience in the application of the means already at hand.

Neuroses of the Velum Palati and Uvula.—These may be either sensory or motor. With the former may be classed anæsthesia, hyperæsthesia, paræsthesia, to which may be added vaso-motor neuroses, and, possibly, neuralgia. Motor disturbances include spasm, or increased mobility, and paralysis, or diminished mobility. The causes of these neuroses may be either central or peripheral, and they may be either unilateral or bilateral.

In addition to the central causes which may produce anæsthesia of the velum, it may also be present in epilepsy, chorea, and hysteria. It commonly occurs after diphtheria. It may be caused artificially by certain drugs, among which may be mentioned cocaine, morphine, chloral, and bromide of potassium. The symptoms, if present, consist usually in a feeling of relaxation of the part, or a sensation as of the presence of cotton or wool in the pharynx, sometimes associated with a feeling of pain.

Hyperæsthesia is often met with, and may be due to elongation of the uvula, inflammations of the pharynx, acute and chronic, the presence of a new growth, or a dilated condition of the blood-vessels.

Neuralgia seems to exist in certain rare cases, in which, without apparent cause, lancinating pain is experienced, and areas of localized tenderness may be found.

Paræsthesia often occurs. Schech observes that the affection, when independent of disease of the mucous membrane, is most frequently associated with hysteria and hypochondriasis, or with a fear of diphtheria or syphilis. Those individuals are most prone to it whose occupation demands excessive use of the vocal organs, as also are chlorotic or anæmic persons, women who suffer from gastric or uterine disease, and those whose temperament is excitable; more rarely it is a symptom of disease of the brain, or of bulbar paralysis.

Of the motor disturbances from which the velum may suffer, spasm is the more unusual. It is almost always associated with a similar condition of the pharynx, and is found associated with the same disorders as those which cause it in the latter region.

Paralysis of the velum is a common condition, and one of much importance. It may be due to central causes, such as acute, chronic, and degenerative diseases of the brain; to diphtheria; to local diseases; or, finally, it may be associated with facial paralysis. The paralysis may be either unilateral or bilateral, partial or complete. When it is unilateral the velum and uvula are drawn toward the unaffected side, the faucial arch on the affected side is wider, and that of the sound side is narrower than normal. During phonation there is distinct distortion toward the healthy side. In bilateral paralysis the uvula hangs loosely in the pharynx, showing no sign of voluntary motion, and flapping back and forth with the acts of respiration. During phonation, in partial paralysis, a slight upward movement of the soft palate may be noticed, while, when the paralysis is complete, it remains immovable.

Besides the causes mentioned, there are several influences under which paretic conditions of the velum may occur. Thus, it is not uncommon to find this organ more or less paralyzed after severe acute affections of the pharynx other than diphtheria, and while the presence of such paralysis, after what appeared to have been a simple follicular tonsillitis, may cause the accuracy of the diagnosis to be held in question and suggest the presence of diphtheria, there are so many other disorders, evidently not diphtheritic, by which it may be brought about that the possibility of its occurrence from simple causes is beyond doubt.

Not only may paresis be found after acute affections of the throat and nasopharynx, but, as is more common, it may be present in chronic conditions, as, for instance, chronic pharyngeal catarrh, chronic hypertrophy of the tonsils, and hypertrophy of the adenoid tissue at the pharyngeal vault. It is found in cases of chronic nasal catarrh, and associated with posterior hypertrophy of the inferior turbinated bodies. It may also occur as an accompaniment of an elongated uvula.

The results of this condition are generally evident, both to the patient and to the observer, and it is probable that the defects of speech generally present in, and attributed to, adenoid hypertrophy at the vault, are due rather to the attendant paresis of the soft palate than to the mechanical obstruction of the pharynx.

The treatment of neuroses of the soft palate must be conducted in accordance with the exciting cause present in a given case. This must be demonstrated, and, if possible, removed. Catarrhal conditions must be treated, hypertrophied masses of adenoid tissue must be removed, and the various systemic disorders with which it may be associated properly dealt with.

