FROM NEUROLOGY TO PSYCHOANALYSIS

SIGMUND FREUD'S NEUROLOGICAL DRAWINGS AND DIAGRAMS OF THE MIND

LYNN GAMWELL MARK SOLMS

2006

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SIGMUND FREUD IN 1891

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BINGHAMTON UNIVERSITY ART MUSEUM
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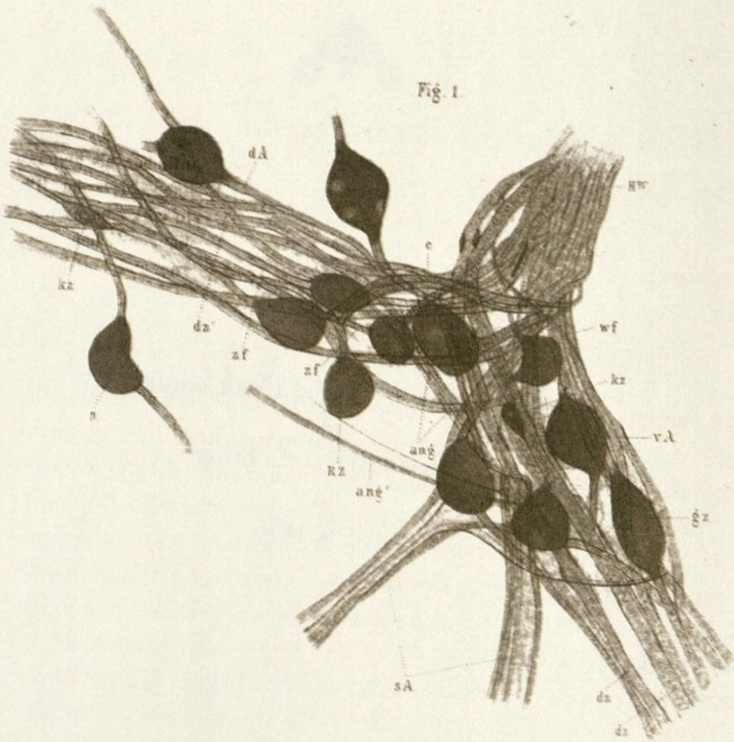
In commemoration of the 150th anniversary
of
Sigmund Freud's birth
on
May 6, 1856



See Plate 6.

The Role of Scientific Drawings in 19th- and Early 20th-Century Research

Lynn Gamwell

THIS EXHIBITION PRESENTS drawings of cells, especially nerve cells, and diagrams of the workings of the human mind that Sigmund Freud made throughout his long career, beginning in 1876 when he was a 20-year-old student, and drawing his last image in 1933, four years before his death at 83. This complete collection of Freud's diagrams includes some famous icons of psychoanalysis and other relatively unknown, rarely-seen images. As curator, I was honored that the multi-talented Mark Solms agreed to help bring these images to life for us. Fluent in German and in the medical vocabulary of Freud's era, Solms began by translating Freud's original captions. Learned in neurology, psychoanalysis and the history of psychiatry, Solms then described each image, offering thoughts about what these pictures tell us about Freud's journey from neurology to psychoanalysis. In my introduction to Solms' rich text, I will comment on the role played by such drawings and diagrams in the history of science in Freud's era.

Nineteenth-century scientists used drawing as a tool to record observations that they made looking through a microscope. As a medical student Freud learned to prepare a thin slice of animal tissue, which was usually dead, by pressing it between two pieces of glass. Using chemical dyes Freud stained the colorless tissue to bring out details, such as nerve fibers or a cell nucleus. Looking through the microscope Freud saw light transmitted through the transparent tissue, with the stained bodies standing out in silhouette. Thus Freud's earliest diagrams of cells and nerve tissue are typically simple outlines of overall, flat shapes, within which the relations of the various parts are delineated.

Freud viewed the micro-world through a so-called "achromatic" lens that had been invented in the 1830s; because it was composed of layers of glass, each of which had different rates of refraction, the lens avoided the chromatic distortion from which earlier lenses suffered and produced an enlargement in crystal-clear focus, inspiring a flurry of investigation of microorganisms and cells. Other experimenters with lenses in the 1830s, Louis-Jacques Daguerre and William Henry Talbot, invented photography and used early cameras and projection microscopes to capture images of microorganisms, such as dust mites, as well as tissue samples of cells. However, such early, albeit grainy, mechanical recordings were treated as little more than curiosities, and drawing by hand remained the method of choice for 19th-century researchers using microscopes because their goal was not to capture the exact appearance of their subject but to direct the viewer's attention to selectively chosen details that they depicted within a general, schematic outline.

