

II. *A Description of that curious Natural Machine, the Wood-Peckers Tongue, &c. By Richard Waller Esq; late Secretary to the Royal Society.*

THE *Picus Martius* or Wood-Pecker has several Particularities in the Structure and Mechanism of its whole Body, which may deserve a nice and accurate Observation and Description: all which are wisely contrived and adapted, either for catching the Food and Sustainance of the Individual, or continuing the Species.

That this Bird makes a round Hole even in sound and hard Trees, such as the Oak, Horn-beame, Beech and the like, is commonly observed; and that within these Holes, the Hollow being enlarged, the Nest is made, the Eggs laid and Hatch'd; and the young Brood fed, as by other Birds.

For this purpose, that he may be enabled to perform such hard work, the Muscles of his Neck, Breast, and Thighs, are exceeding strong in proportion to the bigness of the Bird: he has also a very firm strong sharp Bill, his Legs are strengthened with very strong Tendons; and his Toes, which are two before and two behind, (as it is in some other Birds) are provided with sharp strong hooked Claws or Talons: Besides this, his Tail consists of ten very stiff large and strong Quills, firmly set into a robust strong *Uropygium* or Rump; so that when he has fastened his Claws and Feet into the Clefts and Inequalities of the Bark of the Tree, he claps his strong Tail-Feathers against the Body of the Tree; and so stands with his Head erect, to give the strokes with his Bill with the greater Force.

K k k k

That

That he is of the Insectivorous kind is certain, and lives not only upon Insects caught creeping on the outside of Trees, but also on such as are under the Bark between the Bark and Wood, as likewise on those in rotten Wood; and as I am very confident on Worms and other Insects in the Ground: for I have frequently observed the Roots of their Bills very dirty, as it is in *Crows* and *Rooks*, &c. Whence I suppose he strikes his long sharp Bill into the soft Earth to take the Worms out of it. I have also found their Craws full of small Ants.

But the Contrivance and Mechanism of the Tongue in this Bird being the most Remarkable, I shall presume to lay before this Illustrious Society some few Remarks of this curious Contrivance of Nature, with some Figures I have drawn by the Parts themselves, in order to explain the whole.

This Bird is known to throw out a long, slender, round Tongue, to a considerable distance beyond the End of his Bill; and to draw it in again very quick into his Mouth or Bill, with the caught Insect spitted on the Tip of it.

The *Chameleon* indeed darts out its Tongue to a considerable length; and having intangled the Fly in the glutinous Matter at the End of it, draws it into its Mouth, together with the Prey; but the Mechanism in that Animal is wholly different from that of the present Subject: as may be seen by the Account the Gentlemen of the *Academy Royal* give thereof, in their *Memoirs* for a History of *Animals*.

The Protrusion therefore of the Tongue to the length even of three or four Inches in this Bird, being very extraordinary, and the Mechanism of the several Parts for that end no less Curious; several learned and diligent Enquirers have attempted to explain it; but I am of
opinion

opinion they have been, in some Particulars at least, mistaken. I shall mention some of these.

The learned and curious Enquirer into Nature, *Monf. Perault*, describes it after this manner *.

This long Tongue he throws out by the means of two small bony Cartilages, about seven Inches long, and of the thickness each of a middling Pin, which are perfectly Smooth and Slippery. These two Cartilages are united at the End, and being in this place covered with Flesh make the fore-part of the Tongue. The rest of these Cartilages are separated from each other, and pass turning round under the Ears; and then rising up behind the Head, where they meet again, they pass over the Top of the Head, and so extend themselves to the Root of the Beak. These Cartilages which make the hinder part of the Tongue, are also inclosed in a Channel Fleshy on the out-side, and whose inside is covered with a very smooth slippery Membrane.

Now these Fleshy Channels, which encompass and keep in these Cartilages, are the Muscles by which the Tongue is moved: for having their origine at the *Larynx*, and their insertion at the extremities of the Cartilages, it comes to pass, that when those Muscles of the two Fleshy Channels, which make the hinder part of the Tongue are shortned, they force the fore-part of the Tongue out of the Beak, by drawing the posterior or farthest end nearer to the *Larynx*: and on the contrary, when the Fleshy Channel which makes the anterior Part acts, it draws the fore-part of the Tongue into the Bill towards the *Larynx*.

This Mechanism of making a hard part, such as the bony Cartilages are, to come out and return into another,

* *Essays de Physique*, Tom. 3. Part 2. p. 148.

such as the Canals are, by the means of Cords drawing them, which are the Muscles, is made use of in Coaches to pull up the Glasses of the Doors; for the String, being fasten'd to the lower part of the Glass-Frame, makes it rise when drawn, which resembles that action of the Muscles by which this Tongue is moved:

Of these Cartilages and other Parts, and of the Head of the Bird, Mr. *Perault* gives the Figures.

Either the Wood-peckers in *France* are different from ours in *England*; or this Figure of the Head is very ill designed; it being much too broad and large, and the Beak too short. Besides he makes the two Cartilages to come to the Root of the Beak separately, one on one side, the other on the other side of it; whereas in all the Wood-peckers Heads I have met with, the two Cartilages joyn close together about the Top of the Head, and thence proceed joyned, tho' not fastned to one another, a little slanting towards the right Nose-hole, where they end together.

