Only so far as the state of the general health or an impaired nutrition may be benefited are internal medicines indicated. With this sole purpose in view may be tried cod-liver oil, chalybeates, and tonics, care being taken that the deleterious action on digestion does not exceed the benefit derived. Of other remedies recommended, but of doubtful value, may also be mentioned iodide of potassium, iodoform, quinine, arsenic, creosote, and chloride of calcium.

Local Treatment.—This consists in the destruction and removal of the lupomata with as little disfigurement as possible. In making a selection of the most suitable means to this end, the variety of the disease must be taken into careful consideration.

In the case of small lesions the ideal treatment is excision with or without a Thiersch's skin graft. The results, when this method is successful, are most satisfactory, but unfortunatetly the number of selected cases in which it is applicable is small, and the reports show that recurrences are by no means unknown.

If there is no chance to extirpate the lesion, the best results are obtained either by curetting or by the use of the scarifier. In curetting, as much as possible of the soft tissue is scraped away and usually some caustic is subsequently applied. The lesion is allowed to cicatrize, after which the curetting can again be repeated if it is found necessary. Dr. G. H. Fox has devised a method for removing the nodules, when they are deeply situated, by means of the dental burr. This penetrates the meshes of the scars, and undoubtedly reaches small granulation areas that the dermal curette would not enter. Other instruments have been contrived for the same purpose. Curettage meets the indications best in case of a rapidly advancing margin, in ulcerated cases, with or without hypertrophic outgrowths, and in cases with recurrence. If large areas are to be treated, a local or general anæsthetic should be employed. The worst hindrance to the operation is the impenetrability of the scar tissue and hence the difficulty of getting at the deeply situated lupomata.

Linear Scarification.—This method was proposed by Volkmann and afterward modified by Vidal and others. Parallel cuts, about one-tenth of an inch apart, are made by a sharp knife through the lupous tissue. Many special instruments have been invented for scarification, that devised by Vidal himself having two cutting edges. The knife has to be very sharp and is held like a pen, the strokes being rapidly made. The depth to which the cuts penetrate can be easily regulated after a little practice. Free bleeding is encouraged, and when it has been checked a little, other cuts at angles of from 60° to 90° to the first set are made. This operation is not painful and requires no anæsthetic. It should be repeated every six to eight days until the desired result is obtained. Here again the operation is not possible in badly sclerosed cases, but is specially applicable in cases showing much vascularity and on the border of a lupous ulcer.

Other methods entailing surgical interference are by cauterization with the thermo-cautery or with the electro-cautery. Besnier, to whom the perfection of the operation with the galvano-cautery is due, has invented a number of special cautery points suited for both superficial and deep application. Small lesions are riddled with punctures and then allowed to heal up. This method is also to be recommended for the destruction of small inaccessible lupomata and of small areas of granulations.

Of the medicinal means employed for the treatment of lupus many are still extant, but most have been superseded by the surer methods of instrumentation. Formerly, caustic applications were extremely popular. Among them the treatment by the solid stick of nitrate of silver still survives. The stick is pushed into the soft tissue and a mechanical as well as caustic effect is produced. This gives good results in small and discrete patches. Vienna paste containing white arsenic and cinnabar is also used to-day. The application is very painful and has to be kept up for two or three days. The amount of destruction of the lupous tissue is considerable, but the healthy tissue is for the greater part spared.

Another method of directly destroying the lupomata is that recommended by Unna. This consists in preparing small splinters of wood by soaking in a solution of carbolic acid and corrosive sublimate, and then driving them directly into the lupomata, where they are held in place by plasters and allowed to ulcerate out. Pledgets of cotton may be used for the same purpose. Other writers have advised various liquids to be injected into the tissue or sprayed or painted on the surface. With the object of macerating the epidermis and exposing the lupomata, many ointments and other preparations are used. At the head of these probably stands the salicylic-acid plaster. After its use stronger and more destructive applications should be employed.

Lately, there have come to the front in the treatment of lupus two entirely new methods which bid fair to be *the* treatment of the future. The first, devised by Professor Finsen, of Copenhagen, consists in the concentration of sunlight or the arc light, by a system of lenses, directly on the lupous patches. In this light the heat and red rays are cut off by water chambers, and as far as possible the ultra-violet and chemical rays alone are used. These rays are believed to have powerful bactericidal qualities and the power of penetrating the skin. The second method is now more universally used and consists in the application of the x-rays. Both these methods have been reported as affording excellent results, although they are not invariable. One of the great advantages which they both possess is the small amount of scarring that remains after a cure. The disadvantages are the expense and long time required for treatment.

