or more, for the use of physicians. Upon the cover is printed a set of instructions having reference to the subject of causes of death and the best methods of stating such causes.

In the State of Michigan special attention has been given in recent years to the subject of registration, and a decided advance has been made in the appointment of an intelligent physician whose duty it is to supervise the collection and publication of vital statistics throughout the State, and therefore to act in the capacity of a registrar-general for the State.

The following certificate of death has been recently adopted in Michigan, and is a very good model:

MARGIN RESERVED FOR BINDING.—This is a Permanent Record. Write Plainly with Unfading Ink.

MICHIGAN
DEPARTMENT OF STATE
LANSING
VITAL STATISTICS DIVISION.

CERTIFICATE AND RECORD OF DEATH.

[The Registrar should number each certificate received *at once*, in space below, beginning with "No. 1" for each year.]

REGISTERED NO. .....

Place of death: County ..... Township ..... Village ..... City .....

{Location in city} .....Ward; No....., ...St.

Full Name.....Date of Death.

Month.	Day.	Year.
		1.....

{Hospital, institution or transient} ..... {Late or home residence} .....

{How long an inmate or resident} ..... {Single, married, widowed or divorced} .....

Sex..... Color.....

Age

Years.	Months.	Days.

{If married, age at (first) marriage.....years.
Parent of.....children, of whom.....are living.

Date of birth.

Year of birth.	Month.	Day.
1.....		

{Occupation, if over 10 years of age.} .....

{Birthplace (State or Country.)} .....

{Name of father} ..... {Birthplace father (State (or Country)} .....

{Maiden name of mother} ..... {Birthplace of mother (State or Country} .....

{Date of burial or removal} ..... {Place of burial or removal} .....

{Signature of undertaker.} ..... {Address of undertaker} .....

CERTIFICATE OF REPORTER.

The personal and family particulars herein given relative to deceased are true to the best of my knowledge and belief.

(Signed) .....

(Address).....

MEDICAL CERTIFICATE OF CAUSE OF DEATH.

I HEREBY CERTIFY that I attended deceased from..... 1..... to..... 1.....,

that I last saw h..... alive on..... 1....., that ..... died on ..... 1.....,

about ..... o'clock, ...M., and that to the best of my knowledge and belief the CAUSE OF DEATH was as hereunder written:

	Duration of each cause.
DISEASE CAUSING DEATH *.....	.....
Immediate cause of death	.....
Contributory causes or complications, if any	.....
Post-mortem..... {Place where DISEASE CAUSING DEATH was contracted, if other than place of death.}	

*In case of a *Violent Death*, state (1) mode of injury and whether accidental, suicidal or homicidal; (2) what was the nature of the injury and the immediate cause of death; (3) contributory causes or conditions, *e. g.*, septicæmia. Also whether operation was performed, etc.

In deaths from tuberculosis, cancer, etc., always specify what organ or part of the body was affected. In septicæmia, give cause, especially if puerperal.

Witness my hand this ..... day of ..... 1.....

{Signature of physician, health officer, or coroner} .....M.D.

(Address).....

Upon the back of this certificate instructions to the undertaker are printed, together with an extract from the registration laws of the State. *Samuel W. Abbott.*

DEATH, MODES OF. — Life, whether systemic or molecular, depends upon the proper performance of the functions of circulation and respiration; so death, whether the result of disease, of violence, or of senile decay, is due ultimately to the cessation of these functions.

The causes which result in the permanent suspension of circulation and respiration operate directly upon their mechanism, or remotely through the nerve centres which regulate their action. So important indeed to the proper continuance of these functions is the maintenance of an uninterrupted action of the nerve centres of organic life that it is customary to adopt the classification of Bichat and to speak of death beginning at the heart, death beginning at the lungs, and death beginning at the head. For practical purposes this is sufficiently accurate, and it must be admitted that any attempt at a more definite classification is merely theoretical. The phenomena attending each of these modes of dissolution are at least sufficiently distinct to merit separate consideration.

