tubes 1 c.c. of the incubated culture obtained in 3, and keep in the dark at room temperature.

B. coli coagulates milk in from one to three days. Other forms usually take more time.

6. If inoculations from the colonies obtained in 4 be examined as "hanging-drop" cultures, the bacilli will be found to be motile if they be *B. coli*. This motility may be manifested, however, by only a portion of the bacilli present in the field, and its intensity will be far less than that shown by the typhoid bacillus.

7. Add 25 c.c. of the water to a flask of "nitrate solution" and place in the incubator for three days. Test the contents of the flask at the end of that time for "nitrite."

B. coli reduces the nitrate to nitrite.

A moment can be properly spent here upon the often broached topic of the recognition of the typhoid germ in water, and also a word added with reference to the diagnostic value of the demonstration of the presence of *Bacillus coli communis*.

Laws and Andrewes, in their report to the London County Council, show that the chance of discovering *B. typhosus* in sewage is exceedingly small. They entirely failed to find it in London sewage. Finally, they examined the sewage flowing (without disinfection) from the Eastern Hospital at Homeston, which same received the dejections of forty typhoid patients. Out of a whole series of samples examined from this latter source, only two colonies of *B. typhosus* were differentiated with certainty.

A similar experience has been recorded by practically all the recent observers, and consequently search for the typhoid germ in water is becoming very unusual.

The present position of this question is tersely summed up by Dr. W. H. Welch, of Johns Hopkins University: "The most which can be expected is the determination, not of the actual presence of the typhoid bacillus, but of the possibility or probability of its presence. Our principal guide at present in drawing conclusions as to the possible presence of the typhoid bacillus in suspected drinking-water is the recognition of fæcal bacteria, and more particularly of members of the colon group."

With regard to the diagnostic value of the colon group as supplying the much-needed "index of fæcal pollution," it must be stated that the group is widely distributed, and is often found in waters that a "sanitary survey" would unquestionably pronounce pure; but it cannot be denied that its persistent presence in large numbers is an indication of pollution that must not be overlooked; and, moreover, the proof of its absence serves materially to aid in formulating an opinion concerning the purity of a water.

It is, of course, possible to proceed much further than has been here outlined in the bacteriological examination of water, but for routine work it is doubtful if it pays to go beyond the tests already given. Moreover, it should be said that to make such tests of real value, they should be comparative in character; and the interpretation of results should be based upon data furnished by closely related local standards.

"Microscopical" examination of water has for its object the study of such suspended material, whether organized or not, as may be examined directly without the intervention of the "culture" methods required for bacteria. Plants and animals, dead or alive, amorphous organic material and inorganic particles of all kinds, are classified and their numbers estimated by this form of investigation. It is of especial value in determining the cause of those disagreeable odors and tastes which occur in stored water from the abundant growth of certain small aquatic plants. Concentration of the water sample is, of course, necessary in order to make a proper examination possible, and this end is accomplished by a modification of the original Sedgwick-Rafter apparatus.

This is a glass cylinder two inches in diameter, terminating in a conical base. The small cylindrical prolongation of the cone's apex is two and one-half inches long and one-half inch in diameter. A perforated rubber stopper, with its hole covered by a disc of fine bolting-cloth, is fitted to the smaller end of the funnel and about three-fourths inch of carefully screened fine sand (between eighty and one hundred mesh) is poured into the narrow tube and wet down with distilled water. From 250 to 500 c.c. of the water under examination are now permitted to filter through the sand. After the water has run through, the sand with the material strained off by it is washed into a test tube by 5 c.c. of distilled water delivered from a pipette. The organisms, sinking in the test tube much more slowly than the sand grains, may be decanted, with the water in which they float, into a second test tube. From this decanted portion, after agitation, 1 c.c. is delivered by a pipette to a covered "counting cell," which it completely fills. The objects discovered in this counting cell will, if multiplied by five, give the total number originally existing in the entire volume of water filtered.

It is manifestly impossible, in an article such as this, to dwell at length upon the very extensive subject of microscopic examination; therefore for purposes of general differentiation recourse must be had to the writings of biologists who have made such work a specialty.

William P. Mason.

WATER-GAS, POISONING BY.—Water gas is a mixture of carbon monoxide and hydrogen with some nitrogen and carbon dioxide, obtained by the action of steam on highly heated carbon (*e.g.*, coke or anthracite). It is nearly odorless and burns with non-luminous flame. For use as an illuminant, it is enriched; that is, charged with hydrocarbons from petroleum or bituminous coal. In this form it has come into extensive use. Owing to the highly poisonous character of carbon monoxide as compared with the hydrocarbons that form the bulk of the older "coal gas," a great increase in fatalities from the inhalation of illuminating gas has been noticed in the mortality statistics of late years. The characteristic effect of carbon monoxide is its affinity for hæmoglobin, with which it forms a compound that cannot be broken up by free oxygen. Hence, even a small amount of carbon monoxide in the inspired air will cause a steady accumulation of the toxic material until so much of the hæmoglobin is rendered inactive that death results from a chemical asphyxia. The symptoms are marked muscular weakness, rapid pulse, flushed face, and a strong tendency to sleep. The blood becomes abnormally red, the breathing becomes stertorous, and the patient dies from failure of respiration. If the patient be rescued before the condition is far advanced, the return to consciousness is slow, even under treatment, and a fatal result from brain disease may yet occur. In advanced cases, red spots are noted on the skin. The blood putrefies much more slowly than normal blood. The fatal period is somewhat uncertain, but may be several hours. The treatment is not satisfactory. Artificial respiration does little good. Inhalation of oxygen under pressure has been proposed, but this method does not promise much. Transfusion of blood has been successful in experiments on animals. Good results have been claimed for the administration, by the stomach and hypodermically, of hydrogen dioxide, but this seems doubtful. Hot applications should be used to restore normal temperature. The bright redness and slow putrefaction of the blood are important post-mortem data. Several chemical tests have been proposed, but they are not very satisfactory in actual practice, as ordinary illuminating gas contains several active substances.

Henry Leffmann.

WATSON'S SPRINGS.—Greene County, Georgia.

Post-Office.—Maxey's boarding-houses and cottages.

These springs are located eleven miles north of Greensboro, on the Georgia Railroad, and eight miles west of Maxey's Depot, on the Athens branch of the Georgia Railroad. The group is one-quarter of a mile from the Oconee River, which will be navigable at this point when the government works on the river are completed.

The springs are reached by private conveyance from the points above mentioned. The scenery in the neighborhood of the springs is varied and the climate delightful, the temperature rarely falling below the freezing point in winter or rising above 90° F. in summer (95° F. is the highest temperature known). The springs are four in number, viz.: the "Sulphur" Spring, the "Chalybeate," the "Alum," and the "Ice" Spring. The following partial analysis of two of the springs was made some years ago by Dr. J. R. Duggan:

The Sulphur Spring contains calcium carbonate, potassium carbonate, iron carbonate, potassium sulphate, sodium sulphate, sodium chloride, silicic acid, hydrogen sulphide gas, and carbonic acid gas. The temperature of the water is 59° F.

The Chalybeate Spring contains iron carbonate, magnesium carbonate, sodium chloride, potassium sulphate, calcium sulphate, and silica. The temperature of the water is 61° F.

The "Ice" spring has not been analyzed, but its waters are delightfully cold and refreshing and palatable at all times. The sulphur and chalybeate springs yield about one gallon of water per minute. Their waters are stated to be highly efficacious in rheumatism and dyspepsia, and in renal, cutaneous, and blood diseases.

James K. Crook.

WAUKESHA MINERAL SPRINGS.—Waukesha County, Wisconsin.

Post-Office.—Waukesha. Hotels and boarding-houses.

Access.—Viâ Chicago and Northwestern, Chicago, Milwaukee, and St. Paul, and Wisconsin Central Railroad. An electric line is also being built from Milwaukee.

