

in the kidney and require surgical treatment. They are solitary cysts, the tumors of polycystic degeneration, and echinococcus. The solitary renal cyst is a benign trouble and can do injury only by pressure, in case it reaches a large size. Such a cyst contains clear serous or cloudy fluid, possibly stained with blood pigment. Large cysts of this kind are rare. They arise in the cortex and are probably due to retention beginning in a glomerulus or in a tubule. The cyst may be strictly solitary, or two or more may coexist. Their situation is usually along the convex border, or in the lower pole of the kidney. In only a few instances has operation been performed for this trouble. If an operation is undertaken, the cyst should be extirpated and the renal parenchyma sutured; or, if complete suture is impossible, the cavity may be drained.

Polycystic degeneration is a serious and usually fatal disorder which may affect the kidneys either before or after birth. The etiology is still obscure. Schede affirms that there are two forms of polycystic degeneration. In one form overgrowth of the interstitial tissue obstructs and strangulates the tubules and thus leads to the development of multiple cysts. In the other form the epithelium, especially of the tubules, undergoes proliferation and subsequent degeneration, so that the condition may properly be called adenocystoma.

Congenital polycystic degeneration is usually bilateral; and since it causes a speedy death it has little surgical interest. The polycystic degeneration of later life is sometimes unilateral, so that occasionally incision of the cysts, nephrotomy, or even nephrectomy might be of benefit. Before the kidney is removed the functional capacity of the other kidney should be definitely determined.

The natural course of polycystic degeneration is the destruction of the renal tissue. It is often associated with the formation of multiple cysts in the liver, and is frequently accompanied by arteriosclerosis and cardiac hypertrophy. Therefore death is usually not long delayed. Still there are instances in which a patient has lived ten years after such a cystic renal tumor was palpable.

The diagnosis of polycystic renal degeneration is difficult. The enlarged kidney will probably be mistaken for malignant disease. It is sometimes possible to feel the pebbly surface of the organ and in rare instances to make out fluctuation in the larger cysts. Cachexia may be absent for a long time.

Echinococcus may develop in the kidney, giving rise to a single smooth cyst which may feel as hard as a fibroma, or may yield an indefinite fluctuation or the peculiar thrill found in echinococcus cysts elsewhere. If the cyst bursts into the renal pelvis, hooks or daughter cysts may be found in the urine. Such cysts, as far as known, are always single. As the renal tissue is unaffected except by reason of pressure, the kidney should not be removed. The cyst, whether suppurating or not, should be incised, sutured into the abdominal wound, and drained.

**Suprarenal Gland.**—While little is known of the physiology and pathology of the suprarenal gland, it is usually found diseased in connection with a group of symptoms described by Addison, and which are therefore known as Addison's disease. The affection of the suprarenal gland under such circumstances is almost always tuberculous. The bronzing of the skin which is generally supposed to be characteristic of Addison's disease does not exist in about one-sixth of the cases in which the suprarenals are diseased, and it is present sometimes when the suprarenals are apparently normal. Some hold the view that Addison's disease is an affection of the sympathetic ganglion which lies near the suprarenal body, and that the gland is involved only as the lesion spreads. There are some cases which seem to show that the early removal of the tuberculous suprarenal may benefit the patient, since the disease may for a time be unilateral. In some of the few cases which have been operated upon, the suprarenal gland and kidney were so intimately adherent that it was found necessary to remove both. Benign tumors, encap-

sulated hæmatomata, and malignant tumors, of the suprarenal gland, are pathological rarities which a surgeon may be called upon to treat. It is not likely that a differential diagnosis can be made between a tumor of the suprarenal gland and one of the upper pole of the kidney. This point is not of much importance, however, since practically the same operation is required for the two conditions, and very likely both organs will have to be removed together. The gland may be reached through a lumbar or an abdominal incision. If the former is chosen, it will need to be large, and should extend well upward.

Edward Milton Foote.

