the heat that he gives off in such liberal quantities. We have already seen that Dr. Mayer, of conservation-of-energy fame, was the first to ask this question. As soon as the doctrine of the persistence and convertibility of energy was grasped, about the middle of the century, it became clear that this was one of the most puzzling of questions. It did not at all suffice to answer that the sun is a ball of fire, for computation showed that, at the present rate of heat-giving, if the sun were a solid mass of coal, he would be totally consumed in about five thousand years. As no such decrease in size as this implies had taken place within historic times, it was clear that some other explanation must be sought.

Dr. Mayer himself hit upon what seemed a tenable solution at the very outset. Starting from the observed fact that myriads of tiny meteorites are hurled into the earth's atmosphere daily, he argued that the sun must receive these visitants in really enormous quantities—sufficient, probably, to maintain his temperature at the observed limits. There was nothing at all unreasonable about this assumption, for the amount of energy in a swiftly moving body capable of being transformed into heat if the body be arrested is relatively enormous. Thus it is calculated that a pound of coal dropped into the sun from the mathematician's favorite starting-point, infinity, would produce some six thousand times the heat it could engender if merely burned at the sun's surface. In other words, if a little over two pounds of material from infinity were to fall into each square yard of the sun's surface each hour, his observed heat would be accounted for; whereas almost seven tons per square yard of stationary fuel would be required each hour to produce the same effect.

In view of the pelting which our little earth receives, it seemed not an excessive requisition upon the meteoric supply to suppose that the requisite amount of matter may fall into the sun, and for a time this explanation of his incandescence was pretty generally accepted. But soon astronomers began to make calculations as to the amount of matter which this assumption added to our solar system, particularly as it aggregated near the sun in the converging radii, and then it was clear that no such mass of matter could be there without interfering demonstrably with the observed course of the interior planets. So another source of the sun's energy had to be sought. It was found forthwith by that other great German, Helmholtz, who pointed out that the falling matter through which heat may be generated might just as well be within the substance of the sun as without; in other words, that contraction of the sun's heated body is quite sufficient to account for a long-sustained heat-supply which the mere burning of any known substance could not approach. Moreover, the amount of matter thus falling toward the sun's centre being enormous—namely, the total substance of the sun—a relatively small amount of contraction would be theoretically sufficient to keep the sun's furnace at par, so to speak.

At first sight this explanation seemed a little puzzling to many laymen and some experts, for it seemed to imply, as Lord Kelvin pointed out, that the sun contracts because it is getting cooler, and gains heat because it contracts. But this feat is not really as paradoxical as it seems, for it is not implied that there is any real gain of heat in the sun's mass as a whole, but quite the reverse. All that is sought is an explanation of a maintenance of heat-giving capacity relatively unchanged for a long, but not an interminable, period. Indeed, exactly here comes in the novel and startling feature of Helmholtz's calculation. According to Mayer's meteoric hypothesis, there were no data at hand for any estimate whatever as to the sun's permanency, since no one could surmise what might be the limits of the meteoric supply. But Helmholtz's estimate implied an incandescent body cooling—keeping up a somewhat equable temperature through contraction for a time, but for a limited time only; destined ultimately to become liquid, solid; to cool below the temperature of incandescence—to die. Not only so, but it became possible to calculate the limits of time within which this culmination would probably occur. It was only necessary to calculate the total amount of heat which could be generated by the total mass of our solar system in falling together to the sun's centre from "infinity" to find the total heat-supply to be drawn upon. Assuming, then, that the present observed rate of heat-giving has been the average maintained in the past, a simple division gives the number of years for which the original supply is adequate. The supply will be exhausted, it will be observed, when the mass comes into stable equilibrium as a solid body, no longer subject to contraction, about the sun's centre—such a body, in short, as our earth is at present.

This calculation was made by Lord Kelvin, Professor Tait, and others, and the result was one of the most truly dynamitic surprises of the century. For it transpired that, according to mathematics, the entire limit of the sun's heat-giving life could not exceed something like twenty-five millions of years. The publication of that estimate, with the appearance of authority, brought a veritable storm about the heads of the physicists. The entire geological and biological worlds were up in arms in a trice. Two or three generations before, they hurled brickbats at any one who even hinted that the solar system might be more than six thousand years old; now they jeered in derision at the attempt to limit the life-bearing period of our globe to a paltry fifteen or twenty millions.