Oscar H. Holder.

LYCETOL.—Dimethyl piperazin tartrate [$NH(CH_2\text{-}CHCH_3)_2NH + H_2C_4H_4O_6$]—is obtained by distilling glycerin with ammonium bromide and reducing the dimethyl pyrazin thus formed with metallic sodium. It is a white, odorless powder with acid taste and reaction, and is readily soluble in water. Like piperazin this salt is a solvent for uric acid, and is used in cases of gouty diathesis. Wiltzack reports considerable diuresis, the urine having a low specific gravity, non-occurrence of an otherwise regularly recurring attack of gout, and diminution of gravel when the remedy was continued a long time. Hamonic found it to improve the urine in purulent cystitis. The dose is 1–2 gm. (gr. xv.–xxx.) dissolved in plenty of water, its lemonade-like taste making of it a pleasant drink.

W. A. Bastedo.

LYCOPODIUM.—*Vegetable Sulphur.* "The spores of *Lycopodium clavatum* L. and of other species of *Lycopodium* (fam. *Lycopodiaceæ*)," U. S. P. These plants are evergreen creepers, common throughout the north temperate zone. Their ament-like spikes bear numerous sporangia. These spikes are collected, chiefly in Northern Europe, dried, and threshed. Considerable dirt is inevitable, and this amount is frequently largely increased for purposes of adulteration; hence the necessity for estimating the amount of ash, and for microscopical examination. The following is the official description:

"A fine powder, pale yellowish, very mobile, inodorous, tasteless, floating upon water and not wetted by it, but sinking on being boiled with it, and burning quickly when thrown into a flame. Under the microscope the spores are seen to be sphæro-tetrahedral, the surfaces marked with reticulated ridges, and the edges beset with short projections.

"Lycopodium should be free from pollen, starch, sand, and other impurities, any of which are easily detected by means of the microscope.

"When ignited with free access of air, lycopodium should not leave more than five per cent. of ash."

It contains forty-seven per cent. of fixed oil (Flückiger), and has no other important constituent. It is used only as a non-adhesive powder for the protection of moist pills from sticking together, and for dusting upon excoriated

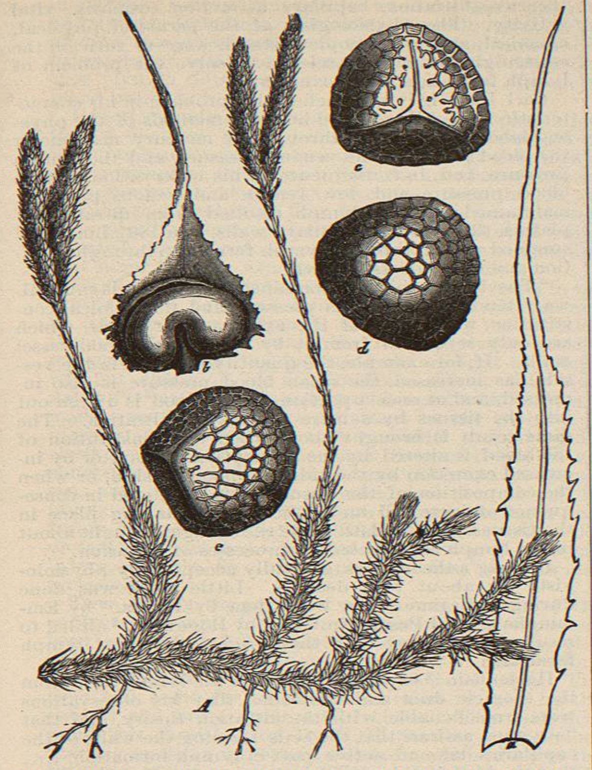

FIG. 3261.—Lycopodium Plant and Spores. *A* is the plant, something less than natural size; *a*, one of the leaves, enlarged; *b*, a scale of the spike with the sporangium at the base, enlarged; *c*, *d*, *e*, different views of the spores. (Luerssen.)

places—to protect the surface and to prevent chafing; its action in both cases is wholly mechanical.

Henry H. Rusby.

LYMPH.—1. DEFINITION.—Lymph is one of the circulating fluids of the body. It is the all-pervading fluid of the body. It has been said that the higher animals as well as the lower are really aquatic, inasmuch as each cell of a reptile, bird, or mammal lives in a liquid medium—the lymph.

Blood comes into contact with the endothelial cells of the blood circulatory system, and with the cells within the spleen pulp—with these cells and with these alone. But these cells comprise a vanishingly small proportion of the cells of the body. All the rest of the cells—and that is, nearly all of the cells of the body—never come into immediate contact with the blood. They receive their food and their respiratory oxygen through the lymph; while the lymph in turn receives these materials for the sustenance of the cells from the blood.