**KINO.**—"The inspissated juice of *Pterocarpus Marsupium* Roxb. (fam. *Leguminosæ*)." U. S. P. Many substances, from different parts of the earth and different plants, have, at one time or another, appeared under this name. That which is in the market at present is chiefly the product of various species of *Eucalyptus*, the official article being very scarce and dear. Very recently, however, it has been reported that extensive new districts have been opened up, capable of yielding any required amount of official kino at a low price. The plant yielding the latter is a large, handsome Indian tree, whose wood is also valued for timber. In common with other species of *Pterocarpus*, this tree contains a bright-red juice, which exudes upon incisions being made in the trunk, and hardens, upon evaporation and drying, into dark, reddish-brown, brittle tears.

This, the East Indian (Malabar) kino, has been imported since the beginning of the present century, and for medical purposes has superseded the African and other varieties which were then used. It always comes in fragments or angular pieces, generally not larger than split peas, and oftener considerably smaller; occasionally these fragments cohere together in crumbly lumps. Kino is of resinous lustre and fracture, very brittle, its pieces are smooth and shining, opaque, except at their edges, where they are ruby-red and transparent; general color dark reddish-brown, sometimes almost black; odor, none; taste very astringent and sweetish. The saliva is colored bright red when kino is chewed. It is partially soluble in cold water, wholly so in boiling water and in alcohol, not in ether.

Kino is a homogeneous uncrystallizable substance, related to the tannic acids of cinchona and krameria, and more closely to catechu. Its deep red solution becomes violet on addition of a proto-, and dirty green with a persalt of iron. It appears to consist principally of *kino-tannic acid*, a red, transparent substance, soluble in alcohol and water, and capable of decomposing upon long standing in watery solution into insoluble *kino-red*; *kinoïn* and *catechin* may be obtained from it in small quantity, and *pyrogalllic acid*, by distillation and other means.

**ACTION AND USE.**—Kino is an active astringent of the logwood and catechu kind, and is employed for exactly the same purposes. For subacute or chronic diarrhoea or dysentery it is equally good with other astringents, and less unpleasant than many of them. As a local application or injection, *tannic acid* is to be preferred. Kino can be given in substance, if desired—dose, 1 gm. (1 gm. = gr. xv.) or in aqueous infusion; as the latter is apt to gelatinize, it should be made freshly. The official tincture (*Tinctura Kino*, U. S. P.; strength  $\frac{1}{10}$ , with fifteen parts of glycerin) keeps better, and is the most generally useful form, but this also shows a strong tendency to gelatinize after a time.

W. P. Bolles.

**KISSINGEN.**—Kissingen, one of the most important and best known of the German spas, is a town of 4,306 inhabitants, beautifully situated in the valley of the Saale in Bavaria, about sixty miles from Frankfort-on-the-Main. It is 554 miles from Paris via Frankfort and Würzburg, and can be reached from the former city in eighteen hours. It is about six hundred feet above sea-level, and is surrounded by wooded hills affording opportunity for the "Terrain-Cur." In the circular valley in

which it is situated are extended pleasure grounds and promenades. The climate is mild, although there is considerable rain. The mean yearly temperature is 45.1° F. and the mean monthly is: May, 54.8° F.; June, 60.2° F.; July, 62.7° F.; August, 60.4° F.; September, 54.3° F. The yearly rainfall is 25.3 inches.

The season extends from May 1st to October 1st, and during this time a large number of visitors frequent this spa; in 1899, the number was 19,416, the majority of which were Germans. The accommodations are excellent and sufficient for three or four thousand persons. The drinking-water is from well source, but said to be good, and the drainage is efficient. The springs are cold saline, the principal constituents being chloride of sodium, ferrous carbonate, sulphate of magnesia, carbonate of calcium, and free carbonic acid. Three of the springs: the Rakoczy, Pandur, and Maxbrunnen are situated in the town, and two, the Schönbornsprudel and the Sool- or Salinensprudel, a short distance beyond the town limits. The Rakoczy, Pandur, and Maxbrunnen are used for drinking, and the Soolsprudel and Pandur are the ones principally used for baths.