The controversy as to solar time thus raised proved one of the most curious and interesting scientific disputations of the century. The scene soon shifted from the sun to the earth; for a little reflection made it clear that the data regarding the sun alone were not sufficiently definite. Thus Dr. Croll contended that if the parent bodies of the sun had chanced to be "flying stars" before collision, a vastly greater supply of heat would have been engendered than if the matter merely fell together. Again, it could not be overlooked that a host of meteors are falling into the sun, and that this source of energy, though not in itself sufficient to account for all the heat in question, might be sufficient to vitiate utterly any exact calculations. Yet again, Professor Lockyer called attention to another source of variation, in the fact that the chemical combination of elements hitherto existing separately must produce large quantities of heat, it being even suggested that this source alone might possibly account for all the present output. On the whole, then, it became clear that the contraction theory of the sun's heat must itself await the demonstration of observed shrinkage of the solar disc, as viewed by future generations of observers, before taking rank as an incontestable theory, and that computations as to time based solely on this hypothesis must in the mean time be viewed askance.

But, the time controversy having taken root, new methods were naturally found for testing it. The geologists sought to estimate the period of time that must have been required for the deposit of the sedimentary rocks now observed to make up the outer crust of the earth. The amount of sediment carried through the mouth of a great river furnishes a clew to the rate of denudation of the area drained by that river. Thus the studies of Messrs. Humphreys and Abbot, made for a different purpose, show that the average level of the territory drained by the Mississippi is being reduced by about one foot in six thousand years. The sediment is, of course, being piled up out in the Gulf at a proportionate rate. If, then, this be assumed to be an average rate of denudation and deposit in the past, and if the total thickness of sedimentary deposits of past ages were known, a simple calculation would show the age of the earth's crust, since the first continents were formed. But unfortunately these "ifs" stand mountain-high here, all the essential factors being indeterminate. Nevertheless, the geologists contended that they could easily make out a case proving that the constructive and destructive work still in evidence, to say nothing of anterior revolutions, could not have been accomplished in less than from twenty-five to fifty millions of years.

This computation would have carried little weight with the physicists had it not chanced that another computation of their own was soon made which had even more startling results. This computation, made by Lord Kelvin, was based on the rate of loss of heat by the earth. It thus resembled the previous solar estimate in method. But the result was very different, for the new estimate seemed to prove that since the final crust of the earth formed a period of from one hundred to two hundred millions of years has elapsed.

With this all controversy ceased, for the most grasping geologist or biologist would content himself with a fraction of that time. What is more to the point, however, is the fact, which these varying estimates have made patent, that computations of the age of the earth based on any data at hand are little better than rough guesses. Long before the definite estimates were undertaken, geologists had proved that the earth is very, very old, and it can hardly be said that the attempted computations have added much of definiteness to that proposition. They have, indeed, proved that the period of time to be drawn upon is not infinite; but the nebular hypothesis, to say nothing of common-sense, carried us as far as that long ago.

If the computations in question have failed of their direct purpose, however, they have been by no means lacking in important collateral results. To mention but one of these, Lord Kelvin was led by this controversy over the earth's age to make his famous computation in which he proved that the telluric structure, as a whole, must have at least the rigidity of steel in order to resist the moon's tidal pull as it does. Hopkins had, indeed, made a somewhat similar estimate as early as 1839, proving that the earth's crust must be at least eight hundred or a thousand miles in thickness; but geologists had utterly ignored this computation, and the idea of a thin crust on a fluid interior had continued to be the orthodox geological doctrine. Since Lord Kelvin's estimate was made, his claim that the final crust of the earth could not have formed until the mass was solid throughout, or at least until a honeycomb of solid matter had been bridged up from centre to circumference, has gained pretty general acceptance. It still remains an open question, however, as to what proportion the lacunæ of molten matter bear at the present day to the solidified portions, and therefore to what extent the earth will be subject to further shrinkage and attendant surface contortions. That some such lacunæ do exist is demonstrated daily by the phenomena of volcanoes. So, after all, the crust theory has been supplanted by a compromise theory rather than completely overthrown, and our knowledge of the condition of the telluric depths is still far from definite.