Locally, direct therapeutic measures are required, the most important thing being to restore tone to the enfeebled muscular structures. To this end the faradic current is valuable, the negative pole being applied to the affected part, or outside, along the angle of the jaw. Systematic exercise of the velum is also beneficial, and may be secured by such gymnastic exercises as frequent gargling, the singing of high notes, or, better still, blowing through a small tube. In the case of children this may be accomplished by allowing the patient to practise daily at blowing soap bubbles. *D. Bryson Delavan.*

VACCINATION is defined as "Inoculation with vaccine, or the virus of cowpox, as a preventive of smallpox; in an extended sense, inoculation with the virus of any specific disease. . . . It consists in the introduction under the skin, or application to an abraded surface,

usually on the upper arm or thigh, of a minute quantity of vaccine."—*Century Dictionary.*

"Inoculation with the attenuated or modified virus of a disease, to produce a mild form of it, and so prevent a virulent attack; specifically, and originally, inoculation with cowpox as a preventive of smallpox; performed by introducing vaccine through a puncture of the skin, or an abraded surface."—*The Standard Dictionary.*

For legal purposes, it should be added that the term "vaccination" not only implies the application or introduction of vaccine to or into the body, but its *successful* application or introduction.

In this article the term will be employed only in its limited sense, as applied to the specific disease vaccinia or cowpox.

The *object* of vaccination is, ultimately, protection against smallpox. As a means to the same end, it is also largely employed for the purpose of propagation, continuance, and multiplication of the virus of vaccinia.

History.—To Edward Jenner, an English surgeon of the eighteenth century, must be accorded the honor of introducing and establishing the practice of vaccination as a protective measure against smallpox. The history of vaccination is like that of many other important discoveries. It had a traditional existence from an earlier period, and had undoubtedly been practised to a limited degree in other countries. Von Humboldt states that it had been known and practised from an early period among the Mexicans. Sülzer in 1713, and Sutton and Fewster in 1765, called attention to the properties of vaccine.[1] But no one had given to the subject careful observation and study until Jenner, then a surgeon's apprentice living at Sodbury, near Bristol, noticed that people who acquired cowpox by milking cows affected with that disease acquired an immunity from smallpox. From the time of his first observation, in 1768, to the date of his announcement of the result of his researches to the world, a period of thirty years elapsed, during which time he had patiently and carefully investigated the subject both by observation and by experiment. Dr. H. A. Martin says of him: "He was a truly great and philosophic man, worthy to be, as he was, the chosen pupil and life-long friend of John Hunter. If ever a discovery was announced to the world with due deliberation, it was that of vaccination. We have evidence that for at least thirty years, during which he encountered many perplexing and discouraging obstacles, and one by one mastered and overcame them, this mighty matter occupied the brain of Jenner before he published 'An Inquiry into the Causes and Effects of the *Variolæ Vaccinæ*, a Disease discovered in some of the Western Counties of England, particularly Gloucestershire, and known by the name of Cowpox.' It was ten years after the discovery first engaged his attention that, in the year 1780, timidly, and under the seal of confidence, he revealed to his bosom friend, Gardner, his mighty hopes for the great good of his fellow-creatures. . . . Such was the slow, careful, almost painful deliberation and completeness with which the mind of Jenner moved to its great goal."[2]

Jenner made his first vaccination upon the human subject in 1796, published the results of his inquiries in 1798, and established the first public institution for the performance of vaccination in 1799. In 1800 the practice was introduced into Germany, France, and the United States.

To Dr. Benj. Waterhouse, of Cambridge, Mass., must be credited the honor of introducing vaccination into New England in 1800, and to President Thomas Jefferson that of introducing it into the Southern States a few months later. It was also introduced into France in May, 1800, by Duke de Rouchefoucault, his efforts being seconded by Napoleon, and especially by his brother Lucien Bonaparte, who was then Minister of the Interior. Dr. Woodville also came over from London to insure the success of the movement.