Nineteenth-century scientists also used diagrams to help them formulate a hypothesis about things they could not see. Within a decade of having drawn his first cells, Freud was diagramming mental processes for which, given the physiology of his day, he lacked the tools to observe the presumed physical substrate. Purely speculative, Freud used his diagrams to guide his research and to predict an effect that could be observed. Then, as we witness in the exhibition, as Freud focused on increasingly complex mental functions such as disorders of language and memory, he put aside any attempt to diagram the underlying physiological structure, such as neurological pathways, and he began making schematic images of hypothetical psychological structures.

In Freud's day attitudes towards the scientific value of a diagram made from life, as opposed to a diagram of a speculative structure or hypothetical process, reflected traditional philosophical debates about where reality lies. The Enlightenment philosophers John Locke and David Hume were British Empiricists who held that one can only know with certainty what one experiences directly – seeing is believing. In the wake of the French Revolution, early 19th-century social reformers in France and Britain first expressed the outlook of positivism: science gives the only valid ("positive") knowledge. Scientists imported these attitudes into 19th-century British and French laboratories where researchers shunned theory and only trusted direct observation, perhaps aided by a microscope. Thus pictures drawn through a microscope were welcome in the halls of science in London and Paris, but theoretical diagrams of hypothesized, unseen realms were dismissed with disdain.

In Germany, however, Enlightenment philosophy had culminated at the close of the 18th century with Immanuel Kant's critiques of the foundations of human knowledge in which he declared that one only knows with certainty the contents of one's own mind, or "ideas." According to Kant's German Idealism, it is physically impossible for a scientist to observe the natural world directly because one knows flowers and songbirds only as mental constructions made out of sensory appearances (colors, sounds). As science developed in Germanic culture, many researchers adopted this outlook and treated sensations of colors and shapes as signs of an ultimately unknowable world-out-there (Kant's so-called "thing-in-itself"). Thus German researchers were comfortable using theoretical models such as diagrams of unseen realms to guide their investigations. But as the scientific method gradually replaced philosophical debate, in order to be confirmed a theory had to predict results that were observable by all. Thus in German laboratories drawings depicting what was seen through a microscope became one method of providing the indispensable observation that supported and helped to confirm a theoretical model.

It was researchers working within this German-speaking scientific community who led the investigation of the inherently unobservable human psyche. The leading German scientist of the second half of the 19th century, Hermann von Helmholtz, grounded Kant's idealist view of human knowledge in the body by demonstrating, in repeatable experiments, how the eye and the ear respond to light and sound, and how humans construct a world picture from abstract signs (nerve impulses): "The nature of the sensation depends primarily on the peculiar characteristics of the (receptor) nervous mechanism; the characteristics of the perceived object being only a secondary consideration. . . . The quality of the sensation is thus in no way identical with the quality of the object by which it is aroused. Physically, it is merely an effect of the external quality on a particular nervous apparatus. The quality of the sensation is, so to speak, merely a symbol for our imagination."[1] Trained in the Helmholtz school of physiology and neurology, of which his teacher Ernst Brücke was a prominent member, Freud compared knowledge of the internal (psychological) world with knowledge of the external (physical) world as described by Helmholtz: "The unconscious is the true psychic reality; in its innermost nature it is as much unknown to us as the reality of the external world, and it is as incompletely presented by the data of consciousness as is the external world by the communications of our sense organs" (*The Interpretation of Dreams*, 1900).[2]

Helmholtz urged all scientists to find a balance between theoretical speculation and observed data, as he put it, between "a penetrating knowledge of theory" and a "broad, practical experience in experiment." He criticized French scientists for being too narrowly focused on collecting facts, but he felt that certain German scientists, such as his contemporary, the evolutionary biologist Ernst Haeckel, erred in the opposite direction by not sufficiently grounding their hypotheses in laboratory data: "To flee into an ideal world is a false resource of transient success . . . when knowledge only reflects itself, it becomes insubstantial and empty, or resolves into illusions and phrases."[3] Freud shared Helmholtz's view that a theory that was unsupported by observation in controlled laboratory experiments was not science but "phrases" – in other words, a philosophical theory that was confirmed or refuted, not by experiment, but by endless argument, heralding a return to a pre-scientific era. Freud labored throughout his career to make psychoanalysis as rigorous a science as the elusive psychic data he observed in his laboratory – his consulting room – would allow.

