

the formation of rain under these circumstances seems disproved, in another place, by the author himself, who rejects the theory that any considerable precipitation can be produced by the mixture of masses of hot and cold air. Mr. Scott acknowledges that nothing definite is known as to the origin of atmospheric electricity; but his conjecture that the coalescence of cloud-droplets into rain-drops may be due to electricity will hardly be accepted by meteorologists at present. The description of a peculiar electrical manifestation observed in the Alps, July 10, 1863, is very similar to that given by Siemens while on Cheops pyramid, April 14, 1859.

The division of thunder-storms into heat and cyclonic is hardly applicable to the United States, where it appears as if no thunder-storms occur, except as largely influenced by, or directly dependent on, the presence of a barometric depression.

The error of more than forty million square

miles in the earth's surface between the equator and 30° north latitude should be corrected in the next edition.

The statement, that at great depths in the ocean a probable uniform temperature of 32° F. prevails, has been disproved by the researches of Professor Verrill and the U. S. fish-commission.

We notice on p. 362 the surprising statement, that, as the central office of the U. S. weather bureau is in the eastern part of the country, there is a great advantage to those predicting storms by the use of the telegraph.

The chart of mean January isobars does not incorporate Stelling's work in Siberia, published in 1879, and accepted by Mohn in the last edition of his Meteorology. Mohn's chart shows a mean pressure over central Siberia of 780 mm. (30.79 in.), while the highest figure in Scott for the same region is 30.4 inches.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE thirty-second annual meeting of the American association was opened in the halls of the university of Minnesota, Minneapolis, Aug. 15, at 10.30 A.M. Dr. J. W. Dawson, the retiring president, introduced the president elect, Prof. C. A. Young, who briefly and gracefully expressed his thanks to the association for the distinction they had offered him. After welcomes spoken by the governor of the state and the mayor of the city, the principal address was made by the acting president of the university, Dr. W. W. Folwell, on behalf of the local committee. From his address we print the closing sentences:—

I should do a wrong to my city if I should leave upon you the impression that we are so overwhelmed and engrossed with our material labors as to have no care for the things of the mind and the higher life. If that were true, why should we welcome with so much sincere ardor the assemblage of your association? From the villages of New England, and the farmhouses of the Middle states, our people have brought that perennial curiosity, that thirst for knowledge, that intense though sombre imagination, which have given American civilization and American literature a cast and hue of its own. I must, in a word, praise our system of public schools, both city and state, which under able management and popular support cannot, we believe, be ranked below those of any communities of our size in the Union. Minnesota is the first place which has organized its secondary as well as its primary education, and offered to

every child in the state a free course of studies, from the alphabet to the degree of master of arts. Our churches, goodly in size and number, may speak for the interests of religion. The future will attest the diligence and the fidelity of those who love music and the sister arts, of whom far older cities might be proud. It is thus, however, Mr. President, that we Minneapolitans, alert, pre-occupied, pause in the midst of our labors to welcome your already venerable association. We hail you as the survivors of a generation of great investigators,—the Sillimans, the Baches, the Morses, the Rogerses, who have made their own country famous and their own names as imperishable as science herself. We hail you as the worthy successors of such a generation, perpetuating and enlarging their work. In common with civilized people, we recognize the immense debt of the modern world to science; yet often, no doubt, while we are filling the sky with applause to some lucky inventor, we are not remembering the years, perhaps generations, of inconspicuous and painful labors, carried on in our studies and laboratories, which made the invention possible. Let the inventor have his glory and his profit without envy and without stint; but let us not fail to build the cenotaph of a thousand nameless geometers, stargazers, and natural philosophers, who, working in silence and obscurity, without thought of fame or hope of reward, put it in his power to bless and captivate the world. We are grateful, therefore, to science for the telegraph and the microscope, for chloroform, for the photograph, for all the nameless applications of electricity. To science we owe that magnificent apparatus of transportation which is the crowning and distinctive feature of modern material life. To

science we owe the thousand appliances which yield comfort and even elegance to the humblest household. Immense as are these contributions of science to material comfort and happiness, she has still, I think, performed greater services to mankind. The scientific method developed in the study of nature has spread to all branches of investigation. It has permeated all our education: it has boldly leaped the boundary between physics and metaphysics. It has even penetrated into industry and business and common life. The modern man first collects what knowledge he can about his enterprise or adventure, and assures himself of its value. He then makes the best quest he can in regard to the future. Then he assembles new facts, and, as the facts require, revises and amends his theory, till at length it becomes a working rule, maxim, and principle. He knows not merely how to know, but how to guess. The penetration of the scientific method into the operations of trade in great commercial centres is very conspicuous. We even endeavor to gamble scientifically. No Drew, or Armour, or Gould ever forms his corner without a most careful study of the situation; and his venture is his bet on the correctness of his theory. The farther extension of the scientific method, till it shall become the guide of conduct in the every-day life of all men, is now the chief problem in education.

