

knowledge of a large assortment of theorems is necessary; but the practical value of the study to students who are neither engineers nor architects is another matter.

There is, however, another kind of mathematical drawing which does not fall under any of these heads, and which consists in the invention of graphic solutions of equations which can be solved with great difficulty, if at all, by the stock processes of accurate mathematics. This branch is at once the most useful and the most vague; it is impossible to lay down its principles in systematic order—it must be learnt by abundant exemplification.

The ordinary academic problems of statics and hydrostatics furnish many examples of this subject, but only a few of these can be noticed here.

If AB and BC are two ladders freely jointed together at B, of different weights and lengths, placed with the ends A and C resting on a rough horizontal plane, A being prevented from moving while C is drawn out along the plane, the inclinations, θ , ϕ , of AB and BC to the ground when the limiting position is reached are determined from two equations of the forms

$$a \sin \theta - b \sin \phi = 0; m \tan \theta + n \tan \phi = k,$$

where a , b , m , n , k are all given quantities. The graphic solution of these equations is effected with great ease thus:—draw a line OH equal to m , and produce OH to O' so that HO' = n ; at H draw HC perpendicular to OO' and equal to k ; through O draw any line OQ meeting HC in Q; take a point R in CH such that CR = HQ, and draw O'R; then the point P, of intersection of OQ and O'R is a point on the locus represented by the second of the above equations, the angles θ , ϕ being POO' and PO'O. These points, P, are therefore constructed with great ease and rapidity. Also the locus represented by the first equation is a circle having for diameter the line joining the points which divide OO' internally and externally in the ratio $a:b$, and the points of intersection of these two loci give the required values of θ and ϕ .

The following problem leads to precisely the same equations as the above:—rays of light emanate from a fixed point P in one medium separated by a plane surface from a second medium; find the ray proceeding from P which will be refracted to a given point, Q, in the second medium.

Again, the fact that when a uniform chain hangs with free extremities over two fixed supports of equal heights there are either two figures of equilibrium or none results from the solution of an equation of the form $xe^{ax}/x = k$, which is effected by drawing the curve $y = e^x$ and the right line $y = kx/a$, and then it is at once seen that there are either two points of intersection or none.

When a heavy wire rope has its ends fixed at two points in the same horizontal line, and a load is suspended from the lowest point of the rope, the rope forms parts of two distinct catenaries, and the determination of these curves leads to an equation of the form

$$e^{k/x} = [(x^2 + a^2)^{\frac{1}{2}} + a] / [(x^2 + b^2)^{\frac{1}{2}} + b],$$

in which x alone is unknown. The tracing of the curve obtained by putting y equal to the right-hand side of this equation is quickly effected by means of two fixed circles and the drawing of right lines.

The figure of equilibrium of a revolving self-attracting liquid spheroid gives an equation which is a particular case of $x(a + bx^2)/(c + x^2) = \tan^{-1}x$, and this is best solved by the tracing of two curves. If we put y equal to the left-hand side we have a curve of the third degree the geometrical construction of which is exceedingly simple, and requires only a fixed circle and right lines.

Whenever a problem involves two unknown angles in two equations one of which is of the form $m \cos \theta + n \cos \phi = c$, where m , n , c are given, all angles satisfying this equation can be represented as the base angles of a triangle the base of which, AB, is fixed, and the vertex of which describes what may be called a quasi-magnetic curve, the geometrical construction of which is this: take any two fixed points, A, B; about A as centre, with radius $m \cdot AB/c$ describe a circle; about B describe a circle with radius $n \cdot AB/c$; draw any line perpendicular to AB meeting these circles in Q and R respectively; then the lines AQ and BR intersect in a point on the required curve. When $m = n$ we have the common magnetic curve the construction of which is not nearly so well known as it should be.

The solutions of the above examples have all been of a purely geometrical kind, and have not involved the plotting of points by coordinates arithmetically calculated. There are other problems of a slightly different kind, still independent of plotting, but involving trial; the value of a certain unknown quantity which has to satisfy a certain geometrical condition is found by trial to do so very nearly if not completely. In all such cases Taylor's theorem furnishes a still closer value than the observed one, and completes the solution with all desirable accuracy.

For example, many problems lead to the equation $a \sin 2(\theta - \alpha) = b \sin \theta$ for an unknown angle θ , the other quantities being all given. This can be solved by two circles thus:—draw a line AB equal to b , and on it as diameter describe a circle the centre of which is C; draw AD making the angle BAD = α and cutting the circle in D; draw CD and produce it to E so that CE = a , and on CE as diameter describe a circle. Now find on the circumference of the first circle a point P such that if CP meets the second circle in Q we have BP = EQ. This is done with great accuracy by the eye, and Taylor's theorem will improve the solution.

