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MEMOIR

ON THE

GANGLIA AND NERVES

OF THE

HEART.

BY

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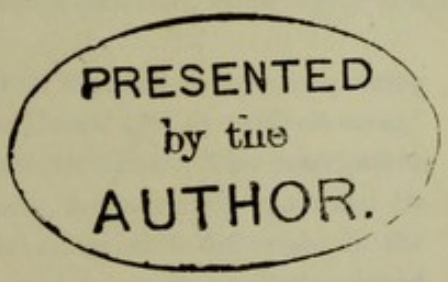
WITH FIVE ENGRAVINGS.



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MEMOIR

ON

THE GANGLIA AND NERVES OF THE HEART.

THE human heart was considered by the ancient Greek philosophers to be one of the noblest organs of the body, and to be copiously supplied with nerves. Galen, on the contrary, asserted that it receives only one small filament, which descends to it from the brain. Vesalius, adopting this opinion, has represented in an engraving a minute branch of a nerve proceeding from the recurrent to the heart. Fallopius, in 1523, stated that he had demonstrated to his pupils a great plexus of nerves, lying between the aorta and pulmonary artery. "A quo abundans copia nervosæ materiæ," he says, "totam cordis basim amplexetur, perque ipsam plures propagines parvorum nervorum dispergit." Fallopius being aware that the kidneys, stomach, liver, and spleen are all abundantly supplied with nerves, believed that Vesalius had committed an error by representing only one small nerve proceeding to the heart. In 1628, Harvey's Treatise "De Motu Cordis et Sanguinis" was published. In the dedication to Charles I., Harvey says, "Cor animalium, fundamentum est vitæ, princeps omnium, microcosmi sol: a quo omnis vegetatio dependet, vigor omnis et robor emanat." Harvey considered the motions of the heart to be muscular. "It becomes erect," he says, "hard and of diminished size, during its action; the motion is plainly of the same nature as that of the muscles." "Quoniam erigi, rigorari, minorari et durescere in omni motu videtur: ipsiusque motum esse, qualem musculorum, dum contractio fit secundum partium nervosarum et fibrarum." He inferred therefore, on physiological grounds, that the heart, like all other muscular organs, was supplied with nerves; but nothing is directly stated by Harvey respecting the cardiac nerves. In a pigeon he observed that, after both auricles and ventricles had ceased to pulsate, by keeping the warm finger moist with saliva a short time upon the heart, it recovered new strength and life, so that both ventricles and auricles pulsated, contracting and relaxing alternately, recalled, as it were, from death to life.

In 1783, a detailed account of all the opinions entertained by anatomists, from the earliest ages, respecting the cardiac nerves, was given by Senac in his Treatise on the Structure of the Heart. "Les nerfs de cœur," he observes, "sont en très grande nombre: nul muscle n'en recoit autant de ramifications." The descriptions given of the cardiac nerves by Willis, Winslow, Lieutaud, Lancisi, and others, are minutely examined by Senac, and the discordance which exists amongst them is pointed out. The remarkable difference in the number, origin, and distribution of these nerves, stated to have been observed by so many distinguished anatomists, he was disposed to attribute more to the want of care and dexterity in conducting the dissections, than to any want of natural uniformity or constancy in the formation of the cardiac nerves. None of these anatomists have made any allusion to the existence of ganglia on the nerves of the heart.

Haller, Wrisberg, Soemmerring, and other eminent anatomists who flourished in the course of the last century, affirmed that no nerves are distributed to the muscular substance of the heart, and that its contractions do not depend upon nervous influence.

B. I. Behrends, a pupil of Soemmerring, in 1792 published a memoir entitled, "Dissertatio qua demon-

stratur Cor Nervis Carere," in which it is admitted that nerves accompany the coronary arteries; but it i distinctly asserted that the muscular structure is entirely destitute of nerves. "Ac primo quidem nervorun cordis examini scrupulosius intendens, tum observando, tum analogice concludendo didici nullos omnin nervos ne surculum quidem in ipsam cordis carnem dispergi." An engraving accompanies this essay, i which the muscular substance of the heart is represented as absolutely destitute of nerves. In contradictio to the above statements made by Behrends, he admits in his dissertation that he had traced two filaments c the nerves accompanying the coronary arteries into the muscular substance of the heart.

The splendid work of Scarpa, entitled, "Tabulæ Neurologicæ ad illustrandam Historiam Anatomica Cardiacorum Nervorum," &c., was published in 1794. This work contains five engravings of the nerve of the human heart, and four of the heart of the horse and heifer. The first of these, Tab. iii., gives a vie of the human cardiac nerves of the right side, and Tab. iv. of the left side of the heart. In Tab. iii. ther are seen, as in the plate of Behrends, filaments of nerves accompanying the coronary arteries from th base, to near the apex of the heart; but there are few, if any, branches of nerves seen passing into th muscular structure of the heart unconnected with the blood-vessels. Those branches marked No. 12 appear to be filaments distributed to the muscular substance; but Scarpa describes them as accompanyin the arteries. "Tenues nervi plexus coronarii dextri, qui ramos arteriæ coronariæ anterioris, per priore cordis faciem pereptantes comitantur." Where several of these branches sub-divide into smaller branche there is an appearance of a slight ganglionic enlargement; but Scarpa has not stated in the text that the are ganglia; and no anatomist, until half a century after the publication of Scarpa's work, declared ther to be so. Tab. iv. gives a view of the nerves of the same heart on the left side. In this plate there ar represented only a few small filaments of nerves which do not accompany the coronary arteries. Th most striking of these are marked Nos. 67 and 70, but even these are represented as accompanying th artery. No. 67, he describes as follows: "Bina nervea stamina ad anteriorem cordis faciem reflexa, ul coronaræ arteriæ posterioris ramo priori se adjungunt;" and No. 70, "Tenuissima nervea stamina, quæ magno et profundo plexu cardiaco emissa retro arteriam pulmonalem, et supra sinum venarum pulmo nalium, longo itinere ad complanatam faciem descendunt, ubi cum filis nerveis, plexus coronarii posteriori copulantur." Nothing is said about these filaments of nerves being distributed to the muscular substanc of the heart, nor is it stated in the text that ganglia exist on these nerves. That Scarpa did not regar these branches as distributed to the muscular structure unconnected with the arteries is obvious from th following description, Tab. iii. No. 129: "Generatim vero omnes, singulique nervi hactenus in superfici cordis descripti nullibi penetrant intra cor, nisi qua arteriæ incipiunt in muscularem hujus visceris sub stantiam delitescere, vel prope ea loca. Nam si qui nervuli interdum cor seorsum ingredi videntur, quem admodum nonnulli in hac Icone prope apicem cordis præsertim, ii diligenter perscrutari sub prim fibrarum muscularium strato reptantes, breir emenso itinere, ad proximas arterias tenui carne obruta accedere reperiuntur." The same observations are strictly applicable to Tab. v., which represents th posterior pulmonary plexus of the eighth pair, and the nerves accompanying the coronary arteries on th flat surface of the heart. In this engraving there is not a single filament of nerve represented passing int the muscular substance of the heart unconnected with the arteries, and no ganglia formed upon any o these nerves. Tab. vi. gives views of the nerves accompanying the coronary arteries on both surfaces of th heart. After examining these, and the descriptions given of them by Scarpa, it must be inferred that if th whole nervous structure of the organ is here fully represented, the surface of the human heart i almost, if not wholly, destitute of nerves, as Behrends has asserted, and that the actions of the heart do no depend upon its nerves. It is impossible to avoid concluding, from these engravings, that Scarpa adde little or nothing to the anatomy of the human cardiac nerves. Tab. vii. contains four views of the cardia nerves of the horse and heifer. In these, several large branches are represented passing obliquely acros the coronary arteries and ramifying on the surface of the heart, where the arteries are not passing int the muscular substance. On one of the branches accompanying the left coronary artery there is represente

