instrument was nearly two years old when it went to sea, there is a difficulty in supposing that the correction was very much greater at the first half than at the second half of the voyage.

"On the whole I should be disposed to state the result in the following manner:—

"That the influence of the variation of gravity does not exceed, in passing from lat. 45° to the equator, a change of refraction for the yellow of the spectrum equal to about three-fourths of the interval of the D-lines; but more observations must be made before it can be asserted that this apparent change is not due to known causes.

"Yours very truly,

"*J. P. Gassiot, Esq.*" "B. STEWART."

So favourable an opportunity of making correct observations with a delicate apparatus like the rigid spectroscope may not again offer, and consequently, in acknowledging the receipt of Captain Mayne's letter of 17th Feb., an extract from which is inserted in the preceding communication, I explained how desirable it will be while the 'Nassau' remains in the Straits of Magellan if one observation on each day is taken, or two when any very considerable range of temperature occurs, for the purpose of being made use of both for change of zero and as checks upon temperature observations to be taken on shore on the return to this country, as otherwise the observations thereon would not be so useful.

Should it be found practicable on the return of the 'Nassau,' it is purposed to take a few days' readings before the spectroscope is removed from the ship to Kew Observatory, as this would much promote the correctness of the final result which may then be anticipated.

J. P. G.

Clapham Common, June 3, 1867.

III. "On some Elementary Principles in Animal Mechanics." By the Rev. SAMUEL HAUGHTON, M.D., Fellow of Trinity College, Dublin. Received May 15, 1867.

There are some elementary principles in animal mechanics which are so natural that they may be assumed as probable, and as such, have not received from observers the attention they really deserve.

Among these principles I select for illustration the two following:—

i. *The force of a muscle is proportional to the area of its cross section.*

ii. *The force of a muscle is proportional to the cross section of the tendon that conveys its influence to a distant point.*

i. In order to test the first of these statements, I made a careful examination of the cross sections of the muscles that bend the fore arm and leg, in a very finely developed male subject, with the following results:—

Neglecting the slight effect of the *Supinator radii longus* in flexing

the fore arm, I found the cross sections of the *Biceps humeri* and *Brachiæus* to be as follows :—

	Cross section.
1. *Biceps humeri*	1·914 sq. in.
2. *Brachiæus*	1·276 „
	3·190

The cross sections of the muscles that bend the leg were found to be in the same subject—

1. *Biceps femoris* (long head)	2·59 sq. in.
„ (short head)	1·14 „
2. *Semitendinosus*	1·87 „
3. *Semimembranosus*	2·25 „
4. *Gracilis*	0·89 „
5. *Sartorius*	0·59 „
	9·33

When the arm was held vertically, and the fore arm horizontally, with the fist shut and in supination, I found that 39 lbs. was the limit of the weight that could be lifted when suspended at $12\frac{1}{4}$ inches from the axis of the elbow-joint; and that the perpendiculars let fall upon the directions of the muscles from the same axis were—

1. *Biceps humeri*	2·06 inches.
2. *Brachiæus*	1·07 „

Hence if K denote the force of the muscle, per square inch of cross section, we have, adding 2lbs. for the weight of the fore arm at $12\frac{1}{4}$ inches from the axis of the joint,

$$41 \text{ lbs.} \times 12\tfrac{1}{4} \text{ inches} = K \times \left\{ \begin{array}{c} 1{\cdot}91 \times 2{\cdot}06 \\ +1{\cdot}28 \times 1{\cdot}07 \end{array} \right\}$$

$$502\tfrac{1}{4} = K \times \left\{ \begin{array}{c} 3{\cdot}935 \\ +1{\cdot}369 \end{array} \right\}$$

$$= K \times 5{\cdot}304$$

and finally $K = 94{\cdot}7$ lbs.

This represents the force per square inch of cross section that the muscles flexing the fore arm are capable of exerting.

In order to measure the force of the muscles flexing the leg, I placed the observer lying upon his face upon a table, with the legs extended over its edge, and having fastened down the thighs, I observed the maximum weights, suspended from the heel that could be conveniently lifted, and found that 34 lbs. was the limit; to this must be added 3 lbs. for the weight of the leg, supposed suspended at the heel, which was measured as $16\frac{1}{2}$ inches from the axis of rotation of the knee-joint. The perpendiculars let fall upon the directions of the several muscles flexing the leg were then measured :—

		Perpendicular
1.	*Biceps femoris* (long head)	0·95 in.
	„ (short head)	0·56 „
2.	*Semitendinosus*	0·40 „
3.	*Semimembranosus*	0·65 „
4.	*Gracilis*	0·25 „
5.	*Sartorius*	0·00 „