If so much uncertainty attends these fundamental questions as to the earth's past and present, it is not strange that open problems as to her future are still more numerous. We have seen how, according to Professor Darwin's computations, the moon threatens to come back to earth with destructive force some day. Yet Professor Darwin himself urges that there are elements of fallibility in the data involved that rob the computation of all certainty. Much the same thing is true of perhaps all the estimates that have been made as to the earth's ultimate fate. Thus it has been suggested that, even should the sun's heat not forsake us, our day will become month-long, and then year-long; that all the water of the globe must ultimately filter into its depths, and all the air fly off into space, leaving our earth as dry and as devoid of atmosphere as the moon; and, finally, that ether-friction, if it exist, or, in default of that, meteoric friction, must ultimately bring the earth back to the sun. But in all these prognostications there are possible compensating factors that vitiate the estimates and leave the exact results in doubt. The last word of the cosmic science of our century is a prophecy of evil —if annihilation be an evil. But it is left for the science of another generation to point out more clearly the exact terms in which the prophecy is most likely to be fulfilled.

II.—PHYSICAL PROBLEMS.

In regard to all these cosmic and telluric problems, it will be seen, there is always the same appeal to one central rule of action—the law of gravitation. When we turn from macrocosm to microcosm it would appear as if new forces of interaction were introduced in the powers of cohesion and of chemical action of molecules and atoms. But Lord Kelvin has argued that it is possible to form such a conception of the forms and space relations of the ultimate particles of matter that their mutual attractions may be explained by invoking that same law of gravitation which holds the stars and planets in their course. What, then, is this all-compassing power of gravitation which occupies so central a position in the scheme of mechanical things?

The simple answer is that no man knows. The wisest physicist of to-day will assure you that he knows absolutely nothing of the why of gravitation—that he can no more explain why a stone tossed into the air falls back to earth than can the boy who tosses the stone. But while this statement puts in a nutshell the scientific status of explanations of gravitation, yet it is not in human nature that speculative scientists should refrain from the effort to explain it. Such efforts have been made; yet, on the whole, they are surprisingly few in number; indeed, there are but two that need claim our attention here, and one of these has hardly more than historical interest. One of these is the so-called ultra-mundane-corpuscle hypothesis of Le Sage; the other is based on the vortex theory of matter.

The theory of Le Sage assumes that the entire universe is filled with infinitely minute particles flying in right lines in every direction with inconceivable rapidity. Every mass of tangible matter in the universe is incessantly bombarded by these particles, but any two non-contiguous masses (whether separated by an infinitesimal space or by the limits of the universe) are mutually shielded by one another from a certain number of the particles, and thus impelled toward one another by the excess of bombardment on their opposite sides. What applies to two masses applies also, of course, to any number of masses—in short, to all the matter in the universe. To make the hypothesis workable, so to say, it is necessary to assume that the "ultra-mundane" particles are possessed of absolute elasticity, so that they rebound from one another on collision without loss of speed. It is also necessary to assume that all tangible matter has to an almost unthinkable degree a sievelike texture, so that the vast proportion of the coercive particles pass entirely through the body of any mass they encounter—a star or world, for example—without really touching any part of its actual substance. This assumption is necessary because gravitation takes no account of mere corporeal bulk, but only of mass or ultimate solidarity. Thus a very bulky object may be so loosely meshed that it retards relatively few of the corpuscles, and hence gravitates with relative feebleness—or, to adopt a more familiar form of expression, is light in weight.

This is certainly heaping hypotheses together in a reckless way, and it is perhaps not surprising that Le Sage's conception did not at first arouse any very great amount of interest. It was put forward about a century ago, but for two or three generations remained practically unnoticed. The philosophers of the first half of our century seem to have despaired of explaining gravitation, though Faraday long experimented in the hope of establishing a relation between gravitation and electricity or magnetism. But not long after the middle of the century, when a new science of dynamics was claiming paramount importance, and physicists were striving to express all tangible phenomena in terms of matter in motion, the theory of Le Sage was revived and given a large measure of attention. It had at least the merit of explaining the facts without conflicting with any known mechanical law, which was more than could be said of any other guess at the question that had ever been made.

