regeneration, the relation of regeneration to nutrition, to reproduction, to age, and to environmental conditions. The author's exposition is lucid, and there is an illustration on every second page. In the second part of the book we find an account of grafting or transplantation in plants and in animals, with strange figures of grafted polyps and worms, pupæ and tadpoles, frogs and newts—an altogether quaint assemblage. At the end of the book there is an exhaustive bibliography, certainly amazing in its dimensions, very usefully subdivided into sections relating to different aspects of the subject. As to the general theory of regeneration, Prof. Korschelt seems to incline to a compromise between the views of Weismann and Morgan, admitting that there is a great deal to be said on both sides. He seems—for he is anything but dogmatic—to believe that the regenerative capacity is a primary quality of living matter, which, along certain lines of evolution, has been accentuated and specialised by natural selection. Thus the regenerative capacity is, in general, a primary quality, but in particular cases an adaptive character.

Organische Zweckmässigkeit, Entwicklung und Vererbung von Standpunkte der Physiologie. By Dr. Paul Jensen. Pp. xiii+251. (Jena: Gustav Fischer, 1907.) Price 5 marks.

PROF. JENSEN has produced a book which attempts to deal in a philosophical manner with some of the most difficult problems that confront the biologist. The reader will perhaps be inclined to deprecate an attitude of "cock-sureness" that rather pervades the whole, but he will at the same time recognise that in many places the author is stimulating and suggestive.

A great part of the whole volume is devoted to the examination of the various explanations that have been put forward to account for adaptation in the organic world, as well as of those which have attempted to deal with the meaning and the method of evolution.

After a somewhat lengthy discussion of these topics, the author puts forward the analogies shown by various cosmic mechanisms to assume positions of relative or absolute stability, and he regards them as useful in throwing light on the problems of evolution. The whole of the constructive part of the book strikes us as very speculative, and though of undoubted interest, it may be doubted whether the point of view as advocated by Jensen will find much sympathy amongst working biologists. The title of the work indicates that it is written from the standpoint of physiology, but we have searched its pages in vain to find any serious physiology, as ordinarily understood, discussed in it at all. There is much philosophy of a sort, and much acute destructive criticism of many ideas and notions that are widely current. But it does not appear that in grappling with the problems he has set himself to face and to solve, the author has expressed himself so clearly as did Herbert Spencer many years ago. There is much in the work before us that recalls the "Principles of Biology," though there is a great difference between the lucid expression of Herbert Spencer and that of our author. The following passage, relating to the causes of extinction of species and genera in the past, will furnish a fair sample of the method of treatment:—"According to our theory of development, a natural extinction of species is to be anticipated as the expression of a general law. Organisms that are dying out in this way fall into the same category as those systems which, after enduring through a long period in a stationary condition, pass finally, as the result of slowly advancing changes, into a relatively stable state (death); a destiny that . . . in time will overtake many existing organisms, in spite of the 'rejuvenating' effects of amphimixis" (p. 237).

J. B. F.

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LETTERS TO THE EDITOR.

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The Windings of Rivers.

At the meeting of the British Association at Edinburgh in 1892 I read a paper on the subject of the winding of rivers before the geographical section. It was illustrated by a large number of diagrams, but, as these could not be included in the report of the meeting, only the title of the paper appeared. It may not be out of place to give a short account of it, as the subject is now attracting some attention.

In Fig. 1 the courses of three streams are shown. These are distinguished by the letters A, B, C, without indication of their identity or of the scale on which they are drawn. If anyone were to try to select the one which represents the largest or the smallest of these streams he might do so correctly, but he would not be surprised if he were told that he had guessed wrongly, for it could only be a guess. The length of each tracing is the same. In nature it represents in A nine English miles, in B two hundred and sixteen miles, and in C one and a half miles.

Tracing B represents the part of the Mississippi between the mouth of the Arkansas River and that of the Red River. Tracing A represents the Devon Water, a tributary of the Forth, and tracing C represents a quite insignificant brook called the Catter Burn, a tributary of the Endrick, one of the principal affluents of Loch Lomond. These tracings, and indeed the maps of all countries, show clearly the great family likeness exhibited by rivers in all parts of the world. This likeness rests on the fact that in all rivers the relation between the length of an arc or bow and that of its chord is nearly the same. It is an organic rather than a family likeness, and resembles that which exists between dogs of different breeds or birds.

