The leverage of the lower human jaw : (an excerpt from the author's note-book) / by John Gorham.

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Hogg, Jabez, 1817-1899
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Publication/Creation

[London] : [publisher not identified], 1875.

Persistent URL

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Reprinted from the 'British Journal of Dental Science,' February, 1875.]

THE LEVERAGE OF THE LOWER HUMAN JAW.

(*An excerpt from the author's note-book.*)

By JOHN GORHAM, M.R.C.S. Eng., &c.

(Reprinted from the 'Medical Times and Gazette.')

DATA.—*Average Weight of each Single Tooth in Grains—Average Weight of all the Teeth in Grains—Weight of lower Jaw in Grains, without the Teeth—Weight of Lower Jaw with its Full Complement of Teeth in Grains—Centre of Gravity of Lower Jaw—Position of Fulcrum—Long Arm in Inches—Short arm in Inches—Fulcrum of all the Teeth—Long Arm of each Tooth in Inches—Short Arm of each Tooth in Inches—Moment of each Tooth—Sum of Moments of all the Teeth.*

The Weight and Bulk of the Teeth are always in the same ratio.*

OWING to the equal density of all the teeth, their weight and bulk coincide; hence these terms are convertible, and are thus used in the following section. If the bulk of a lower incisor, for instance, which weighs ten grains, is equal to the one fiftieth of a cubic inch, then the weight of an upper canine, the bulk of which is equal to the one twenty-fifth of a cubic inch, will be twenty grains, and so on. In other words, if one tooth weigh twice as much as another, it will have twice the bulk.

Relative Size of the Teeth.

The largest teeth in the head are the upper molars (33·4 grs.), and the smallest are the lower incisors (10·8 grs.): an upper molar is about three times as large, therefore, as a lower incisor. From the lower incisors the teeth increase in magnitude in the following order:—A lower bicuspid (14 grs.) is bigger by about four grains than a lower incisor, and an upper bicuspid (16 grs.) exceeds a lower in size by about two grains. Next in order come the upper incisors (16·4 grs.), which scarcely exceed in bulk the upper bicuspid. The lower canine stand next (17·9 grs.), being a little larger than the upper incisors. Then follow the upper canine (21·4 grs.), which are much bigger than the lower, and about twice the size of the lower incisors. In the remaining groups the teeth are much larger: an upper wisdom (32 grs) is about thrice the size of a lower incisor; the lower wisdom (31·9 grs.) is nearly the same in bulk. Finally, the largest teeth in the head are the molars.

Relative Size of the Teeth in the Upper and Lower Jaw.

The teeth in the upper jaw are larger than those in the lower. The weight of all the teeth in the upper jaw is 370 grs., that of those in the lower 330 grs.,—showing a difference of 40 grs.

The Difference between the Size of the Teeth in the Upper and Lower Jaw diminishes as they recede from the Front of the Mouth.

The mean difference of an upper as compared with a lower incisor is 5·6 grs.; of an upper canine to a lower, 3·5 grs.; of an upper

* For the loan of some thousands of teeth, in order to conduct these experiments, the author is indebted to Charles James Fox, Esq., Dental Surgeon to the Dental Hospital, London, and to John Franks, Esq., Surgeon, Sevenoaks, Kent.