distinct ganglion. This is No. 30, and is termed "Cardiaci sinistri ganglion insigne." At the root of e right coronary artery (Fig. 1, Plate vi.) there is also represented a distinct ganglionic enlargement on e nerves accompanying it on the human heart. This is marked No. 7, and called "Gangliformis tumescentia." On the branches of those nerves which do not accompany the arteries there are no ganglia presented in any part of their course; but in the text, at page 2, it is stated, "Præcipui autem nervorum rdiacorum trunci ad basim cordis, et inter majora vasa arteriosa intumescunt in vera et genuina ganglia; Equo autem et Bove etiam en iis ramis cardiacorum, qui per cordis superficiem reptant nonnulli olivaria rpora gignunt." Whether the cardiac nerves in the larger quadrupeds had been examined by any natomist before Scarpa, I have not ascertained; but many of the ganglia and nerves can be seen through e investing membranes of the heart without any dissection.

In Mr. Swan's engravings, published in 1830, only a few small branches of nerves have been figured, hich accompany the coronary arteries, and the muscular substance of the heart is represented as completely estitute of nerves. M. Chassaignac, who translated, in 1838, Mr. Swan's "Demonstration of the Nerves of e Human Body," has repeatedly denied in the most positive manner that any nerves, except those which company the coronary arteries, have yet been demonstrated in the heart, and consequently that the assertion ade by Behrends is true, that the heart has no nerves, and is a stupid and insensible viscus. "Anatomie n'a nstaté jusqu'à present," observes M. Chassaignac, "dans le cœur, que des nerfs arteriels,"—"l'existence filets nerveux independants des vaisseaux propres au tissu charnu est encore à demontrer."—p. 23. I beeve Mr. Swan, who is generally regarded as the greatest neurologist now in Europe, accords entirely with is assertion of his translator.

In 1839, Remak stated that he had discovered in the human subject small ganglia on the filaments of the rdiac nerves, as they ramify on the substance of the heart. These ganglia he described as very small, but hen examined with the microscope, the characteristic grey corpuscles placed among the filaments of the erves left no doubt as to their nature.

In September, 1846, I resolved to dissect the nerves of the heart immersed in alcohol, as I had done ose of the uterus, with magnifying powers of six and twelve diameters. The investigation was carried during two years, and from examinations made of the nerves of the healthy and malformed fœtal heart—the hearts of birds—of the heart of the child at the ages of six and nine years—of the heart of the adult the sound state—of the human heart slightly and greatly hypertrophied, and of the heart of the young d adult heifer and horse, the following conclusions may be deduced.

I. That the blood-vessels and the muscular structure of the auricles and ventricles of the heart are ndowed with numerous ganglia and plexuses of nerves, which have not hitherto been described or represented the works of other anatomists.

II. That the nervous structures of the heart which are distributed over its surface to the apex, and throughut its walls to the lining membrane, and columnæ carneæ enlarge with the natural growth of the heart before irth, during childhood and youth, until the heart has attained its full size in the adult.

III. That the ganglia and nerves of the heart enlarge like those of the gravid uterus, when the walls of e ventricles are affected with hypertrophy.

IV. That the ganglia and nerves which supply the left ventricle in the natural state are more than double e size of the ganglia and nerves distributed to the right side of the heart.

This anatomical demonstration of the ganglia and nerves of the muscular substance of the heart comletely overthrows the last remaining argument employed by those physiologists, who still defend the doctrine hat the irritability and contractility of muscular fibre are independent of nervous influence. This demontration of the existence of numerous ganglia on the surface and throughout the walls of the heart, further learly indicates the source of the actions of the heart as an entire organ, and how its detached parts can coninue to contract after its total separation from the body. It likewise furnishes a satisfactory explanation of nany phenomena observed in the progress of organic diseases of the heart.

In prosecuting this investigation into the nervous system of the heart, I found that the great difficulty of

dissecting and displaying the cardiac ganglia and nerves, did not arise so much from their extreme softnes from their close and intimate connexion with the blood-vessels, or from the quantity of adipose matter which they were embedded, as from the presence of a dense fibrous membrane, or fascia, which w interposed between the serous membrane and the muscular coat, of whose existence as a distinct tissue the heart I had no knowledge when these researches commenced. In the most recent systematic writers Anatomy, the heart was represented as consisting of muscular and tendinous structures, blood-vesse nerves, and absorbents, enclosed between two serous membranes.

