

## HOW TO OBTAIN THE BRAIN OF THE CAT.

*Felis domestica.*

BY PROFESSOR B. G. WILDER, M.D.

In the first number of "SCIENCE," under the title "A Bit of Summer Work," the writer suggested that teachers and students of the several sciences in which an acquaintance with the brain is required should try to gain some definite and personal knowledge of the organ by the preparation and dissection of the brain of the domestic cat.

The publication of the article was followed by numerous expressions of a desire to adopt the suggestion, but accompanied often by requests for reference to some work containing explicit directions as to the best methods of manipulation.

No such work is known to the writer. The "Dissector's Guides" and some general treatises on Human Anatomy give more or less complete instructions for the removal of the human brain: but the conditions are usually such that the most expert manipulator can hardly avoid some injury to the organ.<sup>1</sup>

For the removal of the brains of the lower mammals, no adequate directions have been published, so far as the writer is aware, although Chauveau enters (A, 716)<sup>2</sup> into some detail with regard to the horse's brain. Straus-Durckheim expressly states (B, I, 321) that the method for animals is the same as that for the human subject, and the "Practical Physiology" (Foster & Langley, A, 215) contains merely the caution that "the brain of the dog or sheep should be removed from the skull as carefully as possible, especial pains being taken to cut the internal carotid arteries and the cranial nerves close to the skull."

As guides to practical work for beginners in anatomy, the works just mentioned may, in respect to the brain, be likened to some "Manuals for Young Housekeepers," whose accomplished authors seem to realize neither the inexperience of their readers nor the possibility of conditions very different from their own, and whose teachings, therefore, prove ill-suited to the comprehension and the circumstances of those whom they desire to assist.

Now it is probable that few readers of "SCIENCE" have had the benefit of a full medical education, and it is certain that the anthropotomical method for the extraction of the brain does not answer for the removal of the brains of most other mammals. The skulls are usually so irregular in outline that the use of the saw is difficult and apt to do injury to the brain; moreover, at least for the purposes of preliminary study, the integrity of the brain should be ensured even when it involves the complete destruction of the skull.

The writer is therefore led to hope that the number of those who desire to obtain and dissect the brain of the cat is large enough to warrant the publication in "SCIENCE" of the directions which are followed by the students in the Anatomical Laboratory of Cornell University. Any criticisms or suggestions will be thankfully received. The method here described in detail is to be preferred when the brain is wanted entire, and especially when the length of the nerve roots is an object. The more expeditious methods which may be adopted under other conditions will be described hereafter.

**INSTRUMENTS AND MATERIALS.**—Medium scalpel;<sup>3</sup> sharp scalpel; arthrotome; tracer; curved scissors;

bone-scissors; forceps; nippers; a cat's skull; large tray for the cat; small tray, or a folded cloth, for the head; block; small towel, or piece of muslin, for aiding the grasp of the head; paper for scraps; basin and towel; dish of 7 p.c. brine, about 6 cm. deep, and 20 wide, containing some well-soaked cotton; bowl of normal saline solution (15 grains of salt to 2000 cc. of water) sufficient to cover the head after its separation from the body; bowl for catching the blood; wide-mouthed jar or covered dish, of 60-70 p.c. alcohol, with some well-soaked cotton at the bottom.

Some of these items need explanation. The *arthrotome*—sometimes called "disarticulator"—is a short and strong double-edged scalpel, with a steel handle like that of the common "cartilage knife." The same use can be made of any short strong scalpel ground down so as to have two edges of only moderate sharpness. Such an instrument saves the keener and thinner edges of the ordinary scalpels. The *tracer* looks something like the ordinary dental excavator, but its end tapers to a blunt point, which is so curved as to form about the quarter of a circle, and moderately sharpened on the concavity. This is used for tracing and isolating nerves and vessels, and is not only safer than the scalpel, but less liable to injury. Its cost is only 25 cents. The *bone-scissors* are simply a strong pair of curved scissors, employed for comparatively rough work. The *nippers* here referred to are the "diagonal side-cutting pliers" of the dealers in hardware. Instead of being parallel with the handles, as with most "bone-nippers," or at a right-angle therewith, as with the ordinary "cutting-pliers," the blades of these form with the handles a very open angle, conferring upon the user an advantage similar to that which is gained by the employment of curved scissors. The nippers are to be had of seven sizes, from 10 to 20 cm., (4 to 8 inches) in length, and cost from 70 cents to \$2.25, according to the size and the maker, those of Stubbs being the more expensive and highly finished. For use upon cats, those which are 5 inches long are to be preferred, and their points, if too wide, may be ground off.