The following is the analysis (from Eulenburg) of the five springs:

NUMBER OF GRAMS OF SOLID CONSTITUENTS, IN EACH LITRE OF WATER.

	Rakoczy.	Pandur.	Max-brunnen.	Sool-sprudel.	Schönborn-sprudel.
Sodium chloride.....	5.822	5.207	2.316	10.554	11.719
Calcium chloride.....	.286	.241	.379	.250	...
Lithium chloride.....	.020	.016	.007	.020	.024
Magnesium chloride.....	.303	.211	.108	.330	...
Magnesium sulphate.....	.588	.597	.200	.904	1.472
Calcium sulphate.....	.389	6.300	.190	.856	.332
Calcium carbonate.....	1.061	1.014	.565	1.304	1.855
Ferrous carbonate.....	.031	.027	.002	.030	.019
Calcium phosphate.....	.005	.005	.005	.004	.007
Sodium nitrate.....	.009	.005	.077	...	...
Sodium bromide.....	.008	.007	Trace.	.009	.011
Silicic acid.....	.012	.004	.003	.001	.013
Organic matter, etc.....	.022	.362	.064	.037	.383
Total solids.....	8.556	7.996	3.913	14.299	15.847

There are three bath establishments, the property of the Government: (a) the Kurhaus with forty bathrooms; (b) the Saline with one hundred bathrooms; (c) the formerly called "Actienbad" with one hundred and twenty bathrooms. For bathing purposes the waters of the Sool- or the Schönbornsprudel are often rendered more stimulating by the addition of the mother liquor remaining after the extraction of the sodium chloride at the salt works. There are also carbonic-acid gas baths, mud baths, inhalation rooms, douches, massage, and a medicomechanic institute. There are also private sanatoria for the treatment of various diseases. The Rakoczy is the best-known spring, and over four hundred thousand bottles of this water are sent abroad every year. The usual time for drinking the waters is before breakfast, from seven to nine. From two to six glasses are drunk, a fifteen minutes' walk being taken after each glass.

Kissingen waters are recommended for a variety of maladies: Hemorrhoidal troubles, constipation, catarrhal conditions of the stomach and bowels, gouty and rheumatic affections, uric-acid diathesis, bronchitis, anaemia, scrofula, amenorrhœa, functional nervous disorders, glycosuria, obesity, malaria, neuralgia, the headache from dysmenorrhœa, cardiac diseases, and some chronic skin affections. According to Dr. Thomas More Madden, "the mother lye or concentrated saline water of the Soolensprudel, is applied with wonderful results as a local application to scrofulous glandular swellings and similar affections."

It is well to advise the visitor that here as at all other spas, the waters and baths should be used only under the direction of one of the local physicians, as otherwise harm

instead of benefit might ensue. It is not only the use of the waters, but quite as much the carefully arranged daily plan of life as to diet, rest, exercise, etc., which produces favorable results.

Edward O. Otis.

**KLAMATH HOT SPRINGS.**—Siskiyou County, California.

**LOCATION.**—These springs are located on the Shasta Division of the Southern Pacific Railroad, some eighteen miles from Ager. The resort is 2,700 feet above the sea-level, and is surrounded by a wild and picturesque country with snow-capped mountain peaks and hills clad in evergreen forests. There are ample accommodations for invalids and guests, as well as excellent bathing facilities. The waters are alkaline, saline, and sulphurous. Some of them are carbonated. The springs have already gained considerable celebrity in the treatment of chronic rheumatism, gout, synovitis, chronic cutaneous diseases, dyspepsia, etc.

James K. Crook.

**KNEE-JERK. (PHYSIOLOGICAL.)**—This term is used to indicate a perfectly normal physiological contraction of certain extensor muscles of the upper leg in response to a blow upon the *ligamentum patellæ* ("tendon tap"), the reply resembling a jerky kick.