More recently, however, another explanation has been found which also meets this condition. It is a conception based, like most other physical speculations of the last generation, upon the hypothesis of the vortex atom, and was suggested, no doubt, by those speculations which consider electricity and magnetism to be conditions of strain or twist in the substance of the universal ether. In a word, it supposes that gravitation also is a form of strain in this ether—a strain that may be likened to a suction which the vortex atom is supposed to exert on the ether in which it lies. According to this view, gravitation is not a push from without, but a pull from within; not due to exterior influences, but an inherent and indissoluble property of matter itself. The conception has the further merit of correlating gravitation with electricity, magnetism, and light, as a condition of that strange ethereal ocean of which modern physics takes so much account. But here, again, clearly, we are but heaping hypothesis upon hypothesis, as before. Still, a hypothesis that violates no known law and has the warrant of philosophical probability is always worthy of a hearing. Only we must not forget that it is hypothesis only, not conclusive theory.

The same caution applies, manifestly, to all the other speculations which have the vortex atom, so to say, for their foundation-stone. Thus Professors Stewart and Tait's inferences as to the destructibility of matter, based on the supposition that the ether is not quite frictionless, Professor Dolbear's suggestions as to the creation of matter through the development of new ether ripples, and the same thinker's speculations as to an upper limit of temperature, based on the mechanical conception of a limit to the possible vibrations of a vortex ring, not to mention other more or less fascinating speculations based on the vortex hypothesis, must be regarded, whatever their intrinsic interest, as insecurely grounded, until such time as new experimental methods shall give them another footing. Lord Kelvin himself holds all such speculations utterly in abeyance. "The vortex theory," he says, "is only a dream. Itself unproven, it can prove nothing, and any speculations founded upon it are mere dreams about a dream."

That certainly must be considered an unduly modest pronouncement regarding the only workable hypothesis of the constitution of matter that has ever been imagined: yet the fact certainly holds that the vortex theory, the great contribution of our century toward the solution of a world-old problem, has not been carried beyond the stage of hypothesis, and must be passed on, with its burden of interesting corollaries, to another generation for the experimental evidence that will lead to its acceptance or its refutation. Our century has given experimental proof of the existence of the atom, but has not been able to fathom in the same way the exact form or nature of this ultimate particle of matter.

Equally in the dark are we as to the explanation of that strange affinity for its neighbors which every atom manifests in some degree. If we assume that the power which holds one atom to another is the same which in case of larger bodies we term gravitation, that answer carries us but a little way, since, as we have seen, gravitation itself is the greatest of mysteries. But again, how chances it that different atoms attract one another in such varying degrees, so that, for example, fluorine unites with everything it touches, argon with nothing? And how is it that different kinds of atoms can hold to themselves such varying numbers of fellow-atoms—oxygen one, hydrogen two, and so on? These are questions for the future. The wisest chemist does not know why the simplest chemical experiment results as it does. Take, for example, a waterlike solution of nitrate of silver, and let fall into it a few drops of another waterlike solution of hydrochloric acid; a white insoluble precipitate of chloride of silver is formed. Any tyro in chemistry could have predicted the result with absolute certainty. But the prediction would have been based purely upon previous empirical knowledge—solely upon the fact that the thing had been done before over and over, always with the same result. Why the silver forsook the nitrogen atom, and grappled the atom of oxygen, no one knows. Nor can any one as yet explain just why it is that the new compound is an insoluble, colored, opaque substance, whereas the antecedent ones were soluble, colorless, and transparent. More than that, no one can explain with certainty just what is meant by the familiar word soluble itself. That is to say, no one knows just what happens when one drops a lump of salt or sugar into a bowl of water. We may believe with Professor Ostwald and his followers, that the molecules of sugar merely glide everywhere between the molecules of water, without chemical action; or, on the other hand, dismissing this mechanical explanation, we may say with Mendeleef that the process of solution is the most active of chemical phenomena, involving that incessant interplay of atoms known as dissociation. But these two explanations are mutually exclusive, and no one can say positively which one, if either one, is right. Nor is either theory at best more than a half-explanation, for the why of the strange mechanical or chemical activities postulated is quite ignored. How is it, for example, that the molecules of water are able to loosen the intermolecular bonds of the sugar particles, enabling them to scamper apart?