The following were the principal points which Jenner had established by his inquiries:

1. That the vaccine disease casually communicated to man has the power of rendering him insusceptible to smallpox.
2. That the specific cowpox alone, and not other eruptions affecting the cow which might be confounded with it, has this protective power.
3. That the cowpox may be communicated at will from the cow to man, by the hand of the surgeon, whenever the requisite opportunity exists; and
4. That the cowpox, once engrafted on the human subject, may be continued from individual to individual by successive transmissions, conferring on each the same immunity against smallpox as was produced in the one first infected directly from the cow.

The practical usefulness of this great discovery lies in the possibility of transmitting vaccinia from one human being to another, or, as is largely practised at the present time, from the cow to the human species.

Phenomena of Vaccinia in the Cow.—Vaccinia in the cow is an eruptive vesicular disease, the eruption being usually limited to the udder and the teats. It may occur in single cases, either in an animal kept alone, or in a single animal of a herd, or it may attack a whole herd, or a part only.

It is confined almost exclusively to milch-cows. Ceeley's earlier observations supported this statement; but in a later paper he reports a single case of primary infection in an animal not giving milk. The earlier stages of the disease are so mild as rarely to attract attention, and hence are rarely seen by the expert at this period, except in herds in which the disease attacks a considerable number. After its first appearance in a herd, it is readily conveyed from one animal to another by the milker's hands, unless the greatest care is taken to prevent infection.

Distribution.—Vaccinia has been met with and described in all parts of the world where the cow exists. In Great Britain, France, Germany, Holland, Italy, Bengal, South America, Mexico, New England, and other States of the Union, cases have been reported and described, and in not a few of these the genuine character of the disease was proven by experiment. It was found in epidemic form at Valladolid and at Atlisco, in Mexico (near Puebla), in 1803. Genuine cowpox was also observed in Würtemberg, on 69 different occasions, between 1827 and 1837, and was transferred successfully to the human subject in at least 170 out of 210 trials (Hering: "Ueber Kuhpocken an Kühen"). Seaton says of its prevalence: "After the first ardor of search had relaxed, there were for many years but few recorded instances of the disease being found, and it was believed to have become much rarer, in great measure, no doubt, because it was less sought for. There can be no doubt that much more would be found than really is found, if it were only looked for." Other noted cases were those which were observed at Passy (1836), at Esneux (1868), at Rouen, at Dijon, at Stuttgart, at Beaugency (1866), at St. Mandé, and at Cerons (1884).

A very careful report of an epidemic of vaccinia is presented in the Eighteenth Report of the Local Government Board of England (supplement containing the report of the medical officer for 1888).

Not far from the foregoing case, at Cricklade, in the neighboring county of Wiltshire, other cases of cowpox were discovered in the autumn of 1887, of which an account is given in the second volume of Crookshank's "Vaccination: Its History and Pathology."[3] This region also is not far from the district in which Jenner made his early observations. In a herd of one hundred and twenty cows here, all were attacked except a dozen, which proved refractory.

Occurrence of Natural Kinepox in the United States.—Kinepox is not of unusually rare occurrence, as some have believed. It has been observed on various occasions, and at various places, in the United States, and reported as follows:

1. Dr. John Yale, of Ware, Mass., reports having observed it in 1844, at Torringford, Conn., and in 1855 at

Ware; in the latter case confirming its character by testing it upon the human species, and also by continuing its use upon calves. (Transactions of the American Medical Association, 1872, p. 216.)

