of mine published in SCIENCE, appears to convict me of inconsistency and to derive the conclusion that certain subjects introduced in an illogical manner into his 'Elements of Geometry' find a satisfactory treatment in his 'Elementary Synthetic Geometry.' These subjects are *the straight line as a minimum length* and the general notion of *the length of a curved line.* As a matter of fact, neither of these subjects is discussed in the latter work. The only curved line there considered is the circle.

THOMAS S. FISKE.

A QUESTION OF CLASSIFICATION.

TO THE EDITOR OF SCIENCE: The communications by Profs. Hollick and Ward in your recent numbers, commenting upon Prof. Marsh's determination of the Jurassic age of the Potomac and Amboy clays of the south New England island series and New Jersey-Virginia coast, and Prof. Marsh's reply to Prof. Hollick in the November number of the *American Journal of Science*, are of interest to all workers in American Mesozoic formations.

Prof. Marsh, in his early papers on the vertebrates of the Atlantosaurus beds of the age of Colorado and the Potomac beds, has referred both of these to the Wealden epoch. American geologists * do not assert the existence, in this country along the present Atlantic slope, of Jurassic beds of Atlantic sedimentation representing the whole or part of that vast period of time below the Wealden. In view of these facts, it is no inference to state that the broad generic term 'Jurassic period,' as applied by Prof. Marsh to this portion of our country, is a synonym for the term Wealden epoch, as used by others. Hence that part of the controversy, so far as it involves the oldest or Potomac beds, narrows down to the question of whether the beds of the Wealden epoch should be classified as the top of the Jurassic or the base of the Cretaceous period of geologic time.

* With the exception of Prof. Jules Marcou, who originally maintained that the Middle and Lower Cretaceous of Texas and the Plains Tertiary were Jurassic, and who still maintains the Jurassic age of the Middle Cretaceous beds of New Mexico and the Lower Cretaceous of Texas. This position has been disproved by research.

This is an old and much discussed question of English geology. It would be impossible here to give even brief reference to the extensive literature of the question. It is sufficient to say that, after the most thorough sifting of the evidence pro and con, European opinion and usage of to-day uphold the Cretaceous age of the Wealden beds. Against the opinions of a few who hold to the contrary, a volume could be filled with the data of eminent European authorities who maintain the Cretaceous age of the Wealden, including L. Agassiz, Lyell, Jukes, Prestwich, Zittel, Etheridge, Woodward, Pavlow, Fischer and others. Even as I write these lines the mail brings, fresh from the press of the official Geological Survey of Great Britain, an elaborate monograph of five volumes on the English Jurassic by H. B. Woodward, which excludes the Wealden from the Jurassic and places it at the base of the Cretaceous period. Furthermore, the consensus of opinion in all the reports of the meetings of the International Congress of Geologists places the Wealden as the base of the Cretaceous system.

Prof. Marsh, however, has assumed the position in several writings that the Wealden epoch belongs to the Jurassic period and not to the Cretaceous, and this opinion explains his use of the term Jurassic in this country. On the other hand, all the able authorities of this country, except Prof. Marsh, who have studied or reviewed the Potomac and allied formations of Wealden affinities have reached the final conclusion that they are of Cretaceous age. Among these may be mentioned Dana, Newberry, Ward, McGee, Hollick and others. The U. S. Geological Survey has also mapped these formations as Cretaceous upon its latest atlas sheets.

The controversy, in part, thus narrows down to the problem of the age of the beds of the Wealden epoch, and naturally arouses an inquiry as to what criteria can be depended upon to settle the limitations of the geologic periods. There are three plausible methods that suggest themselves: (1) precedents and usage; (2) correspondence of the rock of each period with great cycles of sedimentation, and (3) the presence of characteristic, distinguishing fossils.

The weight of precedent and usage, as shown by the eminent authorities cited, undoubtedly assigns the Wealden beds to the base of the Cretaceous. In view of this almost unanimous opinion of the ablest individual authorities, the established usage of the official surveys of Great Britain and the United States, and the expression of the representative International Congresses of Geologists, to the effect that the Wealden is the base of the Cretaceous system, it will require more than the assertion of one savant, however eminent in research, to change the accepted geologic classification. At least some preconcerted action and international agreement on the part of the geologic societies should be had before one would be justified in using the broad term Jurassic for beds which at the utmost could only doubtfully be referred to it, and which, if so referred, would represent only a minute fraction of the great time period of the Jurassic.