The writer has been accustomed to use the nippers since 1872 for the removal of the brains of cats, dogs and young human subjects. It was not until after the year mentioned that he noted, in Flower's paper (3, 194), a remark as to "clipping away the skull from the brain of a monkey," the instrument, however, not being specified.

The nippers are equally applicable to living animals; with the rabbit, cat, and all but the larger dogs, the skull may be penetrated with them, and the opening easily enlarged to any extent desired. Perhaps the surgical "bone-forceps" have been employed for this purpose, but the "Hand-book for the Physiological Laboratory" (Sanderson, A, 305 and 418), directs that even so thin a skull as the rabbit's should be removed with the trephine and the scissors, and Dalton's recent paper (2) mentions only the trephine for exposing the brain of dogs.

Alcohol of the proper strength is readily prepared by adding 1 part of water to 2 parts of 95 p.c. alcohol. According to the size of the bowl or jar, the amounts may be 100 and 200, or 150 and 300 cc.

For the hardening and temporary preservation of the brain, the common deep finger-bowl is convenient. It may be covered with a piece of window-glass. Flat-bottomed dishes, with wide edges ground for the reception of covers, are made by Messrs. Whitall, Tatum & Co., of New York and Philadelphia, and the same firm have on hand wide-mouthed vials and specimen-jars of many sizes.

**KILLING AND BLEEDING THE CAT.**—When the brain is to be studied the animal should not be "pithed," on account of the injury to the medulla, and the settling of blood at the base of the organ. The cat may be drowned, but the following method is to be preferred as less distressing, more convenient, and permitting the evacuation of most of the blood. The *bleeding* may how-

<sup>1</sup> The writer has employed a modification of the ordinary method, and will take an early opportunity of submitting it to other anatomists.

<sup>2</sup> The system of references adopted in the present paper is the same as that described by the writer in No. 38 of this journal, p. 122, excepting that the numbers of papers published since 1873 are in smaller type than those of the papers which appeared prior to that date, and which are included in the "Royal Society Catalogue."

<sup>3</sup> Cases of dissecting instruments containing the arthrotome, tracer, scalpels of three sizes, curved scissors, forceps, fine-pointed forceps and curved scissors, and blow-pipe, are sold by Messrs. Codman & Shurtleff, of Boston, for \$9.00. The nippers and bone-scissors must be obtained separately, as will be explained presently.

ever, be dispensed with. Put the cat in a close box, little larger than itself, and pour in 5 cc. of chloroform, or 20 cc. of ether. It usually becomes quiet in from 5 to 15 minutes. When touching the conjunctiva causes no winking, remove the cat to the large tray. Bring the head and neck nearly into line with the trunk. Part the hair upon the neck along a line between the angle of the mouth and the convexity of the shoulder. Along this line, divide the skin for 6—8 cm., opposite the larynx. This will either expose the *Vena jugularis* at once, or permit it to be seen when the borders of the skin are raised.

With the tracer, separate the vein from the adjoining parts for about 1 cm., and pass a bit of string endad\* of it. Then turn the cat on the side, with the exposed vein over a bowl; the string makes it easier to pass the scalpel or blade of the scissors endad of the vein, which may then be cut. Let the blood flow into the bowl, occasionally lifting the body so that the blood may come more readily from the abdomen.