Besides upon viewing and examining several Subjects, I could not find them agree in divers particulars with his Account and Explication. For the Muscles which are fastened to the end of the Cartilages at the Root of the upper Beak, are not inserted at the *Larynx*, but pass on and are fastened to the lower Bill. This pair I take to be the Muscles chiefly concerned in forcing the Tongue out of the Bill. There is another pair of Muscles, which, being fastened to the place where the two bony Cartilages are articulated with one single Bone in the fore-part of the Tongue; (as will be shewn in the 4th Figure) is, as I apprehend, the chief pair concerned in the drawing the Tongue with its Prey into the Mouth. These proceeding from that articulation of the Cartilages as far as the *Larynx*, (each of them sending a Branch to the *Cartilago Scutiformis*) from thence go on along with the

the Neck, (tho' not fastned to it) till they come within the Cavity of the *Thorax*, where they are inserted under the *Clavicula* or *Merry-thought-bone*, as 'tis called. This pair is represented by *k. k.* in the second Figure; and by *q. q.* in the First.

There is likewise a very slender white Thread, (whether Tendon or Nerve, I am uncertain) which accompanies this Muscle its whole length; and which drawn gently, (for fear of breaking) pulls in with it the end of the Tongue. As there is such another all along the *Vagina* to the End at *c.*

Volker Coiterus, as he is mentioned by *Gerard Blasius*, in his *Anatome Animalium*, *Cap. 24. p. 64.* treating of the Tongue of this Bird, makes it to be made of three slender Bones, round, and as he says bound together; (*invicem colligatis*) which is a Mistake; for tho' reckoning the two bony Cartilages for *Ossicula*, yet the third is not bound up with them, but articulated to the End of them. The same Person says the Tongue may be thrust out to the length of an Inch and a half, whereas when drawn in, it is scarce half an Inch long; when in reality it may be thrown out near four Inches; and I believe cannot be drawn in, so as to be less than an Inch and quarter, *viz.* to that place where the two Cartilages are articulated with the single Bone. Besides he makes the use of the long flat Muscle running over the Top of the Head, to be (if I rightly apprehend his meaning) to draw the Tongue to the upper Jaw, whereas their use is for thrusting the Tongue out of the Birds Mouth.

But this Person having given no Figures, has rendred what he says less intelligible; tho' indeed he mentions two pair of Muscles, as there are so many chiefly concerned, yet there are at least two other pair, that assist the Performance.

Where

Wherefore I shall leave him, and proceed to the Account given by *Alphonfus Borellus* in his Treatise *de Motu Animalium*, part. 2. pag. 24. which is in several Respects likewise unsatisfactory, and the Figure given by him to explain it very defective and ill designed.

He makes the pair of Muscles concerned in thrusting the Tongue out, to be fastened indeed as they are to the lower Beak towards the Point; but then he makes their Insertion at their other End to be at the extremities of the two *Ossa Hyoidea*; whereas they really reach to the very end of the long Cartilages that go round the Head: These by another Mistake, he makes to be the Retractors of the Tongue, and joins another pair as Assistants in the same Action, which he makes to be twisted spirally about the *Trachia*. None of all which agree with the Subjects I have met with, as will be seen by the descriptions of my Figures.

In the History of the *Academie Royale des Sciences*, publish'd in Latin by *Monf. du Hamel*, 1698. *Lib. 4. Cap. 5.* There is another Description of this admirable Contrivance of Nature, by *Monf. Mery*, read at a Meeting of the *Academie*, November 16, 1695.

In this he differs from both *Perault* and *Borelli*, taking the Horny End and Bone to which it is joined, to be only the Tongue properly so called, and that the next two Bones answer the *Hyoïdes* with the long Cartilages annexed to them. But even in this he seems to me not to be so clear; confounding, as I apprehend, the two Bones with the Cartilages. He describes the *Vagina*, in which the Bones and part of the Cartilages are encompassed, and which is fastned to the Horny end, and is protruded and drawn back with the Tongue: he takes notice of the little sharp Points or Prickles on the Horny Part being moveable, and with their Points bending towards the Throat; but I apprehend it is a Mistake to make the

Philosophical Transactions. N. 350. Tab. I.

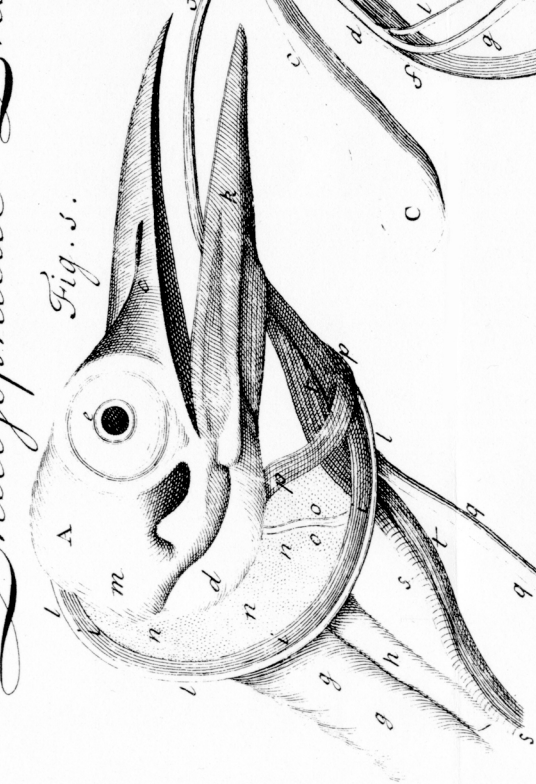


Fig. 2.

