must *put on* 6 similar weights on the opposite *positive* pan, showing the result to be $+6$.

To show that the product of -2 by -3 is $+6$, the balance is put into equilibrium with a number of weights on it, six or more on a negative pan. A group of two is *removed* from a negative pan, then a second group, and a third group from the same pan. As to kind each group is -2 . The operation of subtraction was performed three times, which is written -3 . Therefore the change made is indicated by saying -2 was taken -3 times. Again measuring on the opposite side we find that putting on 6 similar weights on the *positive* pan restores equilibrium, showing the product to be $+6$.

The writer has used the apparatus in his classes with good results. Pupils of another class were shown the nature of transposition, and of negative number, once only, and that rather hurriedly. After the lapse of several months they volunteered the testimony that it cleared up their ideas and helped them very much.*

ASTRONOMY AS A HIGH SCHOOL SCIENCE.

BY DR. J. A. MILLER,
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As to whether astronomy should be a high school science depends upon so many things concerning which I possess no expert knowledge that I hesitate to discuss it. So much has been learned, or at least written, about the psychology of adolescents since I was a student of psychology that I am utterly at sea whenever I try to draw any hard and fast conclusions touching secondary education or even to apply much of it to two adolescents of my own. Then, too, the purpose of education, particularly of secondary education, has been recently the subject of so widespread and varied consideration and the conclusions reached vary so much among themselves that I am equally without chart or compass in the sea of literature. There seems to be fairly universal agreement upon the proposition, however, that the primary purpose of the high school is not to fit students for college, but for life,

*Mr. Donecker informs the Editor that arrangements are being made for putting this very useful apparatus on the market by the opening of the next school year. Further particulars may be obtained by applying to the writer of this article, 588 East Sixtieth Street.—Mathematical Ed.

whether or not the immediate future life be spent in or out of the schoolroom. If an essential element of this preparation is that the student should learn those things only that may be directly translated into food and clothing, Astronomy should not find a place in the high school curriculum. For there are many other sciences richer in this element of education than astronomy. If this preparation means that it is to train boys that they become scientists then certain other subjects lend themselves more readily to high school methods; there is, nevertheless, much misapprehension as to the time, labor and expense necessary to acquaint a student with the rudiments of astronomy. There is at least one firm that will supply apparatus for a year's course in astronomy, one-half of which is laboratory work, for a cost less than that of equipping the usual chemical or physical laboratory. It is true, too, I think, that as much skill in compelling instruments to give one information and of interpreting and recording results can be obtained by such a course as in the ordinary course in any of the inorganic sciences. The chief advantages that the other sciences have, it seems to me, is that the student is working with processes which to a certain extent he may control, and which therefore he may modify at will, and for that reason they become of commercial value.

If an element of this preparation is to develop power then astronomy may find a place in the high school curriculum. If, farther, one element of this preparation is a campaign for knowledge as against ignorance then astronomy should find a place in the high school curriculum. For, its subject matter, dealing as it does with such momentous masses, separated by such great distances, moving with such great velocities, controlled by stupendous forces according to well-established laws, contains elements not found in any other science with the possible exception of geology. Elements of bigness that appeal with peculiar force to men and women of this adolescent age. It affords him his best opportunity to go to the frontiers of science, where conditions are pure, and unaffected by disturbing influences and the man who leaves school without some knowledge of astronomy has suffered a loss.

In a recent paper G. Stanley Hall says:

Next to English in the high school should come science, which teaches love and knowledge of Nature—the great mother of us all, and from which religion, art and literature as well as science, have sprung. The science and topics chosen should give largeness