Waukesha, the county seat of Waukesha County, is located sixteen miles west of Milwaukee, and ninety-eight miles northwest of Chicago. The elevation here is about 800 feet above tide-water. The surrounding country is of a rolling character, well wooded and has a sandy, gravelly soil. The natural advantages of the place have made it a general society centre of the Northwest during the summer season. The usual population, of about sixty-four hundred, is increased during the hot months to more than ten thousand. In the year 1895 there were one hundred and forty-three clear days, one hundred and thirty partially cloudy, and ninety-two cloudy days. The summer weather is usually of a delightful character, and quite free from days of oppressive heat. The average annual rainfall from 1892 to 1895, inclusive, was 28.02 inches. The village contains eleven hotels and more than forty boarding-houses. In addition, the houses of private citizens are often thrown open to visitors. Among the best-known hotels are the Fountain Spring House, which accommodates 800 guests, the Park, 300; the Spring City, 250; National, 150; Terrace, 100, etc. Most of the hotels maintain bands during the season. Open-air public concerts are also given morning and evening. There is one theatre in the place besides two public halls. The Fox River runs through Waukesha, and is large enough for row boats. This is a region of lakes, there being no less than thirty-six in Waukesha County, the most remote being only eighteen miles distant. The lakes are surrounded by hotels and cottages, and during the summer they constitute a vast picnic ground. The prime attraction of Waukesha, however, is found in the great group of mineral springs located here. The waters of these springs are chiefly alkaline, chalybeate, and calcic. They have become known throughout the United States. Following are analyses of some of the most important:

One United States Gallon Contains:

Solids.	Bethesda. C. F. Chandler. Grains.	Clysmic. 1. Rathbone. Grains.	Clysmic. 2. R. O. Doremus. Grains.	Clysmic. 3. R. O. Doremus. Grains.	Fountain. Blaney. Grains.	Hygeia. A. Thiel. Grains.	Silurian. W. S. Haines. Grains.	Vesta. G. Bode. Grains.
Sodium bicarbonate	1.26	1.26	4.31	0.80	1.02	2.36	0.30	0.41
Calcium carbonate	....	....	....	....	....	....	9.93	
Calcium bicarbonate	17.02	16.04	16.15	15.90	13.78	16.73	....	13.43
Magnesium carbonate	....	....	....	....	....	....	6.83	
Magnesium bicarbonate	12.39	13.56	9.22	8.54	9.20	13.14	....	10.74
Iron carbonate	....	....	....	....	....	....	.13	
Iron bicarbonate	.04	.04	.57	.69	.05	.58	....	.05
Iron phosphate	....	....	....	....	....	....	Trace	
Sodium sulphate	.54	.56	.69	1.08	.36	.52	.29	.55
Manganese phosphate	....	....	....	....	....	....	Trace	
Potassium sulphate	.46	.46	.50	.20	....	.82		
Sodium phosphate	....	.03	.43	.45	....	.04		
Sodium chloride	1.16	1.17	.35	.55	Trace	1.25	.19	0.30
Aluminum oxide	.12	Trace	....	....	.09	.72	.59	.13
Alumina	....	....	Trace	Trace	....			
Silica	.74	.72	.80	.81	.85	.15	.70	.85
Organic matter	1.98	1.62	Trace	Trace	.31	Trace	Trace	
Total	35.71	35.46	33.02	29.02	25.36	36.21	18.69	26.46

Other well-known springs at Waukesha are the "White Rock," "Glen," "Horeb," "Gibson," "Siloam," "Mineral Rock," and "Vitaqua." It will be observed that the principal ingredients of all these waters is the bicarbonate of magnesium. Their action in the system is antacid, mildly laxative after continuous use, and diuretic. They have a useful application in dyspepsia, abdominal engorgement, Bright's disease, diabetes, and bladder troubles. Some of them are excellently adapted for table use.

James K. Crook.

WAX; BEESWAX.—(*Cera Flava*, U. S. P., B. P., P. G.); A peculiar, concrete substance, prepared by *Apis mellifica* L. (Ord. *Hymenoptera*).

Wax is an animal product secreted by bees under the rings of the abdomen, where it accumulates, when the insects are comb-making, in scales or flakes. These flakes are disengaged by the bees, and, with jaws and legs, moulded into that remarkable structure, the honeycomb. It appears to be an analogue of the sebaceous secretion of the skin. The wax is obtained by depriving the comb of its honey by draining and pressing, and is purified by melting one or more times in boiling water and cooling. It is then melted and cast in large solid cakes.

Wax is too familiar to need description, were it not for its very frequent adulteration, which unfortunately is not always easily detected. The Pharmacopœial description and tests are as follows: "A yellowish or brownish-yellow solid, having an agreeable, honey-like odor, and a faint, balsamic taste. It is brittle when cold, but becomes plastic by the heat of the hand. It melts at 63°–64° C. (145.4°–147.2° F.), and congeals with a smooth and level surface. Specific gravity, 0.955–0.967. It is insoluble in water, but soluble in 35 parts of ether and in 11 parts of chloroform; also soluble in the oil of turpentine and in fixed or volatile oils. Cold alcohol dissolves it only partly, but it is almost completely soluble in boiling alcohol." Boiled with a solution of soda, wax does not saponify like the fats and resins, and their mixture with wax can be detected in this way; if the liquid so boiled, after the wax has been separated by cooling, remains turbid, or gives a precipitate when acidulated with hydrochloric acid, fat, resin, soap, or something of that kind is present. "If 5 gm. of wax be heated, in a flask for fifteen minutes, with 25 gm. of sulphuric acid, to 160° C. (320° F.), and the mixture diluted with water, no solid, wax-like body should separate (absence of paraffin)."

The composition of wax is: *Cerin*, an ether of cerotic acid and ceryl alcohol, $\left.\begin{matrix}C_{27}H_{53}O\\C_{27}H_{55}\end{matrix}\right\}O$, ten per cent.; and *myricin*, an ether of palmitic acid and myricyl alcohol, $\left.\begin{matrix}C_{16}H_{31}O\\C_{30}H_{61}\end{matrix}\right\}O$, ninety per cent. ("Encyclopædia Britannica"), together with traces of coloring and aromatic substances. White wax (*Cera Alba*, U. S. P.) is yellow wax bleached, usually by being cut into thin ribbons or shreds and exposed for a few weeks to the atmosphere and sunlight, being also frequently watered. It may also be bleached by the less desirable method of treatment with the oil of turpentine or some chlorine solution. It is a yellowish-white solid, somewhat translucent in thin layers, having a slightly rancid odor and an insipid taste, answering otherwise nearly to the description and tests given above.

Action and Uses.—Wax is insoluble in the body, and therefore exerts only a mechanical action upon it. Its use internally is entirely obsolete. Formerly it was occasionally recommended for diarrhœa or dysentery, and later, as a pill-coating. Its plasticity and very great permanence make it useful as a temporary tooth-filling where the cavities are tender and away from the grinding surfaces. Its principal employment in medicine, however, is as a component of cerates (which derive their name from it), plasters, and ointments, to which it gives durability and consistence. It is perfectly unirritating.

The most important uses of wax are ceremonial and domestic—candles and mechanical moulding and modelling.

Allied Substances.—Chinese wax, secreted by Coccus ceriferus upon a Chinese ash; a hard, translucent, spermaceti-like substance; Japanese, from the surface of the fruits of several species of Rhus; bayberry wax and several other vegetable products. See also *Spermaceti*.

W. P. Bolles.

WAXY DEGENERATION. See *Amyloid*, and *Necrosis*.

WEIGHTS AND MEASURES.—Balances and measures of capacity are brought into constant use in chemistry, pharmacy, and medicine. Means for the accurate determination of values are indispensable to science, industry, and commerce, and the development of scientific metrology is a concomitant of advancing civilization.