Periods of geologic time usually correspond with one or more great oscillations of land and accompanying migration of the marine shore lines, producing cycles of sedimentation. These cycles are recorded by successive variations in the character of the sediments manifested: First, by estuarine and other unsorted marginal deposits, representing the beginning of the subsidence. In turn these are succeeded by more finely sorted and deeper-water or off-shore beds, as subsidence of bottom and landward migration of shore progresses. The Wealden in England and the Potomac in America most clearly represent the basement littorals of the Lower Cretaceous epochs of sedimentation, belonging by every physical affinity and gradation with the overlying beds.

Furthermore, the Potomac from New Jersey nearly to the Rio Grande is undoubtedly a marginal, land-derived formation, laid down at oceanic deposition level, and one which marks the initiation of the great cycle of Lower Cretaceous sedimentation, recording the encroachment of the Cretaceous sea upon the pre-existing Jurassic continent. In Texas these beds certainly lie unconformably alike upon Algonkian, Silurian, Carboniferous, Permian and alleged Triassic, and there is not a trace of pre-existing Jurassic sediments.

The third method, based upon the presence of characteristic fossils, is likewise valuable, but least trustworthy. The land and fresh-water animals, land plants and marine mollusks each present a widely varying standard, and leave room for differences of opinion upon the part of their respective students. While each of these (except the fresh-water mollusks, which seem of little diagnostic value) has peculiar characteristics for each of the great periods, there is no reason to presume that research may not often lead to the discovery of the persistence of supposed characteristic Jurassic forms into the Cretaceous, or Cretaceous forms into the Tertiary, as has been done in some instances. In such cases, however, no one has ever changed the period designation of the beds. For instance, ammonites were once reported to be found in the Eocene of India, but no one has transposed the Eocene epoch from the Tertiary to the Cretaceous on that account, and even if Prof. Marsh has found Jurassic land vertebrates in the Wealden it is doubtful if he would be justified, in face of the opposing evidence of the plants, mollusks and sediments, in making such a radical step as transferring the Wealden beds from the Cretaceous to the Jurassic period. It would be far more logical, in my opinion, to consider that the vertebrate life of the Jurassic land has persisted slightly into the Cretaceous period.

Regardless of European analogy, however, there is every stratigraphic and paleontologic reason for placing the Potomac-Trinity formations of America as the base of the Cretaceous. In Texas, plants, vertebrates and marine mollusks are found associated in the basement Trinity beds, the equivalent of the lowest Potomac. The plant life and molluscan life which have been most thoroughly studied show no more Jurassic characters than are usually found in these basement beds.

With all due deference to the opinion of others, there are reasons for suspecting that no marine Jurassic formations of Atlantic sedimentation have as yet been discovered north of Argentina on the present Atlantic slope of the American hemisphere, and furthermore I hold that there are strong reasons for believing that this absence is due to the fact that the conti-

nental expansion towards the east was far greater in Jurassic time than now, especially in the tropical and South American regions. That lacustral deposits of the alleged nature of Prof. Marsh's Atlantosaurus beds of Wyoming and Colorado may have been made upon this Jurassic land mass is not only possible but plausible, but Jurassic deposits at marine sedimentation level are undoubtedly missing or undiscovered upon the Atlantic slopes of both American continents.

Robt. T. Hill.
U. S. Geological Survey.

Since the above was written, Prof. Marsh has published another contribution upon 'The Jurassic Formation of the Atlantic Coast.'* This contains many statements with which American geologists will differ, and conflicts more or less directly the results of others, who for years have carefully explored and described the Mesozoic formations of this country.

