to the growers. The sugar industry, however, is in a critical condition, the native product failing to compete with sugar from the West, but it is hoped that the industry can be remodelled on scientific lines.

Turning to the memoirs published recently from Pusa, Mr. and Mrs. Howard have succeeded in crossing rust-resistant wheat from northern Europe with some of the native wheats. It was not possible to do this at Pusa, on account of the impossibility of getting the rust-resisting parents to flower in time for crossing to be done and for the resulting grain to ripen before the hot weather set in. The difficulty was overcome by sending the Indian parents to Cambridge for spring sowing, and by carrying out the actual hybridisation work in England. In this way crosses were made between various Indian types and American club and other rust-resistant wheats that promise to be very useful.

In the chemical department Mr. Annett has begun an important study of the date-palm sugar industry, which has hitherto been entirely worked by native methods, involving considerable losses. There can be no doubt of the value of this kind of work; success in putting native industries on a sound foundation would be an achievement of which any department might be proud. The saltpetre industry has already been investigated by Dr. Leather, and we may hope for further good results. Dr. Leather also reports further work on the water requirements of crops.

The Entomological Department has proceeded on its usual lines. Progress has been made with inquiries into the life-histories and habits of injurious insects, amongst the more important being the rhinoceros beetle, the surface and painted grasshoppers, potato bug, lucerne *Hypera*, small cabbage caterpillar, termites, &c. Steady progress has been made in the preparation and issue of coloured plates illustrative of insect pests of crops, and these have been distributed to various institutions. Useful work has also been done on sericulture.

The Bacteriological Department is now in full work, and may be expected shortly to turn out useful results; whilst the mycologist, the agriculturist, and the cotton specialist are all able to report good work done.

THE BRITISH ASSOCIATION AT DUNDEE. SECTION F.

ECONOMIC SCIENCE AND STATISTICS.

FROM THE OPENING ADDRESS BY SIR HENRY H. CUNYNGHAME, K.C.B., PRESIDENT OF THE SECTION.

HAVING endeavoured to the best of my ability to protest against the idea that economics is not a science, but a mere collection of copybook aphorisms that may be used at random like quack medicines, I should like, with your leave, to endeavour to establish its claim to come among the exact sciences by the surest test that can be applied—namely its capability of being demonstrated by means of geometry and mathematics.

Everyone in this room is no doubt acquainted with the machine known as a barograph or registering barometer. It is constructed as follows: A vertical cylinder covered with white paper revolves once in a week. A light arm is hinged on to a series of hollow elastic circular chambers, from which the air has been pumped out. As the pressure of the atmosphere varies, the air chambers dilate and contract, carrying the arm with them. The arm carries a pen which marks with a dot on the paper the height of the barometer at any time. As the paper moves the dot is drawn out into a line, which gives a continuous

record of barometric variations. This diagram is a picture of one of the records.

Now, a little consideration will show what a useful diagram we have here. If we were to attempt to give the information contained in it in words we should have to say something like this. On Monday at 0 a.m. the barometer stood at 28.8 in.; during the morning of Monday it rose until about 2 p.m., when it remained stationary for three hours. It again steadily rose in the evening, until at midnight it stood at 29.9 in. (Fig. 1). On Tuesday it still continued to rise until midday, when it again experienced a fall, &c. Or, if the same results were put into arithmetical form, we should have quite a column of figures.

But this diagram shows us the height of the barometer at any time, and all its fluctuations. Its

FIG. 1.

life-history for the week and the law of its variations are obvious at a glance, in a way which no words could convey to us. So great are the advantages of this method that barographs are printed in many of the newspapers.

But the use of such curves is not confined to the registration of atmospheric pressure or temperature. They may be used for all purposes. Thus, for example, we might have a curve indicating the variation in successive years of the number of marriages per head of the population.

Line 1 (Fig. 2) shows the proportion of marriages to population from 1870 to 1910. The advantages of this synoptic view are obvious. But they become more obvious still when we add other curves. For instance, line 4 shows the price of wheat in various

FIG. 2.

years, line 3 the price of coal, line 2 the average of money wages, and line 1 the number of marriages per head of the population. A simple inspection shows that these curves rise and fall sympathetically, and proves beyond doubt that the facts they represent are causally connected.