Old Weights and Measures.—The expressions used in ancient writings to indicate size, or quantity, the oldest units of measure, and the origin of decimal arithmetic, all have reference to the human body and its members. Bulk was measured by armfuls, handfuls, pinches; linear measure was expressed in such terms as "the height of a man," the fathom, stride, forearm (cubit), foot, hand, palm, finger, thumb, nail; the oldest expressions of weight had reference to loads or burdens; and decimal arithmetic had its origin in the number of fingers on the human hand. Seeds were later used as standards of comparison for the determination of weight, and also for linear measure; the "karat" and the "grain" originated in this manner. When coins were introduced they were frequently employed as weights, and the intimate relations which weights and coins sustained to each other are shown by the use of the same words to designate units of weight and monetary units, as "drachma," "livre," "pound," "mark," etc.

Commercial intercourse between different countries helped to spread the various weights, measures, and money from one country to another; but in the absence of proper governmental regulation, and in consequence of national prejudices and conflicting interests, the systems and units suffered changes which created confusion. The same, or very similar, names were given to units of differing values, and different methods of subdivision increased the diversity. This chaotic condition of the weights and measures of the civilized world is sufficiently shown in the following tables:

Pounds and Grains Used at Various Times in Different Countries.

Country or locality.	Value of the pound in grams.	Number of grains in each pound.	Value of the grain in grams.
France ("livre métrique")	500.0	9,216	0.054
Germany ("zollpfund")[1]	500.0		
France ("livre poids de marc")	489.5		
England and the United States (avoirdupois pound)	453.59	7,000	.065−
Sweden[2]	425.0		
Austria	420.0	5,760	.073+
Netherlands and Switzerland	375.0	5,760	.065+
England and the United States (troy pound and apothecary's pound)	373.24+	5,760	.065−
Amsterdam	371.0		
Bavaria and Greece	360.0	5,760	.063−
Poland	358.5		
Russia	358.3	5,760	.062+
Norway	357.85−	5,760	.062+
"Nüremberg Pound"[3]	357.664−	5,760	.062+
Sweden	356.25−	5,760	.061−
Prussia	350.8−	5,760	.061−
Spain	345.1	6,912	.050−
Portugal and Brazil	344.25		
Tuscany	339.5	6,912	.049+
Papal States	339.7		
Turin	322.0	6,912	.048+
Naples and Sicily	320.8	7,200	.045−
Sardinia	307.4	5,760	.053+
Venice	301.2	5,760	.052+
Mons	279.0		
Baden	214.25		

[1] Subdivided into 30,000 "korn."
[2] Subdivided into 10,000 "korn."
[3] Officially recognized by many pharmacopœias, among which were those of Nüremberg, Finland, Hamburg, Schleswig-Holstein, Russia (military pharmacopœia of 1840), Baden, Hanover, Hesse, Bremen, Lübeck, Nassau, etc.

The ounces, drachms, and scruples, of course, varied as much. The pound was generally subdivided into 12 ounces; but sometimes into 16; the ounce into 8 drachms, but one of them into 16; the scruple into 20 grains, but sometimes into 24.

Varying Value of the Foot.

	Value in millimetres.
Hesse (the Grand Duchy)	250
Saxony	283
Frankfurt a. M.	284
Brunswick	285
Würtemberg and Hamburg	286
Hesse (Kur-Hessen)	287
Bavaria	291
Hanover	292
Sweden	297
Baden	300
England	305
Prussia (Rheinish)	313
Norway	314
Austria	316
Paris	324

In England alone there have been four different kinds of gallons, quarts, and pints.

Legislation relating to weights and measures aimed to fix the values of existing units so as to prevent variation

but not to establish new systems in accordance with recognized scientific principles, nor to secure any degree of international agreement. The following examples of early English laws will indicate their character: "An English penny, called a sterling, round, and without clipping, shall weigh thirty-two wheat corns from the midst of the ear, and twenty pence shall make an ounce, and twelve ounces one pound, and eight pounds do make a gallon of wine, and eight gallons of wine do make a London bushel, which is the eighth part of a quarter." (King Henry III., A.D. 1266.)

"Three barley corns, round and dry, shall make an inch, and twelve inches a foot." (Edward III., A.D. 1324.)

"We will and establish that one weight, one measure, and one yard be throughout the land, and that woollens and all manner of avoirdupois be weighed." (Edward III., A.D. 1353.)

Principles of Metrology.—All values, of whatever kind, are expressed by comparison with known standards. Matter may be measured, as to its amount, either by its weight or by its volume. Convenience and the desired degree of accuracy determine the choice of method. As by matter we understand the weighable, without regard to space, it follows that a given amount by weight of any substance is a constant quantity without regard to its volume; but a given volume of matter is a variable amount, because the mass occupies more or less space according to its density, temperature, and the pressure to which it is subject. Extension is, however, much more readily and strikingly perceptible to our physical senses than weight, and we can, moreover, think of space as well as of distance without regard to matter; while the idea of weight is inseparable from matter as well as space. Hence a rational system of weights, measures, and money ought to rest upon some fixed unit of linear measure as its basis.

Whatever may be the natural basis of the primary unit of linear measure, if the weights and measures have such a basis, all of the scales and measures used to measure linear extension, and all volume measures and weights must be derived from, or standardized by, comparison with actual *prototype standards*. The British weights and measures do not rest upon any physical constant, but upon the prototype yard and the prototype pound weights. The metric system, however, rests theoretically upon the length of the meridian, and practically upon the platinum rod which represents the theoretical metre, and upon the platinum weight which represents the theoretical kilogram. Distinction must be made between theoretical and actual standards. While the theoretical metre is the forty-millionth part of the length of the meridian, the actual metre, made of platinum, may not be absolutely one theoretical metre in length. The theoretical litre is the cube upon the tenth part of the metre, but the actual litre measure used in practical work may vary from it. The theoretical kilogram is the weight, *in vacuo*, of one cubic decimetre of pure water at 4° C., but the actual (prototype) platinum kilogram, made to represent that weight, may not be true. It will be easily understood, then, that the material standards or models are the real standards; that it is of the utmost importance that a sufficient number of perfect copies of these prototype standards be carefully preserved in different places: but that a knowledge of the exact relation of these prototypes to any geographical constant is of no consequence.

After fixed standards of linear measure have been adopted, the units for the expression of surface measures are furnished by the squares upon the linear units, and measures of capacity or bulk are derived from their cubes. Thus the unit of land measure of the metric system is the square of ten metres, called an ARE; the unit for measuring large bulks of dry substances is the cubic metre, called a STÈRE, and the unit of liquid and dry measure used for less bulky commodities, is the cube upon the tenth part of the metre, called a LITRE. Next in order comes the unit of weight, which is derived from the mass of a given volume of water, under such conditions as are most favorable to exact determinations.

Water has been chosen as the medium by which weight and volume are compared, and its density as the standard unit for the expression of specific weight, because it is universally present, easily obtainable in a pure state, and offers the most favorable conditions for conveniently and accurately determining the relations between its weight and its volume. In the construction of the metric system, therefore, the weight unit is derived from the weight, *in vacuo*, of one litre of pure water at its maximum density (the theoretical kilogram), which is represented by the prototype standard weight of platinum (the actual kilogram of the French Archives). The one-thousandth part of this mass, called a GRAM, is the principal weight-unit of the metric system. The monetary unit of the French, and of several other nations, represents the value of 5 gm. of silver of legal standard fineness, and thus the whole chain of standard units of measures, weights, and money is completed, and all of these units bear simple reciprocal relations.

A perfect system of metrology must also present units of such value as will best subserve the practical requirements of science, commerce, arts, and manufactures, and it should be in harmony with the arithmetical notation in use.

