tendency amongst both vertebrates and invertebrates with a flattened ventral surface to have the lateral or pleural margins produced into processes of some sort. *Cephalaspis* is but one of numerous instances that might be mentioned amongst fishes, and illustrations abound amongst trilobites and various lower invertebrates.

The paired condition of the marginal scales in *Cephalaspis* is without significance, being a necessary accompaniment of the flattened ventral surface. Were the body laterally compressed, we should probably find but a single row of median scutes, as in *Lasanius* and *Birkenia*, although even in the latter genus Dr. Traquair is of the opinion that they are paired. Fulcra, also, are often paired; and it must be remembered that even a typically unpaired structure like the anal fin may occasionally appear as double. That the structures called 'fringing processes' by Dr. Patten can be looked upon in the nature of appendages has been emphatically denied by Dr. Gaskell,* who has studied the actual specimens upon which our Dartmouth friend bases his conclusions. Jaekel, of Berlin, likewise fails to see that there is any evidence of appendages in these forms.† Hence it would appear that paleontologists are not unanimously in favor of deriving the lateral fold of vertebrates from marginal scales such as occur in *Cephalaspis*.

Drepanaspis.—For our knowledge of the organization of *Drepanaspis*, one of the most interesting Paleozic fishes brought to light within recent years, we are indebted almost exclusively to the dean of British paleichthyologists, Dr. R. H. Traquair. In an appreciative review of Traquair's recent memoir on the 'Lower Devonian Fishes of Gemünden,' published in no. 471 of this journal,‡ Dr. Bashford Dean takes issue with the original author regarding the orientation of the creature. It is stated by Dean that Traquair's reasons 'seem inadequate for distinguishing dorsal and ventral sides. In no specimen figured is the relation of the dorsal lobe of the tail shown convincingly to be continuous with the so-called dorsal aspect.'

Whatever may be thought of Traquair's figures, although his plate 2 seems to us conclusive enough, there can be no question about the originals, and those who have examined them attentively are compelled to admit the correctness of the Scottish author's interpretations. The dorsal ridge scales are larger than the ventral, and form a more extended series, beginning further forward and continuing further back than the ventral fulcra. Several specimens in the Edinburgh Museum have been pointed out to the present writer by Dr. Traquair in which this row of prominent ridge scales can be traced continuously from a point shortly behind the median dorsal plate to the tip of the dorsal lobe of the tail. The extent to which the caudal lobes are covered with fulcra is well shown in Pl. 4 and Pl. 1, Fig. 1, of the memoir in question, and their connection with upper and lower systems of body plates appears tolerably distinct.

C. R. Eastman.

Cambridge, Mass.

* *Journ. Anat. and Phys.*, Vol. 37, p. 198, 1903.

† *Zeitschr. deutsch. geol. Ges.*, Vol. 55, p. 84, 1903.

‡ Science, Vol. 19, p. 64, 1904.

SPECIAL ARTICLES.

ON THE FEASIBILITY OF MEASURING TIDES AND CURRENTS AT SEA.

The importance of measuring the rise and fall of the tide, and especially the direction and velocity of the current at points more or less remote from land, is obvious to any one. The following brief discussion of a few questions involved seems to show that such measurements, although rather costly, can probably be made in almost any body of water whose surface at times becomes reasonably calm; at any rate, it should generally be possible to measure the current.

It is here proposed to make use of a species of piano-wire sounding apparatus, in which the 'lead' consists of a large stone, or of a bag or box containing stones, which is attached to the sounding wire by means of a string or a finer wire. This weight when once cast is to remain immovable on the bottom and is not to be recovered. The wire drawn taut serves to indicate when the vessel passes over the weight. The aim of the observers on board is to so manœuvre the boat that the wire shall become apparently vertical as many times as possible throughout the period of observation, and at each such time to note the depth of the water and positions of the floats. For small depths, verticality can be estimated sufficiently well by aid of a plumb line held alongside of the sounding wire. For greater depths, more accurate means must be provided, such, for instance, as a small telescope supplied with vertical sight wires and hung in gimbals, together with a mirror placed alongside of the sounding wire and likewise hung in gimbals. If a boat were to be used exclusively for such work, it should have, at the point of least motion, a well through which sounding operations could be carried on. Of course, means must be provided for securing nearly uniform tension at the time of taking a reading. In small depths the approximation to uniformity need not be very close.

Problem 1.—Ignoring the impulse of the current upon the wire, also the sagging due to the wire's weight, required the amount of error in height or depth and in position due to the want of verticality of the wire.

Obviously,

$$\text{Height error} = l - l \cos \phi_s = l \text{ versed sine } \phi_s,$$
$$\text{Position error} = l \sin \phi_s,$$

where l denotes the length of wire extending from the bottom to the surface, and φ_s, the small angle which it makes with the vertical at the time of reading. Giving to φ_s several values, we have

	$\phi_s =$ ¼°	½°	1°
Height error	$=$ 0.000010	0.000038	0.000152
Position error	$=$ 0.004363	0.008726	0.017452
	$\phi_s =$ 2°	5°	
Height error	$=$ 0.000609	0.003805	
Position error	$=$ 0.034900	0.087156	

In depths not exceeding 100 fathoms, an error of 1 degree in verticality can not cause an error of more than 0.1 foot in height or depth.