Prof. Marsh, in his previous papers, has transferred the Wealden epoch from the base of the Lower Cretaceous to the top of the Jurassic; and the tenor of the present article is to repudiate the Lower Cretaceous entirely, as is shown in the diagram of the 'Geologic Horizons of Vertebrate Fossils,' and in the many places where he makes the Dakota Formation the base of the Cretaceous. Upon the evidence of plants, vertebrates and mollusks, all other students place the Dakota Formation in the middle of our American Upper Cretaceous and at the base only of the upper of the two great series into which the Cretaceous of this country is divided. It is considered also as the time equivalent to the Middle Cretaceous of Europe. Between the Dakota and Jurassic time positions, both in this country and Europe, there are extensive series of sediments representing the great interval of the Lower Cretaceous time. Even Prof. Jules Marcou, who has here alone upheld the Jurassic age of the Lower Cretaceous formations in part, admits that there are extensive Lower Cretaceous beds below the Dakota. These Lower Cretaceous beds, to which the Potomac belongs, and not the Dakota, as alleged by Prof. Marsh, are the true base of the Cretaceous system in the Rocky Mountain region, at least in the Trans-Pecos, Texas and Mexican portions of the Rocky Mountains. Neither is it improbable that they are the true base of the Cretaceous in the Colorado region, if the Atlantosaurus beds are of the Lower Cretaceous series. The latter clearly occupy the stratigraphic position where the Lower Cretaceous beds ought to be, lying beneath the Dakota and above the last determinable Jurassic. For years students of American stratigraphy have desired to know the relationship between these Atlantosaurus beds of Colorado and the nearest allied Potomac-like formations of undoubted Atlantic sedimentation. Some have even suspected that they might ultimately prove to be a part of the great basement littoral of the Lower Cretaceous of the Texas and Potomac regions. In a previous paper I have suggested that there might be stratigraphic relationship between the Trinity-like sands at the base of the Tucumcari series of New Mexico and the Atlantosaurus beds of Colorado. An attempt to trace this connection, however, resulted in the conclusion that it would be impossible to prove it, owing to discontinuity of outcrop along the flanks of the Rocky Mountains in New Mexico. Prof. Marsh, however, now assures us that the Atlantosaurus beds are the western extension of the Potomac formation of the Atlantic coast, and hence those who still believe in the Lower Cretaceous position of the latter, would hereafter be justified by his correlation in mapping the Atlantosaurus beds as Cretaceous.

An impression is obtained from Prof. Marsh's writings that his deductions are based entirely upon the vertebrates, and that he has not fully considered the correlative testimony of other life forms the species of which occur in greater abundance and have a more world-wide distribution than the vertebrates. In discussing the relative merits of plants and vertebrates as stratigraphic criteria, he even states that the attempt to make out the age of formations by the use of fossil plants is too often labor lost. Whatever may heretofore have been the diagnostic value of paleobotany in stratigraphic determination, the recent detailed researches in this country have created for it a position that com-

* This Journal, December 5, 1896, and *American Journal of Science*, December, 1896.

mands respect. On the other hand, the discovery and description of vertebrates in America has been accomplished by so little stratigraphic and comparative data that the exact value of these forms as aids in stratigraphic interpretation is uncertain. A single contribution to the stratigraphy of the vertebrate beds, or critical comparison of the forms with European affinities, such as Prof. Ward has recently given us of the plants of the Potomac formation,* would be a most welcome contribution to American geology. In any event, ridicule cannot overcome the fact that research has not as yet shown the existence in the Jurassic of dicotyledonous plants, such as the Cretaceous beds of the Atlantic coast contain.

The following statements in Prof. Marsh's paper are also of interest: "The invertebrates known from these strata are few in number, but some of the mollusks among them point to the Jurassic age, as Whitfield has shown." "There is now positive proof that the southern end of this series is Jurassic, and it is certainly a fair conclusion that the remainder is of the same age. The burden of proof will rest upon those who hold to the contrary." The writer has been studying the southern extension of the Potomac formation in Arkansas and Texas for many years, but is not aware of Prof. Marsh's having ever examined the beds at all. There the continued Potomac beds, as above stated, contain plants, vertebrates and mollusks in intimate association. The counsel of the ablest authorities and specialists has been sought in the interpretation of these invertebrate fossils. With the exception of Prof. Ferdinand Roemer,† and Prof. Heilprin, who maintained that the beds were Upper Cretaceous, and Prof. Jules Marcou, who still believes them Jurassic, the Lower Cretaceous position of the beds is maintained by all other later authorities who have studied the plants, vertebrates and invertebrates. It is true that invertebrates are few in number in the North Atlantic States, but in the Texas-Arkansas region, 'the southern end of this series,' which Prof. Marsh says is also Jurassic, over 300 species have been noted from the beds below the Dakota which, as a whole, clearly testify to the Lower Cretaceous positions of the beds. In describing the New Jersey forms to which Prof. Marsh refers, Prof. Whitfield, instead of referring them positively to the Jurassic, clearly says: "We get no help of sufficient value to establish the geologic horizon of the beds from these molluscan remains, and aside from the evidence furnished by the plant remains we must rely entirely upon their stratigraphic position."*

It is strange that Prof. Marsh, while discussing the invertebrates and paleobotany, makes no mention of the true Lower Cretaceous vertebrates, and omits them from his 'Horizons of Vertebrate Fossils.' It is true that the vertebrates are rare and have been less fully studied than the plants and invertebrates, but Prof. Cope has already described five species of fishes from the Southwestern beds, and has referred them all to the Cretaceous. Williston† has likewise published several vertebrates from the Lower Cretaceous of Kansas, including turtles, fishes, saurians and crocodiles.