How far the metrological systems now in use accord with these simple principles, may be readily discovered by even a superficial examination.

Arithmetic and Metrology.—The intimate relation of metrology to our arithmetical notation commands universal recognition. Whatever may be the periodical number of our arithmetical notation, that number should also be the periodical number governing the subdivision of the larger metrological units into the next lower. So long as whole numbers are expressed in units, tens, hundreds, and thousands, so must ten, or a hundred, or a thousand of the principal units of weight and measure make the higher secondary units, and the tenth parts, hundredth parts, and thousandth parts must furnish the lower secondary units, because this conformity reduces the labor of computations to its minimum. The main reason, then, why the metric system has become universally adopted for scientific purposes is that it agrees with our arithmetic; and many efforts have been made to impart a decimal character to old systems.

Whether or not the periodical number of our arithmetical notation is the most natural, simple, and useful is, however, questioned. It is admittedly derived from the fact that man has ten fingers, and that in its early childhood the human race needed and made use of this aid in counting, until finally the habit of counting upon the fingers and repeating that count, or counting by tens, became so rooted that it was made the basis of our arithmetical notation. But decimal arithmetic has nothing to recommend it except that it is in universal use. The fact that no other system is at all employed would, however, render a change extremely difficult, no matter how clearly it may be shown that some other system would be so far superior as to be well worth the great labor probably involved in its introduction. The most natural and convenient arithmetical processes are surely those in harmony with the constitution of man's mind, without regard to his fingers and toes. The most simple subdivision and method of counting is by twos, and although education and habit have for several centuries trained mankind in the use of a decimal arithmetical system, the question still continues to force itself upon our attention: Is not any arithmetic unnatural which is based upon a periodical number indivisible by both 3 and 4, and comprehending neither the square nor the cube of any number? Of course, the periodical number must not be too large nor too small, and we have found 10 to be manageable; two other numbers have been suggested as more simple and effective than 10, namely 8 and 12. The number 10 will be readily regarded as more suitable than 7, 11, or 13; but 8 and 12 are each as clearly superior to 10, as the periodical numbers of arithmetical notation as well as of weights, measures, and money. Notwithstanding the universal inclination of the untutored human mind to count upon the fingers and toes, and despite the universality of the decimal system of numeration as the result of that primitive instinct, mankind did not adopt decimal division and multiplication in regard to measurements of length, surface, volume, weight, money, or time; but the subdivisions and multiples adopted were by 2, 4, 8, 16, and 32, and by 3, 12, 24, and 60.

The number 12 has been recommended as a periodical number, because it is evenly divisible by 2, 3, 4, and 6; and 8 has been proposed, because, without being either too small or too large, it is the cube of 2, which is the smallest number above the unit; one-half of 8 is the square of 2, and three successive divisions by 2 gives 1 as the last quotient.

Octonary notation would, of course, be quite as easy as decimal notation, and more natural. It would require but eight figures including the cypher; two figures would be used to write eight, and three figures to write eight times eight, etc., and we would have an octonal point instead of the decimal point.

To show the most common subdivisions of weights and measures, the following will suffice:

Distance Measure: 1 mile = 8 furlongs. 1 furlong = 40 rods. But furlongs and rods are not so often mentioned as "half miles," "quarter miles," eighths of a mile, etc.

For shorter linear measures we find: 1 yard = 3 feet. 1 foot = 12 inches.

The yard is used most frequently in measuring cloth, but no one uses such expressions as "a yard and one foot or "a yard and one foot and six inches"; we would instead say "a yard and a third," or "a yard and a half." Halves, quarters, and eighths of a yard are more commonly referred to than any other fractions when the measure need not or cannot be exact, notwithstanding the subdivision of the yard into three feet or thirty-six inches. But the yard was derived from the length of the arm of King Henry I., in 1101; and it was divided into three feet, because the third of it was not very far from the length of a man's foot; and the subdivision of the foot into twelve inches was continued, because one-thirty-sixth of the yard was about the length of a man's thumb from the end to the first joint. In other words, these units were adopted for the sake of preserving the use of the valuable object lessons afforded by the members of the body, rather than to insure the most convenient and valuable mathematical results. Inches are subdivided into halves, fourths, eighths, sixteenths, and thirty-seconds, more frequently and naturally than into tenths. And yet the foot has, in some countries, been subdivided into ten inches instead of twelve, and each inch into ten lines instead of twelve, in obedience to the demand that the metrological subdivisions shall agree with the arithmetic.

Land Measure.

1 square mile = 640 acres.
1 acre = 4 roods.

But we speak commonly of half acres and quarter acres, and not of roods.

Volume Measure.

1 bushel	= 4 pecks or 8 gallons.
1 peck	= 2 gallons or 8 quarts.
1 gallon	= 4 quarts or 8 pints.
1 quart	= 2 pints or 8 gills.
1 pint	= 4 gills or 16 fluidounces.
1 gill	= 4 fluidounces or 32 fluidrachms.
1 fluidounce	= 8 fluidrachms.
1 fluidrachm	= 60 minims.

In these subdivisions there was nothing to prevent the consistent application of the natural inclination to divide the larger units into two, four, eight, sixteen, or thirty-two parts, until the fluidrachm was reached; but the fluidrachm was subdivided into sixty minims, because it was desired to make the subdivisions of the fluidounce, which was used only by physicians and apothecaries, parallel with the subdivisions of the ounce.

In the imperial pint there are twenty fluidounces instead of sixteen, as the unavoidable result of making the avoirdupois ounce commensurate with the fluidounce, while the gallon was made to represent the volume of ten pounds of water.

Avoirdupois Weight.

1 pound = 16 ounces.
1 ounce = 16 drachms or 437½ grains.

But the awkward subdivision of the ounce into 437.5 grains was simply the direct result of combining portions of two different systems, and avoirdupois weight did not originally include any smaller unit than the drachm. We no longer make use of the avoirdupois drachm, but do make use of halves, quarters, and eighths of the avoirdupois ounce, having weights of these denominations among the sets in common use in our shops.

Troy Weight.

1 pound	= 12 ounces, or 240 pennyweights.
1 ounce	= 20 pennyweights or 480 grains.
1 pennyweight	= 24 grains.

Old Medicinal Weights.

1 pound	= 12 ounces.
1 ounce	= 8 drachms or 24 scruples.
1 drachm	= 3 scruples or 60 grains.
1 scruple	= 20 grains.

Sometimes the scruple contained twenty-four grains.

From the above examples it will be seen that two principal considerations have determined the subdivision of the larger into smaller units, namely: (1) Capacity for continued integral bisection down to unit; and (2) divisibility by a variety of aliquot parts.

The Romans divided their acre, their foot, and their pound, each into twelfths (*unciæ*, from which our "ounce" and "inch"); the signs of the Zodiac, the division of the year into twelve months, and of the day into twelve hours, and the use of the "dozen" and the "gross" also show that the number twelve has, next to eight, been a favorite periodical number. The number sixty has also been much used, because divisible into a great variety of aliquot parts. In the division of the earth's longitude and latitude, and in the division of time, the number sixty has been found valuable.

But we find no subdivisions by ten in the old methods of dividing measures, weights, time, or money.

The following table forcibly illustrates the natural tendency to binary and quarternary subdivision, and at the same time the redundance of units, which is a common fault in the several systems of weights, measures, and money.

In Baden the weights at one time used were:

4 richttheilen	= 1 gränchen.
4 gränchen	= 1 gran.
4 granen	= 1 karat.
4 karate	= 1 pfennig.
4 pfennig	= 1 quentchen.
4 quentchen	= 1 loth.
2 lothe	= 1 unze.
4 unzen	= 1 vierling.
2 vierling	= 1 mark.
2 mark	= 1 pfund.

