TABLE XI.—To show the relation of temperature of the body to that of the air in the shade, especially in the tropics.

		Temperate Zone. Temperature of air between				Tropics. Temperature of air between			
		57° & 60°.	60° & 65°.	65° & 70°.		70° & 75°.	75° & 80°.	80° & 84°.	
Highest		98°	99°	99½°		100°	100°	100°	
Lowest		98	98	98		98	98	98	
Range		0	1	1½		2	2	2	
Averages		98	98·3	98·6		98·63	98·8	99·08	
Total averages			98·3				98·836		
					Totals.				Totals.
Number of markings of temperature of body, taken thrice a day, viz. at 9 A.M., 3 P.M., and 9 P.M.	98°	7	6	9	22	20	18	6	44
	98½°	...	1	1	2	4	37	3	44
	99°	...	2	6	8	18	32	6	56
	99½°	...	...	3	3	4	23	12	39
	100°	...	...	...	...	2	1	4	7
			Total	.....	35		Total	.....	190

Unfortunately the statistics were not sufficiently numerous to draw satisfactory deductions as to the effect of humidity on the temperature of the body in mid-ocean in the tropics, where the amount of moisture is usually considerable. This would be interesting, as would others regarding tropical terrestrial climates, in some of which the hygrometric range is sometimes smaller, though in the majority greater.

V. "Observations on the Mode of Growth of Discoid and Turbinated Shells." By ALEXANDER MACALISTER, Professor of Zoology, University of Dublin. Communicated by the Rev. S. HAUGHTON, F.R.S. Received May 4, 1870.

A most interesting paper on the geometrical forms of turbinated and discoid shells was published by the Rev. Canon Moseley in the Philosophical Transactions for 1838, p. 351, in which some important points were noticed regarding the geometrical construction of shell-forms. The author of that paper describes discoid shells as generated by the revolution around a central point of the perimeter of a geometrical figure, which latter, although regularly increasing in size, yet remains always geometrically similar in form. The producing figure in many Gasteropodous Mollusks is represented by the operculum, and in all it may be recognized by making a vertical section in the plane of the radius vector. A turbinated shell is similarly generated, but the generating figure in the production of the helix slips down along the axis instead of revolving in a constant plane. The Rev. Mr. Moseley gives, as illustrations of these points, measurements of *Nautilus pompilius*, *Turbo phasianus*, *Turbo duplicatus*, and

Buccinum subulatum, and describes many interesting particulars regarding the formation and growth of the operculum in different shells.

This subject does not seem to have attracted much attention from naturalists, as, with the exception of a notice in Professor Goodsir's lecture "On the Use of Mathematical Modes of Investigating Organic Forms" *, it is not, to my knowledge, referred to by any writer on zoology.

While engaged in arranging the large collection of shells in the Museum of the University of Dublin, I was led to make measurements of univalve shells in order to see whether any deduction of zoological importance might be drawn from these valuable geometrical observations, and more especially to determine whether it might be possible to arrive at constant specific numerical parameters in these cases; and in all instances I have been surprised by finding that, in well-formed shells, the ratios of the successive whorls have been specifically constant. In making these measurements, the points to be determined are three, viz. :—1st, the ratio of elongation of the radius vector of the spiral (k); 2nd, the degree of linear expansion of the generating figure in the successive whorls (m); and 3rd, the degree of translation or slipping of the spiral on the central axis (n). The second of these we may call the discoidal coefficient, and the third the helicoidal coefficient.

On applying these measurements to univalve shells, we find that the possible combinations are five in number:—

1st, those in which $n=0$ and $m<k$,
2nd, those in which $n=0$ and $m=k$,
3rd, those in which $n=m$,
4th, those in which $n>m$,
5th, those in which $n<m$.