From the first there has been a diversity of opinion as to the nature of the phenomenon and this has led to the use of a great variety of synonyms, as: Knee-jerk (K.J., K.), knee-kick, knee phenomenon, knee-reflex, patellar (tendon) reflex (Pa.R.), Patellar (tendon) phenomenon, Westphal's symptom, myotatic contraction (Gowers), and their equivalents in other languages.

Similar responses are obtained by striking other tendons, possibly any tendon. The knee-jerk is merely the best studied and most convenient member of a large group of tendon reflexes or phenomena. There are also periosteal reflexes and "muscle jerks" of a very similar character but held by many to have a different origin.

It seems strange that a phenomenon of such simplicity remained so long unnoticed. Nowadays even children play with it, but there is no clear mention of the subject in medical literature before the articles of Erb and Westphal which appeared together in the *Archiv für Psychiatrie* in 1875. Westphal speaks of the jerk as known to many laymen "as a curiosity" and admits that his attention was drawn to it by a patient. Guérin, as early as 1856, had mentioned a contraction of tendons, but he does not seem to have had the knee-jerk in mind. As these first articles laid stress upon the diagnostic importance of the subject with reference to pathological conditions of the spinal cord, the keenest interest was at once manifested and an enormous literature began to grow.

For the demonstration of the knee-jerk a very light blow upon the ligament suffices. Such a blow may be given with any thin and relatively firm body (percussion hammer, stethoscope, back of a thin book, ulnar border of extended fingers, etc.) and is commonly effective even when the knee is covered by a moderate amount of clothing. The knee should be flexed so as to put the extensor muscles in a condition of slight tension. For ordinary examinations this is accomplished by crossing the legs, by sitting on the edge of a table with the knee resting on a cushion, or even by letting the leg hang from the arm by which it is lifted from the bed. In more careful studies it is necessary to use special devices to counterbalance the weight of the leg. The tendon tap is followed immediately by a swelling of the *m. quadriceps femoris*, easily seen or felt, and a partial extension of the lower leg. The blow itself may be barely perceived, particularly when the attention is diverted. The sensation of the "jerk" is curiously vague and remote; when the movement is more brisk there is a consciousness of the moving mass but with no feeling of a corresponding effort.

The first investigators of the phenomenon, while recognizing that it was abrogated by certain pathological conditions of the cord, were not quite clear as to its constancy in health. Later and more refined studies justify

the conclusion that the knee-jerk is a perfectly physiological act, but subject to very marked variations; its absence may be assumed only after a careful and repeated examination.

Thus Eulenburg (1878) found no K<sub>j</sub> in about 4 per cent. of the 204 young children examined, and in 5 per cent. of his adult cases; Berger (1879) reported 22 failures in a series of 1,409, 900 of them being young soldiers, or 1.56 per cent.; Bloch's studies of 694 school children resulted in 0.72 per cent. of failures which, however, may be justly corrected to about 0.3 per cent.; Pelizaeus (1888) examined 2,403 boys (nine to thirteen years) with but one failure, or 0.04 per cent., and this boy had a knee-jerk when examined more carefully a couple of years later; Jendrassik (1885) could demonstrate the jerk in all but one of 1,000 persons examined, and this one was found to have diabetes, a disease which often causes the K<sub>j</sub> to disappear; Ferguson (1892) noted no absence in 200 cases examined for life insurance.

The blow on the patellar tendon sometimes causes other muscular responses. Many observers have noted a genuine "crossed knee-jerk," a simple extension of the knee of the opposite leg. This is seen in animals and occasionally in man but probably only under pathological conditions.