American Weights and Measures.—No civilized country has failed to enact complete and specific laws establishing standards for the weights and measures used by its people, except the United States of America. All other nations have laws enumerating the several units

which shall be used, establishing their relations to each other, fixing their respective values, and providing for the construction and proper preservation of prototypes or models by which the weights and measures intended for the use of the people shall be standardized. In the United States there is no law for the establishment of any weights or measures other than one declaring a certain copy of the British prototype troy pound to be the standard "conformably to which the coinage shall be regulated." The weights and measures in actual use throughout the United States are the avoirdupois weight of the present British "Imperial System;" the troy weight and apothecaries' weight, which was abolished in England by a law passed in 1824, to take effect January 1st, 1826; the English linear measures; and the wine measures and Winchester measures, abolished in England simultaneously with the abolition of the apothecaries' weights. No law now exists, in this or any other country, which directly fixes the value and subdivisions of the liquid measures, the dry measures, or the medicinal weights and measures used in the United States.

The only United States laws relating to weights and measures are these: "For the purpose of securing a due conformity in weight of the coins of the United States, the brass troy pound procured by the minister of the United States at London, in the year 1827, for the use of the Mint, and now in the custody of the Mint at Philadelphia, shall be the standard troy pound of the Mint of the United States, conformably to which the coinage thereof shall be regulated." (R. S., 3548.)

By the act of July 28th, 1866, it was enacted that "it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract, or dealing, or pleading in any court shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system." (R. S., 3569.)

Tables of equivalents, showing the relations of the metric weights and measures to those in common use, were also made part of the law of 1866. (R. S., 3570.) The legal equivalents may be said to fix indirectly the values of our mile, yard, foot, inch, acre, wine-gallon, bushel, peck, quart, gill, fluidounce, fluidrachm, avoirdupois pound, ounce, and grain, with reference to the units of the metric system; but the equivalents thus established, however sufficient for the purposes for which they are intended, are inconsistent as well as inexact; they do not suffice to establish the weights and measures which may be lawfully used; they do not fix the values and subdivisions of the units sanctioned by usage and in common law, except indirectly and partially.

On the day preceding the date of the executive approval of the act to render the use of the metric system permissive, Congress passed a joint resolution requiring the Secretary of the Treasury to furnish to each State of the United States "one set of the standard weights and measures of the metric system for the use of the States, respectively;" but we have no legalized standard metre and standard kilogram, any more than we have legalized prototype standards of the weights and measures in common use.

The *present ultimate standards* upon which all weights and measures employed in the United States are based are the American national prototype standards of the metre and the kilogram, made of irido-platinum, received by the American Government from the International Bureau of Weights and Measures (near Paris) in 1890, which are in the custody of the National Bureau of Standards at Washington.

The American *yard* is defined to be equal to $\frac{3,600}{3,937}$ metre; the American commercial *pound* is defined as being equal to $\frac{700,000,000}{1,543,235,639}$ kgm.; and the American liquid *gallon* is the volume of 3,785.434 gm. (58,418.144 grains) of water at the temperature of its maximum density, weighed *in vacuo.*

While the liquid gallon is designed to be a *volume* of 231 cubic inches, it is determined or adjusted *by weight* on the assumption that 252.892 grains of water, at its maximum density, weighed *in vacuo*, measures one cubic inch. This value is derived from the accepted equivalents of the metre in inches and of the kilogram in grains, coupled with the assumption that the mass of one cubic decimetre of water is identical with that of the actual standard kilogram.

Equivalents.

1 metre = 39.3700 inches.
1 yard = 0.914402 metre.

1 litre	= 0.26417 liquid gallon.
1 gallon	= 3.785434 litres.
1 fluidounce	= 29.5737 millilitres.

1 kgm. = 2.20462 pounds, or to 15,432.35639 grains.

1 pound	= 453.5924277 gm.
1 commercial ounce	= 28.3495 gm.
1 medicinal ounce	= 31.10348 gm.
1 grain	= 64.7898 mgm.

1 fluidounce of water weighs 29.5737 gm., or 456.392 grains.

1 medicinal ounce of water measures 31.10348 millilitres, or 504.829 minims.

British Weights and Measures Prior to 1826, and now Used in the United States.—The weights and measures in use in England, prior to 1826, were the following. They are the weights and measures in common use in the United States at this time, except the beer measures, which are no longer used anywhere.

Linear Measures.

1 league = 3 miles = 5,280 yards = 15,840 feet.
1 mile = 8 furlongs = 1,760 yards = 5,280 feet.
1 furlong = 10 chains = 40 poles, or perches, or rods = 220 yards = 660 feet.
1 chain = 4 poles, or perches, or rods = 22 yards = 66 feet.
1 pole, or perch, or rod = 5½ yards = 16½ feet.
1 yard = 3 feet = 36 inches.
1 foot = 12 inches.

Superficial Measures.

1 square mile = 640 acres.
1 acre = 4 roods = 10 square chains = 160 square poles = 4,840 square yards = 43,560 square feet.
1 rood = 40 square poles = 1,210 square yards = 10,890 square feet.
1 square pole = 30¼ square yards = 272 2¼ square feet.
1 square yard = 9 square feet.
1 square foot = 144 square inches.

Cubic Measures.

1 cubic yard = 27 cubic feet.
1 cubic foot = 1,728 cubic inches.

Dry or Winchester Measures.

1 bushel	= 4 pecks	= 32 quarts	= 2,150.42 cubic inches.
1 peck	= 2 gallons	= 8 quarts	= 537.6 cubic inches.
1 gallon	= 4 quarts	= 8 pints	= 268.8 cubic inches.
1 quart	= 2 pints	= 67.2 cubic inches.	
1 pint	= 33.6 cubic inches.		

Beer Measure.

1 hogshead	= 2 barrels = 72 gallons.
1 barrel	= 36 gallons.
1 gallon	= 4 quarts = 8 pints = 282 cubic inches.
1 quart	= 2 pints = 70.50 cubic inches.
1 pint	= 35.25 cubic inches.

Wine Measure.

1 hogshead = 2 barrels = 63 gallons.
1 barrel = 31½ gallons.
1 gallon = 4 quarts = 8 pints = 231 cubic inches.
1 quart = 2 pints = 57.75 cubic inches.
1 pint = 4 gills = 28.875 cubic inches.
1 gill = 7.219 cubic inches.

Medicinal Fluid Measures.

1 gallon = 4 quarts = 8 pints = 128 fluidounces = 231 cubic inches.
1 quart = 2 pints = 32 fluidounces.
1 pint = 16 fluidounces = 128 fluidrachms.
1 fluidounce = 8 fluidrachms = 480 minims.
1 fluidrachm = 60 minims.

Measures of Weight for General Merchandise.
(Avoirdupois.)

1 ton = 20 hundredweight = 2,240 pounds.
1 hundredweight = 8 stones = 112 pounds.
1 stone = 14 pounds.
1 pound = 16 ounces = 7,000 grains.
1 ounce = 16 drachms = 437½ grains.
1 drachm = $27\frac{11}{32}$ grains.

Measures of Weight for Precious Metals, Jewels, and Coin.
(Troy.)

1 pound = 12 ounces = 240 pennyweights = 5,760 grains.
1 ounce = 20 pennyweights = 480 grains.
1 pennyweight = 24 grains.

Measures of Weight for Medicines.

1 pound = 12 ounces = 5,760 grains.
1 ounce = 8 drachms = 24 scruples = 480 grains.
1 drachm = 3 scruples = 60 grains.
1 scruple = 20 grains.

The British Imperial System.—The English weights and measures were reconstructed in 1824, when a law was passed which went into effect January 1st, 1826, establishing the "Imperial System of Weights and Measures," which is at the present time still in force. It includes the linear measures previously employed and the avoirdupois pound, the value of which was defined to be $\frac{7000}{5760}$ of the old standard troy pound of brass made in 1758. The new feature of the Imperial system was the Imperial gallon and its subdivisions, the old corn, beer, wine, and medicinal measures being replaced by the

Imperial Measures of Capacity.