Hence we find, for the determination of K (the coefficient of muscular contraction per square inch of cross section),

$$37 \times 16\tfrac{1}{2} = K \times \begin{cases} 0{\cdot}95 \times 2{\cdot}59 \\ 0{\cdot}56 \times 1{\cdot}14 \\ +0{\cdot}40 \times 1{\cdot}87 \\ +0{\cdot}65 \times 2{\cdot}25 \\ +0{\cdot}25 \times 0{\cdot}89 \\ +0{\cdot}00 \times 0{\cdot}59 \end{cases}$$

or,

$$610{\cdot}5 = K \times \begin{cases} 2{\cdot}460 \\ 0{\cdot}638 \\ +0{\cdot}748 \\ +1{\cdot}462 \\ +0{\cdot}222 \\ +0{\cdot}000 \\ \overline{5{\cdot}530} \end{cases}$$

and, finally,

$$K = \frac{610{\cdot}5}{5{\cdot}53} = 110{\cdot}4 \text{ lbs.}$$

It appears from the foregoing considerations that the force of contraction of the muscles, per square inch, is in

The arm	94·7 lbs.
The leg	110·4

These numbers are, perhaps, as near to each other as this class of observations admits of, but I believe that they do not differ so much, really, as they appear to do, for the following reason:—

As it was not convenient to procure a good subject destroyed by a violent death, I made use of a powerful man who had died of cholera *, and who had been a blacksmith by profession. Now, it is natural to suppose that the muscles of the arm of a blacksmith are more developed than those of his leg, so that their cross section would be relatively too great, and the coefficient derived from that cross section, therefore, too

* It is well known that after death by *Cholera*, life continues in the muscles, and manifests itself for some hours by movements, and by the existence of the muscular *susurrus*. This latter fact, the first notice of which belongs to Dr. Collongues, of Paris, I have repeatedly verified, as also the continuance of the *susurrus* in cases of death by *tetanus*. It appeared to me, therefore, that such a subject as I selected was one well suited to the purpose of my observations.

small. I therefore compared the sections of the *Biceps humeri* and *Brachiæus*, found by me, with the only other measurements, with which I am acquainted, for the knowledge of which I am indebted to Dr. W. Moore of Dublin, who translated the results for me, from the Dutch, of Messrs. Donders and Mansfelt * of Utrecht.

Cross Sections of *Biceps humeri* and *Brachiæus*.

		millims.	sq. in.
1. *Biceps humeri*	(long head)	530	0·821
„	(short head)	452	0·701
2. *Brachiæus*		614	0·952
		1596	2·474

If this estimate of the cross section of the muscles be assumed instead of my own, the coefficient found by me should be increased in the proportion of 3190 to 2474; or

Coefficient of muscles of fore arm . . . $94{\cdot}7 \times \frac{3190}{2474} = 122$ lbs.

The mean of the coefficients found from my own measurement of the muscles of the arm, and that of Professor Donders, is 108·4 lbs., which agrees nearly with that obtained from the muscles of the leg, viz. 110·4 lbs., and the mean of all the observations on arm and leg would be **109·4 lbs.**, a result which I consider to be not far from the truth.

The cross sections of the muscles were found by cutting them across with a sharp scalpel, and marking out their section on cardboard, and afterwards weighing the marked portions, the weights of which were then compared with the weight of a known number of square inches of the same cardboard, and so the cross sections in square inches calculated.

I give here, for the purpose of illustration, the actual sections of the muscles of the leg. (Figs. 1–6.)

The perpendiculars let fall upon the directions of the muscles were measured by stretching strings from the origin to the insertion of the muscles, and measuring, by means of a compass, the perpendiculars let fall upon these strings from the axis of the joint.

The weights of the muscles themselves were as follows:—

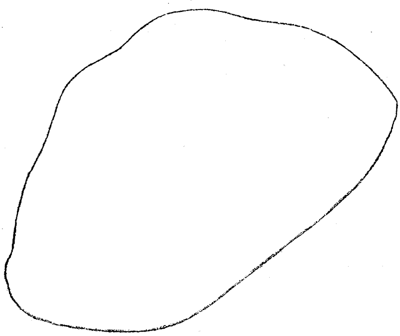
	oz.		oz.
1. *Biceps humeri* . .	4·22	5. *Semimembranosus* .	7·25
2. *Brachiæus*	5·04	6. *Gracilis*	2·98
3. *Biceps femoris* . .	10·74	7. *Sartorius*	5·66
4. *Semitendinosus* . .	5·17		

ii. The principle of economy of force or of material in nature would lead necessarily to the principle that each tendon conveying the effect of a force to a distant point should have the exact strength required, and neither more nor less; for, according to the doctrine of *final causes*, it was originally contrived by a perfect architect, and according to La-

* Over de Elasticiteit der Spieren. Utrecht, 1863.