CESSATION OF THE CIRCULATION may be sudden or gradual. The former is witnessed in deaths from syncope and shock; the latter, in those from asthenia. The chief force in the maintenance of the circulation is the normal difference in pressure of the blood in the arteries and veins. Any influence, therefore, that overcomes this difference will cause the circulation to stop. As the maintenance of this blood pressure is due chiefly to the

action of the heart, the lesions that produce a fatal interruption of it are found for the most part in that organ. They may be found also in the vessels.

In the Heart.—When, from the occurrence of any organic or structural lesion, the heart is rendered no longer capable of propelling its contents into the arteries, the circulation is obliterated and death ensues. The movements of the heart may be suddenly and permanently arrested also by either direct central impulses, as by a gunshot injury, a blow upon the head, or such violent emotion as of fright, joy, or grief; by such direct or reflex impressions as those resulting from a blow upon the lower chest or epigastrium, or from the rupture of abscesses, cysts, or the gravid uterus; by the action of corrosive poisons on the mucous membrane of the stomach, or even by the ingestion of cold liquids in excess or when the body is in an overheated condition. Crile's recent experimental research leads him to the conclusion that collapse or death from violence applied upon the lower chest or abdomen is due mainly to the loss of rhythmic contraction from the mechanical irritation of such violence exerted on the heart muscle itself; that the solar plexus may be disregarded as a factor in it, and that the vagal terminal mechanism in and near the heart may contribute to it in a minor degree.

Syncope may be transient, however, as in fainting. There is then a momentary cessation of the heart's action, producing an anæmia of the cerebral centres, resulting in a brief period of unconsciousness and apparent death.

In a fatal syncope the individual suddenly turns pale, a cold sweat manifests itself, he becomes dizzy, the pupils dilate, vision becomes dim, the pulse slow, irregular, flickering, and in an instant life is gone. Or, the individual may suddenly become pale, make two or three convulsive gasps and drop dead. When the death is a little less sudden, as in fatal cases of hemorrhage, or when the perforation of an intestinal ulcer takes place, we may observe great restlessness, tossing to and fro, labored respirations, muttering delirium, and, as the scene closes, single or repeated convulsions.

In the Vessels.—When the cause of a sudden failure of the circulation is situated in the blood-vessels, it generally proves to be a rupture of their coats and the rapid reduction of blood pressure by the resulting hemorrhage. A condition closely allied to this sometimes results from an extreme dilatation of the blood-vessels of a single region. The most notable example of this is seen in the state of collapse that follows severe blows upon the abdomen, in which case the abdominal vessels are so distended as virtually to remove the greater part of the blood from the general circulation, and the heart soon ceases to beat from a lack of its normal stimulus. The individual is then said to die of shock. Shock differs from syncope in that the victim may for some time retain his consciousness; there may, however, be associated with shock a syncope due to the reflex inhibition of the heart, in which instance we have combined the symptoms of each. Shock, like syncope, may be transient, the vitality being gradually regained after a longer or shorter period of great depression.

A GRADUAL FAILURE OF THE CIRCULATION is the usual termination of a large number of diseases, particularly those of a chronic character. The heart ceases then on account of a failure of its own contractile power. This may result from degenerations of the muscular fibres, produced by continued high temperature, senile, fatty, or atrophic changes, the action of the micro-organisms of the infectious diseases, or of the poisons which they develop, or from such toxic sedatives as aconite, digitalis, and tobacco. In this category are classed also deaths from cholera, acute peritonitis, and such wasting affections as phthisis, diabetes, and cancer, as well as inanition and exposure to intense cold.

In this mode of death, the most prominent symptoms are great muscular debility and a feeble, rapid pulse. The intellect may remain clear to the last; but this, as well as the presence or absence of many other symptoms, must depend largely on the character of the disease upon which the death ensues.

CESSATION OF THE RESPIRATION.—Death from this cause is known as death by apnœa or asphyxia, and may be sudden or gradual.