In the next place, I think science may at length fairly claim to have wrought out, under great difficulties, a working hypothesis of our universe in the nebular hypothesis and its almost necessary corollary, 'evolution.' It cannot be denied that we are all, in some sense, evolutionists, — some of us against our prepossessions, some of us by insensible but progressive lapses. I am not competent to argue out this great theme. I feel bound to admit that the evolution doctrine, in one form or other, has quietly taken possession of the modern mind. Why may we not gladly accept it as a most useful working hypothesis of the mode of creation? I say, of the mode of creation; for the mystery of creation will forever mock the powers of man. Only this we know: that unless human consciousness is a juggle, and human language a mockery, there can never be to man a creation without a creator, nor an evolution without an evolver.

Another great service of science is the maintenance in the world of a body of men, a lay priesthood, devoted to the search for truth for its own sake and its own value. In a mercenary age, when, in the opinion of a distinguished contemporary, mercantilism has become a huge disease and excrescence on society, the example of such a body of men is of supreme value in the training of the new generations. Youth are formed, a wise Greek has taught us, not so much by schools as by the example of distinguished men.

A still greater benefit of science to mankind is the emancipation it has wrought for us, in the last generation, from superstition and the dominion of imaginary powers. It is no long time since it was generally believed by civilized men, that human affairs were

under the control of the spirits of the air, good or evil. Men walked in cringing terror, by day and night, of demons and goblins damned. The earthquake, the tornado, the lightning's stroke, they looked upon as instruments of punishment for the sins of rulers and peoples. Thanks to science, the modern world has emerged from this cloud of gloom. We have some certain knowledge. Knowledge is not merely qualitative, but quantitative. Truth ever makes free. Above all, we know that all things in nature are governed by law, — law, "whose seat is in the bosom of God, whose voice is the harmony of the world." The beautiful conception of the Greeks of the universe as a kosmos, that is, an embodiment of divine and perfect order, is pervading modern thought. We now know that the phenomena of nature have no relation to human conduct, the impartial rain falling alike on the just and unjust. Men walk the earth erect and free, fearing no bogies, or warlocks, or demons of any kind. How vast and how blessed the relief to childhood! In dispelling superstition, science has incidentally wrought her greatest service to mankind in the purification of religion. The time is coming when grateful thanks will be rendered by the minister of religion for the emancipation which science has wrought for the faith; when the conflict of science and religion will only be remembered as the antagonism of crude theories on the one hand, and cruder superstitions on the other. Grateful we are for the knowledge which science has collected and collated and perpetuated to our use. All honor to the men who are consecrated to truth in her service! We may not know what marvels, far surpassing all the gifts of the past, the science of the future may reveal. Still, we must remember that the human mind is finite, while truth is infinite. The vast unknown engirdles our little circle of light. The mystery of life and death, no son of earth has ever penetrated. Welcome, then, the faith which points to the continuance of life in a land where study will be no weariness to the soul, where no veil of flesh will cloud the vision, where science and religion shall be forever one, where men shall know even as they were known.

To welcome you as a body of scientists, lovers and seekers after truth from love of it and of your kind, would be well worth our while, were it our only motive to improve and inspire the children and youth of our city. In doing you honor, we give them a lesson no books nor masters could impart. For their sake we renew our welcome.