On examining this fibrous membrane after the removal of the serous covering, it is found to be possess of great strength and firmness, glistening, semi-transparent, and resembling in all respects the aponeuro expansions or fasciæ covering muscular organs in other parts of the body. It is much stronger over t ventricles than the auricles, and it adheres so firmly, where it is in immediate contact with the muscul substance of the auricles and ventricles, that its separation cannot often be effected without tearing up son of the muscular fibres to which it is attached. From the inner surface of this fascia, which I have named t *Cardiac Fascia*, innumerable strong fibres pass to the blood-vessels, nerves, and muscular fasciculi and adipo matter. These strong, slender fibres, connected with or proceeding from the inner surface, accompany a surround all the blood-vessels and nerves, and they are interlaced together, so as to form a peculiar stroma- if it may be so termed—of considerable thickness, between the fascia and all the various structures beneat which it invests and binds together in the strongest possible manner. These fibres form a complete shea around all the arteries, veins, and nerves on the surface of the heart, and accompany them as they dip dow between the muscular fasciculi to which these branches are distributed throughout the entire walls of the hea from the surface to the lining membrane. The cardiac fascia is obviously one of the principal causes of t firmness and strength of the central organ of the circulation of the blood, as it binds together into one mas and gives support to the muscular fibres, like the fasciæ investing other muscles. The thin serous covering the heart can possess little power, and add nothing to the strength of the parietes, and probably but for t fascia now described, the heart would often yield in all directions, especially at the apex.

In a pathological point of view, the cardiac fascia is perhaps not less worthy of notice. Muscular structur it is well known, is not liable to attacks either of common or specific inflammation. It is impossible to avoi suspecting that rheumatic inflammation of the heart has for its principal seat this dense fibrous membra lying between the serous and muscular coats of the heart, and that attacks of rheumatism of the heart do n commence primarily in the muscular structure. The tunica sclerotica of the eye sometimes becomes inflame softens, and yields; and from these changes it is known that sclerotic staphyloma, and other diseases, are th results. Whether in dilatation of the heart a similar morbid change is not first set up in the fascia, and wh influence this fibrous membrane has in modifying all the diseases of the heart, future observations mus determine.

After the removal of the serous membrane from the surface of the ventricles, there are plexuses of ganglioni nerves readily seen with the naked eye through the cardiac fascia, ramifying on the muscular substance the heart. If these superficial nerves, situated immediately under the cardiac fascia, be traced backward towards the base of the ventricles, they are found to terminate in a great ganglionic plexus, situated betwee the pulmonary artery and aorta, to the outer coat of which it adheres much more firmly than to the pulmonar artery. This is the nervous plexus between the aorta and pulmonary artery described by Fallopius more tha three hundred years ago. Into this great nervous mass, which enlarges as it passes to the base of the ventricles branches of nerves enter from the recurrent and sympathetic nerves. From the par vagum or recurrent an great sympathetic, branches pass to the heart behind the aorta and pulmonary artery; but the great ganglioni mass of nerves situated between the aorta and pulmonary artery is properly the root of all the cardiac nerve and ganglia. From the right side of this ganglionic mass, several broad, flat branches of nerves, invested wit a soft neurilemma, and accompanied by small blood-vessels, proceed to the right auricle, right ventricle, an to the septum between the ventricles. From the left side of this nervous mass, under the arch of the aorta

eral large flat nerves, likewise enveloped in a neurilemma, and accompanied by small blood-vessels, proceed he left auricle, left ventricle, and the inter-ventricular septum. These large flat nerves pass to the root of left coronary artery, which they not only completely surround like a sheath, but likewise cover a portion he aorta near its origin. Many large branches of nerves, with ganglia formed upon them, accompany not y all the branches of the coronary arteries to the apex, but all the branches which pass into the muscular stance of the ventricle, and are distributed throughout its walls to the lining membrane and columnæ neæ. From the deep nerves and ganglia of the ventricles, the muscular structure is chiefly supplied. m the great mass of nerves situated around the roots of the coronary arteries and aorta, there are numerous nches of nerves with ganglia distributed over the muscular walls of the ventricles of the human heart, and ch do not accompany the blood-vessels. On the portions of the ventricles which are devoid of fat, these glia and nerves are distinctly visible to the naked eye, through the serous membrane and cardiac fascia, l present a very remarkable appearance. These superficial cardiac nerves are remarkably soft, flat, and newhat transparent, as Scarpa has described, with a grey colour, and the smallest branches are enveloped a soft sheath or neurilemma. Towards the left side and apex of the left ventricle these nerves lie in oves or depressions in the muscular substance, and they spread out into ganglionic enlargements, from ch laterally innumerable small filaments are sent off, which ramify on the muscular walls. Ganglia are ned of considerable size on these superficial nerves, where they are crossing the blood-vessels, and n these chains of ganglia over the arteries branches are sent off to the coats of the blood-vessels which k deep into the substance of the heart. It can clearly be demonstrated that every artery distributed ughout the walls of the uterus and heart, and every muscular fasciculus of these organs is supplied h nerves upon which ganglia are formed, and which are the sources of all their contractile powers.

The preparations from which the following engravings have been made are preserved in the Museum St. George's Hospital.

EXPLANATION OF THE PLATES.

PLATE I.

FIG. 1, *represents the great cardiac ganglionic plexus of nerves, situated between the aorta and pulmonary artery, which receives branches of nerves from the sympathetic, par vagum, and recurrent nerves of both sides: and likewise the ganglia and nerves distributed over the surface of the left ventricle of the heart of a child nine years of age. Natural size.*

a. The arch of the aorta.
b. The pulmonary artery truncated at its origin.
c. The anterior surface of the left ventricle of the heart.
d. The anterior surface of the right ventricle.
e. The left par vagum and recurrent nerve.
f. The great cardiac ganglionic plexus of nerves situated between the aorta and pulmonary artery, from which all the principal cardiac nerves are derived.
g. The ganglionic plexus of nerves accompanying and surrounding the trunk and branches of the left coronary artery, and the ganglia and nerves distributed over the muscular substance of the left ventricle to the apex; the serous membrane and cardiac fascia having been removed.

FIG. 2, *represents the ganglia and nerves at the apex of the anterior surface of the adult human heart in the natural state, with a portion of the cardiac fascia dissected off from the blood-vessels, nerves, and muscular substance, to which it firmly adhered.*

a. The branches of the coronary artery at the apex of the heart surrounded by ganglia and nerves.
b. Ganglia and nerves on the muscular substance of the heart at the apex not accompanying blood-vessels.
c. The cardiac fascia.