The following table shows, for a selection of well-known rivers, the degree in which the above relation holds good:—

River on the stretch		Length of stretch		Ratio	Number of bows	Average length of bows
From	To	Direct	Along windings			
<i>Mississippi</i>		Miles	Miles			Miles
Columbus	Memphis	124	204	1·65	23	8·87
Memphis	Natchez	270	490	1·83	62	8·10
Natchez	Baton Rouge	88	133	1·51	18	7·39
Baton Rouge	Carrolton	72	124	1·72	20	6·20
Columbus	Carrolton	554	955	1·72	122	7·83
<i>Thames</i>						
Marlow	Walton	18·7	30·0	1·61		
Teddington	Isle of Dogs	16·8	26·5	1·58	11	2·4
<i>Danube</i>	Near mouth	11·4	22·5	1·97	13	1·73
<i>Rhine</i>		kilom.	kilom.			kilom.
Germersheim	Mannheim	34·1	69·2	2·03	11	6·3
<i>Main</i>		114	144	1·27	44	3·27
<i>Neckar</i>						
Heilbronn	Mannheim	80	112	1·40	26	4·30
<i>Lahn</i>						
O. Lahnstein	Limburg	17·2	29·7	1·73		
<i>Mosel</i>	Nr. Coblenz	7·0	10·0	1·43		
<i>Ahr</i>						
Altenahr	Ahrweiler	4·6	9·6	2·09		

From the table it will be seen that over a length of nearly one thousand miles of the Mississippi the average length of stream, following the windings, is 1·72 times greater than the direct distance. In the Lahn we find

almost the same factor. The Lower Danube, the Rhine, and the Ahr show a factor approximating to 2. The Main, Mosel, Neckar, and Thames have lower factors. The mean of all the factors is 1.68. For a certain number of the rivers the number of "bows" is given with their average length. The size of the bows stands in some relation to the volume of the river. What that relation exactly is I am not able to state. To arrive at it will require a careful study of the flood waters of the river in connection with the form of its bed. It is the flood waters which form the bed. When the river falls to low-water

specification until some were obtained which resembled the courses of actual rivers. Fig. 2 shows one specimen out of many which were exhibited at the meeting of the British Association.

It is assumed that the rhythmic motion set up in a mass of water which is disturbed in its uniform rectilinear motion will be reducible to two reciprocating motions, one in the direction of the fall of the stream and the other at right angles to it. When the gradient of the stream is very steep and the nature of the bed homogeneous, as it is in the case of water flowing down the front of a glacier, the longitudinal oscillation is swamped by the powerful and continuous action of gravity, which does not affect the transverse component. In these circumstances we often meet with small streams which describe an almost perfect simple harmonic curve.

In the ordinary stream of the meandering type the gradient is very small, in the case of the Mississippi from 2 inches to 4 inches per mile, so that the longitudinal pulse can produce its full effect. When the two oscillations are simple pendulum motions and have the same period they produce an ellipse, which, when combined with the steady onward flow due to gravity, produces sinuosities unlike those of actual streams. When the period of the transverse oscillation is twice that of the longitudinal one, their combination produces a figure of eight (8). When a figure

FIG. 1.

level we often see it cutting out a secondary bed on a much smaller scale, which is obliterated by the next following flood.

It may be taken that the mean track of a stream traces the line of lowest level in the valley. Consequently, the ground must rise on both sides of it. The cross-section of the valley through the river resembles that through the middle of a watch glass, rising at first very slightly on both sides of the stream, then more rapidly as the confines of the valley are approached. It is evident that water displaced to one side of the river will, in returning to it, tend to pass to the other side, and to oscillate about the lowest point.

If the bed of a stream flowing through alluvial ground were rectified so as to direct the water along a straight trough cut in the material, it might preserve a straight course for a time, but a stream following such a course

of eight is combined with steady forward motion so that both are travelled over in the direction of the arrows in the figure, then it does delineate a curve which may resemble the course of an actual stream. This is illustrated in Fig. 2. In it the sinuous curve falls into three parts, each consisting of a double bow, corresponding to a complete excursion of the tracing point round one of the figures of eight. The horizontal line indicates the path of undisturbed flow of the stream running from left to right in the direction of the arrows. It is divided into seventy-two equal spaces, each of which represents the distance which would be covered by the undisturbed stream in the interval of time in which the circle which generates the transverse reciprocating motion describes one twenty-fourth of a revolution, so that the undisturbed stream passes over twenty-four spaces in the time that the tracing point passes once round the figure

FIG. 2.

is in a state of unstable equilibrium. The smallest accident or obstruction disturbs the uniform rectilinear motion of the water, and tends to induce oscillations, both longitudinal and transverse. These begin immediately to cut into the banks, if they are yielding, and take larger and larger dimensions until they reach a limit when they have produced a course of the sinuosity which corresponds to the laws of the harmonic motion of its waters.

No attempt was made to arrive at these laws *a priori*. The method of investigation used was purely empirical. Curves were traced according to all kinds of harmonic

of eight. The resultant path of the tracing point is the sinuous curve, which cuts the horizontal line at 12 and 24 when the symmetrical 8 is used, and in 36, 48, or 60, 72 when one of the other two figures is used. It is an essential condition that the tracing point shall go round the 8 in the direction of the arrows, so that it shall be moving in the same sense as the undisturbed water when it traverses the outside parts of the figure which are approximately parallel to the path of undisturbed flow. In describing the sinuous line it is convenient to draw the figure of eight on tracing paper. Then, when the

centre of the 8 is placed over any mark on the horizontal line numbered, say, 9, the point on the periphery of the 8 numbered 9 must be superposed on the point on the sinuous curve also numbered 9.