bicuspid as compared with a lower, 1·4 gr.; and of an upper molar to a lower, 1 gr. The greatest difference is that between the six front teeth, the incisors and cuspids, in each jaw. The upper incisors and cuspids weigh exactly 108·4 grs.; the same teeth in the lower jaw, 79 grs.—difference, 29·4 grs.;—whereas the difference between the six upper and lower molars amounts to 2·1 grs. only. There must, of course, be a necessity for this disparity in bulk, else it would not have existed. Why should there be a difference in the upper and lower front teeth amounting to 29 grs., and a difference of 2 grs. only between a like number of teeth at the back of the head? Several reasons might be assigned, amongst which may be noticed that, as the front teeth in the upper jaw stand out most prominently in the face, they are most exposed to the effects of blows or other injuries, and require, therefore, great firmness as to their setting in the alveoli, which measure results in no small degree from their superior magnitude. In the next place, they have to bear the succussion from the lower teeth in the act of mastication, for in ascending through a much more considerable space than the back teeth—sweeping as they do through arcs of larger circles—they must of necessity accumulate velocity; and velocity and weight are equal to force.* In the third place, if the teeth in the lower jaw were as heavy as those in the upper, the muscular power required to elevate them in conjunction with the jaw itself would be greatly increased, and might prove altogether disproportionate to the demand. Now, as it has been proved by direct experiment that the teeth in the lower jaw are lighter in weight than those in the upper, and also that they increase in weight according as they recede toward the back of the jaw, one of the advantages—not to say necessities—for this twofold arrangement would appear to consist in the sensible diminution of stress upon the lever power by which the lower jaw is moved; a stress or force which tells more, it must be remembered, inasmuch as, at the best, the use of this kind of lever is always attended with a certain loss or disadvantage. Now, the expenditure of power is, as will be shown, economised to a remarkable degree by the lighter weight of the teeth in the lower, as compared with those in the upper jaw, as well as by the lighter weight of the front teeth in the lower jaw itself as compared with those which are situated behind. In order to make this apparent, it is necessary first to consider the leverage of the lower jaw itself, destitute of the teeth; next, to show the additional power which is required to elevate it when supplied with its full complement of teeth; and then, by way of contrast, further to notice what additional loss of power would be sustained, or, in other words, what greater encroachment would be put on its muscular resources, supposing that the teeth in the lower jaw were all reversed in their position—the incisors being caused to occupy, for instance, the places of the molars, and *vice versâ*; or supposing, in the next place, that the lighter

* As the upper teeth are always in a state of quiescence, and the lower always in a state of motion, an incessant battery is kept up by the latter against the former. The question might be, Which is to succumb? but that is not the question,—it is this: How are both to maintain their stand-point for a long series of years, at the lapse of which neither shall have given way? This will become apparent when the angle at which the lower teeth impinge on the upper is considered, and from which it will be seen that the superior size of the upper teeth, and, by consequence, their firmer articulation in the jaw, were absolutely necessary to prevent their being fairly beaten forwards by the impact of those belonging to the lower jaw.

teeth in the lower jaw were replaced by the heavier ones of the upper. Of the two bones chiefly concerned in the mastication of food and articulation of speech, the upper bone remains almost entirely stationary or passive; whilst the lower bone, on the other hand, is almost incessantly in a state of motion. The provision consists in the fact of the lower jaw being so articulated with the bones of the head that it shall work about a hinge. This kind of motion requires that it shall have a muscular apparatus on purpose that it may be elevated or depressed, moved laterally, or caused to advance and retreat, according to its various exigencies: no similar provision being required for the upper jaw, which is immovable. As the lower jaw turns about a fixed point by the aid of a force acting upon a certain part of its shaft, the bone becomes in effect a lever-rod, of which that portion which is situated at the joint is called the "fulcrum," the bone itself the "rod," whilst the muscles which move it are the "power."

TABLE I.—*Bulk or Volume of the Teeth.*

Name.	Mean weight in grains.	Bulk or relation to cubic inch.
Lower incisor	10·8	0·020, or $\frac{1}{50}$th
Lower bicuspid	14·6	0·027, or $\frac{1}{37}$th
Upper bicuspid	16·0	0·030, or $\frac{1}{33}$rd
Upper incisor	16·4	0·031, or $\frac{1}{32}$nd
Lower canine	17·9	0·034, or $\frac{1}{29}$th
Upper canine	21·4	0·040, or $\frac{1}{25}$th
Lower wisdom	31·93	0·060, or $\frac{1}{16}$th
Upper wisdom	32·0	0·060, or $\frac{1}{16}$th
Lower molar	32·4	0·061, or $\frac{1}{16}$th
Upper molar	33·4	0·063, or $\frac{1}{15}$th

In the above table it was not sufficiently important to carry the calculations beyond three decimal places; hence the bulk of two teeth slightly differing in their mean weight comes out the same.