PLATE II.

Represents a portion of the cardiac fascia, and the ganglia and nerves on the surface of the left ventricle of the Heifer's heart. Natural size.

a. A portion of the serous membrane dissected off from the cardiac fascia.
b. The cardiac fascia, with the numerous ganglia and nerves seen through it, undisturbed by dissection.
c. Branches of the left coronary artery, with ganglia on the nerves where they cross the blood-vessels.

PLATE III.

Exhibits the trunk and branches of the coronary arteries, and the ganglia and nerves distributed over the anterior surface of the ventricles of the young Heifer's heart; the serous membrane and cardiac fascia having been wholly removed.

PLATE IV.

Represents the posterior surface of the same heart covered with ganglia and nerves, from the base to the apex. Natural size.

PLATE V.

Represents the aorta and the anterior surface of a human heart which was hypertrophied, and weighed four pounds. The trunk and some of the branches of the left coronary artery were ossified. The pulmonary artery has been cut away close to the right ventricle. A portion of the wall of the right ventricle has been removed to expose the cavity and the septum between the ventricles. The serous membrane has been reflected off from the cardiac fascia, a small portion only of which has been left covering the ventricle. Natural size.

a. The arch of the aorta.
b. The origin of the pulmonary artery, which has been completely removed.
c. The anterior surface of the left ventricle.
d. The anterior surface of the right ventricle.
e. The great ganglionic plexus of nerves into which branches from the par vagum, recurrent, and sympathetic nerves of both sides enter, and from which the principal cardiac nerves take their origin.
f. The par vagum of the left side.
g. The trunk of the left coronary artery ossified and completely surrounded with ganglia and nerves, which are distributed over the whole surface of the ventricle to the apex.
h. The serous membrane reflected off from the cardiac fascia, a small portion only of which is left covering the ganglia and nerves near the apex.
i. The cardiac fascia.

Fig. 1.