Meanwhile direct observation remained the rule in France, where in 1865 the chemist Louis Pasteur had revolutionized medicine by announcing the germ theory of infectious disease, based upon his observations of microbes. In England Charles Darwin had amassed a mountain of detailed observations in support of his theory of evolution by natural selection, but he enraged his critics by picturing the process of natural selection in a theoretical diagram – a tree of life – on the frontispiece to *The Origin of Species* (1859). Widely denounced in the halls of British science because the process of natural selection was unobservable, Darwin's theory was also rebuffed in Parisian laboratories, where Pasteur remarked: "There are many great problems that arouse interest today: the unity or multiplicity of human races; the creation of man many thousands of years or centuries ago; the immutability of species or the slow and progressive transformism of one species to another; matter reputed to be eternal rather than created; the idea of God being useless, etc.; these are some of the learned questions that men dispute today. . . . I do not discuss these grave topics. . . . I dare speak only on a subject that is accessible to direct observation."[4]

When Freud went to Paris in 1885-86 to study with the leading neurologist of the day, Jean-Martin Charcot, he entered the Salpêtrière Hospital at a rare moment in French psychiatry when unseen, psychological causes of mental derangement were being studied. After a distinguished career in which he considered only physical causes of mental illness, in 1882 Charcot had presented his first paper in which he declared that there are purely psychological causes of hysteria that could be investigated using hypnosis. After Charcot's death in 1893 Parisian neurologists were determined to return to studying only observable behavior and physical features of the mind. They closed the Salpêtrière laboratory for experimental psychology that Charcot had entrusted to his student, Pierre Janet, and French psychiatrists returned to considering only physical (chemical and neurological) disorders well into the early 20th century.

In Germanic lands scientists were not only sympathetic to a theoretical approach but also drawn to the vibrant spirit of Darwin's core idea: nature is a web of dynamic forces without predetermined purpose or meaning. In the 1860s Darwin's natural selection became generally accepted by German-speaking scientists as a master narrative that explained the natural sciences, and some, such as the Russian embryologist, Alexander O. Kovalevsky, made significant contributions to evolutionary biology. By the fin-de-siècle Freud was crafting an evolutionary model of the mind, diagramming trees of branching neurons, and he went on to describe man as an animal driven by passions to reproduce and aggressions to survive.

Another British scientist, Isaac Newton, had written the greatest theoretical pronouncement of early modern science, the law of universal gravitation that described the (unobserved) force that holds the universe together. Like Darwin's pictorial diagram of the tree of life, Newton summarized his law in another abstract language, mathematics. Newton emphasized the theoretical nature of his accomplishment by titling his 1687 treatise *Philosophiae Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy) and he stated at the outset: "I have design to give only a mathematical notion of the forces, without considering their physical causes." In other words he gave a mathematical description of an invisible force whose physical nature was unknown to him. In an intellectual climate dominated by British Empiricism, Newton despaired in private that he found the whole idea of gravity – an unobservable force that acts at a distance – ridiculous.[5] But after a century of accurate predictions, even Empiricists got accustomed to the idea that apples fall down, not up, because of gravity. Then at the opening of the 19th century, during a flurry of experiments on electricity and magnetism as well as early studies of the electrical properties of nerve fibers, certain German scientists who admired Newton's law as the pinnacle of theoretical physics, set their goal on becoming the Newton-of-the-mind. Newton had discovered the force driving the cosmos and they wanted to discover the force driving the mind. That honor fell to the German physicist Gustav Theodor Fechner, who, during a dramatic recovery from depression and blindness, discovered that the force driving his own mind was the intense pleasure he felt when he re-entered the world of life and light. He generalized this finding to all humans, and attempted to bridge the gap between theory and observation by proving a "psychophysical law" relating an observable (objective) physical cause to an experienced (subjective) psychological effect (*Psychophysics,* 1860). In the early 20th century Freud acknowledged Fechner's pleasure principle as a fundamental force in the mind: "An investigator of such penetration as G. T. Fechner held a view on the subject of pleasure and unpleasure which coincides in all essentials with the one that has been forced upon us by psychoanalytic work" (*Beyond the Pleasure Principle,* 1920).[6]

Freud moved back and forth between pictures based on observation and on theory in his pursuit of the elusive human psyche. Along the way he visualized his ideas about the psyche by an intellectual process that resonates with dreamwork, during which the sleeping mind begins with abstract concepts and ends with a picture: "On this path, which is the reverse direction to that taken by the course of development of mental complications, the dream-thoughts are given a pictorial character; and eventually a plastic situation is arrived at which is the core of the manifest 'dream-picture'."[7] Traces of Freud's journey from neurology to psychoanalysis can be found in Freud's diagrams that Mark Solms describes in fascinating detail.