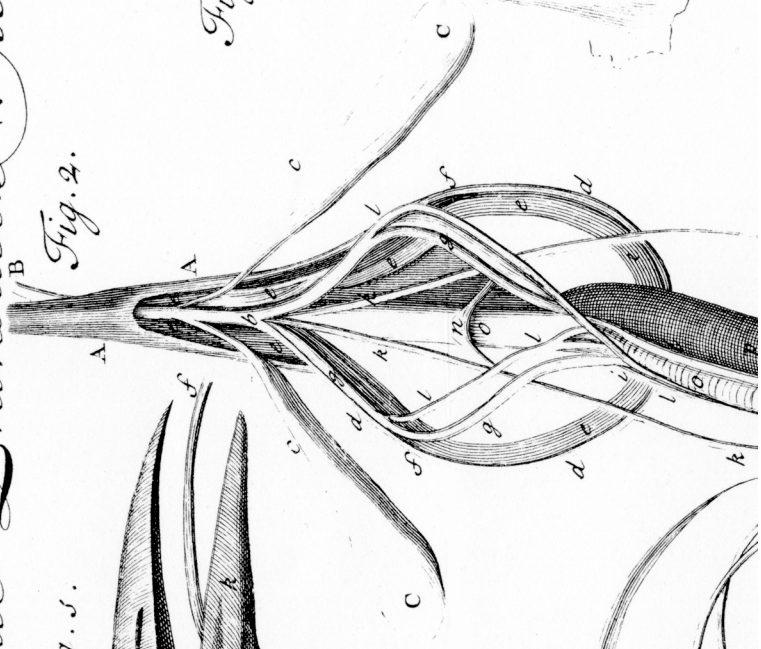
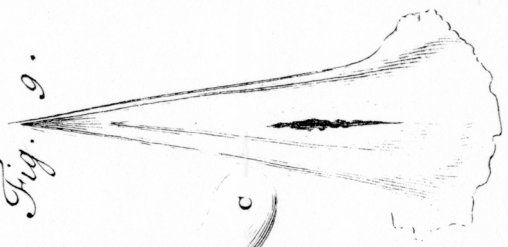


Fig. 9.



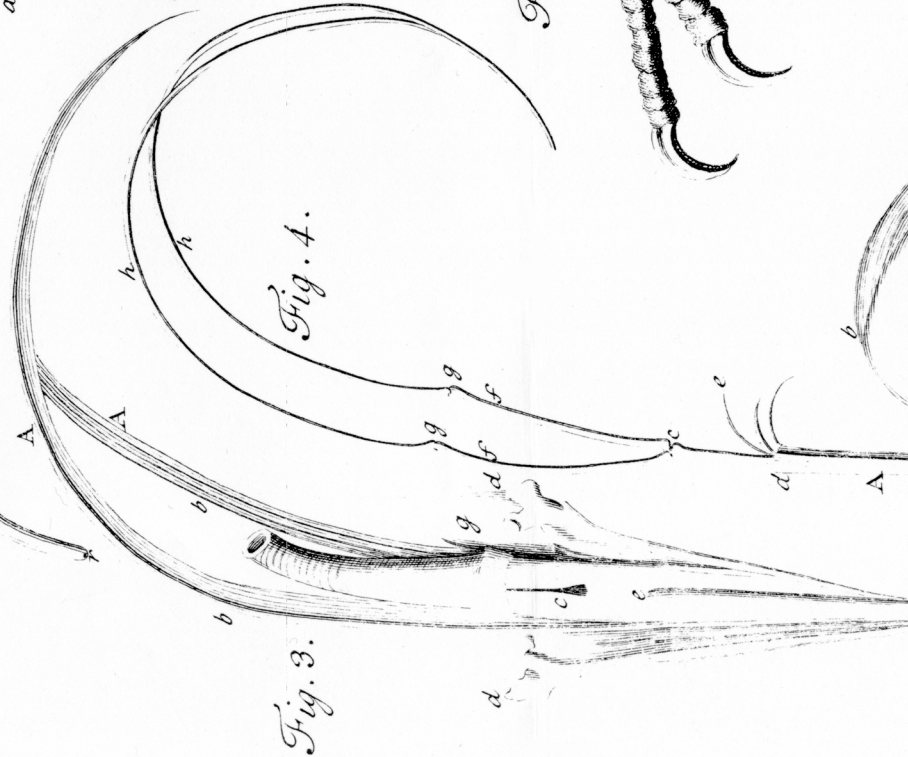
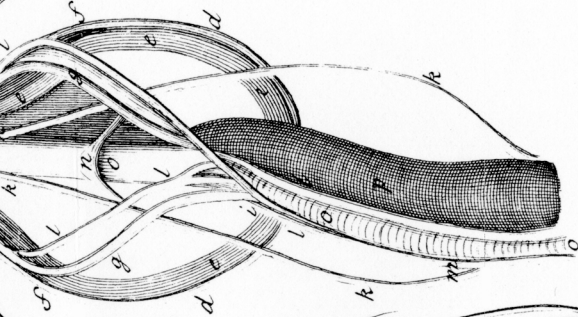
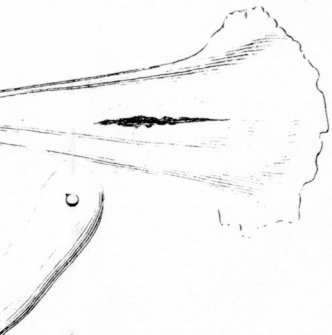


Fig. 4.