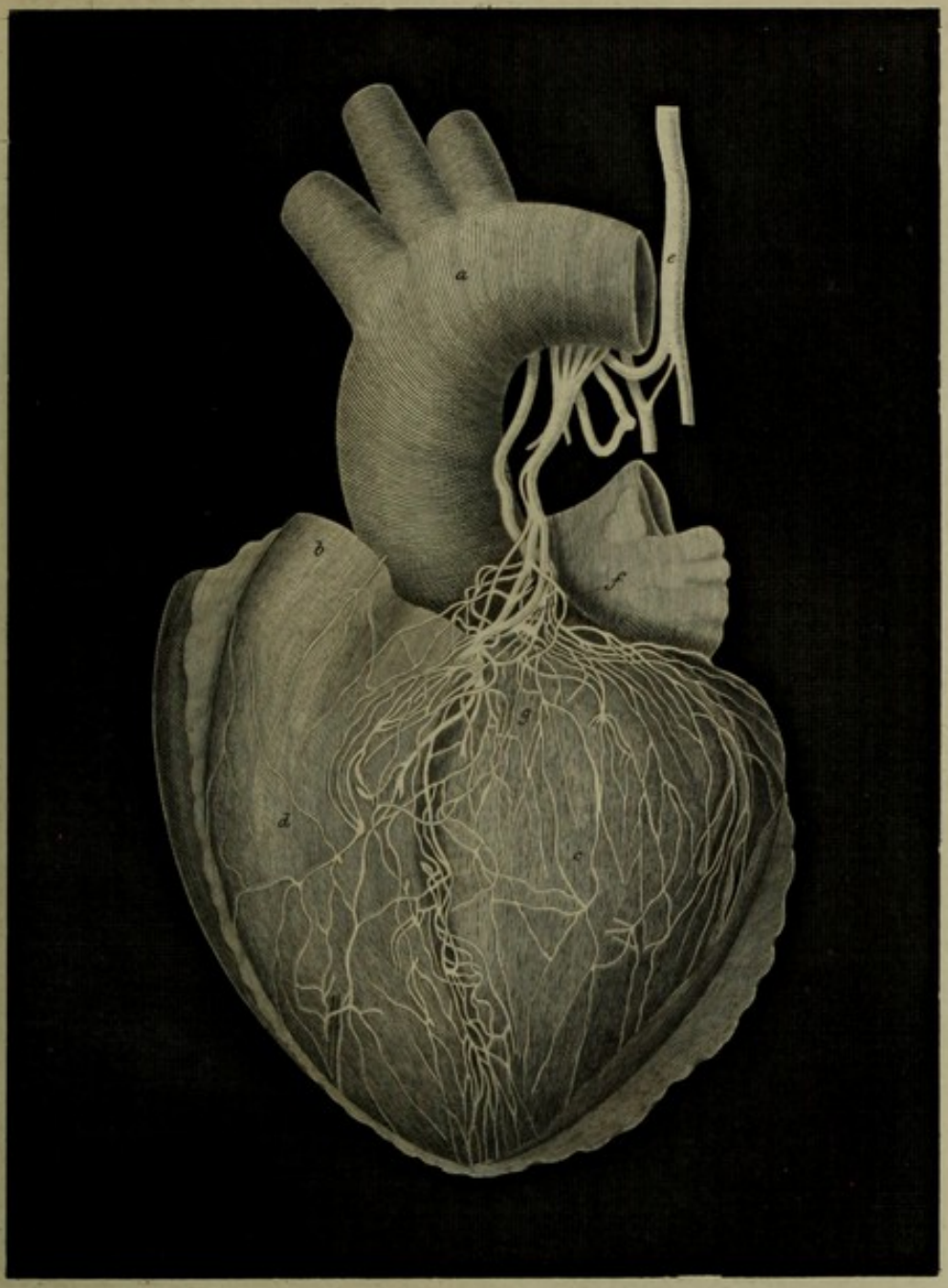
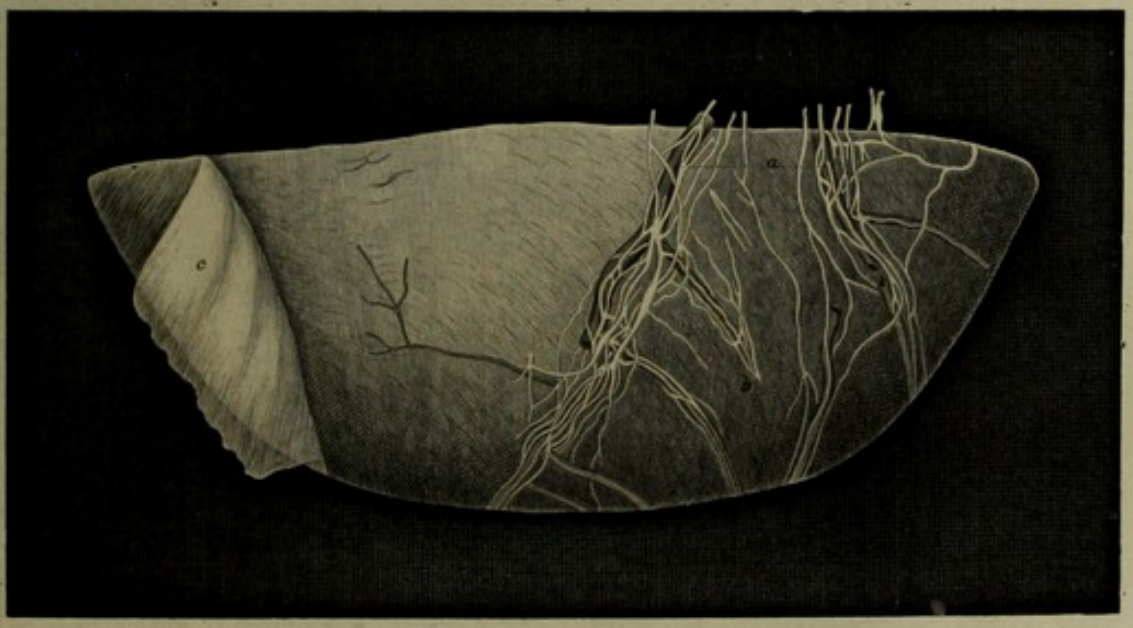
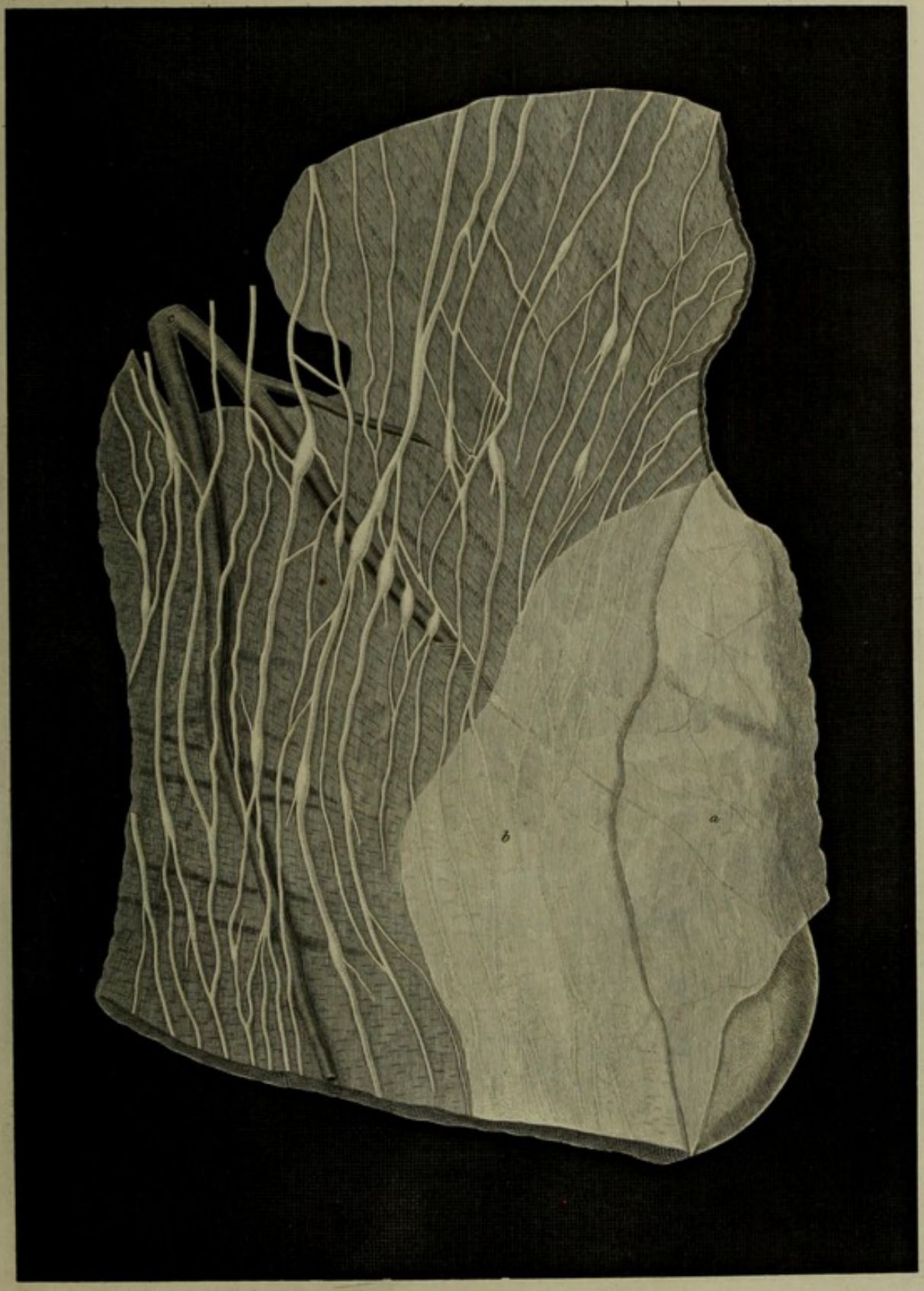


Fig. 2.