Sudden failure of the respiration is due to a number of influences operating within or without the respiratory organs. The former class includes all obstructions and occlusions of these organs and all paralyses of their muscles as a result of injury or disease, local or central in character. Causes external to the respiratory organs include all obstructions by foreign bodies or by pressure upon any part of the respiratory passage, as in suffocation, strangulation by hanging or drowning, and the action of noxious gases.

The phenomena attending this mode of death are, violent efforts at respiration, followed, we are told, by sensations of pleasure and a brief period of remarkable clearness of intellect. The expiratory efforts become violent, unconsciousness and convulsions, or a few irregular twitchings of the muscles supervene, the face becomes swollen and cyanotic, the eyeballs protrude, then follows a period of relaxation, interrupted by occasional deep inspirations which finally become spasmodic gasps, and last of all, the heart stops.

A gradually fatal apnœa is a common result of disease. It is produced by any morbid process which gradually obliterates the lumen of the respiratory passages, *e.g.*, papillomata and other neoplasms of the larynx, œdema of its mucous membrane, false membranes of the trachea and bronchi, œdema of the lungs, and the pneumonic exudation. Failure of the respiration is occasionally the prominent symptom in death from phthisis (catarrhal pneumonia), and it may result from the pressure of large abdominal tumors or ascites.

Individuals dying in this manner exhibit much the same series of symptoms as those whose death is more sudden, but the struggle is less pronounced.

DEATH FROM CENTRAL PARALYSIS.—Paralysis of the vital nerve centres, or "death beginning at the head," operates by causing a failure of the circulation or respiration. Diseases, whether primary or secondary, and injuries located in the cerebrum or the cerebellum, may result fatally through extension of the inflammation to the pons or medulla or through the production of abnormal pressure upon them. Deaths from electric shock, lightning stroke, and electrocution belong to this class. Such poisons as the toxins, ptomaïns, and leucomaïns, and certain drugs, especially the narcotics, impress, as a rule, both cerebral and spinal centres and, when in sufficient quantity, ultimately overcome respiration and circulation.

The most prominent symptom indicative of approaching death from this cause is unconsciousness, or coma, when death is not instantaneous. All reflex movements soon cease; the respiration becomes stertorous, gradually more slow and labored, and at last stops, tranquilly, or after convulsive manifestations.

Finally, it should be remembered that the instances in which a death can be clearly traced to the failure of a single group of organs is the exception and not the rule. On the contrary, it will generally be observed that with the ebbing of life, the failure of one system follows so closely upon that of another as to render it extremely difficult to determine which of the vital functions is the last to cease. Death beginning at the lungs may be delayed by the employment of artificial respiration, death beginning at the head may for a time yield to the influence of appropriate remedies; but when the heart has been stilled no human power can restore it to action.

James M. French.

DEATH, PHYSIOLOGICAL THEORIES OF.—Living things, in the forms most familiar to us, at least, all grow old and die. We infer that this fate is universal with something of the same certainty with which we prophesy that a stone thrown into the air at any spot whatsoever will fall back to the earth's surface. On the other hand,

it is equally a commonplace of observation that the death of the individual does not mean the death of the race, and, inasmuch as every living thing is directly sprung from a preceding form—*omne vivum e vivo*—we may assume that the continuity of life has never been interrupted, and never will be. If the environment remains as favorable in the future as it has been in the past, living things will continue in unbroken succession for all time. From this standpoint we may speak justly of living matter as possessing immortality, or, at least, potential immortality, since it has unlimited powers of propagation. It is one of the final aims of biological speculation to reconcile these two apparently paradoxical properties of living matter; to furnish a satisfactory hypothesis that shall explain the occurrence of old age and death in the individual, and at the same time account for the possibility of unending existence for the race that is implied in the fact of reproduction.