President Young briefly responded: —

GENTLEMEN, — On behalf of my fellow-members of the association, I return you my sincerest thanks for the hearty welcome we have received to this magnificent state, this young and beautiful city, this vigorous, energetic, warm-hearted community. When you first invited us here, it was not in our power to come; but your second invitation we have accepted most gladly, and hope and believe that our meeting here will prove a benefit and pleasure to all con-

cerned. Some of us have known you personally before, and most of us have long been more or less familiar at second hand with your state and city; and yet, I think, to many of us it is something like a new revelation to see for ourselves what a few years have accomplished. I am not enough of a Latin scholar to quote my Virgil well; but I have been all the time most forcibly reminded of the passage in which Æneas first comes in sight of rising Carthage. Most emphatically the work 'hails' here. We see no drones or sluggards; but every shoulder is at the wheel, and every thing is moving. It may, perhaps, seem to you sometimes, when in our sectional meetings we discuss some question about the stars, or some hypothesis as to the formation of rock-strata, or the structure of some worm or insect, that we are out of the current, and contributing nothing to the advancement of the world. But you know it is not so, and your invitation to hold our meeting here shows that you know it. The world advances, not on one line only, but on many,—on lines material, intellectual, spiritual. To some extent, the movements are indeed independent, but not very far. Any true advance on either line implies corresponding movement on each of the others,

if not absolutely simultaneous, yet surely consequent. There is no need to ask you here how much this city owes to modern science, when I see on every side, in your streets and storehouses and mills, the practical application of the highest engineering, mechanical, and electric art; and in the future it is almost certain that science is to contribute still more liberally to business. But not mainly for this reason do I claim your regard to science; but because, made in the image of God as we are, knowledge and understanding are as truly wealth and power as lands and food and money.

I need not add that, as you have invited us here, so we on our part cordially invite you to attend all our meetings, to listen to the papers and their discussion. We cannot promise that every paper will be interesting to all, but each one, I think, will be able to select certain ones he will be glad to hear; and if any of you choose to join us, and enroll yourselves as promoters of the advancement of science, our membership is open on easy terms. Once more, gentlemen, we thank you for the cordial welcome, and address ourselves to our business, in the hope and confidence that our meeting here is to be in the highest degree pleasant and successful.

PROCEEDINGS OF SECTION A.—MATHEMATICS AND ASTRONOMY.

*ADDRESS OF WILLIAM A. ROGERS,
OF CAMBRIDGE, MASS., VICE-PRESIDENT
OF THE SECTION, AUG. 15, 1883.*

THE GERMAN SURVEY OF THE NORTHERN HEAVENS.

THE illustrious Argelander was accustomed to say, in the quaint form of speech which he often employed, "The attainable is often not attained if the range of inquiry is extended too far." In no undertaking is there greater need of a judicious application of this sound maxim than in the systematic determination of the exact positions of all the stars in the visible heavens which fall within the reach of telescopes of moderate power.

The first subject which engaged the attention of the *Astronomische gesellschaft*, at its formation in 1865, was the proposition to determine accurately the co-ordinates of all the stars in the northern heavens down to the ninth magnitude. To this association of astronomers (at first national, but since become largely international, in its character and organization) belongs the credit of arranging a scheme of observations by which, through the co-operation of astronomers in different parts of the world, it has been possible to accomplish the most important piece of astronomical work of modern times. With a feasible plan of operations, undertaken with entire unity of purpose on the part of the observers to whom the several divisions of the labor were assigned, this great work is now approaching completion. While it is yet too early to speak with confidence concerning the definitive results which the discussion of all the ob-

servations are expected to show, we may with profit consider the object sought in the undertaking, the general plan of the work, the difficulties which have been encountered, and the probable bearing which the execution of the present work will have upon the solution of a problem concerning which we now know absolutely nothing with certainty,—a problem of which what we call universal gravitation is only one element, if, indeed, it be an element,—a problem which reaches farther than all others into the mysteries of the universe,—the motion of the solar and the sidereal systems in space.

Our first inquiry will be with respect to the condition of the question of stellar positions at the time when this proposal was made by the *gesellschaft* in 1865. All the observations which had been made up to this time possess one of two distinct characteristics. A portion of them were made without direct reference to any assumed system of stellar co-ordinates as a base, but by far the larger part are differential in their character. This remark holds more especially with reference to right ascensions. Nearly all of the observations of the brighter stars made previous to about 1830 were referred to the origin from which stellar co-ordinates are reckoned by corresponding observations of the sun; but since that date it has been the custom to select a sufficient number of reference stars, symmetrically distributed both in right ascension and declination, and whose co-ordinates were supposed to be well known. The unequalled Pulkova observations for the epoch 1845 form, I believe, the only exception to this statement. From the assumed system of primary stars are derived the clock errors and instrumental constants which are employed