But, for that matter, what is the nature of these intermolecular bonds in any case? And why, at the same temperature, are some substances held together with such enormous rigidity, others so loosely? Why does not a lump of iron dissolve as readily as the lump of sugar in our bowl of water? Guesses may be made to-day at these riddles, to be sure, but anything like tenable solutions will only be possible when we know much more than at present of the nature of intermolecular forces, and of the mechanism of molecular structures. As to this last, studies are under way that are full of promise. For the past ten or fifteen years Professor Van 't Hoof of Amsterdam (now of Berlin), with a company of followers, has made the space relations of atoms a special study, with the result that so-called stereo-chemistry has attained a firm position. A truly amazing insight has been gained into the space relations of the molecules of carbon compounds in particular, and other compounds are under investigation. But these results, wonderful though they seem when the intricacy of the subject is considered, are, after all, only tentative. It is demonstrated that some molecules have their atoms arranged in perfectly definite and unalterable schemes, but just how these systems are to be mechanically pictured—whether as miniature planetary systems or what not —remains for the investigators of the future to determine.

It appears, then, that whichever way one turns in the realm of the atom and molecule, one finds it a land of mysteries. In no field of science have more startling discoveries been made in our century than here; yet nowhere else do there seem to lie wider realms yet unfathomed.

III.—LIFE PROBLEMS.

In the life history of at least one of the myriad star systems there has come a time when, on the surface of one of the minor members of the group, atoms of matter have been aggregated into such associations as to constitute what is called living matter. A question that at once suggests itself to any one who conceives even vaguely the relative uniformity of conditions in the different star groups is as to whether other worlds than ours have also their complement of living forms. The question has interested speculative science more perhaps in our century than ever before, but it can hardly be said that much progress has been made toward a definitive answer. At first blush the demonstration that all the worlds known to us are composed of the same matter, subject to the same general laws, and probably passing through kindred stages of evolution and decay, would seem to carry with it the reasonable presumption that to all primary planets, such as ours, a similar life-bearing stage must come. But a moment's reflection shows that scientific probabilities do not carry one safely so far as this. Living matter, as we know it, notwithstanding its capacity for variation, is conditioned within very narrow limits as to physical surroundings. Now it is easily to be conceived that these peculiar conditions have never been duplicated on any other of all the myriad worlds. If not, then those more complex aggregations of atoms which we must suppose to have been built up in some degree on all cooling globes must be of a character so different from what we term living matter that we should not recognize them as such. Some of them may be infinitely more complex, more diversified in their capacities, more widely responsive to the influences about them, than any living thing on our earth, and yet not respond at all to the conditions which we apply as tests of the existence of life.

This is but another way of saying that the peculiar limitations of specialized aggregations of matter which characterize what we term living matter may be mere incidental details of the evolution of our particular star group, our particular planet even—having some such relative magnitude in the cosmic order as, for example, the exact detail of outline of some particular leaf of a tree bears to the entire subject of vegetable life. But, on the other hand, it is also conceivable that the conditions on all planets comparable in position to ours, though never absolutely identical, yet pass at some stage through so similar an epoch that on each and every one of them there is developed something measurably comparable, in human terms, to what we here know as living matter; differing widely, perhaps, from any particular form of living being here, yet still conforming broadly to a definition of living things. In that case the life-bearing stage of a planet must be considered as having far more general significance; perhaps even as constituting the time of fruitage of the cosmic organism, though nothing but human egotism gives warrant to this particular presumption.

Between these two opposing views every one is free to choose according to his preconceptions, for as yet science is unable to give a deciding vote. Equally open to discussion is that other question, as to whether the evolution of universal atoms into a "vital" association occurred but once on our globe, forming the primitive mass from which all the diversified forms evolved, or whether such shifting from the so-called non-vital to the vital was many times repeated—perhaps still goes on incessantly. It is quite true that the testimony of our century, so far as it goes, is all against the idea of "spontaneous generation" under existing conditions. It has been clearly enough demonstrated that the bacteria and other low forms of familiar life which formerly were supposed to originate "spontaneously" had a quite different origin. But the solution of this special case leaves the general problem still far from solved. Who knows what are the conditions necessary to the evolution of the ever-present atoms into "vital" associations? Perhaps extreme pressure may be one of these conditions; and, for aught any man knows to the contrary, the "spontaneous generation" of living protoplasm may be taking place incessantly at the bottom of every ocean of the globe.