Fig. 3.

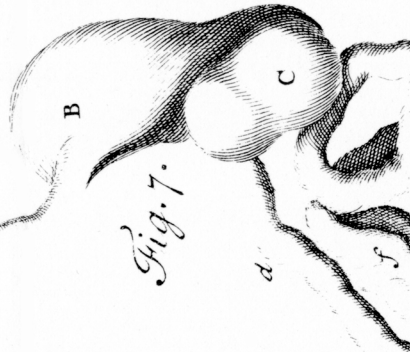


Fig. 7.



Fig. 6.

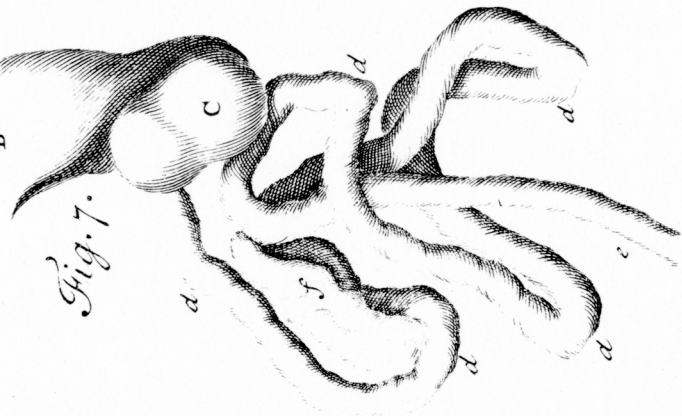


Fig. 7.

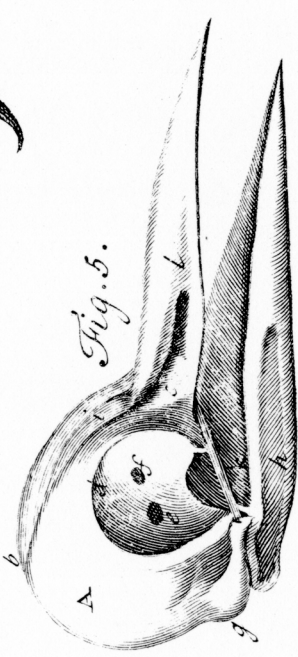
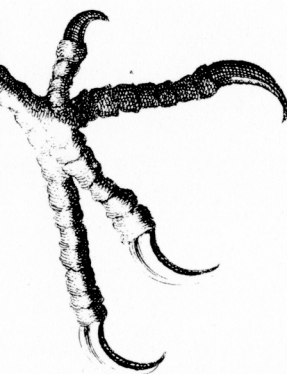


Fig. 5.

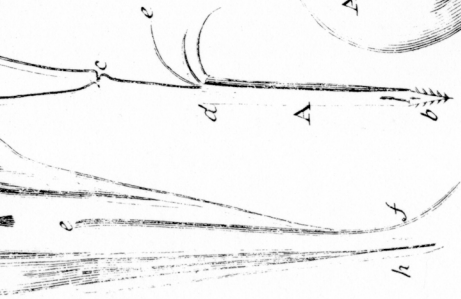
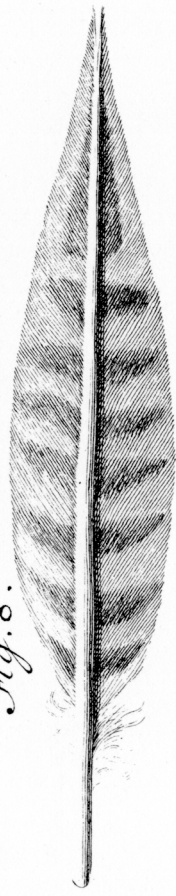


Fig. 8.



Mucous matter Glutinous which is furnished by the two *Pyramidal Glands*; for I take the use of that *Mucus* to be chiefly, if not only, to lubricate the Passage in the *Vagina*, for the more easy slipping of the Cartilages therein.

He describes the Muscles for exerting the Tongue, and extends them from their Insertion at the lower Beak, to the End of the springy *Ligaments*, as he terms what I call *Cartilages*; to which he adds another small Ligament capable of Extension, at the End of the other two next the Nose, which when the Tongue is thrust out is relaxt and stretch'd. He also describes the pair of Muscles fastned to the Root of the Tongue and *Os Hyoides*, serving to draw the Tongue into the Mouth: these he makes to be wound round about the *Aspera Arteria* once or twice, in which I think there is some Mistake; being of opinion the Mechanism for this Action of drawing in of the Tongue, is different from what is here described, as in the Explication of the Figures I shall endeavour to shew. But not to insist on all the Particularities mentioned in this Description, which, for want of more Figures to explain the several Parts in so curiously contrived an Organ, is not so clear as might be desired (there being but One, and that a wooden Cut of the Head, Tongue, Bones, Muscles, &c.) I shall now proceed to the Explication of the several Draughts I made, with what exactness and care I could, in 8 or 10 several Subjects.

FIGURE the First.