When the flow ceases, replace the cat in the box, with an additional 5 cc. of chloroform, or leave it upon the tray, and apply the chloroform upon a towel held very closely at the nostrils so as to prevent access of air. Death usually ensues in a few moments. If it be desired to ascertain the weight of the entire animal, the blood should be weighed.

If the more delicate internal parts or the microscopic structure are to be studied, the remaining operations for the procurement of the brain should be performed within 24 hours. But if the specimen is desired only for the fissures or the coarser anatomy, removal may be deferred for a week, provided the head be kept in a cool place. It should not, however, be allowed to freeze.

*Separation of the skull.*—Connect the angle of the mouth with the incision already made. If the skin is to be mounted, this should be the only incision, and the skin must be dissected from the mandible as well as from the rest of the head. But if, as is more often the case, the skin is not to be preserved, while the muscles etc., of the neck are to be examined, make a corresponding incision from the angle of the mouth upon the opposite side.

In all subsequent operations, unless otherwise stated, both sides are to be treated alike.

Dissect the skin from the maxilla as far as the ventral margin of the orbit and cut the nasal cartilages. Dissect the skin from the nasal and frontal regions, including the upper and lower lids, but leaving the third lid, *Membrana nictitans*, attached to the ball. Remove the skin from the rest of the head, dividing the *meatus auditorius* close to the head. The *parotid gland* will be removed with the ear, but the *submaxillary*, of a darker color, will remain with the head. Reflect the skin from the cervical muscles for about 2 cm. caudad of the *crista lambdoidalis*.

Dissect the origin of the *M. massetericus* from the *zygoma*, noting that its cephalic and caudal borders are strengthened by tendinous bands which must be cut. Push a nipper-blade between the eyeball and the cephalic root of the *zygoma*, and nip the latter as close as possible to the maxilla. Then nip the caudal root at the angle between the transverse and longitudinal parts of the *zygoma*, just laterad of the *Fossa glenoidalis*; remove the *zygoma* with the bone-scissors.

Grasp the lateral aspect of the eyeball with the forceps, and rotate it mesad so as to expose its attachments, by the muscles and *N. opticus*, to the bottom of the orbit; cut the attachments with scissors, leaving the *Mb. nictitans* connected with the ball. If the eyes are to be stud-

ied or preserved, mark them right and left by numbers or tags; the proper position is always indicated by the *Mb. nictitans*.

Slightly ventriduct the mandible and move it from side to side so as to indicate the position of the *Ath. temporomandibulare*. Often the capsule has been opened already in nipping the caudal root of the *zygoma*. If not, it is to be cut while on the stretch by inserting the arthrotome, and cutting until separation is complete on that side.

Dissect the *M. temporalis* from its cranial origin, and then from its insertion upon the *processus coronalis* of the mandible. Then bring the mandible to a right angle with the rest of the head; feel for the caudal border of the hard palate, and for the tips of the *processus pterygoidei*; at a point midway between them push a scissor-blade endad of the soft palate, and divide it; then divide the mucosa forming the dorsal wall of the *postnares*, and dissect it from the basis cranii to the atlas.

The mandibles are now attached to the rest of the head by some muscles, by the mucosa at the angles of the mouth which may now be divided, and by the slender piers of the *hyoid arch*. These last join the skull at the lateral side of the bullæ, where they are to be divided with the arthrotome; if it be desired to examine the mode of their attachment, they may be cut with the bone-scissors at a little distance from the attachment.

Turn the tip of the mandible still farther ventrad and caudad, and dissect off the muscular masses that are inserted between the bullæ; near the caudal ends of the mesal borders of the bullæ emerge several nerves, which should be divided with the scissors or a sharp scalpel at about 1 cm. from the skull. By continuing the removal of the muscles across the *Ath. atlo-occipitale* this is exposed. Put the membranes upon the stretch, and divide them with a sharp scalpel along the cephalic border of the atlas. This exposes the *myelon*, which is to be divided in the same way. The remaining ligaments and the cervical muscles may be cut with the arthrotome and the skull proper is then separated from the rest of the body. Place the skull in the *n. s. s.*, and wash the hands and the instruments which have been used.