This of course is a mere bald statement of possibilities. It may be met by another statement of possibilities, to the effect that perhaps the conditions necessary to the evolution of living matter here may have been fulfilled but once, since which time the entire current of life on our globe has been a diversified stream from that one source. Observe, please, that this assumption does not fall within that category which I mention above as contraband of science in speaking of the origin of worlds. The existence of life on our globe is only an incident limited to a relatively insignificant period of time, and whether the exact conditions necessary to its evolution pertained but one second or a hundred million years does not in the least matter in a philosophical analysis. It is merely a question of fact, just as the particular temperature of the earth's surface at any given epoch is a question of fact, the one condition, like the other, being temporary and incidental. But, as I have said, the question of fact as to the exact time of origin of life on our globe is a question science as yet cannot answer.

But, in any event, what is vastly more important than this question as to the duration of time in which living matter was evolved is a comprehension of the philosophical status of this evolution from the "non-vital" to the "vital." If one assumes that this evolution was brought about by an interruption of the play of forces hitherto working in the universe—that the correlation of forces involved was unique, acting then and then only—by that assumption he removes the question of the origin of life utterly from the domain of science—exactly as the assumption of an initial push would remove the question of the origin of worlds from the domain of science. But the science of to-day most emphatically demurs to any such assumption. Every scientist with a wide grasp of facts, who can think clearly and without prejudice over the field of what is known of cosmic evolution, must be driven to believe that the alleged wide gap between vital and non-vital matter is largely a figment of prejudiced human understanding. In the broader view there seem no gaps in the scheme of cosmic evolution—no break in the incessant reciprocity of atomic actions, whether those atoms be floating as a "fire mist" out in one part of space, or aggregated into the brain of a man in another part. And it seems well within the range of scientific expectation that the laboratory worker of the future will learn how so to duplicate telluric conditions that the play of universal forces will build living matter out of the inorganic in the laboratory, as they have done, and perhaps still are doing, in the terrestrial oceans.

To the timid reasoner that assumption of possibilities may seem startling. But assuredly it is no more so than seemed, a century ago, the assumption that man has evolved, through the agency of "natural laws" only, from the lowest organism. Yet the timidity of that elder day has been obliged by the progress of our century to adapt its conceptions to that assured sequence of events. And some day, in all probability, the timidity of to-day will be obliged to take that final logical step which to-day's knowledge foreshadows as a future if not a present necessity.

Whatever future science may be able to accomplish in this direction, however, it must be admitted that present science finds its hands quite full, without going farther afield than to observe the succession of generations among existing forms of life. Since the establishment of the doctrine of organic evolution, questions of heredity, always sufficiently interesting, have been at the very focus of attention of the biological world. These questions, under modern treatment, have resolved themselves, since the mechanism of such transmission has been proximately understood, into problems of cellular activity. And much as has been learned about the cell of late, that interesting microcosm still offers a multitude of intricacies for solution.

Thus, at the very threshold, some of the most elementary principles of mechanical construction of the cell are still matters of controversy. On the one hand, it is held by Professor O. Bütschli and his followers that the substance of the typical cell is essentially alveolar, or foamlike, comparable to an emulsion, and that the observed reticular structure of the cell is due to the intersections of the walls of the minute ultimate globules. But another equally authoritative school of workers holds to the view, first expressed by Frommann and Arnold, that the reticulum is really a system of threads, which constitute the most important basis of the cell structure. It is even held that these fibres penetrate the cell walls and connect adjoining cells, so that the entire body is a reticulum. For the moment there is no final decision between these opposing views. Professor Wilson of Columbia has suggested that both may contain a measure of the truth.

Again, it is a question whether the finer granules seen within the cell are or are not typical structures, "capable of assimilation, growth, and division, and hence to be regarded as elementary units of structure standing between the cell and the ultimate molecules of living matter." The more philosophical thinkers, like Spencer, Darwin, Haeckel, Michael Foster, August Weismann, and many others, believe that such "intermediate units must exist, whether or not the microscope reveals them to view. Weismann, who has most fully elaborated a hypothetical scheme of the relations of the intracellular units, identifies the larger of these units not with the ordinary granules of the cell, but with a remarkable structure called chromatin, which becomes aggregated within the cell nucleus at the time of cellular division—a structure which divides into definite parts, and goes through some most suggestive manœuvres in the process of cell multiplication. All these are puzzling structures; and there is another minute body within the cell, called the centrosome, that is quite as much so. This structure, discovered by Van Beneden, has been regarded as essential to cell division, yet some recent botanical studies seem to show that sometimes it is altogether wanting in a dividing cell.