Represents the Head with part of the Neck of this Bird, the Skin being taken off, in which,

A. The Skull, having two shallow Grouves or Channels, or rather one broad one with a small Rising in the midst, on the *Sinciput* or Back-part, from each side of the Neck to the Top of the Head, where they unite into

one

one, which passes slanting towards the right Side, and ends at the Hole for the Nostril on that side at *c*.

b. Is the Hole or passage for Hearing.

d. A large white Gland, containing a glutinous Liquor, almost like Cream as to Colour and Consistence, which empties it self into the Mouth; I suppose to lubricate the Cartilages.

e. The Eye, which has a Bony Ring, encompassing the *Iris*.

f. Part of the Tongue, which in this Figure is represented as almost all drawn into the Mouth, of which more when I come to describe the Cartilages; &c. In the 2d Fig.

g. Part of the Neck, which is large and furnished with very strong Muscles.

h. The *Oesophagus*, opening very wide at the *Fauces*, and wholly Musculous.

i. i. i. A long, but thin and flat Muscle in respect of its breadth, which is about $\frac{1}{8}$ of an Inch, reaching from the end of the Cartilage at *c*, to the under Bill or Beak at *k*, to the inside of which it is very firmly fastened; as is such another on the other side.

k. The under Bill very strong and sharp pointed, articulated with the Scull a little behind the Ear-hole *b*.

l. l. l. The Cartilage on one side, the other being exactly the same. This Cartilage is Round, very Smooth, Even and Slippery, about the size of a pretty large Pin; and reaches, when the Tongue is drawn in and the Muscle *i. i. i.* relaxed, from the Root of the upper Beak at *c*, to the Root of the Tongue properly so called, or to the Bones of the Tongue where they are articulated, being bent like a Hoop as in the Figure, slipping very freely in a Sheath or Membranous *ductus* fastned on the outward or convex Edge of the flat Muscle *i. i. i.* which Muscle accompanies it from its end at *c*, almost to the end

end of the Canal or Sheath, which opens at a Hole a little before the *Larynx*; (as will be shewn in the third Figure) and thence the Muscle proceeds to its Insertion into the lower Beak at *k*. From the concave Edge of this Muscle, there is a thin and transparent but very strong Membrane, strained like a Drum-head to the Scull at *m*, where it is very strongly fastned; this Membrane is furnished with Capillary Veins and Arteries, and doubtless is Nervous. *n. n.* represents this Membrane. This Cartilage, when the Tongue is exerted, parts about half an Inch from the Root of the Beak at *c*.

o. o. A pretty large Vein and Artery.

p. p. A Muscle reaching from one Jaw to the other, under the Throat, serving as a Bandage to keep in the Cartilages, and the Root and *os Hyoides* of the Tongue, as I may call it, from starting out at that Part where are the articulations of the Cartilages with the Bones, when by the Muscles, inserted into the Sheath at or near *p* and thence passing to the end of the Tongue, it is drawn into the Mouth.

q. q. One of the last mentioned Muscles, which is round, of the size in the Figure, and fastned to the Breast of the Bird, cut off at *r*.

s. The *Aspera Arteria* consisting of perfect Rings.

t. t. A Muscle accompanying the *Aspera Arteria*.

FIGURE the Second.

A. A. The under part of the lower Bill.

B. b. The Tongue.

b. The Place where the two Cartilages and two Bones represented by *f. f.* in Fig. 4. are brought into and inclosed in one Tube or Membranous Sheath.

C. C. Two Glands displaced in this Figure.

e. e. Two Muscles attending these Glands, and fastned near the end of the Bill.

d. d. The two Bony Cartilages, bent, and passing on each side of the Neck, but united at *b*.

e e e, e e e. The pair of Muscles, one attending each Cartilage from the End of it at the upper Beak, and firmly adhering to the *Vagina*, in which it slips, till about *f f*.

f. f. The place where these Muscles leave the *Vagina*, and pass on to the inside of the Bill, where they are inserted. Their Action is to thrust the Tongue forward, or out of the Mouth.

g. g. A pair of Muscles fastned a little below the *Larynx*, to the Musculous part of the *Aspera Arteria*, at *i*; the other end of them going up to the place *b* at the Root of the Tongue, whence they go on incompassed by the *Vagina* to the articulation of the Cartilages with the two Bones. I take their Action to be to draw the end of the Tongue towards the *Larynx*.

k. k. Two Muscles fastned at one end within the *Thorax*, under the Merry-thought or *Clavicula*; and at the other Ends to the articulation of the Cartilages with the two Bones of the Tongue, marked *f. f.* in Fig. 4. These have the forementioned Nerves accompanying them. I take these to be chiefly concerned in drawing in the Tongue; each of these sends a Branch to the Gristle at the Top of the *Aspera Arteria* at *n*.

l. l. l. Two Muscles running along and fastned to the Sides of the *Aspera Arteria*, from the *Thorax* to the place where they are united, where each of them sends a Branch; which binding over the Bones and Cartilages goes on to the *Fauces*, where they are inserted.

m. Part of the *Gula*.

n. A Cartilage at the Top of the *Aspera Arteria*.

o. o. The *Aspera Arteria*.

p. The Neck bending like an *S*. The Wind-Pipe
and

and *Gula* in this Bird pass always on the right side of the Neck.

FIGURE the Third.

A. A. The two long flat Muscles represented by *i. i.* in the first Figure. These join close to one another at the Top of the Head, and so pass on together to the end of the Cartilages; to the end of which, as I take it, they are fastned: from whence a slender weak kind of Ligament reaches to, and is inserted at, the right Nose-hole, at the Root of the upper Beak. This Ligament is relax when the Tongue is thrust out.

b. b. The Cartilages running in their *Vagina* on the out side of the said Muscles.

c. The *Larynx* or passage to the *Aspera Arteria*. I observed no *Epiglottis*.

d. d. Two Articulations or Joints in the under Beak or Bill.

e. The Hole or Passage, whereby the Tongue in its *Vagina* comes out and is drawn in again.

f. What I call the Tongue, in the inside of which the two Cartilages are brought together, till they are both articulated to one single Bone, at the end of which is the Horny barbed Tip.

g. One of the Pyramidal Glands.

h. The lower Bill.