The cases of discoid shells in which $n=0$ are two, the first and second on the list. The first and most uncommon is that in which the amount of elongation of the radius vector in the formation of the successive whorls exceeds the transverse linear increase of the producing figure. The resulting form of this case (which may be formulated thus, $k>m$) is an open spiral, as in the fossil Gasteropodous genus *Eccyliomphalus*, or the Cephalopodous genera *Gyroceras*, *Nautiloceras*, and *Spirula*. The common species of this last genus gives the following measurements:—

Spirula prototypus, $m=2{\cdot}6$, $k=3{\cdot}3$, $n=0$. Generating figure, a circle. Average width of whorls 0·075 in., 0·2 in.†

It will be noted that all these spirals are true logarithmic curves; and

* Goodsir's 'Anatomical Memoirs,' vol. ii. p. 209.

† In all the specimens measured and referred to in this paper I have made at least three measurements of each individual, and in the majority of cases I have measured at least six specimens of each species. These measurements are in decimal parts of an English inch, and were made with a finely pointed pair of compasses and a diagonal scale, the eye being in some cases aided by a magnifying-glass. Some specimens were measnred by means of sections made in a plane perpendicular to the axis.

hence the widths of the whorls measured on the radius vector will form a series of numbers in geometrical progression, the common ratio of the progression being, in discoid shells of the second group where $m=k$, equal to the coefficient of linear increase of the generating figure. To verify the coefficients deduced from the numbers obtained by measurement, I have used the method given by the Rev. Canon Moseley, which depends upon a well-ascertained property of the logarithmic spiral, that if μ be taken to represent the ratio of the sum of the lengths of an even number (m) of the whorls to the lengths of half that number, then $k=(\mu-1)^{\frac{2}{m}}$. Applying this formula to the cases given below, I have in the majority of cases obtained results which confirm the ratios of the series of measurements otherwise obtained.

The second case of discoid shells, in which $m=k$ and $n=0$, is by far the commoner, as to it belong all genera of discoidal mollusks, with the few exceptions noticed above. The case $m > k$ is one which cannot occur, as then the outer whorl must necessarily crush the inner, and then the generating figure could not retain its geometrical identity while enlarging; hence we find no examples of it in discoid shells.

I have placed in this second case some instances in which the ratio of slipping or translation on the axis is not easily measured, and virtually amounted to nothing.

The following Table of examples illustrate case No. 2:—

Species.	$n=0$, $k=m$.	Generating figure.	Width of whorls in decimals of an inch.							
Haliotis viridis	10	Ellipse	0·075 0·05 0·15	0·75 0·5 1·5						
Haliotis rugoso-plicata	9·3	,, ...	0·02 0·03	0·18 0·28	1·6 2·7					
Sulculus (Haliotis) parvus	6	Oval	0·03	0·17	1					
Padollus (Haliotis) excavatus	4·2	Ellipse	0·06	0·25	1·1					
Natica canrena	3	Segment of circle....	0·025	0·075	0·25	0·76				
Nautilus pompilius	3	Segment of ellipsoid..	0·2265	0·68	2·04					
Dolium zonatum	2·1	......	0·119	0·25	0·525					
Solaropsis pellis-serpentis	2	......	0·023	0·047	0·086	0·17	0·34			
Planorbis corneus	2	Segment of circle	0·02	0·04	0·08	0·172				
Euomphalus pentangulatus	2	......	0·124	0·25	0·48					
Architectonica magnifica	1·75	Rhomboid ..	0·07	0·12	0·2	0·35	0·65			
Architectonica trochleare	1·62	,, ...	0·046	0·075	0·175	0·2	0·325	0·55		
Conus betulinus	1·43	Triangle	0·02	0·03	0·05	0·072	0·09	0·12	0·17	0·25
Conus literatus	1·4	,, ...	0·03	0·04	0·05	0·86	0·125	0·176	0·25	
Conus virgo	1·25	,, ...	0·08	0·1	0·105	0·16				
Planorbis, sp.	1·38	......	0·03	0·042	0·053	0·078	0·1	0·15	0·18	