1. Hermann von Helmholtz, "The Theory of the Sensation of Vision," *Handbook of Physiological Optics,* (1856-67; reprint, New York: Dover, 1962), vol. 2, p. 4.

2. *The Standard Edition of the Complete Psychological Works of Sigmund Freud,* trans. James Strachey (London: Hogarth Press, 1953-74), vol. 5, p. 613.

3. Hermann von Helmholtz made the remark in "Gustav Magnus. In Memoriam," *Popular Lectures on Scientific Subjects,* trans. E. Atkinson (London: Longmans, Green, 1881), vol. 2, pp. 1-25.

4. Louis Pasteur, "Chimie appliquée à la physiologie: des générations spontanées," *Revue des Cours Scientifiques* 1, no. 21 (April 23, 1864), p. 257.

5. As Newton lamented in a letter to the classical scholar Richard Bentley: "That one body may act upon another at a distance through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that, I believe, no man who has in philosophic matters a competent faculty of thinking could ever fall for it."

6. *Standard Edition,* vol. 18, p. 8.

7. *Jokes and Their Relation to the Unconscious* (1905), *Standard Edition,* vol. 8, p. 162.

Fig. 1.

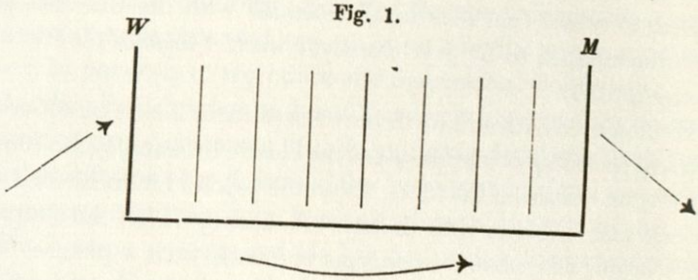


Fig 2.

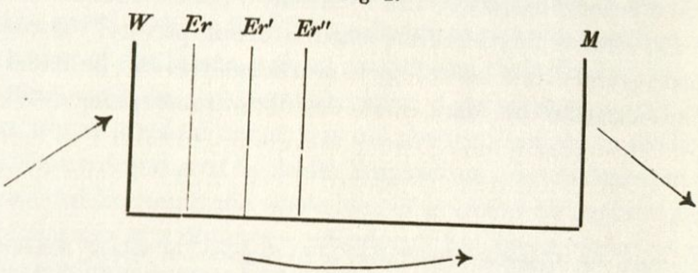
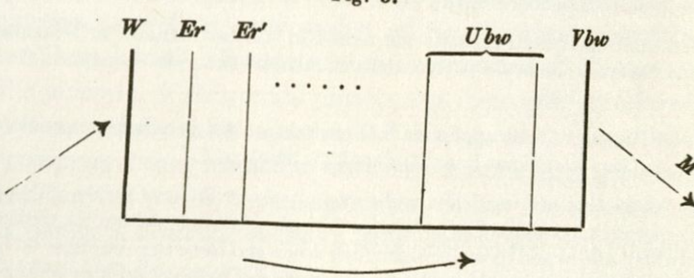


Fig. 3.



See plate 40.

Sigmund Freud's Drawings

Mark Solms

THIS COLLECTION OF FREUD'S complete scientific drawings, assembled by Lynn Gamwell to commemorate the 150th anniversary of Freud's birth, gives us an unprecedented opportunity to reflect on the nature of his contribution to science – and even on the nature of science itself.

There is an obvious progression in the drawings. The first group, dating from 1876, depicts in meticulous detail the morphology of specific anatomical structures, such as the gonads of the eel, the spinal neurons of the lamprey and the fiber pathways of the human brain. The last drawings, dating to 1933, by contrast, are diagrammatic depictions of abstractions such as the "ego", "superego" and "id" – conceptual entities that have no tangible existence in the physical world.

This progression coincided with the well-known shift in Freud's scientific career, away from his early researches in histology and anatomy, via neuropathology and clinical neurology, to his later work in neuropsychology and psychoanalysis. Anatomy is, of course, concerned with concrete, physical things; psychoanalysis with the fleeting and fugitive stuff we call "mind."