FIGURE the Fourth.

A. That part which I think may most properly be called the Tongue; a small Bone running thro' it: This, as far as *c*, is Flat and Thin at the Sides. It is cut away at *d*, to shew the Bones within it.

b. The Horny Tip of the Tongue, about a quarter of an Inch long, strong and sharp, furnished with four or five Barbs on each side; (not with an infinite Number as

Coiterus says) These Barbs are sharp and moveable, like the small Teeth at the Root of the Tongue, and beginning of the *Gula*, in the *Pike* and *Jack-Fishes*, in that of Eagles and the like; so as to let the Prey slip easily on, but not so easily get off again.

c. The End of the Bone of the Tongue where the two bony Cartilages are articulated.

d. The place where the upper part of the Tongue is cut away to shew the Bone.

e. Several small Tendons, or rather, as I take them to be, Nerves running thro' the Tongue. Of these some go to the End of the Cartilages, others accompany the Muscles to the Neck.

f. f. Two Bones or Cartilages, which in the Bird, are united by a thin Membrane as far as the next joynt, so as to open asunder to some distance, but not to separate quite. These two Bones seem to answer to the *ossa Hyoidea* in other Creatures. At the Place marked *g. g.* the Muscle that draws the Tongue into the Mouth is fastened, or rather leaves the Tongue at that place; it having its Insertion near to the End of it: This Muscle is represented by *q. q.* in the first Figure.

b. b. The two bony and springy Cartilages running on each side of the Neck; which being joynd close together on the Top of the Head, pass so joynd to the Nostril, or Nose-Hole on the right Side.

From the Consideration and comparing of these four Figures, the true Mechanism and Motion of the Tongue, seems to be in short thus: The two long Muscles inserted near the End of this lower Beak, and reaching to the End of the Cartilages, being contracted, the round Hoop of the Cartilages is drawn up, from each side of the Neck, close to the Pyramidal Glands; and at the same time the Muscles that draw the Tongue into the the Mouth being relaxed, and the Articulations at *c*
and

and *g. g.* in the 4th Figure, brought near to a straight Line, the Tongue is thrown out to the length of 4 or 5 Inches.

But when those long Muscles are relaxed, the pair of Muscles represented by *k. k.* in the second Figure, being contracted, draw the Articulations *g. g.* where they are fastned, down into the Throat or wide loose Skin of the Neck; and at the same time the Cartilages opening into a wide Hoop, the whole Tongue is drawn into the Mouth.

FIGURE the Fifth.

- A.* The Scull.
- b.* The shallow *Crena* or Groove, for the Cartilages.
- c.* The Place of their Ending at the right Nose-Hole.
- d.* The Orbite of the Eye.
- e.* The Hole for the Optic Nerve.
- f.* A Hole or passage thro' from one Orbite to the other.
- g.* A Bone covering the Hole to the Ear.
- h.* The lower Jaw and Bill.
- i.* A Ridge or *Processus* in the Scull, beginning at the Root of the upper Bill, and keeping the two Ends of the bony Cartilages in their place on the right Side.
- k.* The *Os Jugale*.
- l.* The upper Bill.

FIGURE the Sixth

Represents the right Leg and Foot, in which there are two *Digiti* before, and two behind. The strength, Largeness, and Sharpness of the hooked Claws or Talons are remarkable.

FIGURE

FIGURE the Seventh.

- A. The *Oesophagus*.
B. The *Ingluvies* or Crop, partly Musculous, and lined with a Glandulous Coat. This I found quite filled with small black Pismires; as also
C. The *Ventriculus* or Gizzard, which joyned close to the *Ingluvies*.
d. d. d. The Intestines nearly of the same bigness for the whole Length.
e. The beginning of the *Rectum*.
f. The *Pancreas*.

FIGURE the Eighth.

One of the middle pair of Feathers of the Tail, in which the great Strength of the Quill for so small a Feather, and its bifurcate End, are very remarkable.

FIGURE the Ninth.

The Roof of the Mouth, where 'tis observable, that the *Rima* or Passage for the Air to the Nostrils, is beset on each side with a Row of 10 or 12 little sharp Teeth, with their Points standing inwards, towards the *Gula*. These take the Prey from the end of the Tongue whose Barbs or Prickles are moveable, and are to keep it from going out of the Beak again with the Tongue, and from hence it is conveyed to the Swallow.

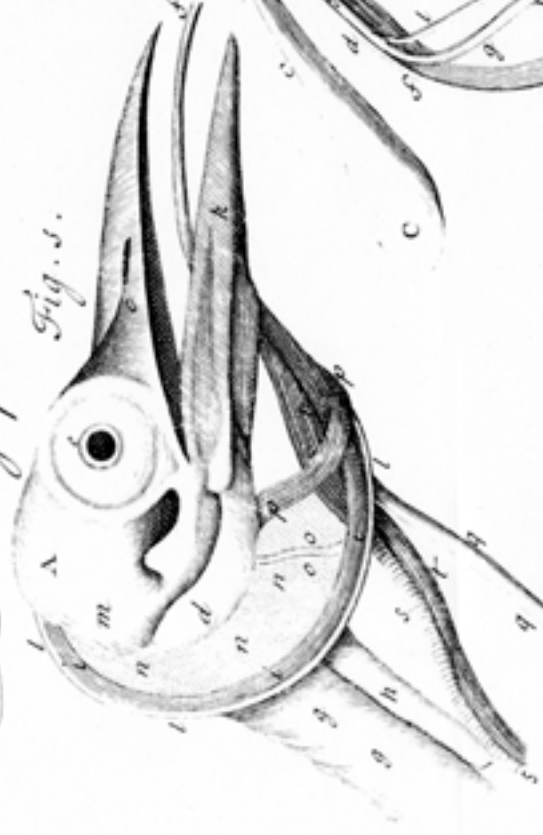


Fig. 1.