*EXPOSURE OF THE BRAIN.*—The method here described is by successively removing bits of the skull with the nippers.

*Caution.*—In the later stages of the operation there is considerable risk of injuring the brain by the unintentional pressure of the nippers. In whatever way the bone is grasped, when force is applied, the tendency is to approximate the cutting edges as nearly as possible, and thus to bring their planes into right angles with the surface of the bone. This of course crowds the convexity of the ental blade against the brain, and may crush it seriously. It may occur either from the turning of the nippers in the hand, or more frequently from the escape of the skull from the grasp of the other hand. The accidents may usually be avoided by keeping the matter in mind, by having the right hand dry, and aiding the grasp of the more or less slippery skull by a small towel or bit of coarse muslin; this last is also desirable during some stages of the operation as a protection of the hand itself from abrasion.

In using the nippers another precaution is to be observed. If the bit of bone to be removed is attached only to bone it may be either cut or broken, or twisted off; but if it adheres to the *dura* or other soft parts, only *cutting* should be employed, and that done with care.

During the exposure of the brain the head should be frequently dipped into the *n. s. s.* If obliged to suspend the operation for more than an hour, wrap the head in a cloth wet with the *n. s. s.*, and set in a cool place.

Nip off the caudal root of the *zygoma*, including the *Fs. glenoidalis*. Insert a nipper-blade into the *meatus auditorius*, and remove the bulla in fragments. With the scissors cut away the membranes attached to the margin of the *Fm. magnum*. Nip off the occipital condyles, with the intervening area of the *basioccipital* for 2-3 mm.

\* The meaning of this and some other unfamiliar terms may be learned from a paper (9) in "SCIENCE" for March 19 and 26. Most of the words employed are to be found in a Human Anatomy, or a dictionary, general or medical.

from the foramen. Insert a nipper-blade between the dura and the bone 5-6 mm. from the meson and in line with the mesal border of the cephalic part of the bulla, and nip out the basioccipital as far as the middle of the length of the bulla. At or near the angle left after the removal of the condyle and the basioccipital, the *N. hypoglossalis* enters the *Fm. condylare*, and passes cephalad to emerge on the ventral aspect of the skull by the *Fm. jugulare*. If the series of roots do not appear, carefully remove a little more bone until they do. If the nerve-roots are to be especially studied, endeavor to nip off the bone surrounding the *Fm. condylare*, so as to save the trunk. On emerging upon the ventral aspect of the skull, the *N. hypoglossalis* will be found to lie practically in the *Fm. jugulare*, and to be more or less intimately attached to the *NN. glossopharyngealis, vagus* and *accessorius*, which penetrate the bone by that foramen. In attempting to separate the *N. hyp.* great care must be used to avoid any traction upon the roots, which readily pull out of the medulla. Of the other three nerves, the *accessorius* is the most caudal, and the most readily distinguished, but at this stage it is as well to leave them together, simply endeavoring to remove the bone surrounding the foramen, and to save the trunks pretty long, at least upon one side. Upon the other, it will save time to cut the roots just entad of the skull, and the same may be done on one side with the remaining nerves, or with all upon both sides in case the brain is not to be employed for the study of the apparent nerve-origins.

The dorsal wall of the bulla is hard, but readily crumbles between the nippers. It may be removed in small pieces, so as to save the *NN. facialis* and *auditorius* which enter the *Fm. auditorium internum*, and the little *Lobulus appendicularis* of the cerebellum which is lodged in a slight fossa just dorsad of the foramen.

Since no nerves are transmitted by the mesal region of the basis cranii, it may be removed with comparative freedom, as far cephalad as the *pituitary fossa* where some care is needed to avoid injuring the *hypophysis*.