2. Dr. Currier observed it at Lexington, Mass., in 1850, and tested it by insertion upon infants.

3. Dr. E. Cutter observed it upon several occasions, as stated in his report of 1872.

4. Dr. H. Darlington observed it and reported upon it as occurring at Concordville, Pa., in 1872.

5. Drs. McMillan and Trask observed it in Marion County, Cal., in 1871, and confirmed its character by experiment.

6. Dr. Jonathan Brown observed it in Wilmington, Mass., in 1867, and tested it by experiment.

7. Dr. H. A. Martin reported a case as observed by him at Cohasset.

8. Cases were reported at Reading, Pa., in 1872.

9. The writer has also visited and inspected at least twenty cases which occurred at seven different dairies or farms in Middlesex and Essex Counties, in Massachusetts, in 1872, 1873, 1881, and 1882. These all occurred during the prevalence of the two smallpox epidemics of those years. They were examined at different stages of the disease, and were found to have the characteristic appearances described by the earlier investigators upon the same subject. At one large dairy farm, where about ninety cows were kept, several cases were seen in different stages, and the disease was prevented from spreading only by isolation and absolute separation from the milkers who milked the remainder of the herd.

Dr. Petry, a noted veterinarian, of Esneux, says: "This disease is much more frequent than is commonly believed. Cowpox may be found in every place, in every land, and in every season of the year; but oftener, it is true, in spring, and in summer at the time of calving." ("Quelques réflexions sur la prétendue rareté du cowpox chez la vache," par M. Petry, M. V. à Esneux. *Annales de la Soc. Méd.-Chirurg. de Liége*, 17, 1878).

Other cases have been observed in recent years in the same vale of Gloucester in which Jenner made his original researches, and also in many other English localities. The writer also has examined dairies at which animals were pointed out by the owners as having had cowpox in previous years. In several of these, by way of experiment, the animals were vaccinated by an expert vaccinator, and in such cases the vaccination invariably proved unsuccessful—a point which may be adduced in support of the genuineness of the disease as at first observed.

In a case observed by the writer at Saugus, in the winter of 1881–82, a lad, twelve years of age, presented the characteristic appearances of infection upon the grasping surface of the index finger and thumb. When first observed most of the vesicles had been broken by the use of the hand in milking. The herd consisted of thirteen animals, but one only of which was found to be suffering with cowpox.

The disease, though not by any means of rare occurrence, is evidently not so common as it was in the eighteenth century, and Dr. Seaton reasonably adduces as causes of its comparative rarity the more common practice of vaccination, whereby milkers do not become susceptible of infection, and, as a consequence, are not the conveyers of such infection from one animal to another; and secondly, the more limited diffusion of variola.

The term "spontaneous" formerly applied to such cases should be abandoned as entirely opposed to all observations as well as modern medical belief as to the natural history of infectious diseases.

Incubation.—The incubative period is probably about three or four days, prolonged occasionally to seven or eight days (Ceeley). At first there are heat, swelling, and tenderness of the parts affected, hard papules are developed of the size of a small pea, especially at the base of the teats, at the junction with the udder. The signs of constitutional disturbances at this time are but slight. In thin-skinned animals the disease may be found, by careful observation, when accidentally transmitted, as early as the fifth day. The papules increase daily, and in three or four days from their first appearance become distinctly vesicular, and have a more or less central depression.

The change from the papular to the vesicular stage is indicated by the appearance of a dull yellowish point at the apex of the prominence; the circumference then increases in substance and extent, and the centre becomes wider and deeper, till at last the flattened vesicle with depressed centre is formed. It increases in size until, in three or four days more, its full development is reached. Their number and size vary. The amount of eruption varies with the severity of the disease. With animals having loose, fleshy, hairless udders, and long, thin-skinned teats, the eruption is ordinarily copious. The shape of the lesions is usually determined by their position, being for the most part circular at the base or neck of the teats, and oval on the body of the teats. Their color varies with the stage of the disease and the color of the skin. When completely formed the vesicle is often from 15 to 20 mm. in diameter, and has a solid, tense, shining margin of a glistening white or silvery hue, and a bluish or slate-colored centre. It contains a viscid, clear lymph, which is at this period quite scanty. Around the base a narrow, rose-colored areola begins to spread with a circumscribed induration. The color of the areola varies with that of the skin. The disease reaches its crisis about the tenth or eleventh day. The lymph becomes more copious, the vesicle becomes more globular in form, and if it is broken, the lymph flows freely. At first it is of a light amber color, and then becomes turbid and opaque. Incrustation now begins at the centre and advances steadily, the crusts attaining their largest size by the thirteenth or fourteenth day. They are of a dark-brown color, and adhere more or less firmly to the skin, the areola and the induration gradually subsiding. The crusts continue to dry and to diminish in size, and become loose and fall off about from the twentieth to the twenty-third day. The cicatrices left are shallow, smooth, and of a pale-rose or whitish hue.