How eloquently this diagram represents on a space that in a printed book may be three inches square, a series of relations which would take three or four pages to describe even imperfectly in words. And would any description in words enable us to follow the changes like this diagram? The diagram, in fact, plays the part that maps play in geography, and when duly appreciated becomes as valuable as maps of countries.

We may use similar diagrams in the exposition of economic facts. It was, however, reserved for Cournot to show that the use of curves might go further still. Not only might they be used to display statistical facts, but they might also be used to solve problems. I will endeavour to illustrate this very ingenious and interesting development.

It is a well-known fact that in certain departments of industry the cost of making an article increases in proportion to the number produced. The growth of corn is a familiar example of this principle. The principle depends on two facts: (1) that corn can be grown in some places with a less expenditure of capital and labour than in others; and (2) that the quantity of the more favourable land is limited. Whence it follows that growers will first have recourse to the most fertile land; afterwards to that which is

FIG. 3.

less fertile. If we were acquainted exactly with the economics of corn-growing we could represent this state of things in any country at any given time by a curve like a barograph.

Along the line OX (Fig. 3), instead of the progressive days of the week, we should mark off successive quantities of corn, and the vertical height of the curve above any given quantity would represent the price per quarter of production of that part which was produced at greatest expense. Thus, the cost of production of the first and most easily grown quarter would be, say 18s., of the next 18s. 1d., and so on. And it would be evident that the total cost of the whole of the wheat grown would be obtained by adding all these prices together, that is to say, by the area of the curve OMBA; for an area is but the sum

FIG. 4.

of all its constituent parallel lines, just as the total of a bill for goods is an addition of all its items.

Let us now dismiss this corn-growing graph from our minds and turn to another side of the question. Let us consider the various prices which consumers would give for various quantities of corn if they could get these and no more. I do not mean the market prices of the quantities, but what might be called the famine prices, which they would give rather than not have the corn. If we draw a corn-consumers' graph it will obviously be a descending curve, for the more they can get the less they will value successive portions. In fact, if the supply of corn were unlimited the surplus would be used first to feed animals, then to consume as fuel, then as manure, and at last have to be destroyed as a nuisance.

The curve would be of the form shown in Fig. 4.

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The contemplation of these curves of corn will no doubt suggest the question whether if we had them we could tell what the market price would be. For it seems obvious that if we know all the conditions, both of demand and supply, we ought to be able to foretell the market price. This is the case and can be easily done. All that is necessary is to superpose the curves, as is done in Fig. 5.

We then see at once that PM must represent the market price of corn per quarter at a given epoch, and OM the quantity produced in a standard time. For if more than OM were grown it could only be sold at a loss; if less the growing of corn would produce an abnormal profit, which would soon cause an expansion, so as to bring the quantity grown and sold up to the maximum that could be profitably produced.

FIG. 5.

These diagrams have therefore done more than present a state of facts; they have solved a problem, just as could be done by a pair of algebraic equations.

Moreover, other illustrations can be derived from Fig. 5. By drawing the series of lines shown in Fig. 6 meanings can be given to various parts of the diagram. The area NPMO represents the total price paid for the corn; the area APMO represents the total cost of growing; the area APN, which is the difference between them, represents the surplus profit obtained from the use of the better lands, or, in other words, rent; the area BPMP represents the total enjoyment the consumer derives from the corn, expressed in terms of money; and since NPMO is the

FIG. 6.

price he pays for it, BNP is the surplus enjoyment he gets by obtaining corn for less than he would have given for it had there been a famine.

Let us go a little further. Suppose that a tax were laid on corn, and that all corn grown in a country were subject to an excise duty like that now levied on the manufacture of spirits. Suppose the duty were 5s. a quarter, and to simplify the problem suppose no corn came in from the outside. Then the curve APS (Fig. 7) would be pushed upwards all along its length by 5s., and assume a position A'P'S'. And notice that the price would rise, not by 5s., but by some amount rather less than 5s. For MP'-MP must always be less than the upward movement of the curve APS. Again, the rent would be decreased, for the area

$N'P'A'$ is less than NPA . The amount grown would decrease from OM to OM' . The proceeds of the tax would be OM' times five shillings, and the consumers' surplus of enjoyment would have considerably diminished. This is all obvious enough if you look at the curves. But I want to ask whether, without a curve, you could have got all that so quickly by logical cogitation? I agree it could have been done by hard thought, but what a help the diagram has been in thinking it out. It is like drawing a genealogical tree when you are thinking out some complex problems of family relationship. A simple inspection of the figure also shows that an *ad valorem* tax on rent would not increase price or diminish production.