1 bushel = 4 pecks = 8 gallons [= 2,218.191 cubic inches].
1 peck = 2 gallons = 8 quarts [= 554.548 cubic inches].
1 gallon = 4 quarts = 8 pints [= 277.274 cubic inches].
1 quart = 2 pints [= 69.3185 cubic inches].
1 pint = 20 fluidounces [= 34.65925 cubic inches].
1 fluidounce = 8 fluidrachms [= 1.733 cubic inches].
1 fluidrachm = 60 minims.

One of the carefully constructed copies (made of bronze) of the former standard yardstick, which had been destroyed, was declared to be the new standard, and a new avoirdupois pound-weight of platinum was made under the supervision of Prof. W. H. Miller, which, by the law of 1855, was declared to be "the legal and genuine standard measure of weight, and shall be, and be denominated, the Imperial Standard Pound Avoirdupois, and shall be deemed to be the only standard measure of weight from which all other weights and other measures having reference to weight shall be derived, computed, and ascertained; and one equal seven-thousandth part of such pound avoirdupois shall be a grain, and five thousand seven hundred and sixty such grains shall be, and be deemed to be, a pound troy. If, at any time hereafter, the said Imperial Standard Pound Avoirdupois be lost or in any manner destroyed, defaced, or otherwise injured, the Commissioners of Her Majesty's Treasury may cause the same to be restored by reference to, or adoption of, any of the copies," provided and available for that purpose.

Thus the avoirdupois pound, which was before based upon the troy pound-weight, became, in 1855, the only basis for all weights, including the troy weight, and also became the basis for the imperial gallon, which was defined to be the volume of ten avoirdupois pounds of pure water at 62° F.

Decimal Weights and Measures.—The first scientific decimal system of weights and measures ever presented was of American origin, being devised and recommended to the House of Representatives of the United States, July 13th, 1790, by Thomas Jefferson, who was then Secretary of State. Mr. Jefferson had been the American Minister to Paris, where he resided during the period of the great Revolution. He had, therefore, come into direct intercourse with the Bishop of Autun and other great men, who were inspired with the grand idea of establishing a common language of weights, measures, and money for the whole world. Mr. Jefferson proposed as a basis for his new system the length of a rod swinging seconds of time in latitude 45°, one-fifth of that length to be called the new foot. This new foot was about one-fourth inch shorter than the English foot. It was to be divided into ten inches, each inch into ten lines, and each line into ten points; ten feet was to be called a decade, ten decades a rood, ten roods a furlong, and ten furlongs a mile. A new cubic foot was to be the new bushel, the weight of the new cubic inch of water was to be the new ounce, and one ounce of silver $\frac{11}{12}$ fine was to be the new dollar.

Thomas Jefferson's decimal system of weights and measures was in every way as meritorious as the metric system, but it was not adopted. Other decimal systems have been proposed at various times, but none has been used except—

The Metric System.—A new system of weights and measures was constructed in 1791, with the view of its ultimate universal adoption. It was not the work of one mind. It was the legitimate offspring of the times. In its conception and development, as in its steadily increasing domain, no nation can claim it as its own.

Its basis was the length of the earth's circumference through the poles. The Dutch astronomer, Huygens, had already, in 1685, recommended the length of the meridian as a suitable standard for measures of length. The distance from the equator to the pole having been measured along the surface of still water, one ten-millionth part of that length was denominated a metre, and a platinum rod was made by Borda to represent the metre. The *theoretical metre* is one forty-millionth part of the length of the terrestrial meridian, and the *actual metre* is the distance between the ends of Borda's platinum rod at 0° C. They are generally supposed to be identical, but some physicists deny this. Be that as it may, the real basis of the metric system is the prototype platinum metre and not the length of the meridian; but this does not detract from the merits of that grand system. The value of the metric system depends upon the following characteristics: (1) Its construction is in perfect harmony with our present arithmetical notation, the multiples and subdivisions of all its units being in decimal progression. (2) The units of length, surface, capacity, and weight, all bear simple relations to each other, respectively, all being derived from the same primary standard, the metre. (3) Each volume unit of the metric system has a corresponding weight unit with which it is commensurate when referring to water, which is the connecting link between measures of extension and measures of weight, and the standard unit used for the expression of specific weight. Thus the units of weight and volume of the metric system are not merely parallel, but their values are readily interconvertible through the

specific weights and specific volumes of the substances measured or weighed.

The word "metre" is derived from the Greek, *μέτρον*, measure, and the term "metric system" from the metre.

There are only five standard units of the metric system. These are:

The *metre*, for linear measure; the *are*, for land measure; the *stère*, for large bulks; the *litre*, for smaller bulks; the *gram*, for weights;

The *are* is the square of ten metres, or a square dekametre.

The *stère* is the cube upon one metre, or a cubic metre.

The *litre* is the cube upon one-tenth of a metre, or a cubic decimetre. But, as all capacity measures are in reality made or adjusted by means of weighing, the actual litre is the volume of one kilogram of water at 4 C. in vacuo.

The *gram* is the weight of one one-thousandth part of one litre (1 c.c.) of water at 4° C. (39.2° F.) *in vacuo.*

Secondary and additional units are obtained by decimal multiplication or division, and the names of these subordinate units are constructed by the use of certain Greek and Latin numerals in the form of prefixes. These prefixes are as follows:

Myria-, meaning ten thousand.
Kilo-, meaning one thousand.
Hekto-, meaning one hundred.
Deka-, meaning ten; and
Deci, meaning one-tenth.
Centi-, meaning one one-hundredth.
Milli-, meaning one one-thousandth.

Of these prefixes, only two are very much employed—namely, "kilo-" and "milli-." The prefix "centi-" is also used to some extent; the rest of the prefixes are not only as superfluous as the "eagle," the "dime," and the "mill" in American money, but they burden the metric system.

"Kilometre" means a one-thousand-metre, or one thousand metres; kilogram is one thousand grams; 0.005 gm. is 5 mgm.; a centimetre is $\frac{1}{100}$ metre, etc.

It is more convenient to say "ten metres" than to say "one dekametre," but less convenient to say "one one-thousandth of a gram" than to say "one milligram." The choice of expression is, therefore, to some extent governed by euphony and convenience. But there is a redundance of units in the metric system which has doubtless retarded its introduction.

The orthography and pronunciation of the metric units are modified in each country according to the language of the people. In France the spelling and pronunciation are, of course, French, as mètre, litre, and gramme; in Germany they are German, being meter, liter, and gramm; in English-speaking countries and in Sweden we say and write metre, litre, and gram; Spaniards write gramo, and Russians gramma; etc. In our country the word centimetre should not be pronounced *sangtimátre* any more than cent should be pronounced *sangt*, or the word gas-metre *gas-mátre.*

In abbreviating the metric terms there is unfortunately no uniformity of practice. The United States Pharmacopœia has adopted C.c. for cubic centimetre and Gm. for gram, and these are convenient and safe.

The metric system presents the following tables of measures and weights:

Linear Measures.

1 Myriametre = 10,000 metres.
1 Kilometre = 1,000 "
1 Hektometre = 100 "
1 Dekametre = 10 "
1 Metre = 1 metre.
1 Decimetre = .1 "
1 Centimetre = .01 "
1 Millimetre = .001 "

In addition to the above units microscopists employ the "micro-millimetre," which is 0.001 millimetre.

Volume Measures.

1 Kilolitre = 1,000 litres.
1 Hektolitre = 100 "
1 Dekalitre = 10 "
1 Litre = 1 litre.
1 Decilitre = .1 "
1 Centilitre = .01 "
1 Millilitre = .001 "

The only volume units employed by chemists, pharmacists, and physicians are the litre and the cubic centimetre. The cubic centimetre is practically identical with the millilitre.