In speculations of this character we must, moreover, keep clearly in mind that forms of living matter are not stable, in the same sense that forms of dead matter are. A given animal exists for a period of five years; but we are all perfectly well aware that no portion of the living substance of this animal has necessarily remained actually the same throughout this time; *i.e.*, the atoms of C, H, O, N, S, P, that constituted the living matter in the beginning, may have been replaced very early by others brought in with the food. What has remained unchanged through the individual's life has been, on the physiological side, a form of activity, and, on the morphological and chemical side, a material substratum of a practically definite composition. However familiar this fact may be, it is, after all, the great distinctive feature of life—or rather, of living matter. We express in the single word assimilation, or nutrition, that property which most distinctly separates living matter from dead. As long as any particle of matter is in the living form, just so long has it the creative power of converting dead food into living substance like itself. Throughout its period of existence there is a steady stream of dead matter coming to it to be rearranged into the living form, and an equally continuous outflow of dead material that had once been in the living form. Nothing can make this conception clearer than Huxley's simile of the whirlpool at Niagara—which fits so well as an illustration of the ever-changing particles that make up the unchanging form of life. From this point of view we may say that living matter is never actually the same, yet it must be evident that, in respect of any given mass of that body which we call protoplasm, it can reproduce itself only in its offspring by transmitting a portion of its actual substance. The formation of a new organism from this transmitted germ is therefore, from a chemical standpoint, no more a creation of a new being or of new living material than is the continued existence of the parent form throughout its period of natural life.

As far as the mere external phenomena of senility are concerned they may be observed and recorded. In the human being this has been done with more or less care. The coming on of the signs of old age in the different tissues, the rate of its normal development, and the conditions that hasten or retard its development, are known to a certain extent, though they have not been investigated with the carefulness of detail that scientific exactness requires. We cannot expect any solid advance in our knowledge of the development of old age until the statistics, which may be determined by experiment and observation, have been recorded. The superficial signs of old age are spoken of usually in the text-books of physiology. In the old, the bones become more brittle because of a continually increasing excess of deposits of inorganic salts; the cartilages become more rigid and calcareous for the same reason; the elasticity of the lens of the eye decreases, bringing on imperfect accommodation; the muscles atrophy and lose their physiological mobility, as shown by the lessened vigor of their contractions and their diminished elasticity; the nuclei of the nerve cells decrease in size and show other signs of deterioration; the hairs lose their pigment, etc. It is important to notice that these signs of deterioration in the machinery of life do not make their appearance first during or after the period of maturity, but begin to develop from the time of birth, or possibly before. At ten years of age the near point of distinct vision is 7 cm. from the eye, at twenty it has lengthened to 10 cm., at forty years of age it is 22 cm., at sixty years it is 100 cm., and so on. The long-sightedness of old age begins to develop in early childhood, and results physiologically from a continual diminution in the elasticity of the lens. We obtain similar facts if we measure the rate of growth of the body throughout life. According to the somewhat unreliable statistics of Quetelet, the average male child weighs at birth 6½ pounds. At the end of the first year it will weigh 18½ pounds, a gain of 12 pounds. At the end of the second year it will weigh 23 pounds, a gain of only 4½ pounds. And so on to full maturity the rate of increase each year falls rapidly. If we measure the rate of growth by the increase in height instead of by the increase in weight, we find that in the first year the gain is 148 mm., in the second year it has fallen to 93 mm., in the third to 72 mm., from the twentieth to the twenty-fifth year it averages 12 mm., and from the twenty-fifth to the thirtieth year only 0.8 mm., while in extreme old age it becomes a negative quantity.