These are the appearances of undisturbed vaccinia in the cow, and they are rarely seen in their perfect form, since the handling of the teats by the milkers injures the vesicles, rupturing the cuticle, and allowing the serum to exude. Raw surfaces and dark crusts are often seen coalescing, and becoming rapidly detached by rough usage. The tender teats, with their raw surfaces, bleed, and finally heal, leaving cicatrices of varying size.

Constitutional Symptoms.—These are usually slight. The appetite of the animal appears to be affected but little. The secretion of milk may be slightly diminished, and the amount actually obtained may be much lessened in consequence of the annoyance to the milkers and trouble in milking.

There is no evidence that the quality of the milk is in the least modified. Both in the casual form of vaccinia and in that which is artificially produced, animals have been known to give milk uninterruptedly through the course of the infection, and such milk has been in constant use, without perceptible detriment to consumers.

Spurious Eruptions.—The cow is liable to other eruptive diseases which may be mistaken for vaccinia. Ceeley mentions three varieties, under the names of the yellow, the black, and the white or blister-pock, the latter being quite contagious. More recently other eruptions of a contagious nature have been observed and described, especially that which is associated with scarlatina, and which appears to have given rise to that disease in human beings, either through the medium of the milk or otherwise ("Local Government Board Report," 1882. Inquiries by Mr. Power and Dr. Klein, p. 63).

The Relation of Vaccinia to Variola.—*The Unity or Duality of the Two Diseases.*—Seaton states that the common origin of the cowpox, horsepox, and smallpox has been established by conclusive experiments, and adduces the experiments of Gassner, of Günsburg, in 1801, who inoculated eleven cows with smallpox virus, in one of which vesicles appeared, from which several children

were successfully vaccinated, the ordinary phenomena of vaccination ensuing (Henke's *Zeitschrift, Ergänzungs.*, p. 57).

In 1865 a commission at Lyons published the following conclusions concerning the relation of these diseases to each other:

1. Cowpox and smallpox can be inoculated in bovine and equine animals; the first energetically, the second feebly.

2. Whatever may be their successive transmissions, direct or crossed, these two diseases breed true on every soil.

3. The protection from one by the other is assured in every case.

Some interesting experiments have been made by Haccius and Eternod, of Geneva, which tend to confirm those already published by Fischer in the *München. med. Wochenschrift*, and make the identity of variola and vaccinia more than probable. The conclusions at which Thiele, Ceeley, Voigt, and Depaul arrived many years ago, namely, that cowpox is a modified form of smallpox, attenuated by its passage through the organism of an animal, were disputed by the Lyons commission, which adduced seemingly unimpeachable experiments of their own, contradictory to the observations of the earlier experimenters.

Haccius and his colleague, following the operative method of Fischer, claim that they have succeeded in imparting smallpox to animals, and in transmitting it through several generations, the disease finally manifesting itself in a mild form not distinguishable from true cowpox, and like it, conferring immunity from variola.