Weights.

1 Kilogram = 1,000 grams.
1 Hektogram = 100 "
1 Dekagram = 10 "
1 Gram = 1 gram.
1 Decigram = .1 "
1 Centigram = .01 "
1 Milligram = .001 "

In medicine and pharmacy the gram and the cubic centimetre are the most important metric units, and to express their close relationship the cubic centimetre has been very appropriately termed a "fluigram." The milligram is also indispensable.

Compromise Systems.—Admiration for the metric system and its evident practical superiority were not sufficient to insure its rapid introduction. The old systems, however awkward and unscientific, were not to be displaced except under compulsion. In countries where legislation is the expression of the popular will the metric system has not yet been adopted for general use, nor was it easy to introduce it in any country. The prejudice against the foreign sound of the terms applied to the metric units proved so strong an obstacle that in some countries new names were invented, as in Italy and Greece, and even the names of old units were applied to the new values which the metric units represented.

In France, where the new system was first introduced by law, there were afterward compromises made between the old and the new weights and measures.

Various attempts were made in different countries to establish simple relations between the units of the old systems of weights and measures and the metric units, especially the weight units. The old systems were also changed so as to connect units of the same kind by decimal multiplication and division.

The German "Zoll-Pfund" was made equal to 500 gm. It was divided into 30 "loth"; but the loth was divided into 10 "quentchen," the quent into 10 "cents," and the cent into 10 "korn." Bremen and Hamburg had the Zoll-Pfund divided into tenths, hundredths, and thousandths, called "Unzen," "Neuloth," "Quinten," and "Halbgrammen." Sweden had a pound equal to 425 gm. and divided it into 100 "ort," each ort being subdivided into 100 "korn." Thus the Swedish korn differed greatly from the Prussian korn, and the quint of Bremen and Hamburg was 5 gm., while the quent of Prussia was but $1\frac{2}{3}$ gm.

Decimal systems of linear measure were also devised and used.

But these compromise systems had none of the merits of the metric system, except their partly decimal character; no simple relations existed between the units of linear measure, the units of capacity, and the units of weight, respectively. Hence they were short-lived.

Suitable Units.—The number and size of the units of weight and measure are important considerations. There are often too many units of each kind of measure. Baden at one time had fifteen different weight units. In order to have convenient units for all ordinary purposes, it is not necessary that they should be near each other in value as they are in the metric system; instead of making a new unit for every multiplication by ten, it would be sufficient to make one for each multiplication by one hundred, or even one thousand.

Each branch of science, trade, or business, will use the units best adapted to its particular purposes; but there is a superabundance of middle terms.

For certain special purposes, however, the smallest units we have are too large; thus it has been necessary to add a new metric unit of length for microscopical measurements (the micromillimetre); the grain is much too large as the smallest unit of weight for medicinal purposes and in analytical chemistry, the milligram being far more suitable; the cubic centimetre is too large as the smallest unit of volume in medicine, where the minim is greatly to be preferred.

Experience has shown that the use of decimal fractions is a source of frequent errors, and that in the practice of medicine and pharmacy the decimal point is dangerous, not only from want of familiarity with its right use, but chiefly because it is so often illegible, or accidentally misplaced, omitted, or duplicated. This undeniable fact must not, however, be regarded as an insurmountable obstacle to the use of the decimal *system* of weights and measures in medicine and pharmacy, but simply as an argument against the use of the decimal *point*. Use the smallest units and write whole numbers instead of fractions. In constructing prescriptions it is better to write "15 milligrams" than to write "0.015 Gm."

No decimal fractions were formerly used in writing prescriptions, because the grain was a small enough unit so long as alkaloids and other extremely potent remedies were unknown; and later, whenever the quantity required was less than a grain, *common fractions* were used to express it.

WEIGHING AND MEASURING.—When the greatest possible accuracy is required, as in some of the operations of physicists and chemists, matter is measured as to its amount by weight rather than by volume, because a given weight of any substance always expresses the same amount without regard to temperature, and because volumes cannot be easily measured with great exactness. In laboratory work, weighing is generally both convenient and accurate; but volumetric analysis is also convenient, and affords correct results.

Medicines are either solid or liquid. The liquid medicines are necessarily taken or administered in doses by measure. Hence they should also be prescribed by measure, and that is the uniform practice in the English-speaking countries. This practice is consistent, accurate, and convenient. In other countries, however, the liquid medicines are prescribed by weight, although the doses can, of course, not be apportioned otherwise than by measure. This is not only inconsistent, but gives very inaccurate results, for the prescriber cannot express definite volumes by weight, nor can he calculate the volume of a mixture composed by weight.

The practice of prescribing, dispensing, and administering liquid medicine by volume is dictated by common sense, and its results are the most accurate that can be obtained.

Many advocates of the metric system seem to labor under the mistaken idea that metric prescriptions cannot or ought not to be written, except exclusively by weight; and, on the other hand, a number of those who do write prescriptions expressing all quantities in grams, actually intend that the liquids so prescribed shall be measured, writing grams when they really mean as many cubic centimetres, overlooking or ignoring the different densities of different liquids.

SPECIFIC WEIGHT AND SPECIFIC VOLUME.—The relation of the weight of a mass to its volume is called its specific weight; the specific weights of solids and liquids are expressed in water units, and of gases in hydrogen units. Thus, the specific weight of water being 1,000, the specific weight of any solid or liquid is found by dividing the weight of a given volume of it by the weight of the same volume of water. Specific weight is commonly, though inaccurately, called "specific gravity," and the number used to express the specific gravity of a solid or liquid, is that number which expresses how many times the weight of that liquid contains the weight of an equal volume of water. The specific weight of ether is called 0.750, because it weighs 0.750 times as much as an equal volume of water weighs. This mode of expression is the most convenient form in which the relative weights of equal volumes of various solids and liquids can be stated and compared.

To physicians and pharmacists, the reciprocal relations of weight and volume are of great practical importance. The abolition of the use of measures of capacity in the pharmacopœial formulas for tinctures, syrups, and other liquid preparations, in the last revision, further increases the importance of the subject. It has become especially desirable to have some convenient means of expressing and comparing the relative volumes of equal weights of different liquids, and of computing readily the volume of any definite amount by weight. For this purpose the writer of this article proposed, in 1883,* to use the term "specific volume" to designate the comparative volumes of liquids, and to express their specific volumes in the same manner as their specific weights are expressed, namely, in water units. Thus the specific volume of ether is 1.333, because a given quantity by weight of ether is 1.333 times as bulky as an equal quantity by weight of water. The specific volume of any substance is obtained by dividing one by its specific weight.

$$\frac{1}{\text{sp. w.}} = \text{sp. vol.}$$

To find the volume of any number of grams of any liquid, multiply by the specific volume; the product is the answer expressed in cubic centimetres.

The utility of a table of specific volumes will be readily appreciated, and such a table should be contained in the Pharmacopœia.

As the volume of any substance is affected by heat, the specific weights and specific volumes must be ascertained and expressed at definite temperatures. The water generally taken as a standard or unit of comparison is water at 4° C. (39.2° F.), at which temperature it reaches its maximum density; but many of the pycnometers, hydrometers, and other instruments used for taking specific weight, are adjusted with reference to water at 15° C. or at 15.6° C. as unit. At the same time, the standard temperature at which specific weights are taken, and to which our "tables of specific gravities" refer, is usually 15° C., but sometimes 15.56° C., 16.67° C., 14° C., and other temperatures. This is confusing. The standard temperatures to which our instruments are adjusted, the temperature which a liquid is assumed to have when its specific weight is taken, or at which it has the specific weight given for it, and the temperature of the water referred to as unit—all should be the same temperature. The writer has recommended for this purpose the temperature of 22° C. (71.6° F.), because that is slightly above the common room temperature at which we do our work, and therefore most convenient, as well as most useful and real under ordinary conditions.