In a word, the architecture of the cell has been shown by modern researches to be wonderfully complicated, but the accumulating researches are just at a point where much is obscure about many of the observed phenomena. The immediate future seems full of promise of advances upon present understanding of cell processes. But for the moment it remains for us, as for preceding generations, about the most incomprehensible, scientifically speaking, of observed phenomena, that a single microscopic egg cell should contain within its substance all the potentialities of a highly differentiated adult being. The fact that it does contain such potentialities is the most familiar of every-day biological observations, but not even a proximal explanation of the fact is as yet attainable.

Turning from the cell as an individual to the mature organism which the cell composes when aggregated with its fellows, one finds the usual complement of open questions, of greater or less significance, focalizing the attention of working biologists. Thus the evolutionist, secure as is his general position, is yet in doubt when it comes to tracing the exact lineage of various forms. He does not know, for example, exactly which order of invertebrates contains the type from which vertebrates sprang, though several hotly contested opinions, each exclusive of the rest, are in the field. Again, there is like uncertainty and difference of opinion as to just which order of lower vertebrates formed the direct ancestry of the mammals. Among the mammals themselves there are several orders, such as the whales, the elephants, and even man himself, whose exact lines of more immediate ancestry are not as fully revealed by present paleontology as is to be fully desired.

All these, however, are details that hardly take rank with the general problems that we are noticing. There are other questions, however, concerning the history and present evolution of man himself, that are of wider scope, or at least of seemingly greater importance from a human stand-point, which within recent decades have come for the first time within the scope of truly inductive science. These are the problems of anthropology—a science of such wide scope, such far-reaching collateral implications, that as yet its specific field and functions are not as clearly defined or as generally recognized as they are probably destined to be in the near future. The province of this new science is to correlate the discoveries of a wide range of collateral sciences—paleontology, biology, medicine, and so on—from the point of view of human history and human welfare. To this end all observable races of men are studied as to their physical characteristics, their mental and moral traits, their manners, customs, languages, and religions. A mass of data is already at hand, and in process of sorting and correlating. Out of this effort will probably come all manner of useful generalizations, perhaps in time bringing sociology, or the study of human social relations, to the rank of a veritable science. But great as is the promise of anthropology, it can hardly be denied that the broader questions with which it has to deal—questions of race, of government, of social evolution—are still this side the fixed plane of assured generalization. No small part of its interest and importance depends upon the fact that the great problems that engage it are as yet unsolved problems. In a word, anthropology is perhaps the most important science in the hierarchy to-day exactly because it is an immature science. Its position to-day is perhaps not unlike that of paleontology at the close of the eighteenth century. May its promise find as full fruition!

CAPTAIN JOHN ADAMS, MISSING

AN INCIDENT OF THE BOER WAR

BY DR. C. W. DOYLE

TWO days after the battle of Elands Laagte, in a little clearing on the right bank of Sunday's River, Captain John Adams, of her Britannic Majesty's Lancers, with a revolver ready to his hand, lay fast asleep, and undisturbed by the bright sunlight that streamed on his face—for he slept the sleep of exhaustion. He had been wounded, as the blood-stained bandage round his knee showed, and he was one of the "missing," whose numbers so greatly swell the British losses in the terrible war now proceeding in South Africa.

The pennon of the lance he had planted in the ground beside him was stiff, and the lance-head was blackened—for it had been used in the charge made by the Fifth Lancers at the end of that day of blood. But although the little flag had lost its jaunty flutter, it had attracted the attention of the young Boer scout, who was now leaning on his rifle and regarding the sleeper.

"It is a fool—and a very reckless fool!—who would display such evidence of his folly as this," thought the Boer, as he plucked the lance from the ground and put the Lancer's revolver in his own belt.

The sleeper's dress and accoutrements, identical with those of some prisoners he had seen despatched to Pretoria, showed him to be a soldier of the hated regiment that had refused quarter to the Boers whom they had ridden down on that day of wrath at Elands Laagte.

To the tall, fair-bearded Boer, whose young brother had been killed on that day—perhaps by this very Lancer—it seemed but right to send the sleeper's soul a-glimmering without any warning.