In one of these series of experiments, Haccius and his colleague succeeded in transmitting the smallpox virus from heifer to heifer to the fourteenth generation; and side by side with a set of similar observations where vaccine virus was used, they had a series under observation where the heifers were inoculated with virus from a case of confluent smallpox. Lymph from "the fourth generation" has given the results of ordinary vaccine when used for purposes of vaccination.

Their conclusions were as follows:

1. Variola is inoculable *with certainty* on the bovine species when the operative method is such as it should be, and the virus is collected at the opportune moment.

2. The inoculation of the heifer with smallpox constitutes a valuable source for new reinforcements of animal vaccine. This may be of great practical benefit, not only to the vaccinal institutes of Europe, but also to tropical countries, where smallpox is endemic, and where the generations of vaccine tend rapidly to deteriorate.

3. Smallpox inoculated in the heifer becomes transformed into vaccine in the course of several generations, by transmission through the animal. *Duality is thus disproved.*

4. Our practical conclusions confirm the views enunciated by Depaul, in 1863, to the Academy of Medicine of Paris.

Following these experiments Chauveau was led by a similar mode of investigation to very different conclusions.

His paper ("Sur la transformation des virus à propos des relations qui existent entre la vaccine et la variole") was presented at the sessions of the Academy of Medicine of October 20th and 27th, 1891. His conclusions are as follows: (1) Vaccine virus never gives smallpox to man. (2) Variolic virus never gives vaccine to the cow or horse. (3) Vaccine is not even *attenuated smallpox*, and cannot be compared to the benign anthracoid infection which is communicated to animals by inoculation with *attenuated anthracoid virus.* (4) If vaccine is a derivative of smallpox it is by reason of a *radical transformation* of the variolic virus, a transformation thus far unattainable by experimenters. (5) These last propositions lead to another more general proposition, which is this: the *attenuation* of virus is not a physical process which can be identified with the *transformation* of virus. The weight of scientific opinion to-day, however, is decidedly against these conclusions of Chauveau.

Satisfactory experiments of this kind are difficult of performance, for no experimentation on animals can be regarded as complete the results of which have not been checked by inoculations practised on the human subject. Now, Haccius and Eternod did not try their lymph—rendered vaccinal, as they believed, by several removes—on the unvaccinated child, nor did Chauveau make any such trials (*Boston Medical and Surgical Journal*, 1891).

On the other hand, it appears that the experiment has been tried upon unvaccinated children in Calcutta, as detailed by the experimenter, Dr. W. J. Simpson, medical officer of health of Calcutta, at a meeting of the Calcutta Medical Society, April 13th, 1892.

Dr. Simpson comments upon Chauveau's experiments as follows: "Seventeen animals were inoculated by that commission with lymph from virulent cases of smallpox, and some small papules were obtained, the secretions from which, when inoculated into other cows, gave rise to papules of an insignificant kind, but which when inoculated into children gave rise to smallpox. On this slender foundation the theory has been based, and is very forcibly put forward, that smallpox in man produces a real smallpox in the cow totally differing in every respect from cowpox.

"To those who have studied the subject these experiments are by no means conclusive. They only show that Chauveau with his coadjutors failed to inoculate the cows successfully, and that the papules raised were rather due to the irritation of the points of insertion by the smallpox lymph, and that the serous matter taken out of these papules was the smallpox lymph itself, which had remained in them unchanged; and under these conditions it was not surprising that smallpox was produced in the children inoculated with this virus.

"Nothing further was attempted in the way of experiment until Dr. Klein, in 1879, inoculated thirty-three cows with smallpox lymph, but failed to raise any vesicles on the cows. Papules appeared in some of the cows at the seat of inoculation, but these were not considered to have turned the experiments into a success, and no serum was taken from these papules and inoculated into children. If such a procedure had met with favor, there would probably, as in Chauveau's cases, have been an after-history of smallpox in the children inoculated.