The skull may now be held more securely by the facial region, especially if a towel is employed. In removing the bone at each side of the meson, and just cephalad of the bullæ, great care is required to disengage the nerves which emerge by the *FF. ovale, rotundum*, and *sphenoidale*. These nerves, the *NN. oculomotorius, trochlearis*, and *abducens*, with the *ophthalmic, superior maxillary*, and *inferior maxillary* divisions of the *N. trigeminus*, penetrate the bone more or less obliquely, and are closely surrounded by dense connective tissue.

Just cephalad of this series of foramina is the *F. opticum*, and the *N. opticus* is particularly hard to disengage without tearing some of the delicate parts (*terma*, or *lamina terminalis*, etc.) which are connected with the *chiasma*. Since the optic nerves are always easily recognized, it is usually better to cut them pretty short with the scissors, than to run the risk of rupturing the *terma*.

The entire maxilla is now to be removed by first nipping the interorbital region just cephalad of the fronto-maxillary suture, and then, with the bone-scissors, cutting toward this point from just caudad of the cephalic root of the zygoma. The scissors should be kept as far cephalad as possible, so that the *Bulbi olfactorii* may not be injured. This plan serves equally well for some dogs, but with the larger breeds, which have prominent *bulbi olf.* the interorbital region should be nipped at about the middle of the length of the nasal bones.

Remove the mesal walls of the orbit, and the turbinated bones, using care not to crush the very soft *Bulbi olf.* The *Nervi olf.* should be divided, a few at a time, with the scissors or the tip of the scalpel, and all pulling and twisting of the parts must be avoided.

During the remaining steps of the operation, the head must be held by the parietal regions, and with great care, so as to avoid pressure of the tips of the fingers upon

the brain. The bone, also, must now be cut by the nippers rather than twisted or broken. Nip off the *supraoccipitale*, including the dura, as far as the *Crista lambdoidalis*. To remove the ventral part of the bony tentorium, introduce a nipper-blade between it and the hemisphere on either side, in such a way that the greater convexity is toward the hemisphere rather than the cerebellum; the cut is to be made at the level of the *Sutura squamosa*; the width of the tentorium at this point is about 8 mm., and the nipper-blade should not be introduced to a greater depth than that, for fear of injuring the *Lobi optici*. In closing the blades the head should be held very firmly so that no rotation may occur. The detached ventral piece of the tentorium may be extracted by the forceps, or by the nippers used as forceps, any adhesions being carefully separated with the tracer or scissors.

Hold the head with the ventral side down, support the caudal divisions of the brain with a disengaged finger, and with tracer and scissors separate the cephalic surface of the cerebellum from the tentorium. Then hold the head with its caudal end down, and complete the disengagement of the *Bulbi olf.* Hold the head over the 7 p. c. brine, with the ventral side down, and nip out, piecemeal, a triangular piece of the calvaria, nearly to the tentorium. The mesal adhesions of the dura may be divided with the scissors, but elsewhere the dura is to be left upon the hemispheres. As the hemispheres begin to fall, hold the head so that they are supported by the brine, and then snip all remaining adhesions until the entire brain is free and floats in the liquid.

REMOVAL OF THE DURA.—Saturate some cotton with the brine, and place it under the brain, so that about one-third of the organ projects above the surface. Avoid handling and lifting the brain; move it by shifting the cotton, or by grasping the dorsal portions of the dura. Remove the dorsal and lateral parts of the dura by grasping the free borders left by cutting along the dorsimeson, and cutting out piece by piece with the scissors. Then grasp the *falx* just dorso-caudad of the *Bulbi olf.*, at the straight transverse fissure—*F. cruciata*; introduce the scissors about 5 mm., and cut the *falx*. Gently draw the cephalic portion cephalo-ventrad between the *Bulbi olf.*, and remove it. Draw the caudal portion caudad, and carefully cut all its attachments.