An equation which can be solved also very easily by trial is $a \sin^2 \theta = b \cot \theta$, which may be taken in the form $a \sin^3 \theta = b \cos \theta$, and a graphic solution suitable to each form is easily found.

Finally, we may notice equations of the form

$$\tan x = ax/(c - x^2),$$

which we obtain from Bessel functions in certain problems relating to vibrations. Such an equation is easily solved by the intersections of the curve $y = \cot x$ with the hyperbola $y = (c - x^2)/ax$, and the construction of the hyperbola belongs to the most simple case of this curve, viz. given one point on the curve and the asymptotes. As compared with the graphic solution of equations given by physical problems, the graphic solution of algebraic equations is unimportant, though not devoid of interest, because Horner is always available for numerical cases.

Prof. Gibson gives many examples of the solutions of quadratics and of cubics by graphic methods; but as regards quadratics it must be confessed that there is no utility in the process, and too much space is usually devoted to it. For cubics in general he gives a graphic solution and an interesting discussion. In a second edition of his book he might treat the biquadratic similarly, because its graphic solution can be easily effected by means of a circle and a parabola, or by means of a right line and a curve easily derived from a parabola. Many curves occurring in physics are dealt with in the book—such as isothermals and adiabatics; there is also a useful discussion of Fourier's theorem, and a treatment of the curves belonging to vibrations, damped as well as undamped. The graphic method is also applied to the solution of some of the simpler mixed trigonometric and algebraic equations, and the book concludes with a chapter on the properties of conic sections.

GEORGE M. MINCHIN.

CENTRAL AMERICAN MAMMALS.¹

THREE years ago the author of these volumes published, in the same serial, a valuable synopsis of the mammals of North America and the adjacent seas. In the present larger work he has taken in hand the mammals of the tract generally known in this country as Central America, but on the other side of the Atlantic termed, at any rate by zoologists, Middle America, together with those of the West Indian islands. The greater bulk of the present work is accounted for, not so much by the greater number of species (690 against 606) as by the increased elaboration of the mode of treatment, the addition of diagnostic "keys" to the various genera, and by a fuller account of the habits of many species, the latter feature rendering these volumes proportionately more valuable to the naturalist, and at the same time of more general interest. The illustrations, too, are more numerous, comprising, besides crania, figures of the external form of a considerable number of species,

¹ "The Land and Sea Mammals of Middle America and the West Indies." By D. G. Elliot. *Field Columbian Museum Publications*, Zoological Series, vol. iv., part. i. and ii., pp. xxi+850 illustrated.

the addition of the latter likewise tending to popularise the work.

In his preface Dr. Elliot reiterates and emphasises the remarks made in the companion volume as to "the excessive and probably unwarranted multiplications of species and races (made easy by the too liberal application of the trinomial system)" of American mammals in general. Many of the forms, he adds, which have received separate names are separated on the evidence of comparative instead of distinctive characters. That is to say, their differences from other types are so slight as to be incapable of definition except by comparison with the latter, often, indeed, involving the necessity of placing specimens of each side by side. Consequently, in many instances specimens cannot be referred to their respective species or races without access to museums.

Perhaps it is rather unfortunate that the author did not see his way to go one stage further, and mention what species and races are entitled, in his opinion, to recognition. A step would then have been made towards the elimination of the forms named on insufficient distinctive characters. Nowadays it is the fashion to assign a distinct name to every recognisable form, however slight may be its points of difference; but some limit in this direction will apparently have to be imposed before long, unless zoology is to become an impossible science. In our opinion, one way of mitigating the difficulty is by using specific terms in a comparatively wide sense, thus leaving the subspecies, or races, to be recognised or not according to the discretion of the individual student.

Nomenclature is another point on which the author has a good deal to say, and he mentions that some of the names employed in the companion volume have been changed in the present work. He hopes, however, that as the result of such changes "a nomenclature that at least will approach stability may, in the distant future, be expected to be reached." Possibly it may—at the cost of rendering all the older standard works on zoology, palæontology, distribution, and scientific travel worse than useless—but a proposal like that of emending such a name as *Odocoileus* (in universal use among his naturalist countrymen) to *Odontocoelus* scarcely seems calculated to pave the way to such a happy millennium!