On the other hand, waste matters, which are constantly forming within active cells, are thrown out of the cells into the lymph and make their way directly or indirectly back into the blood, to be carried to some excretory organ.

The lymph is thus the liquid medium of interchange between the living, active cells of the body (endothelium excepted) and the blood.

The way in which this interchange between blood and lymph, and between lymph and cells, takes place will be discussed under Relation of Lymph to Metabolism (section 5).

2. CLASSIFICATION.—The word lymph is frequently used with a somewhat wider meaning than that given in the definition above. In this wider significance lymph includes not only the lymph in the intercellular spaces but also all liquid, not blood, contained within endothelial-lined cavities or circulating within enthothelial-lined vessels. This more general definition includes the fluid contents of the pleural, peritoneal, and pericardial cavities.

It includes the chyle together with the contents of all lymphatics and lymph spaces.

The aqueous humor of the eye, the cerebro-spinal fluid and the synovial fluid, are closely related to lymph, but differ in certain important properties characteristic of lymph and may not be classed with lymph proper.

Lymph may thus be classified as:

I. *Tissue Lymph* — filling the intercellular spaces throughout the body.

II. *Circulating Lymph*—flowing along the lymph radicles and lymphatics, making its way slowly back to the circulatory system, usually viâ the thoracic duct.

III. *Chyle*—the circulating lymph of the intestinal mucosa and submucosa plus the food-stuffs (mostly fats) absorbed from the lumen of the intestine.

IV. *Serous Lymph*—the contents of the serous cavities.

3. COMPOSITION.—Tissue lymph, circulating lymph, and serous lymph have practically the same composition, as follows:

					Per cent.
Lymph.	Water				95.20
	Solids.	Organic.	Proteids		3.75
			Corpuscles.		
			Serum globulin.		
			Serum albumin.		
			Extractives		.10
			Fats.		
			Lecithin.		
			Cholesterin.		
			Sugar, dextrose		.10
		Inorganic.	Sodium chloride	0.56	.85
			Sodium carbonate	.24	
			Other salts	.05	
			Chlorides, sulphates, phosphates, and carbonates of Na, K, Ca, and Mg.		
					100.00

The proteids of lymph are contained partly in the corpuscles and partly in solution in the lymph plasma. An important constituent of lymph proteid is the fibrinogen—one of the globulins—which is one of the factors in the formation of the clot when lymph escapes from tissues or vessels. All lymph contains fibrinogen; but serous lymph contains no fibrin ferment and will, therefore, not coagulate spontaneously. The serous lymph contains less proteid (about 2.42 per cent.) than tissue or circulating lymph.

The salts of the lymph are the same qualitatively as those of the blood, differing only in their quantitative relations. The proportion of salts of the lymph is less than that of the blood.

Besides the above-enumerated constituents the tissue and circulating lymph contains small and indeterminate quantities of katabolites, chief of which is urea, which is found in amounts approximating 0.016 per cent.

Chyle differs from other forms of lymph in the large admixture of food-stuffs just absorbed from the alimentary canal. Practically all of the fat is absorbed into the lymphatics of the intestinal mucosa and submucosa. It circulates in these in the form of an emulsion. This gives the lymph, otherwise clear and light yellow, the appearance of milk, and called forth from Asellius,[1] the discoverer of the vessels which contain it, the name *lacteals*.

The amount of fat which the chyle contains will vary naturally with the conditions of the observation. If the observation be made upon a dog about two or three hours after a meal rich in fats the lacteals will be found gorged with a chyle as white as milk and very rich in fats. If, however, the observation be made under conditions in which the lymphatics in question are not carrying absorbed fats, the vessels do not differ in appearance from other lymph vessels, and the contained chyle would not differ essentially from circulating lymph in its chemical composition.

Chemical analysis shows the chyle, when drawn from the lacteals after a meal rich in fats, to have the following composition:

				Per cent.
Chyle.	Water			90.67
	Solids.	Organic.	Proteids	2.21
			Extractives – Fat	4.71
			Lecithin	.54
			Cholesterin	.85
			Sugar and other organic substances	.23
		Inorganic:	Salts, similar to those of the lymph	.79
				100.00

The physical composition of the lymph bears a close resemblance to that of the blood. Like the latter it consists of plasma and corpuscles. The plasma differs in no essential character from blood plasma: straw-colored and clear; alkaline in reaction, through Na_2CO_3 and Na_2HPO_4; coagulable under the same conditions as those which govern the clotting of blood, and as a result of the same factors—fibrinogen, fibrin ferment, and calcium salts; saltish in taste, because of the presence of 0.6 per cent. sodium chloride; specific gravity lower than blood plasma because of the smaller proportion of salts.