Problem 2.—Ignoring the impulse of the current upon the wire, and supposing the (vertical component of the) tension at its upper end to be ν times as great as its weight in water, required the error in height or depth and in position when the wire is not exactly vertical.

Let φ_s denote the want of verticality at the surface and φ_b that at the bottom; then

$$\text{True depth} = a\ (\operatorname{cosec} \phi_s - \operatorname{cosec} \phi_b)$$

where

$$\cot \phi_b = \frac{\nu - 1}{\nu} \cot \phi_s$$

and

$$a = \nu l \tan \phi_s.$$

$$\text{Height error} = l - \text{true depth},$$
$$\text{Position error} = a\ [\log (\operatorname{cosec} \phi_s + \cot \phi_s) - \log (\operatorname{cosec} \phi_b + \cot \phi_b]).$$

If the wire is nearly vertical, we have the following approximate equations:

$$\text{True depth} = a \left(\frac{1}{\nu} \cot \phi_s - \frac{1}{2(\nu - 1)} \varphi_s\right),$$
$$a = \nu l\ (\phi_s + \tfrac{1}{3}\phi_s{}^3),$$
$$\text{Position error} = a \log \frac{\nu}{\nu - 1} + \frac{a}{4}\left[1 - \left(\frac{\nu}{\nu - 1}\right)\right]_2 \phi_s^2.$$

By aid of these equations doubtful interpolations can be avoided.

Assuming $\nu = 5$ and an apparent depth (l) of 3,000 units, we have as errors corresponding to a few values of φ_s:

	$\phi_s =$ ¼°	½°	1°
Height error	$=$ 0.035	0.143	0.571
Position error	$=$ 14.60	29.21	58.41

This shows that in a depth as great as 3,000 fathoms the upper end of the sounding wire should not deviate more than one half degree from the vertical if a tide of ordinary amplitude is to be determined.

Problem 3.—Ignoring the sag due to the wire's weight and assuming that the horizontal impulse of the current is the same for each vertical unit, required the error in height or depth and in position when the upper end of the wire is exactly vertical.

The wire forms the arc of a parabola with vertex at the surface and whose equation is

$$x = \frac{\mu y^2}{2T_s}.$$

This gives

$$\text{Position error} = \frac{\mu(\text{depth})^2}{2T_s} = \frac{\mu l}{2\nu w}$$

where μ denotes the impulse per unit length,

w the weight in water of a unit length of the wire, and T_s the tension at the upper end, $=\nu l w$; it is assumed that the wire is nearly vertical throughout its length. From rectifying the parabola, we obtain

$$\text{Height error} = \tfrac{1}{6}\frac{\mu^2}{T_s^2}l^3 = \tfrac{1}{6}\frac{\mu^2}{\nu^2 w^2}l.$$

Assume $\mu = 0.001$ lb., $\nu = 5$, $w = 0.003$ lb.; the position error will be $l/30$ and the height error $l/1350$. As will be noted below, $\mu = 0.001$ lb. and $w = 0.003$ lb., imply, for a steel wire, a velocity of about 0.6 foot per second. For smaller velocities μ/w will be much less. In deep water, with $\nu = 5$, we should not expect to generally find velocities such that the error in height due to the tidal current could exceed one part in 100,000, unless the law of resistance given below does not hold good for feeble currents. See velocities given near the end of this paper.

Problem 4.—Taking into account the weight of the wire and assuming that the horizontal impulse of the current is the same for each vertical unit, required the error in height or depth and in position when the upper end of the wire is exactly vertical.

The forces acting upon a length l extending downward from the surface, give

$$\frac{dx}{dy} = \frac{\mu}{T_s - wl}.$$

From this we obtain, to the third power of the small quantities $\mu y/T_s$, wy/T_s,

$$x = \frac{\mu}{T_s}\frac{y^2}{2} + \frac{w\mu}{T_s^2}\frac{y^3}{3} + \frac{w^2\mu}{T_s^3}\frac{y^4}{4},$$

as the equation of the curve, the origin being the point where the wire crosses the surface. This rectified gives

$$l = y + \frac{\mu^2}{T_s^2}\frac{y^3}{6} + \frac{wu^2}{T_s^3}\frac{y^4}{4}.$$

$$\therefore \text{Position error} = \frac{\mu l^2}{T_s}\left[\tfrac{1}{2} + \tfrac{1}{3}\frac{wl}{T_s} + \tfrac{1}{4}\frac{w^2\mu l^2}{T_s^2} - \tfrac{1}{6}\frac{\mu^2 l^2}{T_s^2}\right],$$

$$\text{Height error} = \tfrac{1}{6}\frac{\mu^2}{T_s^2}l^3 + \tfrac{1}{4}\frac{w\mu^2}{T_s^3}l^4.$$

I have made numerous experiments for determining the force of the impulse of water upon slender cylindrical rods. The rods used were of steel and varied in diameter from 0.036 to 0.5 of an inch. The velocity ranged from 1 to $1\frac{1}{2}$ feet per second. The experiments showed that the force is well represented by the expression

$$\zeta\frac{v^2}{2g}\gamma l d,$$

where v denotes the velocity of the water; γ, the weight of a cubic unit of water at the temperature of the stream; l, the length of the rod; d, the diameter; and ζ an empirical abstract number found to be 0.95, approximately, or about one half of the value (1.86) obtained from the experiments of du Buat and Thibault for the case of a plane perpendicular to the flow of the stream. In all cases where length is involved in the above expression, the same unit of length must be employed.