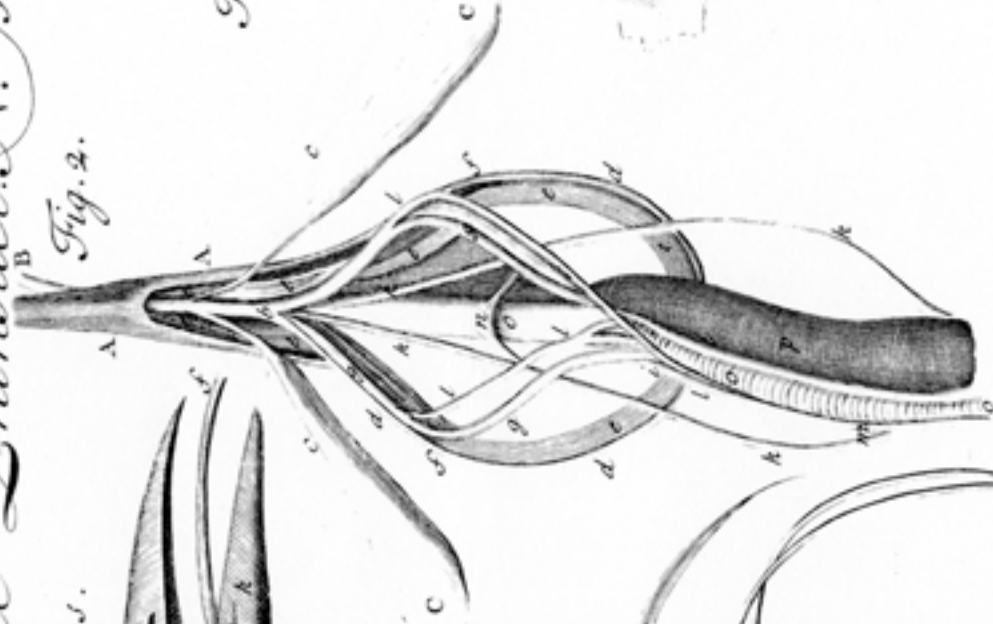


Fig. 2.



Fig. 3.

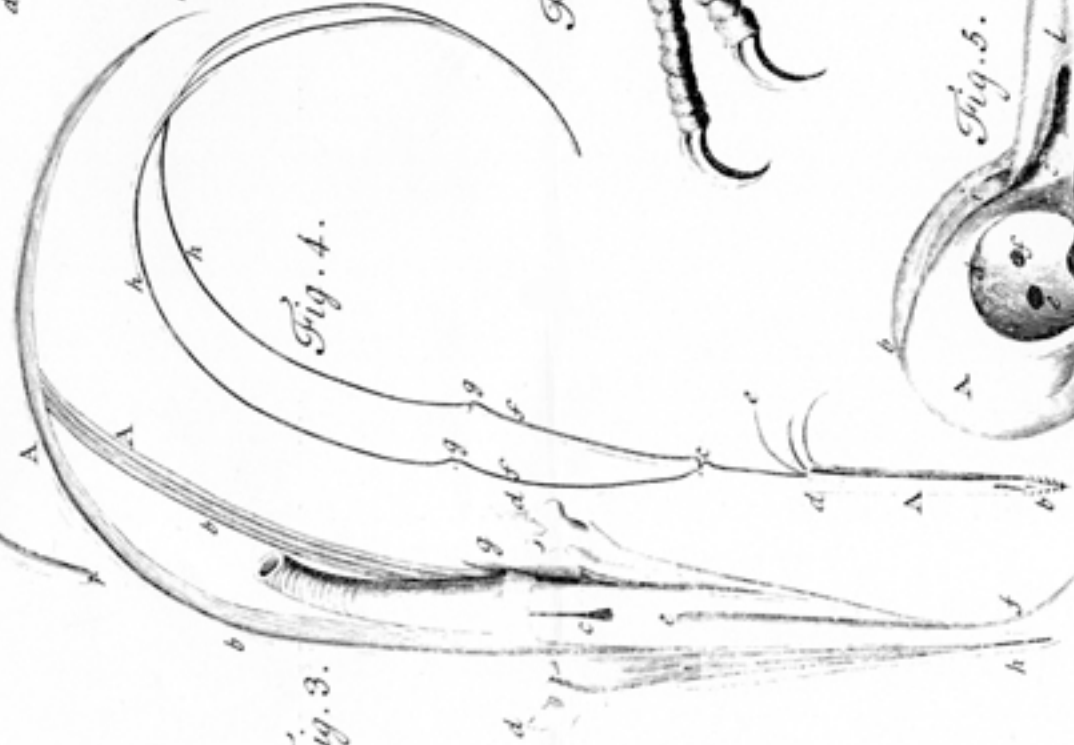


Fig. 4.