The lymph corpuscles are simply leucocytes. They are formed mostly in the lymph glands, and are put into circulation first in the lymph, and with the lymph enter the blood circulation through the thoracic duct.

4. The Theory of Lymph Formation.—A brief historic review is necessary to give one an idea of the way in which the present theory of lymph formation developed.

Asellius[1] discovered the lacteals (1622) and thought that they carried absorbed food to the liver for elaboration into blood.

Rudbeck[2] discovered the general lymphatics (1653) and observed that lymph clots like blood and has a salt taste.

Bartholin[3] discovered, independently, the general lymphatics, and believed that lymph formed from blood by filtering through the tissues and that it represented water and salts of the plasma.

Pecquet[4] discovered the connection of the lacteals with the thoracic duct and through this with the venous system (1654).

Monro[5] believed that the lacteals filled by sucking digested food-stuffs from the intestinal canal (1757).

Bichat[6] believed that tissue spaces filled from the blood-vascular system through exhalant arteries ("vasa exhalantia"), that the lymphatics filled from the tissue spaces through open mouths and lacteal vessels by "capillary attraction," and that lymph kept moving through "vital activity" of cells and tissues (1812).

Dutrochet[7] discovered *endosmosis*, and many physiologists believed the riddle of absorption and formation of lymph to be finally solved. The importance of osmosis has been generally recognized by physiologists since that time; but the part which it plays has been variously estimated (1827).

Hunter[8] believed with the older writers that the lacteals filled by suction from the alimentary canal, and that the general lymphatics filled by suction from the tissue spaces. As to the filling of the tissue spaces he recognized the possibility of a filtration through the walls of the blood-vessels (1835).

Johannes Müller[9] did not accept the mechanical theory (capillary attraction, etc.); but, observing that the lacteals did not absorb all solutions from intestines without respect to kind, conceived the idea of "selection," and believed that the formation of chyle was due to the "vital activity" of the living cells of the intestinal wall (1838).

We come now to the last half of the nineteenth century. Over two centuries of speculation guided by an occasional observation had passed since the lymphatics were discovered. Speculation had run the gamut of theories—filtration, capillary attraction, osmosis, vital activity. The physiologists of the period of physical, chemical, and microscopic research were to turn on the searchlight of modern science to solve the problem of lymph formation and movement.

Carl Ludwig[10] approached this problem in his characteristic way. He applied here the methods of the physical laboratory, testing through the mercury manometer the blood pressure, the venous pressure, and the lymph pressure, and, in consequence of his observation of high blood pressure and low lymph and venous pressure, maintained that the lymph resulted from filtration of plasma through the capillary walls. In 1861 Ludwig[11] summed up his theory of lymph formation through filtration and diffusion as follows:

"The blood which is contained in the vessels must always tend to equalize its pressure and its chemical constitution with those of the extravascular fluids, which are only separated from it by the porous blood-vessel walls. If, for example, the quantity of blood in the vessels has increased, the mean blood pressure is also increased, and at once a portion of the blood is driven out into the tissues by a mere process of filtration. The same result is brought about when the constitution of the blood is altered by the absorption of food or by increased excretion by the kidneys, blood, or skin, or when the composition of the tissue fluids is altered in consequence of increased metabolic changes taking place in the tissues. In the latter case the changes brought about in the lymph are effected by processes of diffusion."

Ludwig's theory was generally accepted by physiologists for about four decades. Little work was done during that time. The work done by Tomsa,[12] by Emminghaus and Paschutin,[13] and by Rogowicz[14] all led to results in harmony with the *filtration* theory of lymph formation.

Heidenhain[15] experimented upon the lymph flow from the thoracic duct and concluded that his observations were irreconcilable with the filtration theory, and that "we must assume that the cells forming the walls of the capillaries take an active part in lymph formation, *i.e.*, that the lymph must be looked upon as a *secretion* rather than as a transudation."

During the last decade of the century the whole field was carefully re-worked by many skilled observers. A question which had seemed to be settled was again opened by Heidenhain's work, and many new experiments were instituted to determine the parts played by physical and vital forces.