In a valuable paper Minot has given the results of a laborious research upon the growth of guinea-pigs, which show much more clearly and accurately the same general fact of a decrease in the rate of growth beginning shortly after birth. Minot bases his figures upon observations taken daily. He defines the term "rate of growth" with an exactness not hitherto employed, in that he calls attention to the fact that usually, in considering the rate of increase, the actual increment at different periods is given instead of the proportionate increment. In other words, if an animal in successive periods gains in absolute quantities only the same amount in weight or height, its rate of growth is in reality decreasing, since proportionately to the weight of the whole animal the increase has been less and less. Making use of his short periods of twenty-four hours, and expressing the rate of growth as the fraction of weight added during that period, he finds that, after the animal recovers from a short post-natal retardation of growth, the rate of growth diminishes during life, at first rapidly, and afterward more slowly. The curve, however, is not by any means a regular one, the steady decline is marked by irregular ascents, the most notable and regular of which is the acceleration at the time of puberty. It follows from these facts that what we may call the creative power of growth, or better, the creative power of assimilation, which measures the capacity of living matter to form matter like itself, decreases steadily from birth. Like a stone projected upward, the initial velocity begins to fall from the outstart. As the height to which the stone travels may be taken as a measure of the force with which it was thrown, so the length of life in any individual may be taken as a measure of the power or capacity of assimilation with which the germ of that individual started its career. When the power of assimilation is insufficient to replace the wastes of nutrition then death for that tissue is at hand. Whatever may be the internal causes which lead to this diminution, and thus serve to bring on old age, we are safe in saying that they begin to make themselves felt in the very first years of post-natal life. The curve of vitality—to use a much-abused but convenient word—does not rise from birth, reach its maximum in the vigor of maturity, and fall in old age, but begins to fall steadily, though not uniformly, from the beginning of life. This statement applies to the mass of living matter in the body, but the same general conception holds good for the organization of this mass into physiological mechanisms, such as the brain, the circulation, etc. These mechanisms are incomplete at birth and become more perfect toward adult life, the maximum efficiency being reached at different periods, that for the neuro-muscular apparatus,

for example, being attained at an earlier age than that for the brain. Exact data are lacking, but we may suppose that the percentage of increase toward this maximum shows also in each case a declining curve with advancing years.

To mankind as individual organisms old age and death are inevitable, but it is interesting to inquire what may be considered the longest possible life under the most favorable conditions this world is likely to afford. We can answer this only by searching the records. If we put aside the oldest accounts on the ground of uncertainty as to the unit of time, and make our estimates on the basis of comparatively modern statistics, we may put the maximum age as lying somewhere between one hundred and twenty and one hundred and eighty years. Perhaps the most celebrated case of longevity is that of Thomas Parr, an account of whose life, together with the results of a post-mortem examination made by Harvey, may be found in the third volume of the "Philosophical Transactions," p. 886. The account relates "that he was a poor countryman of Shropshire, whence he was brought up by the Right Honorable Thomas, Earl of Arundel and Surrey, and that he died after he had outlived nine princes, in the tenth year of the tenth of them, at the age of one hundred and fifty-two years and nine months." Other interesting extracts from the letter of Harvey are as follows: "The cartilages of the sternum were not more bony than the others, but flexile and soft." The cause of his death was imputed chiefly to the change of food and air; "forasmuch as coming out of a clear, thin, and free air, he came into the thick air of London, and after a constant, plain, and homely country diet, he was taken into a splendid family where he fed high and drunk plentifully of the best wines." "He was able, even to the hundred and thirtieth year of his age, to do any husbandman's work, even threshing of corn." It is also stated that he married a widow when one hundred and twenty years of age, and from her own statement had frequent sexual intercourse with her. In an essay by Pflüger on macrobiotics, he refers to other recorded cases of unusual longevity. H. Jenkins, a native of Yorkshire, died, in 1670, at the age of one hundred and sixty nine. It is related that on one occasion, when brought before a justice to testify with reference to an event which had occurred one hundred and forty years before, he appeared accompanied by his two sons, aged one hundred and two and one hundred years, respectively. A more remarkable case still is that of Kentigern, or Saint Mungo, founder of the Cathedral of Glasgow, who reached an age of one hundred and eighty-five, if we may trust the accounts of his life on record. Among the exceptional cases recorded some are stated to have been unusually temperate in their habits of life, while others paid no regard to such precautions. In this last category Pflüger mentions one Brawn, who reached an age of one hundred and twenty, although his tombstone records the fact that he was a confirmed drunkard. Outside of such evidence as this, it is evident that exceptional longevity cannot be referred solely to careful observance of hygienic conditions. We must explain it, in general terms, as due to an unusual power of assimilation in the living substance composing the tissues, and that this tendency to long life is inherited may be accepted as demonstrated by the statistics of life insurance. At the present day we have numerous cases of persons passing the hundred-year mark by a few years, so that this age cannot be regarded as very unusual. Sir C. Brown, for example, in his interesting paper on old age, states that in 1889 the deaths of seventy-six reputed centenarians were reported in England and Wales.