A closely related phenomenon, for which the same name is often used, is a crossed "in-knee-jerk" or "contralateral adductor reflex." It is by no means clear that this is really a different phenomenon, although the distinction is insisted upon by Hinsdale and Taylor. These observers found it in from twenty to thirty per cent. of the cases coming to the clinic for nervous diseases. It was not caused by a jarring of the pelvis, although, according to Russell (1896), it as well as a genuine crossed knee-jerk may be produced by a blow on the distal end of the femur or the proximal end of the tibia. A "Pseudokniephänomen" was described by Westphal (1882) as produced by pinching a fold of skin over the tendon or elsewhere on the leg, or by blows of a percussion hammer on the inner condyle, and consisting of a contraction of the quadriceps which comes on slowly. Certain variations of the K<sub>j</sub> have been called "paradoxical." By this is meant sometimes a preponderating action of the flexor muscles (*e.g.*, Benedict, 1889), sometimes the participation of various muscles of the lower leg (*e.g.*, Eichhorst, 1892). The knee-jerk must not be confounded with the "patella clonus," a clonic contraction of the quadriceps when stretched by a quick pull of the firmly grasped patella and said not to occur in health. Remak (1893) has described a presumably pathological "femoral reflex" produced by a skin stimulation in the region of the median border of the *rectus femoris* and involving the quadriceps along with many muscles of the lower leg. Exaggerated "irradiation" of the knee-jerk, so as to cause violent contractions of both legs and even to involve the arms, belongs to the realm of pathology as do many of the less extreme modifications of the phenomenon.

For more exact study of the knee-jerk a great variety of devices have been suggested. The effort was made to construct forms of apparatus for the precise regulation of the force of the tendon tap, and also for the measurement of the extent of the resulting movement. The first form of hammer for giving a definite blow was that of Franck (1880), a spring regulating the force. Other devices with springs were used by Jarisch and Schiff (1882), Danillo (1882), Duprat (1886), Bowditch, (with a particularly useful splint to fix the hammer in place, 1888), M. Sternberg (1891), the latest form being that of Castex (1901) with a graduation in terms of gramme-centimetres. The most notable use in careful work of a hammer whose blow is determined by gravity is that of Lombard (1887). Less good is the method of Sommer. In general it may be said that the chief advantage of these complicated hammers lies rather in the uniformity of the blow than in any significance attachable to the force of the blow itself. No definite relation is known between the strength of blow and the size of the kick. Castex has recently tried to determine a sort of "normal" value

which he finds to be 130 gramme-centimetres for a surface of one square centimetre. It is quite permissible to be sceptical in this matter.

Devices for recognizing the extent of the movement have been proposed by several observers. Such are the more complicated "Anacomptomètre clinique" of Duprat (1886) and the simpler instruments of Lombard (1888, figured by Mitchell), Mitchell (1888), and Haynes (1899). The first use of a record produced by a simple attachment to mark on smoked paper seems to have been made by Lombard (1887); the method was afterward much refined by Bowditch (1888, 1890) and has been used by some other investigators. Unnecessarily complex is the "Reflexmultiplier" of Sommer (1894), and the "Reflexograph" of von Bechterew (1892) has no obvious advantage. Such records are of course essential to any extended comparison of the jerks under varying conditions. It is very difficult to form an opinion as to the exact angular size of the jerk. The mean arc of swing is said to be 24° to 25°, with a range from 11° to 48°; there are, however, few measurements of this particular character in which the weight of the leg was properly counterbalanced, to make the pull of the muscle uniform. Lombard (1887) was the first to show that, by use of the recumbent attitude and suspension of the lower leg by a cord, the variation in weight of the lower leg could be eliminated.

While there can be no question that the knee-jerk is a physiological act, it is subject to very considerable variations even in perfect health. It is present in the newborn during the first days of life and has been demonstrated in persons who were over eighty or even ninety years old. It seems to be less vigorous in the very old, and this may be a result of senility, analogous to its disappearance in the last stages of fatal sickness, but such cases deserve a more careful examination with refined methods.