"Dr. Klein's failure served to accentuate the theory based on Chauveau's disaster, and both failure and disaster were employed as a basis on which arguments were founded against the pathological identity of smallpox and cowpox. So confident have the supporters of this view since become, that strong doubts have been expressed by them as to the genuineness of the experiments performed by previous observers. A favorite argument appears to be that what was accomplished in the earlier part of the century cannot be done now, and therefore the experiments are not altogether to be trusted. The reason of this is not far to seek. All the conditions under which the cow may be successfully inoculated are not known, and hence it is not every cow that can be inoculated with success. This entails on the investigator much expense, the exercise of a great deal of trouble and patience, and of course it is much easier to read up the subject as Professor Crookshank has done, and side with the view for which you may have the greater predilection, than thoroughly to investigate the subject, not being satisfied with dubious results.

"Apart from the controversial question, it has for a long time been a matter of thought with me as to whether there is any relationship between cowpox, horsepox, sheeppox, and smallpox; whether these four diseases have for their cause a common origin which may be designated by the letter *x*, this common origin having not yet been discovered: or whether horsepox, cowpox, and sheeppox, or any of them, are descendants of smallpox; or thirdly, whether smallpox may be looked upon in the light of a parasitic disease which comes to its full development in man, enters some animal as the cow, losing that which gives it its infectious properties, and then in some other animal, unknown as yet in the soil, regains

that element which it had lost in the cow, and which once more renders it infectious.

"I am inclined to think that it is in this latter direction that investigation will ultimately succeed in discovering the cause of the periodicity of smallpox.

"Vaccine and chickenpox have always seemed to be two elements of smallpox which have become separated in some unknown way, the vaccine retaining the peculiar qualities belonging to the smallpox which affects the body in such a manner as to render it immune from a second attack, while the chickenpox has none of these qualities but has retained the infectious element. If this were true, it might seem to be easily proved by experiment. I have tried the experiment by mixing the two viruses, but without success. There is a difference, however, between mixing and combining, and it is possible that the conditions which affect this have to be found in some other less simple way.

"It is for the reasons stated, and for some others which I need not mention here, that I have been engaged for years, as opportunity arose, in experimenting with smallpox on animals.

"When in Aberdeen I used to search the farms in the country for cowpox, and not without success. I have inoculated cows, horses, sheep, pigs, goats, fowls, monkeys, and dogs with smallpox virus to ascertain the result, and in these experiments I have succeeded incidentally; for it was not the primary object for which I began the investigation, in converting smallpox into ordinary vaccine by passing the virus from an unprotected smallpox patient through the cow.

"In December, 1884, I first succeeded in raising a vesicle in a cow after inoculation with smallpox virus. The lymph was transferred to a ewe lamb, and raised a vesicle in every appearance similar to a vaccine vesicle. This lymph was taken and introduced into a young pig six weeks old, and here it was lost.

"In November, 1885, with smallpox lymph from an unvaccinated patient, I inoculated a cow with fifth-day lymph, and a ewe with eighth-day lymph from the same patient. Both presented vesicles on the seventh day, the lymph of which I sent to London to be used by Dr. Cory, the director of the Animal Vaccine Institute in London. This calf lymph, which Dr. Cory passed through a second calf before using on children, was the starting of a new stock of vaccine at the Institute.

"Between November 21st, 1885, and May 6th, 1886, 1,247 children had been vaccinated with this lymph, and gave 98.4 per cent. insertions of success."

These experiments of Dr. Simpson were also confirmed by similar experiments made by Dr. W. G. King, of Madras, and by Dr. T. W. Hime, of Bradford, England (*Practitioner*, vol. xlix., 1892; *Brit. Med. Jour*, July, 1892).

The Phenomena of Vaccinia in Man.—Vaccinia is communicable to man only by inoculation, and may be communicated with equal certainty from the cow or from other human beings.