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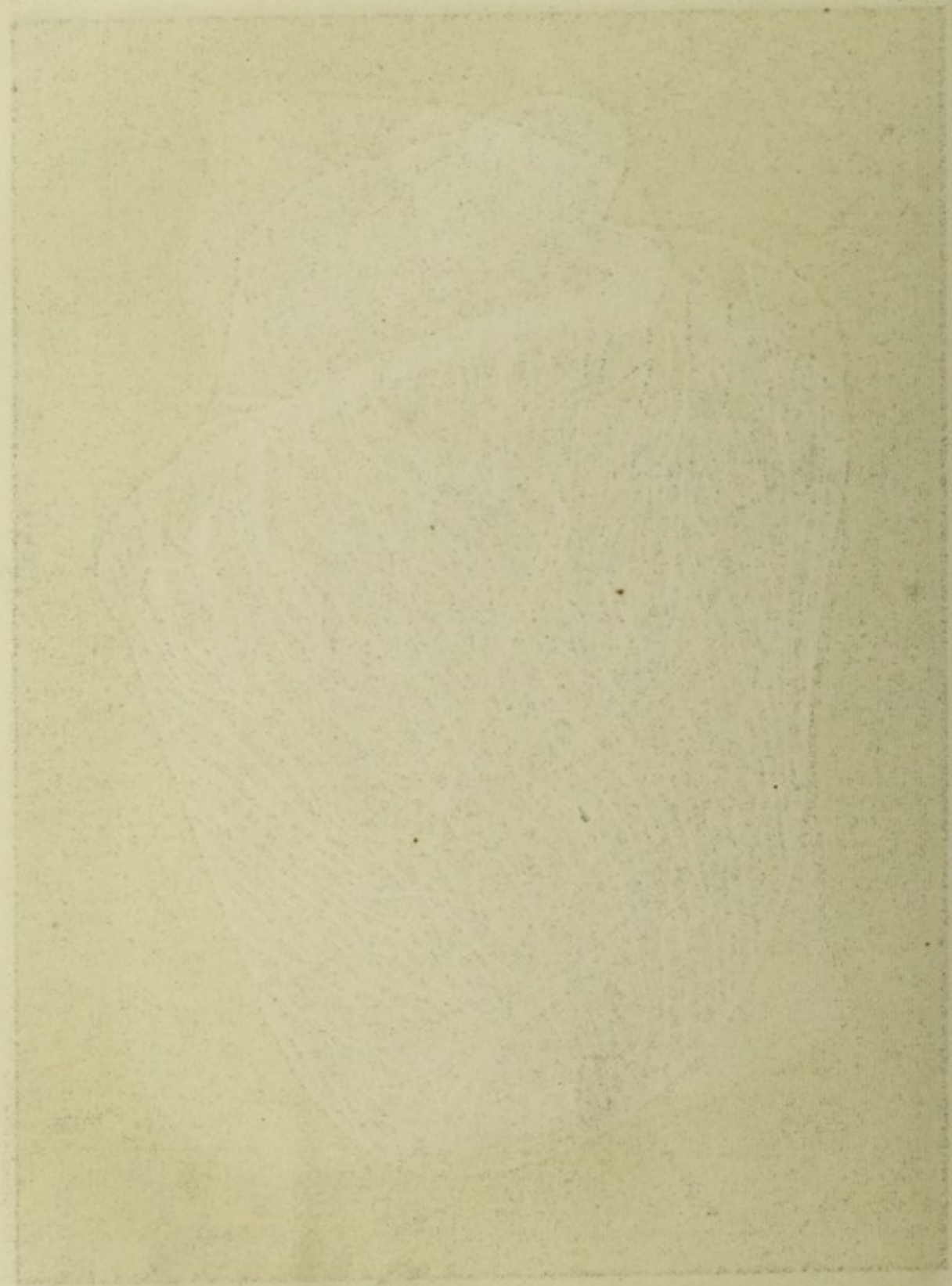