The phenomenon vanishes in sleep. This was first noticed by Rosenbach (1880) in observations in children, but he considered his results uncertain except for deep sleep. Lombard (1887) noted a diminution of the response "when quiet or even a condition resembling sleep had crept on," but he does not seem to have reported its complete absence in sleep. In the Bowditch experiments (1890) it was incidentally demonstrated on some eight or nine different occasions that the response not only grows less as the subject becomes drowsy but actually disappears as the sleep becomes profound, a condition for which there is of course no satisfactory criterion. Noyes (1892) found the influence of sleep particularly easy of demonstration in a case of terminal dementia. According to Ferguson (1893) sleep causes an increase of the jerk as it comes on, but a diminution or complete abolition when deep. It should be noted, however, that Aplegarth does not seem to have observed a disappearance of the phenomenon in sleeping dogs.

Mitchell and Lewis (1886) noted that the kick is less good in the evening than early in the day, and this has been amply confirmed by Lombard to whom we owe extended and careful studies of the diurnal variation in man. Fatigue, bodily or mental, has on the whole a depressing influence, but Sternberg (1887) found that extreme fatigue caused an exaggeration. The taking of food causes the average of a considerable series of kicks to be greater than it was before the meal. No one, I think, has studied the influence of hunger or prolonged abstinence.

There is some reason to suppose that the knee-jerk is affected by the weather. Weir Mitchell and Lewis, I believe, first called attention to the lessened response "on dull damp warm days." Lombard compared his two long series (each of fourteen days with seven to nine groups of observations on each day) with the weather record of the same place. In general the curves seem to show that the jerk becomes larger as the thermometer falls but grows smaller as it rises, while it rises and falls with the barometer. The influence of the humidity, wind, etc., was not well defined; in fact the weather

conditions did not vary enough during these series to make the comparison altogether satisfactory.

In the latter part of pregnancy, also a physiological state, the knee-jerk is often increased; at least, Neumann (1895) says he found it so in many of the five hundred women he examined. The exaggeration is still more marked in parturition and particularly in the last stages of the birth act, when too the other reflexes are frequently more vigorous. In the puerperium there is a gradual return to the normal kick. All this is attributed to an increased irritability of the nervous system, but, as we shall see, other causes may be in play.

The research of Noyes in a case of dementia showed a sort of rhythm in the jerk analogous to the variations of the vascular system. This very interesting lead has never been followed out.

In 1883 Jendrassik reported a discovery which completely revolutionized the study of the knee-jerk and whose significance is not yet fully understood. He noticed that the innervation of the sciatic nerve favored the production of the jerk, which is directly dependent upon the crural nerve, and was led to inquire whether other motor impulses had a similar effect. He found in general that the innervation of all motor nerves increased the reflex twitch of the quadriceps and recommended that the subject should lift a weight with one or both hands or simply strongly contract his muscles. The influence of the sensory nerves he found harder to determine but expressed the opinion that their innervation also increased the reflex. At once investigators began to use this method and soon no examination of the knee-jerk was considered complete in which the method of Jendrassik had not been employed to produce a "Bahnung" particularly in case of feeble responses; "faire le Jendrassik" says a recent author.

This inquiry does not seem to have been pursued by Jendrassik, but in 1886 Mitchell and Lewis printed observations which materially extended our knowledge of the ways of enhancing the knee-jerk. These authors called such procedures "reinforcements," a term which is fairly the equivalent of Exner's "Bahnung." It was shown that not merely the relatively violent movements recommended by Jendrassik but all voluntary movements, even when very slight (as winking, deglutition, phonation, voluntary respiratory movements), may suffice to make the coincident knee-jerk bigger. So general is this that we may say that the voluntary innervation of any muscle or group of muscles, except those immediately concerned in the jerk, acts as a reinforcement. And even for the crural nerve it was found that its milder innervation is effective while its vigorous innervation has an inhibitive action and stops the jerk. Mitchell and Lewis were also able to demonstrate that sensory stimulation has far greater importance as a reinforcement than the vague results of Jendrassik suggest. While mere touch is not usually sufficient, pain (pulling hair, needle prick, skin pinch) makes a very good reinforcement. Electrical stimulation, particularly with the wire brush, has a powerful action. Heat and cold are less certain but sometimes very efficient. A bright light (flashes of burning magnesium wire) reinforces as it becomes painful. Experiments with taste gave negative results; hearing and smell were not tested. Galvanism of the head, in the frontal region, and especially in combination with a skin stimulation gave a large reinforcement. Even galvanization of the spine increased the kick.