When fresh vaccine lymph is introduced into the unvaccinated human subject, either by puncture or by abrasion of the skin, local effects are not usually noticeable within the first forty-eight hours. The period of incubation is brief, and if the vaccination is successful, at about the end of the second day a slight redness and swelling are observed at the seat of insertion. On the third or fourth day a little vesicle appears at the summit of the papule, filled with a clear liquid, which gradually grows larger and larger. As the size of the efflorescence increases, an umbilication appears, similar to that of the genuine variola pustule, which corresponds to the shape of the original wound of insertion; an insertion by simple puncture producing a circular vesicle, and an insertion by a longitudinal incision producing an oval vesicle. The vesicle attains its largest size about the seventh or eighth day, when it contains a clear liquid, which, if the vesicle is punctured, will ooze out upon the surface sparingly. The construction of the vesicle is cellular, like that of the pustule of variola. After the eighth day, and sometimes a few hours earlier, a ring of inflammation called the areola begins to form about the base, and the vesicle and areola together continue for the next two days to spread. The areola is circular, and when fully developed has a diameter of 1–3 in. (2½–7 cm.). It is often attended with considerable hardness and swelling of the subjacent tissues. The establishment of the areola demands attention as the evidence that the specific effects of vaccinia have been produced. If several insertions have been made near each other, the areolæ coalesce.

After the tenth day the areola begins to fade, the vesicle begins to dry in the centre, the lymph remaining in it becomes opaque, the pearly colored pustule becomes yellowish, while at the centre, at the location of the original insertion of the virus, a crust has begun to form. By the fourteenth day the crust has become dry and hard, and gradually assumes a darker hue, and usually falls off from the twentieth to the twenty-fifth day, leaving a cicatrix, commonly permanent, which is usually circular, slightly depressed, foveated, or indented with minute pits, and sometimes radiated. (Plate LVIII.)

There are also constitutional symptoms more or less severe, in proportion to the intensity of the local symptoms. There are fever, restlessness, derangement of the digestive organs, and occasionally swelling of the axillary glands. The constitutional symptoms are usually most severe at or a little before the time when the areola has reached its fullest development. Infants usually suffer less than older children, and these less than adults. In adults the course of primary vaccinia is apt to be more retarded than it is in infants, the areola is often more diffuse, and the swelling of the axillary glands more common.

All of these phenomena may be modified by acceleration, by retardation, or by irregularity of development.

1. The most common form of modification is a slight *delay* in the development of the usual symptoms, of one or more days, so that by the ninth day the vesicle has arrived at the usual condition seen upon the seventh or eighth day. Seaton mentions cases in which a week's delay was observed, and after success had been given up; and Bousquet mentions a case in which a dormant vaccination was revived at the end of three weeks. This delay is sometimes due to the incubation of other diseases. If the phenomena follow a regular course, this retardation does not necessarily imply an interference with the protective power of the vaccination.

2. *Acceleration* of the phenomena of vaccination is to be regarded with more suspicion than retardation. If the acceleration amounts to not more than one day in advance of the usual appearances, and the vesicle and the consequent areola assume the typical form and color, the protective value of the vaccination is not necessarily impaired.

3. Vaccination may present *irregular forms.* The formation of the vesicle may be accompanied by considerable itching and irritation. Its shape may be acuminated or conoidal, and without the central depression, and the fluid contents may not be a clear serum, but a cloudy liquid. The areola may be formed early and may be irregular in shape, arriving at its height on the fifth or sixth day. A crust may form and fall off as early as the tenth or twelfth day. The local effect may have been still more accelerated, and a thin scale formed which is readily detached.

Other irregular forms may be seen, none of which should be depended upon as protective against smallpox, nor should virus be taken from them for the purpose of vaccinating others. Such irregular conditions are doubtless due, either to the use of vaccine lymph which is not sufficiently recent, and has consequently lost much of its active infective power, or it may have been inserted in a subject whose health is bad; so that the results of the vaccination may appear uniform from virus employed under the first of these conditions, but not under the second.

Mechanical irritation, such as may be produced by a coarse woollen sleeve, may occasionally interfere with