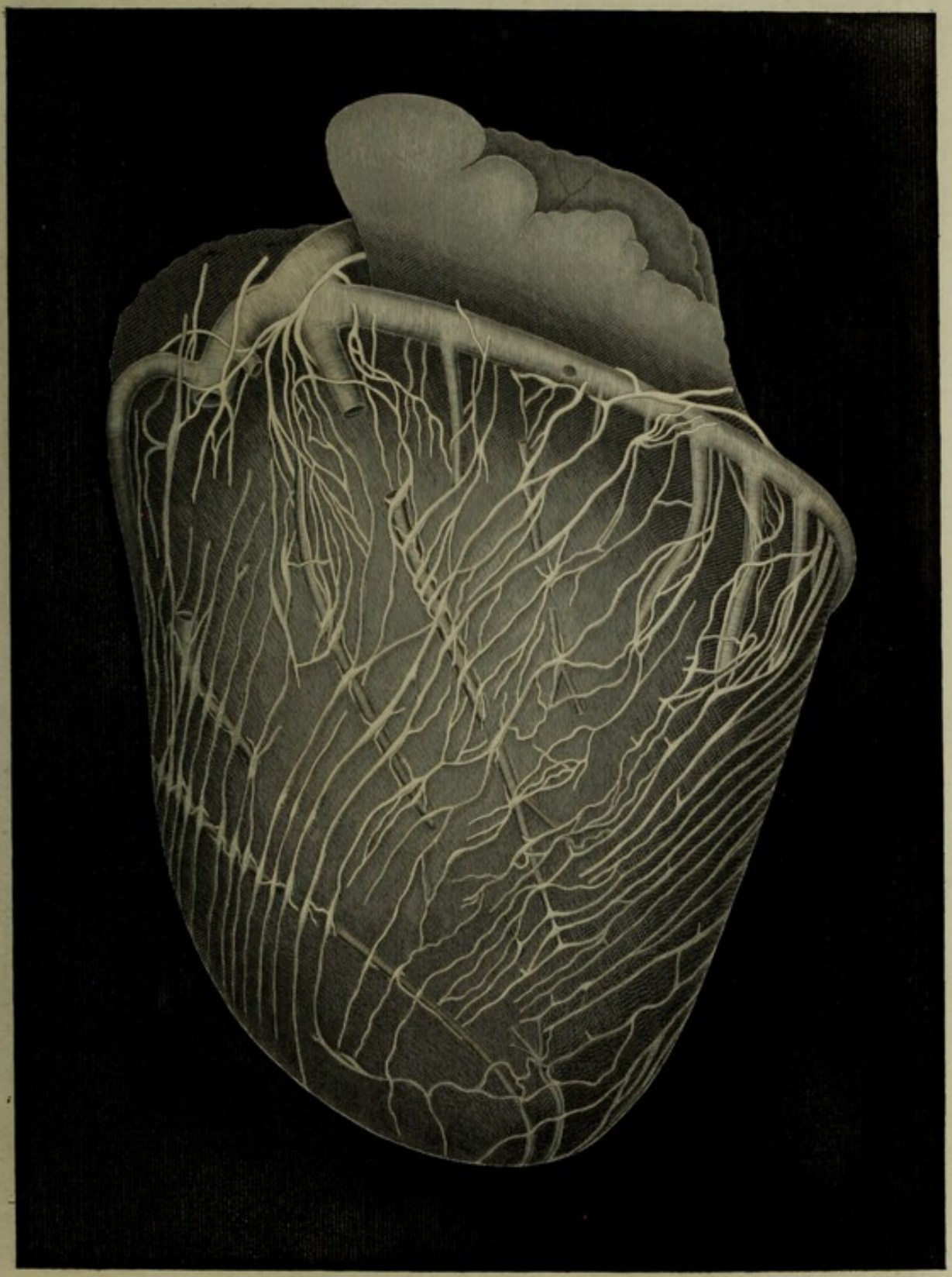

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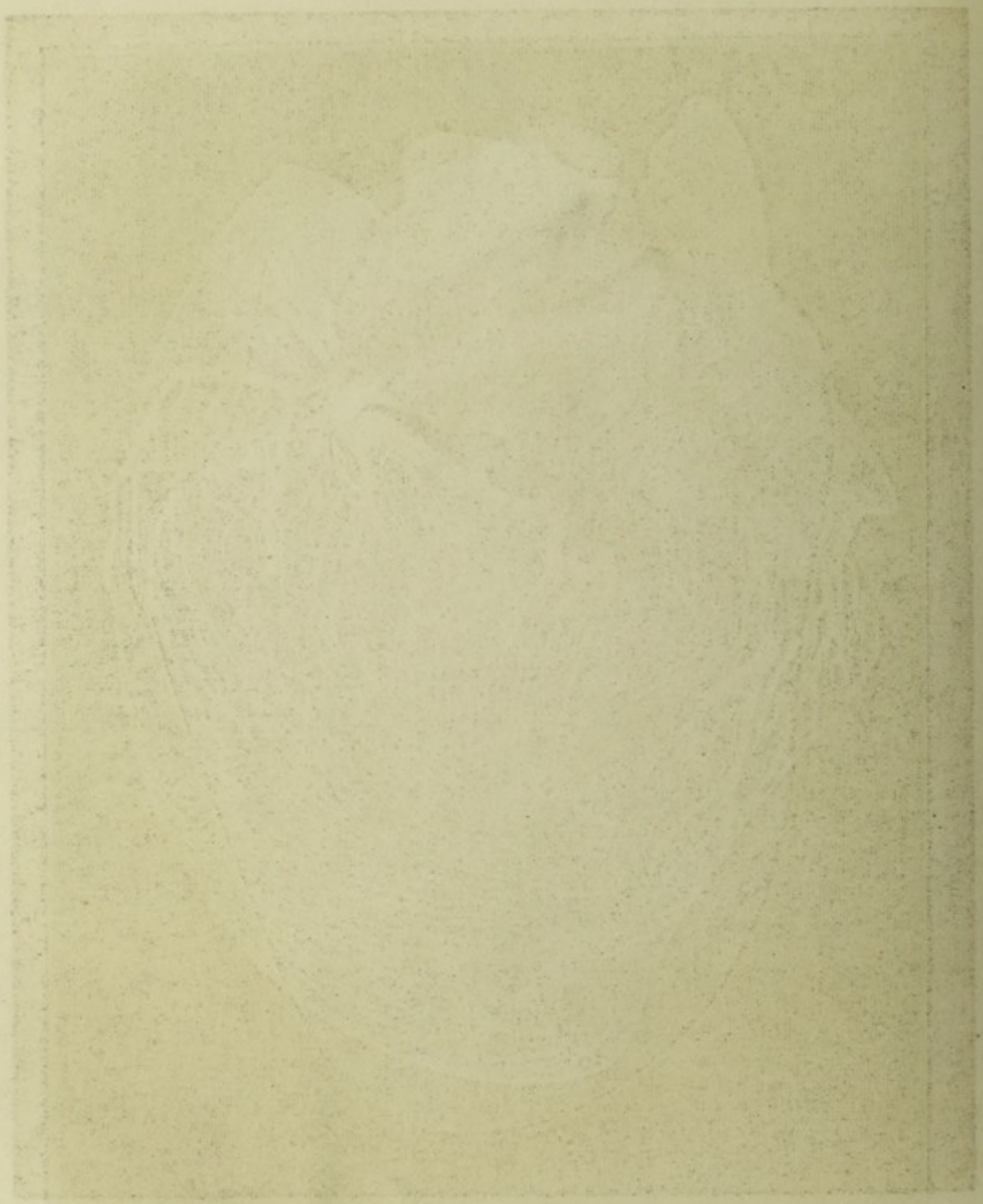