Hitherto we have been examining the formulæ for discoid shells; but by far the greater number of shell-forms are those in which the whorls, instead of remaining in the same plane, slide down on the central axis, thus making a turbinated shell-form. A new principle enters into our calculation here; for the shape of a turbinated shell depends on the mutual relation of three, and not two constants. These are, first, the form of the

generating figure; secondly, the discoidal coefficient m; thirdly, the helicoidal coefficient n. Upon the relations of these parameters to each other depends the shape of the shell. Thus in some n is nearly equal to m, and in such cases the whorls scarcely embrace each other, and the figure produced is that of an elongated cone, as in the genera *Turritella, Cerithium, Acus,* &c. Sometimes n exceeds m; and in this case the resulting form is an open spiral as in *Vermetus,* or a rapidly descending series of whorls. A third possible case is that in which n is less than m, and the resulting figure is globular; but of this case, though a possible one, I have not as yet succeeded in obtaining an example.

The following cases illustrate the formula $n > m$:—

	n.	m.	Width of whorls in decimals of an inch.				Amount of translation.			
Vermetus lumbricalis ..	1·42	1·3	0·075	0·1	0·13	0·175	0·15	0·22	0·3	0·45
Delphinula atrata	6·00	2·85	0·018	0·5	0·148	0·41	0·01	0·05	0·3	

The following instances exemplify the case $n = m$:—

Species.	$n=m$.	Length of whorls in decimals of an inch.											
Helicostyla polychroa....	2	0·41	0·081	0·158	0·32	0·7							
Fusus colosseus	1·71	0·09	0·14	0·26	0·43	0·76							
Phasianella bulimoides ..	1·8	0·07	0·125	0·23	0·45								
Scalaria preciosa........	1·56	0·05	0·078	0·13	0·2	0·32	0·52						
Fusus antiquus	1·5	0·15	0·225	0·343	0·54	0·84							
Mitra episcopalis	1·434	0·245	0·4	0·575	0·82								
Trochus niloticus	1·41	0·2	0·3	0·425	0·63	0·9	1·2						
Fusus longissimus	1·341	0·25	0·3	0·44	0·6	0·81							
Fusus colus	1·33	0·15	0·2	0·26	0·35	0·42	0·54	0·83					
Pyrazus sulcatus	1·33	0·13	0·17	0·29	0·38	0·51							
Acus dimidiata	1·277	0·2	0·267	0·31	0·4	0·52	0·62	0·88					
Acus maculata..........	1·25	0·15	0·176	0·23	0·29	0·37	0·45	0·53	0·7	0·9			
Acus crenulatus	1·25	0·2	0·25	0·32	0·38	0·496	0·6						
Cerithium nodulosum ..	1·24	0·23	0·3	0·37									
Pirena terebralis........	1·23	0·08	0·12	0·15	0·178	0·22	0·28	0·35					
Pyrazus palustris	1·22	0·15	0·182	0·22	0·27	0·34	0·42	0·5					
Zaria duplicata	1·23	0·078	0·1	0·125	0·16	0·2	0·24	0·3	0·26	0·44	0·53	0·625	0·76
Acus subulata	1·163	0·175	0·2	0·23	0·265	0·32	0·367	0·432	0·47	0·641			
Telescopium fuscum	1·14	0·1	0·112	0·125	0·15	0·18	0·2	0·24	0·28	0·325	0·365		

VI. "Contributions to Terrestrial Magnetism.—No. XII. The Magnetic Survey of the British Islands, reduced to the epoch of 1842–5." By General Sir Edward Sabine, K.C.B., President of the Royal Society. Received June 15, 1870.

(Abstract.)

This paper contains a statement of the origin, progress, and completion of this survey. It is accompanied by maps of the declination, inclination, and magnetic force, which have been drawn at the Hydrographic Office of the Admiralty under the superintendence of Captain Frederick John Evans, R.N., F.R.S. The paper consists in great measure of Tables, giving the observation of each of the three magnetic elements, with reductions in every case for the secular change between the date of the observation and that of the epoch (1842–5) for which the maps are constructed.