Valuable contributions were made by Cohnstein. Experiments to reproduce the physical relations of the blood and lymph circulations were tried.[16a] A tube of animal membrane, representing the blood-vessels, passed through an outer tube, representing the lymph spaces of tissue. The fluid in these two tubes was subjected to varying pressures with results that led the experimenter to conclude that the pressure within the inner tube (always much greater than that in the outer) was a more important factor than any variations of pressure in the surrounding liquid. On the whole, the author held to the filtration theory rather than to the secretion theory. Cohnstein[16b, c] showed that a considerable but variable time elapses after an intravenous injection of salt or sugar solution before the lymph is affected, and that simultaneous tests of blood and lymph may be misleading.

Researches made by Lazarus-Barlow,[17] by Bainbridge,[18] and by Moussu,[19] all resulted in conclusions favorable to the filtration theory of lymph formation.

In the mean time other experimenters got results which seemed to point to a secretory activity on the part of capillary walls. Hamburger[20] found in a horse under observation that there was an increased flow of lymph from the ductus colli, at the same time that there was decrease of both carotid and jugular blood pressure.

Tscherewkow[21] found no change in the amount of lymph which passed from the thoracic duct after hemorrhage, and concluded therefore that there is difficulty in affirming a direct relation between capillary pressure and lymph formation. Ostowsky[22] made tests of the efferent lymph stream from the testis after intravenous injections of salt, sugar, peptone, etc., and concluded that "lymph flow is practically independent of general blood pressure."

Popoff[23] made experiments on the intravenous injection of dextrose, varying the method of Heidenhain by injecting rapidly (one to two minutes) rather than slowly (thirty minutes), and found that the maximum amount of sugar in the blood was never less than that in the lymph; that the lymph flow from the thoracic duct was increased, but not in proportion to the amount of sugar injected; that the urine is also considerably increased, and that sugar is freely excreted through the urine.

Pugliese[24] investigated the formation of lymph in the fore leg of a dog, and found that venous stasis caused an increased flow of lymph, thus favoring the filtration theory. He found, further, that either active or passive movements of the leg increased the amount of lymph without changing its composition. About this time Asher,[25a, b] associated in a part of his work with Barbèra,[26] made some important contributions to the problem in question, and though he took a middle ground by declaring that "some of the facts discovered can be accounted for upon the physical basis (filtration and osmosis), and some upon the physiological (secretion)," he involved the problem still more by announcing a new factor, viz., *organic activity*. He presented a strong series of facts to show that whenever the activity of an organ is increased, the flow of lymph from that organ is also increased.

Thus during the period of active investigation of the subject of lymph formation a great mass of facts had been established, but the physiological world was still in doubt as to the relative importance of the various possible factors involved in the formation of lymph. The time had come for an analytical mind to take up the subject and bring order out of chaos. This analytical mind was furnished by Dr. E. H. Starling, of London. Starling made an important series of contributions to the literature of this question in 1894 and 1896,[27, 28] and in 1898 he made a masterly review of the whole problem, weighing in a most liberal and impartial manner the various contributions to the solution of the problem of lymph formation.

The early work was subject to criticism in that the experimenters had studied the flow of lymph from the leg and had been obliged to subject the tissues to massage in order to get a flow.

Tigerstedt[30] had first called attention to this difficulty with the early work. Heidenhain recognized the validity of this criticism and devised a new method to avoid it. He studied the flow from the thoracic duct, and assumed that this represented the lymph formation of practically the whole organism. Heidenhain's long investigation was based upon this apparently tenable conclusion, and, as stated above, led to results irreconcilable with the filtration theory.

Starling[29] showed that the flow from the thoracic duct does not represent the general lymph formation. The lymph flow from the anterior limbs, and head and neck, does not enter the thoracic duct, while that of the posterior is so small in amount that it need not be considered; furthermore, the amount which enters from the thorax is so slight that no difference is observed when the cannula is inserted just above the diaphragm instead of near the subclavian vein. It becomes apparent, then, that the flow of lymph from the thoracic duct represents the lymph formation in the abdominal viscera; and these may be further differentiated into two regions: (1) the portal, and (2) the hepatic; or the lacteal and the liver regions.

Starling next demonstrated that the lymph from the liver is most concentrated (*i.e.*, contains the largest proportion of solids), that from the portal region is next in its degree of concentration, while that from the limbs, head, and neck is least concentrated. He later showed that this varying degree of concentration consisted principally of a varying proportion of proteid, and that the variation of proteid depended upon the varying permeability of the capillaries in the three regions; the permeable liver capillaries allowing proteid to filter through so easily that it makes six to eight per cent. of the liver lymph; the less permeable capillaries of the portal region permitting only four to six per cent. to filter through; while the least permeable capillaries of the extremities permit only from two to four per cent of proteid to pass.