TABLE II.—*Mean Weight of all the Teeth from the Lightest to the Heaviest, from* 844 *Experiments.*

Number weighed.	Lower incisor.	Lower bicuspid.	Upper bicuspid.	Upper incisor.	Lower canine.	Upper canine.	Lower wisdom.	Upper wisdom.	Lower molar.	Upper molar.
139	10·8									
56	....	14·6								
115	....	....	16·0							
108	....	....	....	16·4						
112	....	....	....	....	17·9					
37	....	....	....	....	....	21·4				
32	....	....	....	....	....	....	31·9			
28	....	....	....	....	....	....	....	32·0		
110	....	....	....	....	....	....	....	....	32·4	
107	....	....	....	....	....	....	....	....	....	33·4
844										

In order to find the true leverage of the lower jaw, it must be considered from two distinct and different aspects. The first is that which relates to its anatomy, the second to its mechanism. Under the former are comprised its general configuration, weight, weight of the teeth, and exact line of concentration of the muscular power required to elevate it. The latter embraces the mechanical principles by which it is moved, and in which are involved the kind of lever used, the length of its rod, the position of its fulcrum, the centre of gravity, the point of power. From these data the amount of force required to lift it is calculated. To this must be added the additional force expended in enabling it to perform its proper functions of mastication, articulation of speech, &c. The study of the leverage of this bone in this way becomes at once attractive and instructive, involving as it must do a minute acquaintance with its anatomical details, comprising the weight of the teeth as well as a knowledge of the mechanical powers which are exerted in setting it in motion.

On mapping out the lower jaw into regions for the purpose of converting it into a lever-rod of the third kind, there will be found in this bone several peculiarities not belonging to other bones in the body which are moved by the same kind of lever force. First, the bone is bent at its anatomical angles. Now, as a bend in a lever goes for nothing, ideal lines must be drawn about it in order to procure a straight rod from which to calculate the lever powers. Secondly, the muscular apparatus by which it is raised is not concentrated in a given point on the bone, as in the case of the biceps muscle of the arm, but is spread over a space comprised between the coronoid process and the ascending ramus. The point of power, therefore, which must be somewhere or in some line which defines the concentrated effort of both muscles (temporal and masseters), has to be determined, otherwise the length of the short arm of the lever could not be discovered. Thirdly, the muscles act on the limbs with what is called a mechanical disadvantage. But it must be observed that mechanism has always in view one or other of these two purposes—either to move a great weight slowly, and through a small space; or to move a light weight rapidly through a considerable sweep. Now, while the latter of these two movements is that which the occasions of animal life principally call for—as in the case of the arm, where extent of motion is required rather than the ability to lift a heavy load,—in the mechanism of the lower jaw to overcome resistance was the chief end required; and accordingly muscular fibres constituting the power are found to pass perpendicularly downwards from the sides of the head to the lower jaw-bone, and acting on it in a straight line. The force with which the power acts in this case is immense, particularly when the resistance to be overcome is placed near the fulcrum or directly beneath the action of the muscle. Advantage is taken of this circumstance in cracking nuts by putting them a certain distance back between the jaws. Fourthly, while the resistance or weight to be overcome consists essentially in the substances which are used for aliment, and which may be exceedingly hard or tough, yet, besides this, there is the absolute weight of the jaw itself, amounting to nearly one thousand grains, the power to raise which has therefore to be determined. In this case the bone is the weight, and the point or position of that weight from the fulcrum, in order to determine the long arm of the lever, is the centre of gravity of the bone itself; and this is found by actual experiment. Fifthly, having found the power required to raise the lower jaw-bone by itself, the next question is to determine the additional leverage which would be required, supposing that it is supplied with its full complement of teeth. There is here a very pretty and curious bit of mechanism in connection with the teeth of the lower jaw, any explanation of which, however, could not have been attempted unless the weight of the teeth had been previously ascertained, but which nevertheless is essential to the proper understanding of the leverage of the jaw. It results from the fact that while every tooth has its own specific weight, it has also a different distance from its fulcrum. It is obvious, therefore, that there are as many distinct ideal lever-rods as there are teeth, and each requires a separate calculation in order to find the lever power to lift it. It is in effect like suspending a number of different weights in a row along a lever-rod, taking the power to raise each of them in succession, and then the sum of all the powers collectively to raise them altogether. Sixthly and lastly, the mechanical disadvantage of this kind of lever is partly compensated for in the very weight of the teeth themselves; and to this the attention of the reader has been already directed—for, as the teeth in the lower jaw are much lighter than those in the upper, and lighter moreover in front than behind, such an arrangement puts less stress on the power at that very part of the bone, considered as a lever, where the power acts with the least advantage. The utility of this is rendered still more apparent by contrasting the effect which would be produced by reversing the order of the teeth in the lower jaw from before to behind; or, again, by exchanging those in the lower jaw for those in the upper. In either case a much greater demand, amounting to several hundred grains, would be made on the power.