For sea water γ may be taken as 64 lbs., and the above expression gives as the force for each foot of rod or wire

$$0.995\,\zeta v^2 d = 0.945\ v^2 d$$

pounds, $=\mu$.

In a steel wire suppose $d = 0.003$ foot; the force of impulse per foot $(=\mu)$ is

$$0.945\ v^2 d = 0.002835\ v^2,$$

while the weight per foot for wire immersed in sea water is 0.003 lb. $(=w)$. Hence, for a wire of this diameter the force of the impulse of the water will equal the weight of the wire in water (*i. e.*, μ will be equal to w) when the velocity is a trifle more than 1 foot per second.

For a simple progressive long wave of amplitude A in a body of water whose depth is h, the maximum velocity of the water particles is

$$A\sqrt{\frac{g}{h}}.$$

Let $A = 1$ foot; then the velocities, expressed in feet per second, corresponding to various depths, are as folows:

Depth =	5	10	25	50	100	fathoms,
	30	60	150	300	600	feet.
Velocity =	1.035	0.732	0.463	0.327	0.232	feet.
Depth =	500	1000	2000	3000	4000	fathoms,
	3000	6000	12000	18000	24000	feet.
Velocity =	0.104	0.073	0.052	0.042	0.037	feet.

In deep water the meteorological current is often much stronger than the tidal; but as it has not the period of the latter, the measurement of the rise and fall of the tide and of the velocity of the flow and ebb could hardly be seriously affected by its presence.

The object of looking into the several sources of error has been to ascertain when the errors are small enough to be neglected rather than to attempt correcting for them in actual measurements. R. A. HARRIS.

February, 1904.

SEX DIFFERENCES IN THE SENSE OF TIME.

IN going over the results of a series of demonstration tests of the sense of time given to a mixed class recently, the returns from men and women were separately reduced, the summaries of which presented features of sex differentiation concerning which corroboration or revision on the part of others is sought through this note.

The test involved periods of time extending from a quarter of a minute to a minute and a half in duration. The intervals were filled in four ways: (1) The instructor read aloud to the class from a psychological work unfamiliar to its members; (2) the members of the class marked as rapidly as possible all the letter m's in a page of printed text; (3) the class waited in idleness for the period to pass by, refraining as far as possible from counting or other means of recording the lapse of time; (4) each person estimated as accurately as possible the period in question, using whatever method he had personally found most serviceable for the purpose. As there were fifteen men in the class, the tabulation of returns from the women was brought to a close when an equal number of judgments had been entered therein.

Only in the case of the one-minute period was estimation made under all four conditions mentioned. The results are presented in the following table, in which the signs plus and minus indicate respectively over- and under-estimation of the duration in terms of seconds, and the figures at the tops of the columns the series of conditions enumerated above:

Period. One Minute.				
Sex.	1	2	3	4
Men.	+29	+1.3	+22	—3.5
Women.	+66	+27	+80	+ 24

Incidentally, the purpose of the test was to call attention to the differences in one's estimation of time under conditions (1) and (2), and similarly in the case of (3) and (4). The relation of the members of these two pairs to each other is made apparent in the table. It is also to be noted that with the exception of the first entry in column (4), the only minus quantity in the whole series of tests, the error is throughout one of pronounced over-estimation. This tendency is very much stronger in the women than in the men, the first point of contrast in the comparison of sex differences. For this period of time the constant errors of the two sexes stand in a ratio of one to four. The clearest indication that this over-estimation of short periods of time on the part of women is a persistent habit, and not due to variable factors in the conditions of experimentation, appears in the fourth column of the table. In the case of men, keeping tally of the passing seconds results in the elimination of the positive error and the appearance of a slight under-estimation. In the case of women, on the contrary, over-estimation still persists to the amount of two fifths of the period in question; in other words, their unit of measurement is much in defect of the objective period which it is meant to represent.

The results of the various other tests made in the same series are summed in the following table, in which the same general relations are presented as in the preceding group.

	One quarter Minute.		One half Minute.		One and One half Minute.	
Sex.	3	4	1	4	1	3
Men.	+ 6	+0.5	+30	+ 3	+19	+ 70
Women.	+17	+10	+33	+12	+73	+189

There is also to be considered in such a comparison as the present the average variations of the individual judgments of men and women respectively from objective accuracy, of which the formulation of their constant