Turn the brain upon its dorsal surface, and remove the ventral portions of the dura with great care and in small pieces. Especial pains are needed in connection with the hypophysis and the nerves, and all pulling must be avoided. On one side, at least, it is well to leave the dura still attached to the nerves and the great *Gasserian ganglion* upon the *N. trigeminus*, to be more completely removed at the time of the removal of the pia.

TRANSFER TO THE ALCOHOL.—Place a large spoon or watch-glass at the side of the brain, and pull the cotton which supports it, so as to roll it into the glass, resting upon its dorsum. Let the brain slide off into the alcohol so as to rest on the cotton therein, still with the ventral side up.

Set the bowl with the alcohol in a cool place, and change the position of the brain at intervals of five to ten hours during the first three days, by pulling the cotton in various directions. At the end of about three days, transfer the brain to 95 p. c. alcohol, where it may remain indefinitely. For a few days, however, it should rest upon cotton, and its position be occasionally changed.

WEIGHING THE BRAIN.—If this is to be done, handling the brain may be avoided as follows; Place the bowl of alcohol into which the brain is to be put, upon the scales, and pour in alcohol of the same strength until it balances an even number of grams, *i. g.*, 400, 410, or 420. While the brain is in the spoon or watch-glass, pour over it some of the same alcohol, and then let the latter drain off as much as possible, by tilting the glass.

and supporting the brain with the fingers or a bit of cotton. Then transfer to the bowl of alcohol as above directed, and the increase in weight will represent, with approximate accuracy, the weight of the brain.

**REMOVAL OF THE PIA.**—This is most easily accomplished at the time of the removal of the brain to the stronger alcohol. At any subsequent period the pia is apt to be more firmly adherent. If the brain has been allowed to dry at all during its removal from the skull, the pia comes off with great difficulty.

**Instruments and materials.**—Forceps; fine forceps; medium scissors; wetting-bottle of 15 p. c. glycerine; cotton thoroughly wet with water, and so moulded as to form a sort of shallow cup in which the brain may rest without danger of rolling off.

Place the brain upon the cotton, and wet it with the glycerine. Then let it rest upon its ventral side, and grasp it in the cotton, firmly yet gently. Grasp with the forceps the fold of *pia* which occupies any one of the fissures, especially at the point of forking or junction with another fissure, and pull along the line of the fissure. Usually the fold of pia will come out easily, and with it will be removed some of the pia covering the free surface of the gyri between it and the adjoining fissures. Proceed thus until the pia has been removed from the dorsal and lateral aspects of the hemispheres. Avoid pulling across the line of the fissures. The larger forceps are easier to work with, and less apt to puncture the brain; but the fine forceps are sometimes required for the removal of the pia from the bottom of a deep fissure. The caudal surface of the hemispheres may be reached by slightly ventructing the cerebellum. The mesal pia can only be removed close to the margins of the hemispheres.

On one side, preferably that on which the *N. opticus* was cut shorter, raise the mass of nerves formed by the divisions of the *N. trigeminus* and *N. abducens*, by its lateral border, and cut with the scissors the *N. oculomotorius* which holds the mesial border close to the brain. This will permit the mass to be turned caudad so as to expose the course of the slender *N. trochlearis* which emerges from between the hemispheres and the cerebellum. It also permits the removal of the pia from the region just laterad of the hypophysis. Grasp the pia on the ventrimeson just caudad of the *Bulbi off.*, and pull caudad so as to remove it as far as the chiasma, taking care not to tear the delicate *terma* just dorsad of the chiasma. Then remove the pia from the olfactory tracts.

In removing the pia from the medulla the position of the nerve roots should be constantly kept in mind, and the traction should be laterad and cephalad. One of the most difficult things is to preserve uninjured the series of roots of the *N. hypoglossalis*, for their connection with the pia seems to be closer than with the medulla. Sometimes it may be necessary to let the brain be wholly below the surface of water or alcohol so as to float the roots out, and render them more apparent.

As suggested on a previous page, it is often as well to leave the roots longer on one side than the other, but the choice may be determined mainly by the degree of success in the various operations which have been described.