Anatomy and Mechanism of the Lower Jaw-bone.

The lower jaw, represented in profile (Fig. 1), consists of a horizontal portion containing the lower teeth, and an upright or ascending portion terminating in the joint. These portions are named respectively the "horizontal" and "ascending" ramus of each side, the chin being considered as placed between them in front. The ascending ramus terminates above and behind in a thickened process termed the "condyle," and constituting the articular portion of this bone. The angle formed by the commencement of the horizontal ramus is termed the "angle" of the jaw. Although several muscles are employed in the movements of the lower jaw—such as the two pterygoids, the buccinator, the masseter, and the temporal,—it is to the two latter that its elevation is chiefly due. The concentrated effect of these two muscles is located in a line a little behind the coronoid process of the jaw, the precise position of which it is of some importance to notice, as it defines the point of power in the lever-rod, from which is calculated its short arm.

The lever (see Fig. 1) is here bent in its form for the purpose of convenience; but, whatever be the form of the lever, the mechanical advantage of the power or the weight is always represented by a line drawn from the fulcrum at right angles to the direction in which the forces are respectively exerted.

Fig. 1 is a bent lever, exemplified in the case of the lower jaw with the power P, acting in the line Pp, and the weight C (Fig. 2), at the centre of gravity, acting at W (Fig. 1), while the fulcrum is at F. In this case both the power and the weight act at right angles to an ideal line drawn as from F to W across from the

Fig. 1.

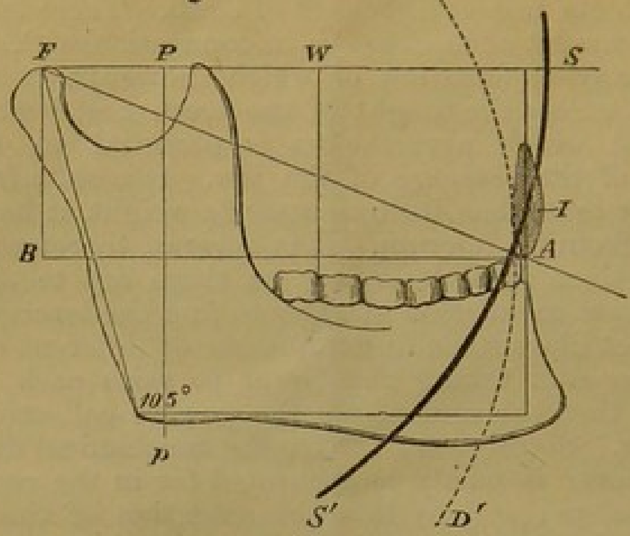

FIG. 1.—Right half of lower jaw-bone with its complement of eight teeth. *F*, Condyle—*i.e.*, position of fulcrum. *p*, Anatomical angle of jaw. *P*, Point of power. *W*, Point of weight—a line let fall perpendicularly to a point between two posterior molars. *FW*, True lever-rod, regardless of bend of jaw at *p*. SS^1, Circular path of lower anterior incisors on a radius *FA*, showing that they move forwards and upwards until they impinge on upper incisors *I*. DD^1, Circular path of lower anterior incisors on a radius *BA*, showing that they move upwards and backwards after impinging on upper incisors *I:* supposing the condyle to be at *B*—that is, in a line with the lower teeth, as in the tiger, cat, etc.