of view, rather than precocious accuracy, and we should remember that man was a naturalist long before the laboratory. Youthful curiosity always strangely gravitates to frontier questions, where we all are children and love to play with great ideas, force atoms, astronomic space, and geological time. * * * First, all high school science should always include the elements of astronomy. Naturally the curiosity about the heavens is now almost at its strongest and best, and the result is reverence, for the undevout astronomer is mad. Very little celestial mathematics is needed, that came late, but a meaty body of facts about nebulae; the number of stars; the distances of those most remote, their motions in systems very different from our own, collisions, comets and dead planets; the sun and moon, which Plato and Aristotle knew no higher gods, the hierology of astronomy which has its saints and its martyrs, its epochs, its culture history and astrology, and what astronomers are now doing. Unfortunately this opinion has not found favor with educators in the United States. The subject has been omitted from the reports of the various committees appointed by the N. E. A. to consider the needs of secondary schools, and school officials generally seem to be hostile to it. In the earlier days no course was considered complete without it. In 1900 only about 3.5 per cent of students enrolled in the high schools were enrolled in astronomy. And in the five years preceding it the per cent had decreased slowly but steadily from 5.2 per cent to 3.5 per cent. It may be of interest to science teachers to know that in this matter astronomy does not stand alone. The per cent of students in every high school science, physical geography excepted, which holds its own, is decreasing. In ten years, 1890 to 1900, physics, upon which the greatest emphasis has been placed by school authorities and educational writers, has decreased from 21.4 to 18.8 per cent; chemistry, from 9.6 to 8 per cent; and for five years, 1895 to 1900, physiology has decreased from 28 to 26.9 per cent, psychology has decreased from 33 to 31.1 per cent, geology has decreased from 5.5 to 4 per cent, astronomy has decreased from 5.2 to 3.5 per cent. In the same period, 1890 to 1900, Latin has increased from 33.6 to 49.9 per cent, French has increased from 9.4 to 10.4 per cent, German has increased from 11.4 to 15.9 per cent, History has increased from 27 to 37 per cent, and in five years, 1895 to 1900, Rhetoric has increased from 31.3 to 37 per cent, and in three years

English literature has increased from 38.9 to 45 per cent. The figures appear better grouped thus, out of 384 per cent of all students in the high school:

79.2 per cent are enrolled in Languages, 78 are enrolled in English, 81 are enrolled in Mathematics, 87 are enrolled in Science, 58 are enrolled in History and Civics.

In Indiana there is practically no work done in astronomy in the secondary schools. A few of the high schools have in the past given courses for some time. Others have recently introduced courses, while others have discontinued them.

But astronomy is now at low ebb in the colleges and particularly in the State universities there has been a distinct revival in the teaching of the science. There has been in the past six years new observatories built and equipped in part at least for teaching purposes. At the University of Pennsylvania, Ohio, Cincinnati University, University of Illinois, Indiana and California, and in addition to these new departments of astronomy put into the universities of Missouri and Nebraska. Beside the recent and now formidable Perry movement in mathematics will give an increased interest to astronomy. So that in the near future I believe that astronomy will come into her rightful estate. The courses in astronomy should be reconstructed somewhat along the lines of natural history and laboratory. It should not consist mainly in finding north and south lines, establishing noon marks, building gnomons, etc. Only enough of this work should be done to insure that the student really understands the subject. The skill of making instruments imparts information to the manipulator and should come from the other sciences. But a part of the study must be made under the sky and be directed by some one who can look the sky squarely in the face, realizing that some of Nature's choicest secrets are hidden there. The purpose should be not to make astronomers, but men.

I am convinced that the study of the more conspicuous constellations should form a much greater part of the study of elementary astronomy than it does at present, and I believe also that this study should form the early part of the course. It must be made under the sky and include a study of their form and location, a generous sprinkle of their mythology, the names and positions of the brightest stars, the location of famous star clusters, double and variable stars and nebulae. An old friend of mine used to

say that "the way to educate a man is to set him to work; the way to get him to the work is to interest him; the way to interest him is to vitalize his task by relating it to some form of reality."

The mythology of these constellations, filled as they are with deeds of chivalry and romance, peopled with powerful heroes and beautiful heroines, appeal with wondrous power to these chivalric youths.

At the request of one of the best teachers of literature in the state a course in astronomy was put into the high school in which she taught because it explained many references in literature. Other myths that have been woven into the lives of peoples or have been made the basis of religious beliefs and practices, or that have found their way into our everyday practices, appeal to these high school students because they have appealed to men of all ages and have in many cases shaped the destiny of individuals and nations. As an illustration, consider the rather repulsive figure representing the signs of the Zodiac in the front of any almanac, the naming of the dog-days, the world-wide admiration of the Pleiades, the naming of the days of the week, etc. And in these things astronomy is far richer than any other science, for the time is not far past since the development of astronomy and civilization was coincident and in learning them he experiences again the travail that gave birth to our civilization.