If desired, later numbers of "SCIENCE" will contain directions for the general dissection of the brain. Meantime, it would be well for the student to make outline drawings of the brain he has prepared, especially of its base. Most of the principal features of this surface can be identified from the figure of the corresponding surface of the human brain to be found in any good Human Anatomy. The drawing should be enlarged two diameters, and the brain should be kept wet with the glycerine mixture, while it is out of the alcohol.

#### LIST OF WORKS AND PAPERS REFERRED TO.

*Chauveau, A.*—A. *Traité d'Anatomie Comparée des Animaux Domestiques*. 2d edition, O., Paris, 1871.

*Dalton, J. C.*—<sup>2</sup>. Centres of Vision in the Cerebral Hemispheres. *Med. Record*, March 26, 1881. 337-339, 2 figures.

*Flower, W. H.*—Observations on the posterior lobes of the cerebrum of the *Quadrumanus*, with a description of the brain of a *Galago*. *Phil. Trans.*, 1862, 185-201; 2 plates.

*Foster & Langley.*—A. *A Course of Elementary Instruction in Practical Physiology*. 3 edition, D., pp. 276, London, 1878.

*Sanderson, J. B.* (Editor).—A. *Hand-Book for the Physiological Laboratory*. 8vo., text, pp. 585; Atlas, 123 plates. *Phil.* 1873. Reprint of the English edition with slightly different paging.

*Straus-Durckheim, H.*—B. *Traité Pratique et Théorique d'Anatomie Comparative, Comprehendant l'Art de Dissequer les Animaux de toutes les Classes et les Moyens de Conserver les Pièces Anatomiques*. 2 vols., D. 870 pages, 4 plates, Paris, 1842.

*Wilder, B. G.*—<sup>3</sup>. A Partial Revision of Anatomical Nomenclature, with Especial Reference to that of the Brain. "SCIENCE," 11, 122-126 and 133-138, March 19 and 26, 1881.

### ATOMS AND MONADS, THEIR METAPHYSICAL DEVELOPMENT.

BY DR. DIODATO BORRELLI.

(Translated from the Italian by the Marchioness Clara Lanza.)

In previous chapters of this work<sup>1</sup> it has been shown that the whole product of our psychological activity typifies a purely metaphysical world. It has likewise been seen, that the vast compound of forms by means of which exterior nature is represented to us, is not an extrinsic reality, but merely our own impressions, the result of slow and unconscious practice. A minute physio-psychological analysis leads us to this necessary conclusion. Colors are mere modifications, induced in certain groups of ganglion and cephalic cells by a stimulus which acts upon the organs of sight. Sounds are another form of cellular modification determined by a different kind of stimulus. Weight and resistance are phenomena of muscular sense. Form and size, synthetic relations, and therefore purely subjective phenomena. All the complex qualities by means of which physics are able to recognize different bodies, are nothing more than our own determinations. From this we may properly conclude that body and matter are not extrinsic realities, but a complication of modifications produced within us by exterior impulses.

Our world is therefore purely phenomenal, and not a reality. Herbart reasonably maintains that the first moment of research must necessarily be one of doubt, or scepticism, which is degraded or elevated in proportion as the uncertainty concerns things as they seem to us, or whether it relates to existence itself. Does the reality exist? This is the first question which presents itself to the philosopher. And if it does exist, what constitutes it and the consecutive research? "We cannot deny the reality," says Herbart, "because, to do so, is to remove all possibility of the phenomenal world before mentioned. Sensations, representations and thoughts would be completely annulled."

This phenomenal world, resulting from the data of experience, is that which induces us to admit the existence of positivism. But these data do not constitute real existence, because they are not self-subsisting, but depend upon something else. That is to say, they exist in something else and by means of something else. *Actual existence* does not admit of either relation or dependence, it is based upon itself, and is, therefore, an absolute con-

<sup>1</sup> Borrelli. *Vita E Natura. Studii sui temi più importanti del Moderno Naturalismo*. Naples, 1880.