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fulcrum to the weight which strikes the line of direction of the forces at right angles. This ideal line, *FW*, therefore, represents the true lever of calculation, and is proceeded with according to the ordinary rule for calculating lever powers. In this manner the bending which takes place at the angle goes for nothing.

In order to arrive at legitimate results it is essential that the anatomical points should be very accurately measured on the jaw itself, and it is equally essential that their distances be as carefully measured on the lever-rod; a slight mistake in either of these particulars would lead to error. The shifting of the point of power or the point of weight, even only the one tenth of an inch, would so modify the answer—*i.e.*, the power in grains required to elevate the lower jaw by lever-force—as to render the calculation useless.

1. The *rod* itself is a line drawn from the fulcrum, *F*, to the point point of weight, *W* (Fig. 1).

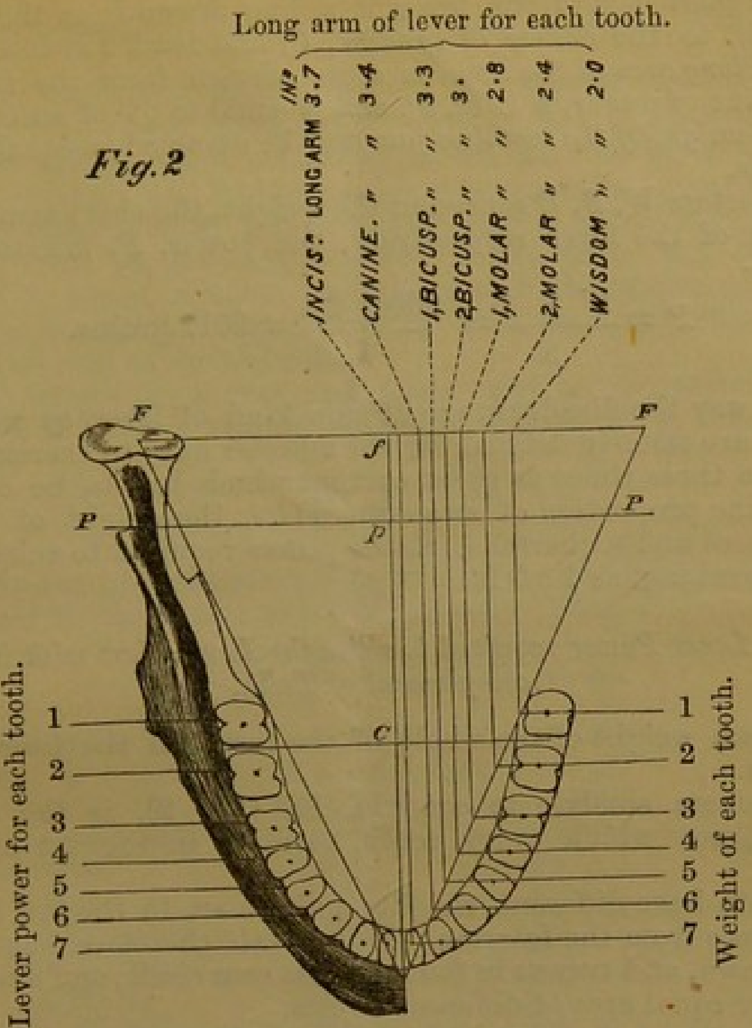
2. The *fulcrum* is a line drawn from condyle to condyle (Fig. 2), and is taken at *f* midway between the two.

3. The point of *power*, *P*, is in a line stretched horizontally from the coronoid process to the condyle, and one third of the distance from the former to the latter process. This point is 0·7 of an inch from the fulcrum, *FP* (Fig. 1), and *fp* (Fig. 2).