Again, what is a monopoly? A monopoly is simply

FIG. 7.

a power of stopping production at a point short of that which it would reach under conditions of free production, sale, and distribution. You can stop production by means of statutes regulating quantities produced, or by combinations to limit production, or to limit the supply of labour produced, or by statutes regulating the employment of capital, or by statutes fixing minima of wages, or in various other ways. If you exercise the power, then the state of things shown in Fig. 8 comes into play. The quantity produced is reduced to OM' . The price rises from PM to $P'M'$, the surplus producers' profit (including rent) rises from ANP to $AQP'N'$. So that profits, interest, and wages increase, but the consumers' surplus enjoyment goes down from NPB to $N'P'B$. The limitation of output plays a far larger part in the regu-

FIG. 8.

lation of prices than is commonly supposed. Those who are engaged in the manipulation of the meat trade, and the bread trade, and the petroleum industry, the supply of machinery or other articles, do not usually advertise the means they have taken to limit supply, nor do trade unions publicly descant upon the means they adopt to limit the labour of adults or apprentices. It is no part of our business here to discuss the necessity or the legitimate limits of such limitations. All that I am here to do is to show how useful diagrams are in explaining their effects.

The monopoly controller seeks, of course, to make the area $AQP'N'$ a maximum, arranging his price just in the way a milliner would do who had to cut the biggest square she could out of a remnant of

material. How much reduction of output and increase of price will the market bear? is the question that all monopolists present to themselves.

I could go on with these curves through a great variety of questions. They become especially interesting where applied to show the effects of tariffs upon export and import trade, but I must forbear.

My principal object has not been to introduce to the notice of the audience a subject already known to many of them, but rather to use it as an illustration of the truth that national economics is subject to laws—laws which, though complicated, are as exact and unfailing as the laws of physics, chemistry, or engineering, and which, if neglected by political engineers, will as certainly bring the State to ruin as the miscalculation of a mechanical engineer in designing a boiler, or of a civil engineer in designing a bridge. Whence, then, instead of consigning economics to Saturn, let us study it, not in a metaphysical or Aristotelian manner, using question-begging epithets, or, on the other hand, in the manner of some moderns, as, for example, Ruskin, by replacing reason by sentiment; but let us approach it in the spirit of positive science.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY PROF. G. ELLIOT SMITH, M.A., M.D., CH.M., F.R.S., PRESIDENT OF THE SECTION.¹

The Evolution of Man.

At the outset it is fitting that I should express our sense of the loss this section has sustained in the death of Mr. Andrew Lang. Meeting as we do so near to his home at St. Andrews, it was hoped at one time that his versatile scholarship and literary skill would have been available to add lustre to our deliberations. But early last winter we learned with deep regret that the state of his health would not permit him to accept the presidency of the section. In associating ourselves with those who are deploring the loss literature and history have sustained, we realise that our science also is the poorer to-day through the death of one of its most brilliant expositors.

The Scope of Evolution.

In a recent address Lord Morley referred to "evolution" as "the most overworked word in all the language of the day"; nevertheless, he was constrained to admit that, even when discussing such a theme as history and modern politics, "we cannot do without it." But to us in this section, concerned as we are with the problems of man's nature and the gradual emergence of human structure, customs, and institutions, the facts of evolution form the very fabric the threads of which we are endeavouring to disentangle; and in such studies ideas of evolution find more obvious expression than most of us can detect in modern politics. In such circumstances we are peculiarly liable to the risk of "overworking" not only the word evolution, but also the application of the idea of evolution to the material of our investigations.

My predecessor in the office of president of this section last year uttered a protest against the tendency, to which British anthropologists of the present generation seem to be peculiarly prone, to read evolutionary ideas into many events in man's history and the spread of his knowledge and culture in which careful in-

¹ This report represents the address as it was delivered at the meeting; it is a somewhat condensed and rearranged form of that appearing in the Association's Reports.