However, leaving aside the reproductive cells, death sooner or later comes to the rest of the cells of the body, no matter how favorable the environments of life may be. It is not altogether hopeless to inquire into the causes which bring this about, though naturally any such investigation is largely made up of speculation of a very general character. We may define death as a cessation of life. In order, therefore, to arrive at even a general conception of its cause one must first define as clearly as possible what is meant by life. Spencer's definition is perhaps the one most familiar to educated persons. According to him life is the continual adjustment of internal to external relations. When properly analyzed the definition includes a great deal, and it is difficult to criticise it justly. But the physiologist will certainly object to it, because it attempts to present, in the most general terms, only the *ensemble* of properties manifested by living matter without pretending to trace these properties in any causative way to the physical substance that manifests them. It is as though one defined light by enumerating its chemical and physiological effects instead of referring it to vibrations of the ether. For the physiologist an adequate definition of life must be one that connects its phenomena with the structure of living matter. As the chemist may deduce the chief properties of a salt from a knowledge of the structure of its molecule, so the physiologist believes that a scientific explanation of life—that is, of the phenomena of assimilation and reproduction—can be obtained only by discovering the essential structure of living matter. To this end all biological work tends. The adjustment of internal to external relations, and the interaction of the different organs that brings about this adjustment, should be deducible from the chemical structure of living matter in somewhat the same way that the adjustments or reactions of benzene to different external conditions may be foretold from a knowledge of its molecular structure. That this kind of explanation of life is not inconceivably remote is demonstrated by the fact that several chemical theories have been seriously proposed and applied in some detail. Pflüger, for example, suggests that the essential difference between dead and living proteid lies in the grouping of the nitrogen in the molecule. In dead proteid it may exist in the form of an ammonia compound, while in proteid that is living it occurs in part, at least, in the cyanogen grouping. As something approaching scientific evidence for this view he asserts that the oxidation products of dead albuminous bodies—that is, as far as the nitrogen is concerned—are always ammonia compounds, amines, or amido-acids, while the end products of the oxidations of living substances may be classed among the cyanogen bodies. Moreover, the cyanogen compounds are characterized by their instability, and this is likewise one of the most prominent phenomena exhibited by living substances; it is doubtless the chemical cause of what is known as the irritability of living things. Cyanogen compounds also exhibit, in a striking way, a tendency to polymerize, and Pflüger suggests that this property of polymerization may be the essence of what we speak of in general as assimilation or nutrition, by which the living molecule takes into itself the molecule of dead proteid. Indeed, says Pflüger, we may look upon the molecule of cyanic acid as showing properties intermediate between those of living and dead matter, as a half-living substance. In a similar way Loew and Bokorney attempt to explain the peculiar properties of living matter on the supposition that its molecule contains an aldehyde group. They find that living protoplasm, in certain plant cells at least, has the property of reducing silver nitrate from alkaline solutions, while dead proteid has no such action. They infer that this reducing power is caused by the presence of an aldehyde group, and they give a schema showing that formic aldehyde, by union with ammonia, may produce aspartic aldehyde, and this, by condensation and reduction, with the addition of S, might give a compound of the molecular formula of proteid, which as long as it retained the aldehyde grouping would be living proteid, and would form the basis of living protoplasm. Latham attempts to combine the theories of Loew and Pflüger by supposing that living proteid is composed of a chain of cyan alcohols, united to a benzene nucleus, thus explaining the irritability or instability of living proteid, as well as its reducing action. However inadequate and premature such hypotheses may seem at present, they at least serve to demonstrate the fact that the physiologists and chemists are looking forward to a definition of life