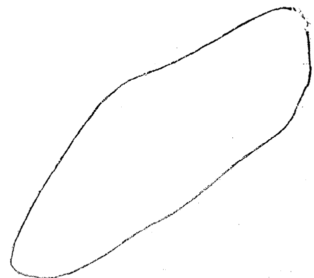
marckian views it must have perfectly accommodated itself to the uses to which it is applied. According, therefore, to either view, if the tendon be too strong, it will become *atrophied* down to the proper limit;

Fig. 1.



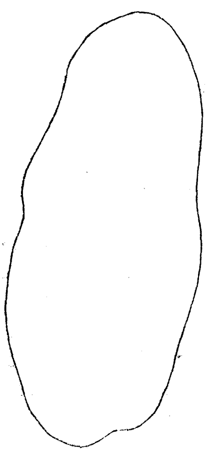
Biceps (long head).

Fig. 2.



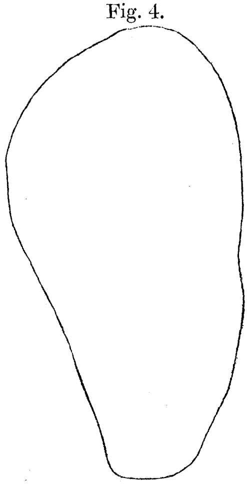
Biceps (short head).

Fig. 3.



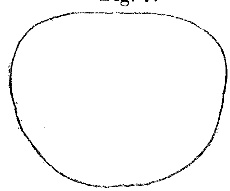
Semitendinosus.

Fig. 4.



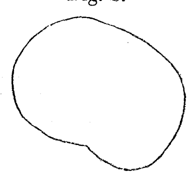
Semimembranosus.

Fig. 7.



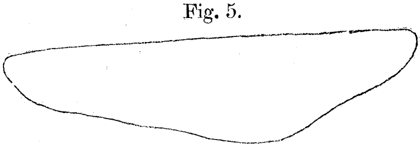
Flexor perforans. (Rhea.)

Fig. 8.



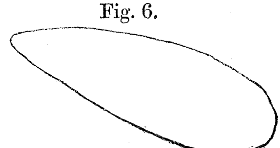
Flexor hallucis. (Rhea.)

Fig. 5.



Gracilis.

Fig. 6.



Sartorius.

and if too weak, it must either break, or be nourished up to the requisite degree of strength. It seemed to me desirable to prove this fundamental proposition in animal mechanics by direct observation; and I selected for this purpose the tendons in the leg of several of the large running birds (*Struthionidæ*); and always with the same result, viz.,

that *the cross sections of any two muscles tending to produce a similar effect are directly proportional to the cross sections of their tendons.*

I shall select as an example the case of the *flexor hallucis longus* and *flexor digitorum communis perforans* of the Rhea, whose tendons unite into a common tendon halfway down the posterior side of the *canneon* bone of the bird.

The cross sections of these two muscles are shown in the annexed figures, taken as in the human subject. (Figs. 7 and 8.)

The areas of these cross sections were found to be as 245 to 160; or the lesser was 65 per cent. of the greater.

Two equal lengths of the dried tendons were then weighed and found to be in the proportion of 845 to 495, which was assumed to be the proportion of their cross sections. The lesser of these numbers is 59 per cent. of the greater; a result that seems to be as near to the former result derived from the muscles, as can be expected in this class of experiments.

IV. "Observations on the Anatomy of the Thyroid Body in Man." By GEORGE W. CALLENDER, Lecturer on Anatomy at St. Bartholomew's Hospital. Communicated by Mr. PAGET, Received June 8, 1867.

(Abstract.)

Much doubt exists as to the earliest connexions of the thyroid body, whether it is developed, that is to say, with the membranous air-tube, or has a common origin with the thymus gland. There are no reliable observations as to the formation of the isthmus or as to the origin of the pyramid, so far, at least, as man is concerned, although, with reference to the isthmus, its absence in an entire class, that of birds, and the observations of Gray on the formation of the thyroid in the chick, countenance the supposition that it results from the growing together of two lateral masses.

In a human fœtus, between the seventh and eighth week, the thyroid body is closely connected with the trachea and with the lower edge of the larynx, and although consisting of but one piece is deeply notched, and thus looks as though made up of three separate lobes. It is quite distinct from the thymus, as may be further seen in the dissection of a fœtal rabbit or fœtal pig, in which, whilst firmly attached to the trachea, it has no kind of connexion with the thymus. In the human fœtus no distinct evidence of the thyroid appears to exist before the sixth week, up to which time it cannot, I believe, be isolated from the structures in front of the neck. It seems to come out from the blastema in the form of a mass in front of the trachea, and quickly acquires an imperfectly lobed appearance.

In the dissections referred to, the presence of a middle portion and its