"'Let God arise, and let His enemies be scattered,'" he muttered in his beard, as he clubbed his rifle to do this killing—he could not shoot the Lancer, for he might be within ear-shot of British scouts, and his horse was too tired for flight from pursuers. But before the blow could descend, an open book lying beside the sleeper caught the Boer's eye. Treading softly, he picked it up. It was a prayer-book of the Established Church of England, and on the fly-leaf was written, *John Adams, Captain, Fifth Lancers.*

"They are all hypocrites, and worse than the heathen," was the thought of the stern young Lutheran. "'God shall wound the head of His enemies,'" he muttered again, quoting from the psalm that had been chanted by Cromwell at the battle of Dunbar.

As he slipped the little book into his pocket, preparatory to resuming his grim work, something fell from its leaves to the ground. He picked it up—and it was the picture of a pretty, fair-haired child about three years old. So rough, and unlovely, and full of the horrors of war had been the past few days that the presentment of a little innocent child, seen at such a time and such a place, took him out of himself for a moment by the contrast it suggested.

At a lonely farm, in the loneliest corner of the Transvaal, he too had a little one, with fair hair and blue eyes, whose prayers, he knew, rose nightly at her mother's knee on his behalf to the God of Battles, who had doubtless listened to his Gretchen—for he had come through the hell of a modern battle unhurt.

A gleam of pity touched his mind as he regarded the picture in his hand. Perhaps the sleeping soldier was the father of the little maid. On the back of the photograph was the simple legend *My Own Sweet Dorothy.* He would wake the sleeper, then, for the sake of the "sweet Dorothy" across the sea, and give him a chance of settling his affairs with his Maker before despatching him.

Having assured himself once more that the sleeping Lancer was unarmed, he touched him with his rifle, saying, "John Adams, awake!"

The Captain opened his eyes—to find himself disarmed. In the excitement of the situation he struggled to his feet, but in the next instant a twinge of pain reminded him of his wound and made him feel faint. He swayed and would have dropped had not the Boer caught him and seated him on a fallen tree trunk. He revived shortly, only to realize in the same moment that he was helpless—and doomed! For the stern, determined Boer had that in his face that forbade any hope. Well, he would die like a man, at any rate. And then it occurred to him that the Boer might have killed him in his sleep! There might be some slight hope in such restraint on the Boer's part—there certainly was some reason. Drawing out his pipe, he proceeded to fill and light it. The man with the rifle should begin the game of life and death.

"You are John Adams?" asked the Boer, in English, and with an accent that told of education at Cape Town.

The Captain nodded affirmatively.

"Your little daughter's name is Dorothy?"

"Now how in the devil's name should you know that?"

"One who is so near to his end should not swear, John Adams. This is the source of my information," and the Boer turned the picture towards the other.

The sight of it was too much for the wounded man, who dropped his head between his hands and groaned aloud.

"Courage! John Adams," said the Boer; "and thank your sweet Dorothy for giving you a chance of making your peace with God."

They meditated awhile in silence—the Boer leaning on his rifle, and the Briton with his head between his hands.

Presently the latter looked up, and asked, "You have little ones of your own?"

"I have a little Gretchen, who is as sweet as your Dorothy."

"For the sake of your Gretchen, would you consider such a—such a request as one soldier might fairly ask of another?"

"Surely."

The proposal the Lancer was about to make was such as a Cavalier of Charles the First might have made to one of Cromwell's Ironsides—the prototypes of the Boers. He involuntarily raised his eyes to the impassive heavens before speaking, and a speck in the clear rarefied atmosphere of the uplands caught his attention. It came to his mind, with a curious thrill, that a pair of eyes far keener than his were watching this present session between Briton and Boer. (Such sessions had brought much good feeding to the vultures of Natal in the past few days. The bearded men and the men in *khaki* were alike good for hungry beaks.)

These anachronistic "seventeenth-century shepherds"—as some one has well styled them—who insist that God is on their side; who think to stay the March of the Ages with modern weapons of precision and dumdum bullets; and whose President incorporates truculent verses from the psalms of the warrior-king with his orders to the farmer-soldiers of the Transvaal to "shoot straight"—such men might possibly produce a few knightly foes amongst their thousands. These thoughts passed rapidly through the mind of the Captain as he considered the terms of his request.