relative intensities of some of the lines of the secondary spectrum alter in a surprising manner, some of the lines being greatly enhanced whilst others become very weak.

From a theoretical point of view the spectrum of helium is second in importance only to that of hydrogen. The lines of helium are prominent in the spectrum of the chromosphere of the sun and of many stars, and their relative intensity varies under different conditions of excitation in the laboratory and in different celestial spectra. There are six chief series of lines in the spectrum of helium, three of which are usually referred to as the "helium" and three as the "parhelium" series. The helium series are the stronger in vacuum tubes containing the gas at pressures exceeding a few millimetres, whilst at very low pressures the parhelium series are predominant. Since the chief visible line of the helium series is yellow and that of the parhelium series green, the colour of the discharge is changed from yellow to green when the pressure is reduced.

There is another spectrum associated with helium which is analogous to the secondary spectrum of hydrogen in that it appears with any considerable intensity only when the gas is exceedingly pure. This spectrum is known as the band spectrum of helium, and its occurrence in a gas which is known to be incapable of forming molecules in the chemical sense of the word is very remarkable, in view of the fact that band spectra are generally attributed to molecules. It may perhaps be suspected that there is some temporary association of atoms during the passage of the electric discharge which cannot be referred to as a molecule in the chemical sense of the word. Prof. A. Fowler has shown that the arrangement of the heads of the bands in this spectrum resembles that found in series of lines which are due to atoms, though the arrangement of the lines which constitute each band is of the type usually found in band spectra.

When powerful condensed discharges are passed through helium a spark spectrum is developed. Two series in this spectrum are known as the 4686 and the T Puppis series, and their discovery by Prof. Fowler has led to some of the most important developments of theoretical spectroscopy. These spark lines of helium are found in the nebulæ and early type stars, and are attributed to helium atoms which have lost an electron.

The energy required to produce spark spectra varies widely with the nature of the gas under investigation, and for elements of the same chemical group is, as a rule, smaller the greater the atomic weight of the element. Thus in the case of helium powerful discharges are required for the production of the spark spectrum and the lines of the arc series are always bright. In the case of argon a much less intense discharge is required to produce the spark lines, and with very powerful discharges the arc lines disappear almost entirely from the spectrum. In addition to the production of these spark spectra one of the effects of powerful condensed discharges is to alter the relative intensities of the arc lines. Generally speaking, the effect of an increase of energy on a particular series of lines is to enhance relatively the more refrangible members of the series, but the effect varies in degree for different series. Experiments of this kind enable us to imitate to some extent in the laboratory the distribution of intensity amongst the lines which is found in the nebular and stellar spectra.

It will be seen that whilst many variations in spectra can be referred to different compounds, to molecules, and to uncombined atoms in successive stages of ionisation, there are a number of other changes for which there is at present no obvious theoretical explanation. The possibility of some specific influence of one gas on the spectrum of another must now be recognised apart from the formation of chemical compounds, which, in the action of helium on the spectrum of hydrogen, for example, appears to be excluded. There is also other evidence, based on a study of the broadening of spectrum lines, of a specific action on neighbouring atoms. We are still awaiting a satisfactory theoretical explanation of phenomena of this kind, though it is now forty years since what is perhaps the first known example, the action of sodium on the absorption spectrum of magnesium vapour, was observed by Prof. Liveing and Sir James Dewar at the Royal Institution.

Mathematics and Public Opinion.

PERHAPS few well-known mathematicians have escaped an experience which would be amusing if it were not so exasperating. Mr. Brown (let us say) is introduced to Prof. Smith, who teaches mathematics at a provincial college. After the usual expression of pleasure at the introduction, Brown generally adds "Of course, although I haven't had the pleasure of *meeting* you before, I know you well by reputation." Then, without so much as pausing to take breath, he proceeds to explain that he was always a duffer in "maths" at school, and that he has now forgotten everything about the subject they tried to teach him as a boy. Now Brown doesn't act in this way to every celebrity. If introduced to Dr. Lasker, and unaware that he is a distinguished mathematician, he does not seize the first opportunity of telling him that, although he occasionally plays draughts with his wife in the evening, chess was always beyond him, and he could not remember the simplest openings. Still less does he act in this way if his new acquaintance is a sportsman or an epicure. Moreover, in making his lamentable confession, Brown shows no sign of regret or humiliation; on the contrary, a sort of satisfied look steals over his face, suggesting that he is glad to be free once for all from the study of such a repulsive and useless subject. England is perhaps the only country where such an occurrence is fairly frequent; and this fact suggests some very unpleasant reflections.