Prof. Marsh's views of continuous sedimentation along the Atlantic coast through the various periods of geologic time are also peculiar. He says: "To place the strata in question in the Jurassic section of the Atlantic coast at once removes many difficulties that have hitherto perplexed students of the Mesozoic of this region. It completes the series, and shows in part at least what was done in deposition during that long interval between the end of Triassic and the beginning of Cretaceous time." It is not exactly clear how the geologic series of the Atlantic coast will be completed by restoring the Jurassic sediments, as he proposes to do, at the expense of the

*Some Analogies in the Lower Cretaceous of Europe and America, by Lester Frank Ward. Extract from the Sixteenth Annual Report of the U. S. Geological Survey, 1894-95, Part I., Director's Report and Papers of a Theoretic Nature, 1896.

†Prof. Marsh lays stress upon the fact that Prof. Roemer told him to look out for the Jurassic in America. It may interest him to know that the writer has a letter from Prof. Roemer, written just before his death, in which he insists upon the Upper Cretaceous age of the Lower Cretaceous beds which Prof. Marsh is now including in the Jurassic.

*Monograph IX., U. S. Geol. Survey, p. 23, 1885.

†Kansas University Quarterly, July, 1894.

Lower Cretaceous beds, which are left out of the geologic column. A great break in the sedimentary sequence would still exist between the Wealden and Dakota. In the light of the testimony of structure and paleontology, the current hypothesis that land conditions prevailed in Jurassic time makes a much more harmonious and acceptable geologic record.

Personally, while differing with Prof. Marsh, the writer feels grateful that he has reopened this question, for we believe it will result in a more thorough understanding and appreciation of the Lower Cretaceous epoch and its influence in the making of our continental history. In conclusion, however, we must confess our inability to see that Prof. Marsh has submitted sufficient proof to maintain his proposition or to upset the accepted results of the minute geologic research throughout the Atlantic Coastal Plain. To prove these beds Jurassic by moving the boundary between periods is not an altogether satisfactory method, nor in harmony with geologic usage. Neither will the testimony of a few vertebrates in beds abounding in Cretaceous-like plants and invertebrates be of sufficient weight to upset the accepted nomenclature, especially when the time position of these vertebrates in the European standard to which they are referred is unknown.

Inasmuch as the evidence contrary to Prof. Marsh's position has all been brought out in accepted scientific literature, and he, as yet, has presented no detailed evidence to maintain his unique position, it is difficult to appreciate his statement that the burden of proof 'belongs upon those who hold contrary opinions' to himself. It appears instead that he is submitting data which may be used to advantage by those who might believe in the Cretaceous age of the beds which he has so long called Jurassic.

R. T. H.

PROFFESSOR WILSON'S ADDRESS AT THE PRINCETON SESQUICENTENNIAL CELEBRATION.

The concluding part of Professor Woodrow Wilson's oration at the Princeton sesquicentennial celebration has been received with general applause by literary and religious journals. The occasion of its delivery made it more than an individual utterance, for the speaker and the hearers must have understood it to present a program for Princeton University. Men of science should, therefore, read Professor Wilson's words in order that they may know of the existence of a point of view which they may have thought obsolete.

Professor Wilson holds that the scientific spirit of the age is 'doing us a great disservice, working in us a certain great degeneracy,' that the limitations of science are known to its own masters, who 'have eschewed sense and confined themselves to sensation.' He is indeed prepared to acknowledge certain achievements of science, but for him 'the scientist' seems to be the man who invents the steam engine or the sewing machine. The practical applications of physical science have, it is true, reformed the world. They have answered with facts Professor Wilson's predecessor whose *a priori* arguments claimed that population must increase more rapidly than the means of subsistence. They have made possible a civilization in which each man may have not only physical well-being, but also time and means for thought and culture. But I believe that science has done more than this; it has not only given opportunity for education and culture; it also offers the best means of culture and the truest standpoint from which to view the world. Keats might see no beauty in the rainbow after its causes had been explained to him, and Professor Wilson may think Phœbus and his horses a nobler conception than those of modern astronomy. But the man of science does not find that the beauty of the world becomes less, as he learns more of its order.

Scepticism, pessimism and the like are much older than the present century; they do not result from scientific study, as Professor Wilson claims, but are rather literary products. It is not the student of science, but Professor Wilson, who 'cowers' 'in an age of change.' If, as Professor Wilson says, classical studies make a boy a gentleman, scientific studies may make him a man. The present writer does not undervalue classical studies, but finds the difficulty to be that in a college such as Princeton the work with grammar and dictionary is a somewhat trivial science and the student does not go on far enough to appreciate classical literature and art or to undertake the scientific study of the causes of the