Fig. 3.



Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 19.

Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

Fig. 24.

Fig. 25.

Fig. 26.

Fig. 27.

Fig. 28.

Fig. 29.

Fig. 30.

Fig. 31.

Fig. 32.

Fig. 33.

Fig. 34.

Fig. 35.

Fig. 36.

Fig. 37.

Fig. 38.

Fig. 39.

Fig. 40.

Fig. 41.

Fig. 42.

Fig. 43.

Fig. 44.

Fig. 45.

Fig. 46.

Fig. 47.

Fig. 48.

Fig. 49.

Fig. 50.

Fig. 51.

Fig. 52.

Fig. 53.

Fig. 54.

Fig. 55.

Fig. 56.

Fig. 57.

Fig. 58.

Fig. 59.

Fig. 60.

Fig. 61.

Fig. 62.

Fig. 63.

Fig. 64.

Fig. 65.

Fig. 66.

Fig. 67.

Fig. 68.

Fig. 69.

Fig. 70.

Fig. 71.

Fig. 72.

Fig. 73.

Fig. 74.

Fig. 75.

Fig. 76.

Fig. 77.

Fig. 78.

Fig. 79.

Fig. 80.

Fig. 81.

Fig. 82.

Fig. 83.

Fig. 84.

Fig. 85.

Fig. 86.

Fig. 87.

Fig. 88.

Fig. 89.

Fig. 90.

Fig. 91.

Fig. 92.

Fig. 93.

Fig. 94.

Fig. 95.

Fig. 96.

Fig. 97.

Fig. 98.

Fig. 99.

Fig. 100.

Fig. 101.

Fig. 102.

Fig. 103.

Fig. 104.

Fig. 105.

Fig. 106.

Fig. 107.

Fig. 108.

Fig. 109.

Fig. 110.

Fig. 111.

Fig. 112.

Fig. 113.

Fig. 114.

Fig. 115.

Fig. 116.

Fig. 117.

Fig. 118.

Fig. 119.

Fig. 120.

Fig. 121.

Fig. 122.

Fig. 123.

Fig. 124.

Fig. 125.

Fig. 126.

Fig. 127.

Fig. 128.

Fig. 129.

Fig. 130.

Fig. 131.

Fig. 132.

Fig. 133.

Fig. 134.

Fig. 135.

Fig. 136.

Fig. 137.

Fig. 138.

Fig. 139.

Fig. 140.

Fig. 141.

Fig. 142.

Fig. 143.

Fig. 144.

Fig. 145.

Fig. 146.

Fig. 147.

Fig. 148.

Fig. 149.

Fig. 150.

Fig. 151.

Fig. 152.

Fig. 153.

Fig. 154.

Fig. 155.

Fig. 156.

Fig. 157.

Fig. 158.

Fig. 159.

Fig. 160.

Fig. 161.

Fig. 162.

Fig. 163.

Fig. 164.

Fig. 165.

Fig. 166.

Fig. 167.

Fig. 168.

Fig. 169.

Fig. 170.

Fig. 171.

Fig. 172.

Fig. 173.

Fig. 174.

Fig. 175.

Fig. 176.

Fig. 177.

Fig. 178.

Fig. 179.

Fig. 180.

Fig. 181.

Fig. 182.

Fig. 183.

Fig. 184.

Fig. 185.

Fig. 186.

Fig. 187.

Fig. 188.

Fig. 189.

Fig. 190.

Fig. 191.

Fig. 192.

Fig. 193.

Fig. 194.

Fig. 195.

Fig. 196.

Fig. 197.

Fig. 198.

Fig. 199.

Fig. 200.

Fig. 201.

Fig. 202.

Fig. 203.

Fig. 204.

Fig. 205.

Fig. 206.

Fig. 207.

Fig. 208.

Fig. 209.

Fig. 210.

Fig. 211.

Fig. 212.

Fig. 213.

Fig. 214.

Fig. 215.

Fig. 216.

Fig. 217.

Fig. 218.

Fig. 219.

Fig. 220.

Fig. 221.

Fig. 222.

Fig. 223.

Fig. 224.

Fig. 225.

Fig. 226.

Fig. 227.

Fig. 228.

Fig. 229.

Fig. 230.

Fig. 231.

Fig. 232.

Fig. 233.

Fig. 234.

Fig. 235.

Fig. 236.

Fig. 237.

Fig. 238.

Fig. 239.

Fig. 240.

Fig. 241.

Fig. 242.

Fig. 243.

Fig. 244.

Fig. 245.

Fig. 246.

Fig. 247.

Fig. 248.

Fig. 249.

Fig. 250.

Fig. 251.

Fig. 252.

Fig. 253.

Fig. 254.

Fig. 255.

Fig. 256.

Fig. 257.

Fig. 258.

Fig. 259.

Fig. 260.

Fig. 261.

Fig. 262.

Fig. 263.

Fig. 264.

Fig. 265.

Fig. 266.

Fig. 267.

Fig. 268.

Fig. 269.

Fig. 270.

Fig. 271.

Fig. 272.

Fig. 273.

Fig. 274.

Fig. 275.

Fig. 276.

Fig. 277.

Fig. 278.

Fig. 279.

Fig. 280.

Fig. 281.

Fig. 282.

Fig. 283.

Fig. 284.

Fig. 285.

Fig. 286.

Fig. 287.

Fig. 288.

Fig. 289.

Fig. 290.