After a careful examination of Heidenhain's experiments on the flow of lymph from the thoracic duct, Starling concluded that, "the lymph production in the organs of the abdomen is directly proportional to the capillary pressure in these organs; and not independent of it as was imagined by Heidenhain."

The next step in the review of the controversy was to determine the influence of hydræmic plethora. It was found that this condition may be artificially produced in two ways: first, by injecting intravenously an isotonic solution of sodium chloride (normal saline solution) to the extent of from 300 to 500 c.c.; second, by injecting intravenously a condensed solution of sodium chloride or of dextrose, thus giving to the plasma a high endosmotic attraction for tissue lymph. The blood plasma promptly draws through the capillary wall the tissue lymph, thus draining the tissues and temporarily decreasing lymph flow and increasing intracapillary pressure. The natural reaction to this condition is a much increased filtration of plasma from the over-filled blood system (condition of hydræmic plethora) into the lymph spaces of the tissues, and this in turn is followed by an increased flow of lymph along the lymphatic vessels.

That the increased lymph flow is conditioned upon the hydræmic plethora and not upon the simple presence of the salt or sugar in the blood was demonstrated by Starling through simply withdrawing an amount of blood equal to the aqueous solution injected or to the tissue lymph drawn in by osmosis; the result being an increase of the salt (or sugar) without increasing the volume of blood. This procedure resulted in no increase in the flow of lymph, thus proving that it was the condition of hydræmic plethora, *i.e.*, of increased blood pressure, which caused the increased lymph flow, and not the presence of the increased quantity of salts (or sugar) in the blood.

These soluble, crystalline substances, salt, sugar, potassium chloride, etc., made Heidenhain's second class of lymphagogues. It is apparent that their lymphagogic effect was due to the increased capillary pressure which accompanied their use, and not to any specific stimulation which they exerted upon the secretory activity of the endothelial cells of the capillaries. In harmony with this opinion are the results of Timofejewsky.[31] But the increased blood pressure causes increased filtration; and thus it transpires that the observation which Heidenhain cited to show the untenability of Ludwig's hypothesis only made that hypothesis more secure when rightly interpreted.

Heidenhain's first class of lymphagogues (extracts of leech, mussel, and crayfish) cause a much increased flow of lymph; but Starling showed that they exert this effect through their toxic action upon the endothelial cells of the capillaries, thus making those cells less able to resist the intracapillary pressure, so that, with the latter normal or even decreased, there will be an increased flow of lymph.

Starling has been able to account for many previously unaccountable things and to reconcile the findings of Heidenhain and his associates with the physical theory. It will be remembered that this theory, as formulated by Ludwig in 1861, accounted for lymph formation on the basis of the combined action of filtration and osmosis. No clearer formulation of the present state of our knowledge of this question can be made than that made by Ludwig forty years ago.

5. The Relation of Lymph to Metabolism.—This relation was indicated, in general terms, under the definition of lymph. As stated above, the lymph is the medium through which every active cell gets its food and its oxygen; it is also the medium into which every cell throws out the waste matter resulting from its metabolism. When we say that lymph is formed by filtration from the blood and modified by osmosis with the blood, we cover the ground of the initial formation of lymph; we must, however, not forget that the lymph is being continually modified, during the time when it is within the several tissues and organs, by the metabolism peculiar to the respective tissues and organs. The blood plasma which filters into leg muscle, intestinal mucosa, and liver is essentially the same in each case, differing only in the respective proportions of proteid, conditioned upon the varying permeability of the capillary walls in these three localities. But the metabolism in these three regions is very different—different not only in respect to what the cells take out of the intercellular lymph, but different also in respect to what the cells throw out into this lymph.

The cells of the muscle will take up fat, dextrose, and proteid from the lymph and throw out various midproducts of proteid catabolism.

The cells of the intestinal mucosa will make no important drafts upon the lymph; they will, however, absorb great quantities of fat, associated with sodium carbonate (Setchenow [32]), and, according to Colin [33] and to Asher and Barbèra,[34] considerable quantities of proteid; and this fat and proteid will be poured into the lymph (chyle).

The cells of the liver will absorb from the lymph not only food and oxygen for their sustenance, but also large quantities of material which represents the midproducts of tissue metabolism. The liver is the great central laboratory of the body where urea, uric acid, bilirubin, and biliverdin are made; where dextrose is taken up from the portal system and changed to glycogen in which form it is stored. To accomplish this, great modifications will be made in both the blood and the lymph which traverse the liver. Of the two fluids the lymph suffers the more profound change.