4. The point of *weight*, *W* (Fig. 1) is the centre of a line passing through the centre of gravity.

5. The *centre of gravity*, *C* (Fig. 2), is found by stretching a thread across from side to side, either in front of the alveoli of the posterior wisdom teeth, or across the centre of the alveoli of the molars. Owing to the variable thickness of this bone, especially

Fig. 2



Lever Power (in grains) for each Tooth.	
1. Wisdom...	90·915
2. Molar, posterior ...	112·808
3. " anterior ...	129·600
4. Bicuspid, posterior ...	62·488
5. " anterior ...	68·380
6. Canine...	86·815
7. Incisor...	57·024

Weight (in grains) of each Tooth.	
1. Wisdom	31·9
2. 2nd Molar	32·4
3. 1st Molar	32·4
4. 2nd Bicuspid	14·6
5. 1st Bicuspid	14·6
6. Canine	17·9
7. Incisor	10·8

FIG. 2.—*FF*, Fulcrum of jaw. *f*, Lever fulcrum of all the teeth. *fp*, Short arm of lever for all the teeth. *fC*, Long arm of the lever of the lower jaw itself, extending from fulcrum *f* to centre of gravity *C*. *P*, Point of power found by drawing a line a little behind the coronoid process on either side. *C*, Centre of gravity of lower jaw. The *weight* of each tooth is shown in the references to the figures in the right column, the *long arm* of the lever at the top of the illustration, while the *short arm* is the measure from *f* to *p*. These three form the data for finding the power by the formula $P = \frac{W \times L}{S}$, and this gives the measure (in grains) for lifting each tooth, as shown in the left-hand column.

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about its symphysis, its centre of gravity varies. The thread must be shifted therefore forwards or backwards, until, when poised on the finger or suspended from its middle by a second thread, the bone hangs horizontally. The centre of gravity, *C*, is thus determined for each individual jaw, and is about 2·2 inches from the fulcrum.

6. The *short arm* of the lever is a line drawn from the fulcrum, F (Fig. 1), to the centre of gravity, C, and is=2·2 inches.

7. The *long arm* of the lever is a line drawn from the fulcrum, f, to the point of power, p (Fig. 2), and is equal to 0·7 of an inch.

8. The *weight of the toothless jaw* may be assumed as equal to about 960 grains.

If the letters W, S, L represent the weight, the short arm, and the long arm of the lever respectively, the power, P, is found by the formula—

$$P = \frac{W \times L}{S} = \frac{960 \times 2{\cdot}2}{{\cdot}7} = 3017 \text{ grains.}$$

In this way the disadvantage of this kind of lever, as well as the measure, are strictly defined, for the muscles have to exercise a force more than three times as great as that which has to be overcome, being in the proportion of two ounces (*i. e.*, the weight of the jaw) to six ounces and a quarter (*i. e.*, the power required to raise it); or, strictly speaking, as 1 : 3·14.

Of the Lever Power required to raise the Lower Jaw with its full complement of Teeth.

The mean weight of the whole of the teeth in the lower jaw is 330 grains.

A line from condyle to condyle, FF (Fig 2), is the common fulcrum about which every tooth revolves in the act of mastication.

The teeth have different weights and are set in the jaw at different distances from the fulcrum. Each tooth, therefore, has a lever-rod of its own, and travels in the arc of its own circle, and every tooth moves over equal arcs of different circles.

The fulcrum of the lever which raises each tooth is a point in the line FF (Fig. 2), exactly opposite the tooth. The long arm is a line drawn from the tooth, meeting its axis, FF, at right angles. The short arm is measured from the point p, where the muscular force is concentrated. The distance from p to the fulcrum, therefore, is the length of the short arm.

The lengths of the fulcrum and of the short arm are constant, and the same for every tooth; but the length of the long arm varies with the distance of each tooth from its axis, being greatest for the incisors and least for the wisdom teeth.

The planes in which the teeth revolve are vertical. No two teeth revolve in the same plane, but each in an imaginary vertical plane of its own, of which the outermost is that of the wisdom and the innermost that of the anterior incisor. Their fulcra, therefore, are separate and adjacent points in the line FF (Fig. 2), from which lines drawn at right angles to their respective teeth represent the true lever-rods.