The description of the sinuous line is a simple case of mechanical drawing, and presents no difficulty. By varying the harmonic composition of the figure of eight and the rate of undisturbed flow of the water, an infinite number of different individual curves can be produced which are all covered by the same generic specification. It is an interesting occupation, in leisure moments, to compose curves of this kind and to compare them with those traced by actual rivers on the face of the earth.

J. Y. BUCHANAN.

It is not difficult to show the character of the flow at the bottom of a small river. For several years I have taken my students along the course of the river Fender near Birkenhead, and we have conducted experiments which confirm the laws of bottom flow first pointed out by Thomson. At first we put down tubes containing coloured liquids, and the stream-line motion was very clearly shown by lines of colour. Later, I have employed lump sugar soaked in a strong alcoholic solution of magenta. On placing one of these cubes at the outer bend of a curve—the “turnpool”—it is found that the water there is almost stagnant. Gradually an aureole of coloured water forms round the sugar as it dissolves, and this slowly creeps across the stream towards the inner bend. The advantage of this method is that the coloured sugar is several minutes in dissolving, and it is very easily carried about.

For surface flow I have found mahogany sawdust to be the best, as it approaches water in density, and the fine particles are not influenced by air currents.

Although in measuring the surface flow the line of maximum velocity is usually more eccentric than the middle line of the stream, there are cases where the quickest flow is near the inner bend.

In a small experimental river in my laboratory I can produce both effects at will. A river is always tending towards a definite adjustment of its parts to correspond with the characteristics of its flow. The floor becomes graded by the filling of hollows and the removal of obstacles, and the swings become regular and rhythmic like the swings of a pendulum. This condition is seldom found except in the flood plains, and I presume this is the special case referred to by Sir Oliver Lodge.

In the ungraded part many exceptional and interfering circumstances come into play. I have noticed in experimenting with my laboratory river that when the stream has become perfectly adjusted the line of maximum flow is towards the outer curves, but if any disturbing cause is introduced, such as an increase or decrease in the quantity of water flowing in the channel, a variation in the slope of the bed giving a more rapid or gentler fall, or the introduction of an obstacle to form narrows, the normal characteristics of the flow are disturbed, and the maximum flow may be on the inner curve or more violently bent to the outer curve. This is determined by the changed conditions and the tendency of the stream to readjust itself. Prof. Thomson's model, not dealing with graded conditions, may easily have produced the abnormal effects he describes.

A comparison of the flow of a river with that of a glacier shows more points of similarity than most people suppose. In a curved glacier such as the Findelen, the surface at the outer bend is higher than at the inner bend, and the inner bend is always marked by a “toe-cap” moraine like the shallows on the inner curve of a river. It is only reasonable to suppose that this is the result of a cross current under the glacier, such as can be demonstrated in rivers. Moreover, we have in glaciers the phenomena of whirlpools and eddies where tributaries join the main stream.

The phenomena of flow are practically the same whether the medium is solid, liquid, or gaseous. The essential feature of flow is *shearing*. In a stream the surface layers shear over the lower, the mid-stream portion shears

through the lateral parts, and in a meandering course momentum impels the water towards the outer bends and shears it round the slower moving water in the inner bend. So in glaciers and even in solid rocks flowing under earth stresses the same laws apply. The only difference lies in the unit of shear. In the case of liquids and gases this is extremely small, whereas in glaciers it is usually the “Kugel” which gives rise to the corn structure in glacial ice. In rocks the unit varies from masses of gigantic size to others of very small dimensions. This, perhaps, may be regarded as a very crude conception of the meaning of flow, but I have found it useful in giving students a graphic idea of the complicated movements in rivers and glaciers.

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J. LOMAS.

Small Flint Implements from Bungay.

THE small flint implements figured in the accompanying drawing were found in a sandy hollow about 2 feet deep at Bungay, in Suffolk. The sand in this hole was littered with minute flakes; in a few minutes I picked up between fifty and sixty, of which the figured ones are typical examples. I hesitate to describe the implements as “pigmy flints,” because their fine secondary chipping is not confined to the thicker edge or “back” of the flakes, but, judging from photographs I have seen, they closely resemble some pigmies found recently near Brighton by Mr. H. S. Toms. So far as the untrimmed flakes are concerned, it is impossible to distinguish them from typical

Small flint flakes and implements from Bungay. Two-thirds actual size.

pigmy flakes, while the trimming of implements 3 and 5 is identical with that of the pigmies.

In consequence of nearly all the English pigmies having been found on the surface of the ground, it has been impossible to say with any confidence whether they belong to the Neolithic, Bronze, or Early Iron period. In view of this, it is interesting to know that the small flakes and implements from Bungay were found in association with a polished axe of grey flint, a black flint lance-head of very delicate workmanship, one of the rare and finely chipped triangular “knives,” and some small convex scrapers showing very delicate secondary chipping. These implements were found in the same sandy hole when the small implements were discovered, and from an examination of the sides of the hollow it was evident that they all came from what might be called a “Neolithic floor” about 18 inches from the surface of the ground. Nowhere on the surface of the surrounding ground could I find a single flake or implement, and if the ground had not been disturbed in order that a small quantity of sand might be carted away, not one of the implements would have been brought to light. As it happened, they were all found within an area of about six square yards. Some