It must not be forgotten that wherever blood and lymph are separated by a capillary wall osmotic action proceeds, and there will be a modification of both fluids with a tendency toward equalization. The circulation through the liver not being a rapid one, the diffusion of substances between blood and lymph will be considerable. Urea is thrown out into the lymph by the liver cells, and a small part is diffused into the blood. The rest, according to Wurtz,[35] amounting to about 0.016 per cent. of the lymph, makes its way along the thoracic duct, where it is all poured into the venous system and carried presently to the kidneys for excretion.

The lymph contains various substances whose presence and whose relation to metabolism are not understood. There are glycogen and a diastasic ferment,[36] and there is rennet,[37] besides various other substances in traces.[38, 39]

Ransom [40] found that when the toxin of tetanus was injected into the blood not more than one-third of it ever found its way into the lymph. Similarly when tetanous antitoxin is injected it is retained to the amount of two-thirds in the blood.

6. The Movement of Lymph.—Frequent mention has been made of the flow of the lymph. Let us now consider what it is that causes the lymph to flow.

Like the veins the lymphatics are thin-walled and provided with valves; like the veins the lymphatics are filled from the capillaries by force from the heart, the difference being that the heart forces the blood in a million of capillary streams into the veins, while it forces the plasma of the blood in many hundred million streams through the pores of the capillary wall into the lymphatics.

The initial and principal force which causes the lymph to flow is the *vis a tergo* from the heart, which pushes it on farther and farther from the tissue among whose cells it escaped from the capillary. As it moves forward it is gathered into the lymph radicles; these in turn are tributary to the smaller lymphatics. Once the lymph reaches a lymphatic there is no retreat because the valves block all backward flow.

The heart force alone would be sufficient to cause the lymph to flow throughout its system of vessels and back to the subclavian vein. There are two forces, however, which are of great importance in assisting this flow. These forces are the negative pressure of the thorax, and the positive pressure exerted upon the blood and lymph vessels by contracting muscles.

Every one is familiar with the influence of negative intrathoracic pressure upon the flow of blood in the veins. Its influence upon the flow of lymph is as important as that upon blood. These fluids are actually pumped into the thorax as water is lifted by a suction pump. Furthermore, the downward movement of the diaphragm makes positive pressure in the abdominal cavity at the same time that it makes negative pressure in the thorax. Thus there is exerted on the lymph in the abdomen both a *vis a tergo* and a *vis a fronte*.

Besides this force exerted by the respiratory movements there is a pressure upon the sides of veins, of lymphatics, and of arteries within contracting muscles. The arteries can by their thicker walls resist this lateral pressure, but the contents of the veins and lymphatics are forced forward—backward movement being made impossible through the closure of the valves.

Hewson [41] believed that lymph was kept moving in the lymphatics by peristaltic movements of the walls of the lymph vessels; but there is no reason to believe that any such movement takes place in any of the higher animals.

The rate of lymph filtration and flow has been investigated by Tschirwinsky.[42] By injecting salicylate of sodium into the blood or lymph stream the time required for it to appear at the upper end of the thoracic duct could be accurately determined. With this method he was able to show: (1) that it required from four to seven minutes to pass from the descending aorta to the thoracic duct; (2) that it required from two minutes ten seconds to three minutes to pass from the femoral artery to the pedal lymphatic; (3) that it required one minute twenty seconds to flow from the pedal lymphatic to the thoracic duct; (4) that it required from thirty seconds to one minute to filter through the tissues.

The flow of lymph seems to be without direct nervous control, though Spallitta and Consiglio,[43] by inducing high pressure in the thoracic duct, observed an increase of blood pressure, and slower, stronger heart beat, which suggested a reflex response to change in the lymph pressure. This points to the probable presence of afferent nerves from the larger lymphatics to the cardiac centres in the medulla.

Winfield S. Hall.

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LYMPHANGIECTASIS.—It might with propriety be expected, from the analogous process in the blood-vessels, that dilatation distal to the obstruction of the lymph vessels would occur with equal regularity. Such a sequence is a common event with interference of the venous current. In the lymph vessels dilatation rarely takes place from simple hindrance to the circulation, and it is quite universally agreed that the anastomoses in this set of vessels are so abundant that a collateral circulation is readily and speedily established after blocking of one of the branches.

Interferences of the circulation in the larger branches, however, may result in disturbances that attract attention; they may be of a transitory nature like the œdema of the arm that surgeons become familiar with, following dissection and removal of the lymph glands of the axilla in cases of carcinoma of the mammary gland; or the symptoms may be of a persistent and serious character, as it is, for example, in the chylous ascites that occurs from obstruction of the thoracic duct. The adult forms of filaria are said to lodge in the larger lymph and chyle passages and cause, among other symptoms, the appearance of chyle in the urine.