Among changes in nomenclature that we specially regret to see is the substitution of *Agouti* for *Cœlogenys* as the name of the paca, largely on the ground that the former is the popular title of a totally different group of rodents, for which reason we think its use in the scientific sense should be barred. It is also distressing to see the familiar

classic *Rome*. One point in regard to the plan of the work—whether intentional or accidental it is not easy to say—strikes us as unsatisfactory. In the case of certain species, such as *Odontocoelus americanus* and *Ovis cervina* (pp. 69 and 84), for example, of which the typical form does not occur within the limits of the area under consideration,

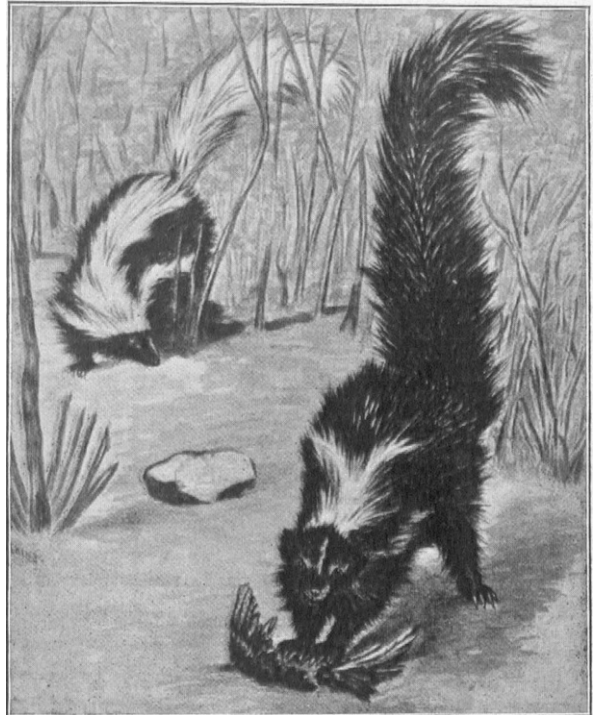


FIG. 2.—Long-tailed Skunk. From Elliot's "Mammals of Middle America."

the species-name itself does not appear in the list at all, but only the subspecies, such forms consequently lacking a distinctive number, and thus rendering the census of specific types occurring within the area inaccurate.

Otherwise we have nothing but commendation to bestow on the general mode of treatment of the subject, and it may be safely affirmed that the author has earned the gratitude of all naturalists on this side of the Atlantic by putting in a convenient and easily accessible form such a vast amount of information with regard to the mammalian fauna of an extremely interesting region. The illustrations (two of which are reproduced), it may be added, are, for the most part, beyond praise.

R. L.

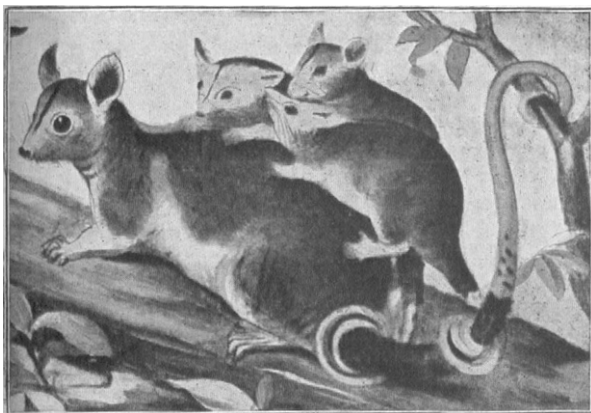


FIG. 1.—Lord Derby's Opossum and young. From Elliot's "Mammals of Middle America."

name *Hapale*, for the marmosets, banished in favour of *Callithrix*, so long used for the titi monkeys, which now figure as *Saimiri*. On a par with the latter is the substitution of *Tayassu* for *Dicotyles*, of *Coendu* for *Cercolabes*, and of *Potos* for *Cercoleptes*, which is like an invasion of zoological Goths and Vandals into the sacred precincts of

THE FISHERIES OF SCOTLAND.

THE twenty-second annual report of the Fishery Board for Scotland, for the year 1903, is issued in three parts as usual, the first dealing with the sea fisheries, the second with the salmon fisheries, and the third being concerned with marine research.

With regard to sea fisheries, tables are given showing the results of the trawl fishing and the line fishing. The number of steam trawlers has been increasing steadily for the last seven years, and rose from 109 in 1896 to 280 in 1903. The average catch per vessel increased from 5030 cwt. to 5594 cwt., while the value of the catch per cwt. was practically the same in 1903 as it was in 1896.

In the line fishing the number of steam liners increased from 39 vessels in 1898 to 91 vessels in 1903, the number having varied somewhat in the intermediate years, 23 vessels having been added in 1903. The total number of boats was slightly less than in 1898, owing to a steady decrease in the number of sailing craft. The catch, since