Each tooth has its own system of leverage, and requires a different power to raise it. If each had the same weight it would still require a different power, owing to its distance from its own proper fulcrum; and if the long arm of the lever were the same for each tooth, the power to raise it must still vary, owing to the difference in its weight. In either case, therefore, a separate calculation is required to find the lever power to raise each individual tooth. Again, although all the teeth move together in their respective arcs, it is still necessary to consider them at first separately, in order afterwards to calculate the leverage of the sum of all of them.*

The true method of calculating the leverage of the teeth will be to estimate the power required to elevate each tooth according to its weight and position, and then to add all the powers together, the sum of which will be the total power expended in raising all of them. A lower incisor, for instance, weighs about ten grains, and requires, from its position, a power of five times ten, or fifty, to lift it. A lower wisdom weighs about thirty-one grains, and requires a power of 31 multiplied by 2·58, or nearly ninety grains, to raise it,—and so for the rest.

Let the weight, long arm, and short arm be represented by the letters W, L, and S respectively, the power, P, is found by the formula—

$$P = \frac{W \times L}{S}$$

A lower incisor, for instance, weighs 10·8 grains, its long arm = 3·7 inches, and its short arm = 0·7 of an inch. Then—

$$P = \frac{10{\cdot}8 \times 3{\cdot}7}{{\cdot}7} = 57{\cdot}08 \text{ grains.}$$

Table showing the Weight, Long Arm, and Short Arm of each Tooth in the lower Jaw.

Name of tooth.	Weight in grains.	Length of long arm in inches.	Length of short arm.
Incisor . .	10·8	3·7	0·7
Canine . .	17·9	3·4	0·7
1st Bicuspid .	14·6	3·3	0·7
2nd Bicuspid .	14·6	3·0	0·7
1st Molar . .	32·4	2·8	0·7
2nd Molar . .	32.4	2·4	0·7
Wisdom . .	31·9	2·0	0·7

The product of the weight and the long arm is the moment of that arm. If, now, the moments are found for all the teeth, and the sum of them divided by the short arm, which is common to them all, the quotient is the power required to raise all the teeth together, as in the following table:

Table showing the Power required to Elevate all the Teeth in the Lower Jaw.

Name of tooth.	Weight of tooth multiplied into its long arm.		Moment of long arm.		Number of teeth in each group.		Sum of moments of long arm in each group.
Incisor .	10.8 × 3.7	=	39·96	×	4	=	159·84
Canine .	17·9 × 3·4	=	60·86	×	2	=	121·72
1st Bicuspid	14·6 × 3·3	=	48·18	×	2	=	96·36
2nd Bicuspid	14·6 × 3·0	=	43·80	×	2	=	87·60
1st Molar .	32·4 × 2·8	=	90·72	×	2	=	181·44
2nd Molar .	32·4 × 2·4	=	77·76	×	2	=	155·52
Wisdom .	31·9 × 2·0	=	63·80	×	2	=	127·60
			Sum of moments			=	930·08

* While the teeth actually travel in arcs, the radii of which are lines drawn from the condyles to their respective teeth, these radii are distinct from those belonging to the lever-lines of calculation. It is essential to notice this. The practical radius of an anterior incisor, for instance, is the hypothenuse, FA, of the triangle $F A B$ (Fig. 1); but the lever radius is the base line, $A B$, of the same triangle—that is, has the same magnitude.

and $930·08 \div ·7 = 1328·68$ grains.
Hence power to raise the jaw = 3017·00 grains.
" " " teeth = 1328·68 "

The lever power required to elevate the jaw, therefore, with its full complement of teeth, is 3017 + 1328·68, or 4345·68 grs.

In following out the argument, let it now be supposed, in the next place that for the lighter teeth in the lower jaw, there be substituted the heavier teeth properly belonging to the upper. With this additional weight thus imposed on the lower jaw, the question is, What further disadvantage is likely to accrue as to its lever power,—what additional force, in other words, will be required to raise it? This is easily ascertained by assuming the lower teeth to weigh as much as the upper—tooth for tooth,—and by calculating the additional power required to raise each of them respectively, and then the sum of them, as in the following table:—

Table showing the Lever Power required to Lift the Teeth in the Lower Jaw, supposing that their Weight were equal to those in the Upper.