Dilatation of the finer branches of the chyle-carrying vessels is readily detected in the lining of the small intestine, during the gross examination, by the fine tracery of whitish or silver-like anastomosing lines and small flat retention cysts with rounded margins, that yield a milky fluid when broken or sectioned; all are very superficially located in the mucosa and are not removable by a stream of running water.

To consider dilatation of the lymph vessels apart from its chief and most important result, elephantiasis, leads naturally to recording unusual and rare conditions of much less importance. Not all accidents, operations, and pathological conditions that interfere with the circulation in the lymph vessels are followed by elephantiasis; in fact, such a sequel is uncommon. Yet when it does occur, it is quite generally ascribed to obstruction of the lymph channels. On the other hand, the clinical history of many cases of elephantiasis denotes an infection that is often unconnected with operations or other mechanical factors which would interfere with the return flow of the lymph. In these cases repeated attacks characterized by chills that are followed by fever, with swelling, itching, and redness of the growing part, have led to the employment of such terms as "recurrent erysipelatous lymphangitis," "erysipèle à répétition," etc.

It does not seem out of place to question the occurrence of elephantiasis without a primary infection, as well as the rôle in its etiology played by obstruction of the lymph channels; at least the extent to which these factors operate, singly or together, is worthy of consideration and investigation. It is not unlikely that the obstruction is secondary to the infection in many cases and that the recurring cellulitis is to a large degree responsible for the hyperplasia of tissue constituting the main element in these singular cases. In other instances the infection occurs following operations which interrupt the continuity of the lymph channels.

Hamann has observed cases of elephantiasis following extirpation of the inguinal lymph glands. One case described in detail occurred in a woman from whom the glands were removed during the dissection of the sac in a femoral hernia. Six weeks after the operation and three after her recovery, chills and fever accompanied by swelling and redness of the labium majus on the same side occurred, and during the following four months seven or eight similar attacks were experienced. During each attack an increasing brawny induration of the labium took place. The diagnosis was made of lymphangitis accompanied by lymphatic œdema due to interference with the flow of lymph, produced by removal of the fat and lymph glands and the succeeding cicatricial contraction. Hamann was at a loss to account for the absence of suppuration. There is small room for doubt that in cases of this kind infection, added to the interruption of the lymph current, brings about the hyperplasia of the subcutaneous tissues, constituting elephantiasis. Other operators have had similar undesirable consequences following removal of the lymph glands and have abandoned extirpation for incision and curettage.

Other cases of elephantiasis with recurring symptoms denoting infection, with each of which there is a progressive enlargement of the affected region not unlike erysipelas, are entirely unassociated with operative procedures. If obstruction to the lymph currents are present in such cases, it may be that they occur early in the course of the lymphangitis. In some of these cases papular eruptions accompanied by an intense pruritus are noticed early.

Whether a cause or a result, lymphangiectasis is a constant feature of true elephantiasis. The enlarged lymph vessels are noticeable in all regions from just below the epithelium—on microscopic examination—to deep within the hyperplastic corium and subcutaneous tissues; they contain no red blood corpuscles, but are found adjacent to the arteries and veins. The arteries are frequently the seat of an endarteritis, obliterative in character, and around all the vessels collections of the so-called round cells—many of which are plasma cells—occur. Dilated lymph vessels are not especially numerous and the structure of the tissue is usually dense fibrous tissue.

There is a very close connection between lymphangiectasis and certain forms of lymphangioma. The definition given by Senn for a lymphangioma is "a tumor composed of lymphatic vessels produced from a matrix of angioblasts." He construes the vessels as newly formed. The proliferation of lymph vessels as a result of inflammation or of even mechanical obstruction of the current must be looked upon as a process of regeneration. The lymphangiomata of the neck, which are usually cystic and congenital, occur in the region of the large lymph channels and are believed to arise from congenital anomalies in them. The lymph collects in them because they are disconnected from the proximal vessels and lymphangiectasis may be said to be present. If, however, proliferative processes are found, as, for example, were present in a case described by Tilger, the lesions are by many authors counted as tumors. It might be possible to consider these proliferative processes, consisting usually of a multiplication of the endothelium, as regenerative in nature, but abortive.

In Wegner's classification of the lymphangiomata, the tumors of one group are said to have their origin in obliteration of efferent lymph vessels through compression, inflammation, or congenital anomalies. Such forms of