It is under the sky with these people that one may most wisely decide what may and what may not be in a course in elementary astronomy. It should include the answers to questions asked them and when these questions are all answered the course is complete. In a general way, whether your audience be old or young, the questions are much the same and nearly in the same order as have been asked and are being asked by the professional astronomer. I have found at such times, too, that some of the most significant facts of astronomy may, with advantage, be brought to his notice. Tell a student when he is looking at Sirius that because of slight shiftings of its position Bessel showed mathematically that it had another sun nearly as large as our own going about it, and he gets some idea of the accuracy of the sciences, the immensity of the system, and he will never forget that it is one of the most interesting double stars in the sky. His curiosity should lead him to ask the significance of a double star.

If he is told that a star is a sun he will ask if there are planets going about them. Then show him Algol, the famous variable star in Perseus. One cannot describe its behavior too minutely. He will be interested in knowing that its range of variation is larger and that its behavior is so punctual that one can predict its brightness at any time. If you happen to be with him when it is losing or gaining its light he can see it vary. He will ask you what causes it to vary and the whole subject of variable stars is introduced, and when it is understood that the variation is caused by a dark body going around it, passing regularly between the eye and the star, he will realize that here is at least another sun with a planet going around it and when he is told of its size and period, he will feel that he has beheld a wonderful system. One leads easily now to the subject of double stars and such other subjects as he desires to discuss. Having learned the constellations he will get benefit from plating the moon and brighter planets as they move in the sky. He may also make such observations as are necessary to lead to an understanding of the apparent motions of the heavens. These may be made with instruments of his own manufacture. He may at a cost of 50 cents make him a telescope and a planisphere. If he has a camera let him point it to the pole for an hour or more some moonless night. He will get a picture of the rotating earth. He is now ready to study the sun, and this should be done in much detail, for we know more, very much more, about this star than any other. He should learn much about the new astronomy, the laws of the spectrum, the spectroscopic and spectrum analysis. It is possible to illustrate some spectroscopic facts at little expense. He should study the moon, for it is the only dead body that we know, and he should be told that this is the state to which all bodies are tending. He should study the planets, not as so many individuals, but rather as comparative geography. He will be interested in knowing that all have their seasons, their days and nights, their satellites, their mountains and valleys, their clouds, their snows and their rains. Little time should be spent with comets. They are relatively unimportant. Likewise I doubt the wisdom of trying his patience with circles and systems of coordinates. It is much better that he try to understand the laws of the matchless Newton, the laws that with one stroke made chaos into system—laws that have influenced the thinking of five centuries. And last, perhaps, some astrology. One of our duties as teachers is to kill

off superstition wherever it is found, and as the tubercle will not live in the sunlight, so superstition dies in the light of science. So also if the tubercle might die with this generation tuberculosis would disappear; likewise we should be free from superstition if we could eradicate it from this generation. Regarding nothing in all nature is there more superstition than the moon and the stars; an insidious superstition, that effects more or less seriously the efficiency of many men and women. It is perhaps fair to say that such a course as here outlined differs widely from that of any offered in text books now published. The sequence of subjects is in the main the same as they were studied by men, and as they would be developed if they followed the order suggested by the questions of boys and girls.

THE EQUIPMENT OF A PHYSIOGRAPHICAL LABORATORY.

BY JANE PERRY COOK.

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About the year 1896, a well known district superintendent of schools in Chicago advocated the substitution of physiography for biology as a study for the ninth grade. He believed that, as physiography was not a laboratory science much expense would be spared the city because it would be no longer necessary to equip and maintain laboratories for the large first year classes. The change was made and physiography has ever since been taught in the first year of the high school course.

Within the past five or six years, however, the teaching of the subject has undergone a radical change. It is no longer taught from text books alone, but every possible means is used to acquaint the pupils with materials and phenomena at first hand.

While physiography is not a laboratory science in the generally accepted sense of that term, in no science is it more necessary to use illustrative material. The use of such material has been found inconvenient in the recitation rooms furnished with ordinary desks, It is necessary to have a place where the pupil may spread out his maps and charts, and can work with globes or consult reference books without this limitation imposed upon a crowded class room with desks in set rows.