Every volume unit of the metric system has a parallel weight unit, with which it is commensurate when referring to water. Thus:

1 litre of water weighs 1 kilogram.
1 decilitre of water weighs 1 hektogram.
1 centilitre of water weighs 1 dekagram.
1 millilitre of water weighs 1 gram.

This close relationship between the units of weight and of volume is of the greatest practical value. It enables us to find the weight of any volume of any liquid by simply multiplying the volume units by the specific weight, or to find the volume of any given weight of any liquid, by multiplying the weight units by the specific volume. The weight of one litre of any liquid, expressed in kilograms (or the weight of 1 c.c. expressed in grams), is the number expressing its specific weight. The volume of 1 kgm. of any liquid, expressed in litres (or the volume of 1 gm. expressed in cubic centimetres), is the number expressing its specific volume. Conversely, the number which expresses the specific weight is the weight of one litre in kilograms (or the weight of 1 c.c. in grams), and the number which expresses the specific volume is the volume of 1 kgm. expressed in litres, or of 1 gm. in cubic centimetres.

* See Proceedings of the American Pharmaceutical Association, 1883.

Commensurate units of weight and volume do not exist in any other system of weights and measures except the metric system and the British Imperial system. The British Imperial system, however, has only one pair of commensurate units—the fluidounce and the ounce—one fluidounce of water at 62° F. weighing one avoirdupois ounce. But it happens that six winepints of water at 60° F. weigh 100.0032 avoirdupois ounces, or only 1.4 grains more than 100 avoirdupois ounces, and hence we can most readily find the weight (in avoirdupois ounces) of six winepints or 96 United States apothecaries' fluidounces of any liquid, by multiplying its specific weight by one hundred, the answer being sufficiently accurate for nearly all purposes.

WEIGHTS AND MEASURES IN PRESCRIPTIONS.—In writing prescriptions all solid substances are prescribed by weight, and all liquids by measure, and when solids and liquids are combined to form a liquid product, it is best, because most accurate, to adjust the total quantity to some definite volume. Thus, if a solution be prescribed containing corrosive chloride of mercury, potassium iodide, syrup, and water, it is, of course, impracticable for the prescriber to predict or calculate what will be the volume of the finished solution if he prescribes a given amount by weight or volume of the syrup and water; the only correct method in such a case is to prescribe water "q.s." to make a stated volume of finished solution.

When the old system of weights and measures is used, the most useful weight units are the grain and the ounce; but the drachm is also convenient and very much used. The scruple ought not to be used, because the sign employed to indicate it looks too nearly like the sign for the drachm. There ought to be a new unit of weight smaller than the grain, for prescribing and stating the doses of remedies intended to be administered in minute quantities, the new unit to be about gr. $\frac{1}{64}$, which is about 1 mgm. The units of capacity are the fluidounce, the fluidrachm, and the minim.

In writing prescriptions in which the quantities are expressed in units of the old system, these units are represented by certain universally recognized signs or abbreviations; the abbreviation "gr." (which should always be written with a *small* initial) denotes grain or grains; " ʒ " denotes drachm or drachms; " ℥ " denotes ounce or ounces; " ℈ " denotes scruple or scruples; " ♏ " denotes minim or minims; "f ʒ " denotes fluidrachm or fluidrachms; and "f ℥ " denotes fluidounce or fluidounces. The quantities directed to be taken are here to be indicated by *Roman* numerals, always placed *after* the signs or abbreviations, as follows: gr. x.; ʒ ij.; ℥ ss.; ℈ ij.; ♏ ix.; f ʒ iij.; f ℥ xij. The sign "ss." is used to express one-half, being an abbreviation of the Latin word *semis*.

When the metric units are employed in writing a prescription, it would save human lives to abstain from using the decimal point, and to use no other units but the gram and milligram for weights, and the fluigram or cubic centimetre for measures. The gram is abbreviated to "Gm," a *capital* initial always being used; the milligram should be abbreviated to mGm; and the fluigram to fGm (or the cubic centimetre, which is the same as a fluigram, to C.c.). The numerals indicating the number of weight units or volume units to be taken, should be always placed *before* the signs or abbreviations representing the units, and in writing them the *common* (or Arabic) numerals should be used, thus: 10 Gm.; 50 mGm.; 30 fGm. (or 30 C.c.).

When quantities expressed in units of one system are to be transposed into their corresponding equivalents in units of the other system, the following equivalents are sufficiently accurate and the most useful:

$\frac{1}{64}$ grain is equal to 1 mGm.
1 grain " " 64 mGm.
1 drachm " " 4 Gm.
1 ounce " " 32 Gm.

1 Gm. is equal to 16 grains.

1 minim is equal to $\frac{1}{16}$ fGm.
1 fluidrachm " 4 fGm.
1 fluidounce " 32 fGm.

1 fGm. is equal to 16 minims.

For further information concerning weights and measures, the reader is referred to the "Manual of Weights and Measures" by the writer of this article; Lowis A. Jackson's Work (London); "The Metric System," by F. A. P. Barnard; the Reports of Thomas Jefferson ("Works of Thomas Jefferson," vol. vii., pp. 472–495) and John Quincy Adams (Washington, 1821); the paper of Alfred B. Taylor on "Octonary Numeration and Its Application to a System of Weights and Measures," read before the American Philosophical Society, October 21st, 1887; and the Report of the Committee on Coinage, Weights, and Measures of the House of Representatives, January 7th, 1879 (45th Congress, 3d Session, H. R. Report, No. 53).

Oscar Oldberg.

WEIL'S DISEASE.—An acute infectious (?) disease characterized by sudden onset with severe symptoms, prostration, a typical temperature, early-occurring jaundice, enlargement of liver and spleen, gastro-intestinal disturbances, and nephritis.

Though first described by Weil in 1886, and taken by him from amongst the diseases characterized by and associated with jaundice, the disease had been previously noted and described under various names: "Typhus hépatique bénin," "bilious typhoid," etc. After his first description it was seen that the disease had prevailed and was prevailing sporadically and not infrequently in the countries of Europe. No distinct descriptions of its occurrence in America are met with. There seems no doubt at present that the affection is distinct from such infections as typhoid, yellow fever, recurrent fever, diseases with which it was frequently confounded; its differentiation from acute yellow atrophy, simple infectious jaundice, and various intoxications is not so clear. Accurate post-mortem reports are few, owing to the benign character of the disease. Recent bacteriological investigations are not convincing.

ETIOLOGY.—Incidence of season, sex, age, and occupation. The majority of cases are met with in the warm months of the year, June to September. Ninety per cent. of those affected are men, usually at about the age of twenty-five to thirty years (third decade). Butchers, meat handlers, sewer and drain workers seem especially prone to infection. Outbreaks in garrisons and prisons occur not infrequently.

SPECIFIC CAUSE.—Although recognized by many as a morbid entity, and though a seemingly definite infection or intoxication, the question as to the specific cause of the disease is most unsettled. The abrupt onset without prodromal symptoms, the occurrence of some cases within a few hours of the ingestion of noxious material, sewer gas, sewage, tainted foods, etc., before bacteria could possibly have developed sufficiently to cause an infection, suggest strongly a ptomaïn poisoning or intoxication. One very typical case followed an overdose of santonin.

The febrile course; the peculiar febrile relapse occasionally seen; the inflammatory complications described in some instances—iridocyclitis, parotitis, adenitis, pleuritis, pneumonia—are more suggestive of a bacterial or infectious agent.

Infection is evidently through the alimentary canal, although it is not easy in some epidemics to exclude the possibility of entrance through the respiratory tract; the