Name of tooth.	Weight of tooth multiplied into its long arm.		Moment of long arm.		Number of teeth in each group.		Sum of moments of long arm in each group.
Incisor .	16·4 × 3·7	=	60·68	×	4	=	242·72
Canine .	21·4 × 3·4	=	72·76	×	2	=	145·52
1st Bicuspid	16·0 × 3·3	=	52·80	×	2	=	105.60
2nd Bicuspid	16·0 × 3·0	=	48·00	×	2	=	96·00
1st Molar .	33·4 × 2·8	=	93·52	×	2	=	187·04
2nd Molar .	33·4 × 2·4	=	80·16	×	2	=	160·32
Wisdom .	32·0 × 2·0	=	64·00	×	2	=	128·00
							1065·20

and $\frac{1065·20}{·7} = 1521·71$ grains.

Now, 1521·71 — 1328·68 = 193·03, making an extra demand upon the lever of nearly 200 grains, by calculating the lower teeth as if they were as heavy as the upper.

It was proposed, in the third and last place, to compare the leverage of the teeth set in their natural or orthodox position in the jaw with the force required to raise them, supposing that their natural order were reversed—the front teeth taking the place of the back, and *vice versâ*, regularly throughout the series. The additional power required in this assumed and unnatural position is shown in the following table:—

Table of the Leverage of the Lower Jaw, supposing that the Natural Order of Position of the Teeth were Reversed.

Name of Tooth	Weight of Tooth multiplied into its Long Arm		Moment of Long Arm				Sum of Moments of Long Arm in each group.
Wisdom (*vice* anterior Incisor) . .	32·0 × 3·7	=	118·40	×	2	=	236·80
Posterior or 2nd Molar (*vice* lateral Incisor)	33·4 × 3·7	=	123·58	×	2	=	247·16
Anterior Molar (*vice* canine) . .	33·4 × 3·4	=	113·56	×	2	=	227·12
2nd Biscuspid (*vice* 1st ditto) . . .	16·0 × 3·3	=	52·80	×	2	=	105·60

Name of Tooth.	Weight of Tooth multiplied into its Long Arm.		Moment of Long Arm.		Sum of Moments of Long Arm in each group.
1st Biscuspid (*vice* 2nd ditto) . . .	16·0 × 3·0	=	48·00 × 2	=	96·00
Canine(*vice* 2nd Molar)	21·4 × 2·8	=	59·92 × 2	=	119·84
Incisor, lateral(*vice*1st Molar) . . .	16·4 × 2·4	=	39·36 × 2	=	78·72
Incisor, anterior (*vice* Wisdom) . .	16·4 × 2·0	=	32·80 × 2	=	65·60
			Sum of moments	=	1166·84

Sum of moments of long arm = 1166·84

$$\text{Moment of short arm} = \frac{1166{\cdot}84}{{\cdot}7} = 1666{\cdot}91 \text{ grains.}$$

Now, 1521·71—1328·68=193·03; showing an extra demand of nearly 200 grains by calculating the lower teeth as if they were as heavy as the upper. Hence with each rearrangement of the teeth the tax imposed on the leverage is only increased as might be anticipated. The conclusion is inevitable that on the whole, and independently of the necessity for their occupying their respective normal places as masticating organs, the order of their arrangement with respect to lightening the weight to be raised by lever power could not be altered for the better, but only for the worse. To pursue the inquiry further in this direction would be unprofitable. Sufficient has been adduced to show the futility of attempting to remodel any portion of an edifice constructed by the Divine Artificer, for human ingenuity may tax itself to the utmost in order to devise another plan by which the teeth may be arranged in the lower jaw in order to lighten its leverage, and come to the conclusion that, after all, their present arrangement is the best and the wisest that could be devised.