This question was followed up by Lombard (1887), who showed that even spontaneous skin sensations of no marked intensity may act as reinforcements. He also showed that a large variety of influences which may be vaguely classified as emotional (noises such as to arouse attention or interest, music, "exciting dreams") exaggerate the jerk. Less clear is the pronounced effect of mental activity (multiplication, recalling a stirring poem) since this may be accompanied by unintentional muscular movements. Others also have observed these effects of mental states (sorrow, joy, mental excitement). Ferguson notes an exaggeration in two cases of fright, and

Russell, more recently, has expressed the belief that a "purely mental process" suffices to increase the knee-jerk. Whether the will alone can influence this movement is at the best uncertain. Some of my own experiments with other tendon reflexes distinctly indicate that it may, but Erb pointed out at the very beginning that it is very difficult voluntarily to inhibit the jerk. On the other hand there is no reason to suppose that volition is in play in the long series of Lombard and of Bowditch; the experiments were too carefully varied to permit any such objection. Some investigations have been made with demented persons in the hope of eliminating at least a portion of the incessant variation of jerk. The results were in no way more satisfactory and the practical difficulties were found to be great. While the feeble knee-jerk of health may be increased by hand clenching, an enfeeblement due to disease may not be thus reinforced (Ferguson).

In the experiments with reinforcements the investigators had laid stress upon a certain coincidence of the tendon tap and the reinforcing act. The time relation of these events was examined with much care by Bowditch using an ingenious and refined method. The results obtained are most surprising and have never received quite the attention they deserve. It was found not only that the voluntary movement must be made within a definite time interval in order that the kick may be distinctly increased, but also that for certain intervals the effect may be a diminution of the movement. Thus we may have either a reinforcement or an inhibition which it is convenient to call a negative reinforcement, just as the physicist calls suction negative pressure.

More precisely the result was this: when the signal for a muscular movement (hand squeeze) coincides with the blow upon the tendon the knee-jerk is larger, having one hundred and fifty to one hundred and seventy per cent. of the average "normal" (*i.e.*, unreinforced) kick of the day or series. When the signal precedes the tendon tap the effect diminishes as the interval increases, becoming a negative reinforcement when the interval has passed a certain value, varying from 0.22" to 0.6" in these experiments. The average decrease in the size of the jerk for many series was sixty to ninety per cent., but in single experiments there was a reduction to zero, a complete inhibition. The greatest diminution was for intervals of 0.6" to 0.9" beyond which there was a gradual return to the normal value, complete after 1.7" to 2.5". Altogether six persons gave very similar results, the details being worked out in very extended series of experiments upon two of them. Two other persons gave only positive reinforcements.

Bowditch also made a careful investigation of the time relations of sensory reinforcements. A sudden auditory stimulus (torpedo) gave almost wholly positive reinforcement in three subjects, the maximum effect being for an interval of 0.2" to 0.3". Visual stimulation by a sudden but not painful flash of light (necessarily involving an involuntary wink) caused almost wholly positive reinforcement in two subjects, while in the third there was a negative reinforcement for intervals greater than 0.4". Very similar results for these three subjects were produced by a brief blast of air directed upon the conjunctiva, which would also cause an involuntary wink. That the wink movement was not the only influence involved was made clear by experiments in which the blast of air was directed to the mucous membrane of the nose, in only one person to be sure, but causing positive and negative reinforcements very similar to those produced by visual or conjunctival stimulation. In two persons a gentle skin stimulation was produced by directing a blast of air against the back of the neck; in one the result was almost entirely a positive reinforcement, in the other there was a positive and a negative phase, the latter being more conspicuous. When the blast of air was directed to the skin of the knee the result, only one person being experimented upon, was nearly altogether a negative reinforcement varying in amount with the interval. In all these experiments the attention was fixed as uni-