One thing clear from Brown's attitude is that he evidently fears lest Smith should introduce some mathematical topic during the conversation. Of course this is the thing Smith is most unlikely to do. If this were all, it would be as harmless as the caricatures of professors and policemen which we see on the stage. But there is a very serious additional reason for Brown's behaviour. An admirable Report has just been published in which it has been thought necessary to emphasise the obvious fact, that an English student who intends to pursue a course in the humanities must, first of all, have a sound and fairly extensive knowledge of his own language and literature. Unless this foundation is well and truly laid, the student's equipment is imperfect, and he is severely handicapped at every turn.

Now, mathematics occupies a precisely similar position with regard to a course in science. To give a full justification of this statement is, of course, impossible here; but an attempt to do so partially will be made by putting an imaginary case. Let us suppose that progress in mathematics had stopped abruptly at the end of the 15th century, a comparatively recent date in the history of the science. The result would be that physics would be almost entirely empirical; there would be no theories at all to account for the motions of the heavenly bodies, for the transformations and indestructibility of energy; no general theories, capable of verification, in physical optics, heat, or electricity. It is extremely unlikely, not to say impossible, that instruments like modern telescopes, microscopes, spectroscopes, or electric and electromagnetic meters of various kinds, could have been invented. Some, at least, of the consequences involved in this can be seen by everyone who considers the matter.

To turn to more banausic or, if the reader prefer it, practical considerations: a single example must suffice. Let us suppose that "practical" engineers had succeeded in constructing a steel steamship, approximating to the modern type. (This in itself is taking a good deal for granted.) The induced variations of its compass would have to be corrected by a blind and tedious process of trial; the skipper would have no Nautical Almanack, no means of determining the exact local time (and consequently his true longitude), no rules to guide him in keeping a great circle course from one given port to another. Similarly biologists and chemists are indebted to physicists and mathematicians for the perfection of their instruments; and such topics as heredity and Mendelism require for their full discussion a good deal of mathematics. Physiology, too, is becoming daily more dependent on physical theory and mathematical formulæ; for instance, a full explanation of the rise of sap in trees must involve a mathematical theory.

Such examples might be multiplied indefinitely. Let us now turn to another aspect of the question. Benjamin Disraeli, who was by no means the charlatan which some people suppose him to have been, is reported to have said that the best way of gauging the commercial prosperity of a country was to find out the condition of the chemical market. We may venture to assert that the intellectual state of a country may be estimated fairly well by its attitude towards mathematics and its progress therein. In this respect England is much inferior to other and smaller nations. For instance, in England many private libraries have been either given to the nation or placed at the disposal of genuine students: very few of these are wholly or mainly mathematical. Contrast with this the Mittag-Leffler endowment, of which an account will be found in Nature of July 6, 1916, p. 384. The founders expressly emphasised the supreme importance of pure mathematics from a national point of view. Again, no one can dispute the practical efficiency of the American nation; compare their treatment of mathematical professors with ours. An American university teacher may be a specialist devoted to the most abstract and "unpractical" parts of his science; he is left perfectly free to pursue his researches; he is provided with a sufficient staff of assistants; the university library contains an ample store of mathematical books, and all other necessary equipment is supplied. Every seventh year the professor is relieved of his official duties; and the use which he generally makes of his respite may be illustrated by the "History of the Theory of Numbers" (now in course of publication), by Prof. L. E. Dickson. His special subject is the highly abstract one of group-theory: but he spent his sabbatical year in ransacking the libraries of Europe, as well as of the United States, for works on the higher arithmetic. The result is an extraordinary display of laborious and accurate research: the first volume alone contains summaries, almost all of them based upon the author's personal examination, of thousands of papers. The value of the work, when complete, can scarcely be overestimated.

Finally, it is dangerous to neglect mathematics in schemes for a course of general education. From a school teacher's point of view the subject naturally falls into two divisions: (*a*) computation, drawing (including graphs), mensuration, and surveying; and (*b*) the theoretical treatment of the elementary parts of the subject. No attempt should be made at premature specialisation; the needs of the exceptionally gifted pupils may be met by giving them free access (with occasional advice as to choice) to the school library, which should contain books beyond the scope of the school course, and also biographies of mathematicians and works on the history of the subject. The main results to be desired, in the case of an average student, are these, among others: at the end of his course he should have a correct idea of the importance of mathematics and some acquaintance with its aims and methods, whatever his actual acquirements may be. Above all, he should have acquired the habit of intellectual honesty. A mistake in a mathematical exercise cannot be concealed by fudge, or argued about, as in the case of a historical essay or the like.

It is most disheartening to find that an organised attempt is being made to restore the study of Greek and Latin to its old position of prestige; fortunately, a number of eminent classical scholars have taken up a reasonable attitude, so that the danger may not be so great as it seems. Moreover, the report already alluded to should convince everyone that even with regard to the humanities it is not Latin-Greek but English that should be made the principal subject in English schools. The great Greek writers had not been condemned, in their school days, to wearisome lessons in Arabic or Hieroglyphics, although everything now argued in favour of Latin-Greek might have been urged equally well in favour of such preposterous procedure. G. B. M.