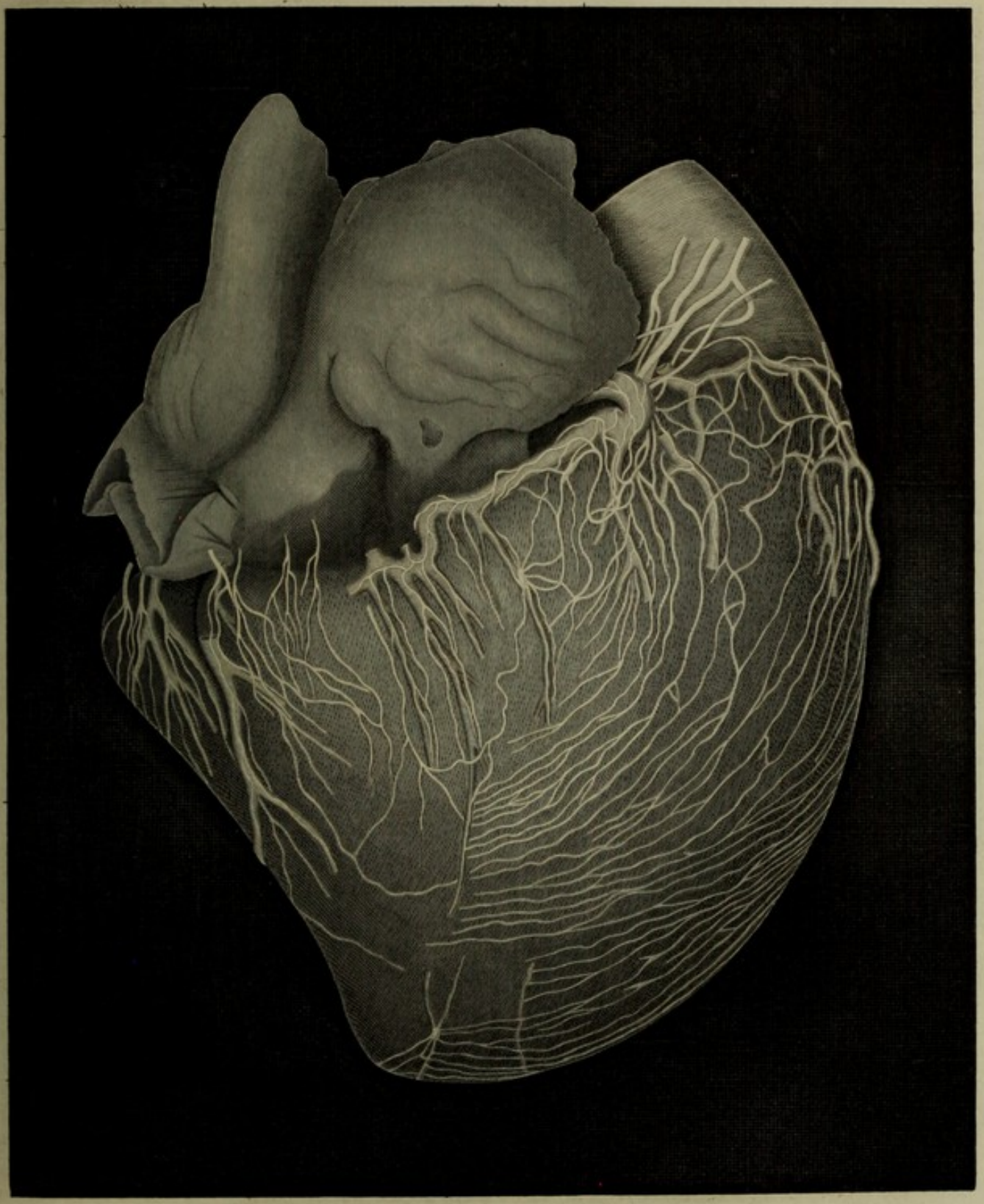

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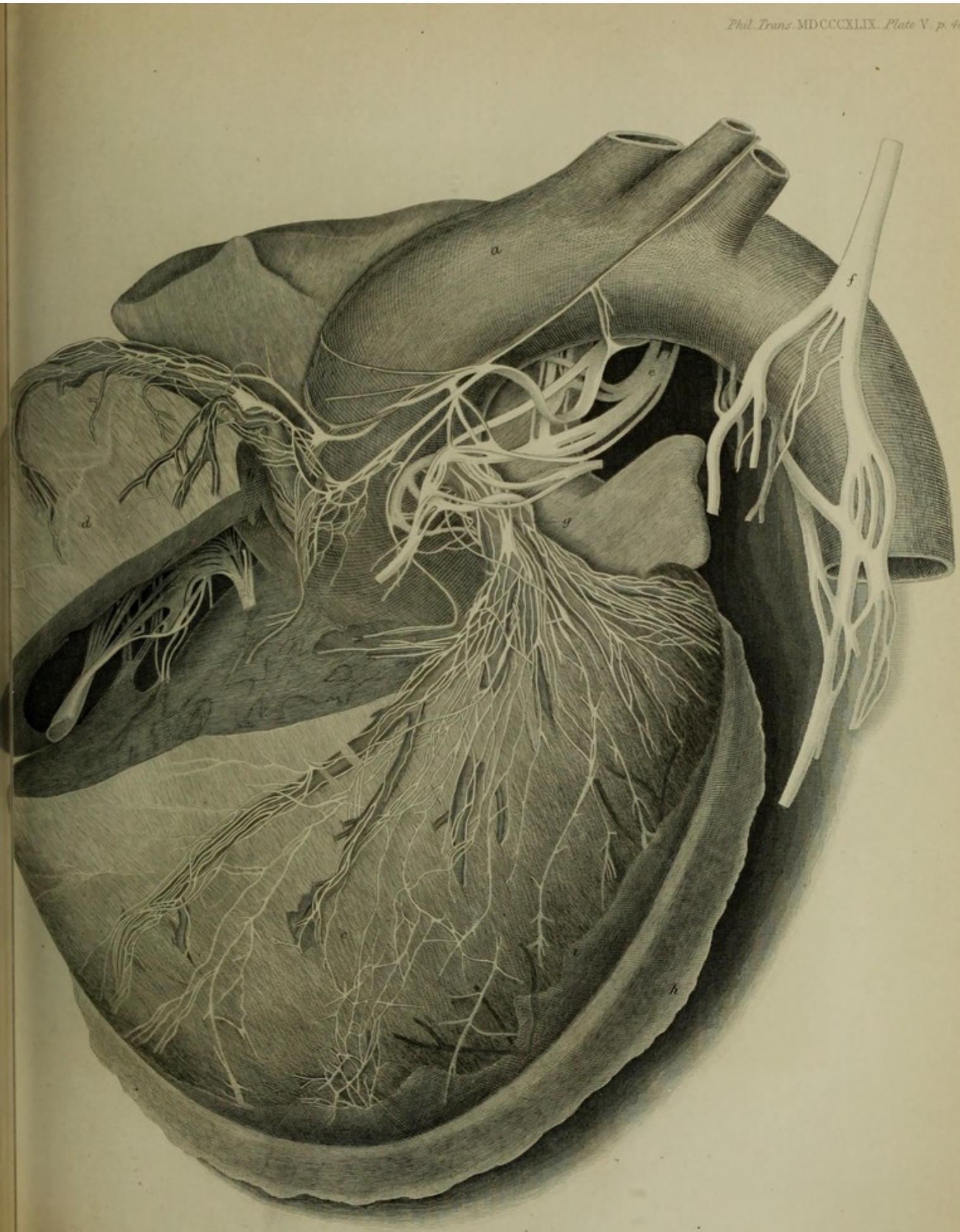

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