It therefore comes as no surprise to learn that Freud's shift from neuroscience to psychoanalysis coincided with a change in his status as a scientist. Freud himself drew attention to this change, more or less at the moment the shift was made, when he wrote in his *Studies in Hysteria* that:

"It strikes me myself as strange that the case histories I write [here] ... lack the serious stamp of science. I must console myself with the reflection that the nature of the subject is evidently responsible for this, rather than any preference of my own."[1]

Freud clearly did not welcome the change. Looking back over his career 30 years later in his Autobiographical Study, his longing for the comfortable respectability of his earlier career is still evident:

"At length, in Brücke's physiological laboratory, I found rest and full satisfaction – and men, too, whom I could respect and take as my models: the great Brücke himself, and his assistants."[2]

What, then, prompted Freud to make this transition? It most certainly was not the abandonment of science. Freud never tired of reminding his readers that as far as he was concerned, psychoanalysis was a natural science like any other – at least insofar as its aims and methods were concerned. In this, despite appearances to the contrary, he followed the scientific ideals of "the great Brücke" who had pledged a solemn oath to the effect that:

"No other forces than the common physical and chemical ones are active within the organism. In those cases which cannot at the time be explained by these forces, one has either to find the specific way or form of their action by means of the physical-mathematical method or to assume new forces equal in dignity to the chemical-physical forces inherent in matter, reducible to the forces of attraction and repulsion."[3]

Freud always remained true to these ideals. All that changed, as he plainly stated in the first quotation, was "the nature of the subject." Since the chemical-physical forces inherent in matter obviously cannot readily be used to explain the mental aspects of the organism, Freud had to "assume new forces equal in dignity to the chemical-physical ones" when he turned his attention to the mind. This was what his transition from anatomy to psychoanalysis boiled down to. Accordingly, as we shall see, there was more that united the two phases of Freud's scientific work than divided them.

What united them was the reductive aim outlined in Brücke's "solemn oath," that is, the goal of reaching beyond the appearance of phenomena to discover their essential nature. To understand the essence of things demands that one finds a way to see more deeply into them; to discern things that are not apparent to the naked eye. Many things in nature exist that cannot be seen. It is the fundamental task of science to discover such things, which bring order to the observable world, for they explain it. All of Freud's work was an attempt to do this – with respect to one particular part of the world, namely the human brain (or nervous system). This is clearly reflected in his drawings.

His first, histological studies of the eel, lamprey and crayfish (grouped under plates 1-21) are straightforward attempts to discern morphological details which are too small for the eye to see. For the purpose of these studies, Freud used a simple instrument: the microscope designed by Hartnack. This enabled him to make individual cells appear up to 520 times bigger than they actually are.

In the next phase of Freud's research, anatomical studies of the human brainstem (plates 22-29), he again made use of the microscope, but the greater complexity of the task required additional observational aids. He wanted to trace the paths followed by particular nerve tracts and identify the nuclei in which they terminate, within an impossibly dense thicket of tracts and nuclei called the medulla oblongata. He therefore adopted a new method pioneered by a colleague named Paul Flechsig: he traced the tracts in relatively undeveloped fetal brains, where the task was accordingly simpler, and then retraced them with greater ease in mature specimens.

Tracing the myriad tracts that interconnect the grey matter of the brain serves only one purpose: to infer what the different parts of the brain *do*. This is called *functional* neuroanatomy. The elucidation of brain function is the ultimate task of all neurological science; and it was, likewise, the culmination of Freud's anatomical work.

Of critical importance in this regard is the bald fact that functions cannot be seen; they have to be deduced. This does not make functions any less *real* than structures. They lack direct observability because they are *dynamic* things; they only exist over time – they involve processes. And such things cannot be easily drawn.

To make matters worse, Freud was not interested in *simple* physiological functions. His interest quickly turned to one of the most complex functions of the human brain: the function of language – a "psychological" function. Freud's studies in this area (see plates 30-31) are accordingly described as neuropsychological studies. However, the interaction between the neurons subserving language is no more or less visible (or real) than those for any other function; it is simply a matter of degrees of complexity.

The transition from representational pictures to abstract diagrams necessitated by these facts can be followed, step by step, in Freud's drawings. They make it absolutely clear that the shift from neurology to psychology was not an ontological one; he was always concerned with the same basic subject – namely, how the brain worked. In fact, the shift of emphasis from structure to function occurred long before he developed psychoanalysis, while he was still a full-fledged neuroscientist.

The further transition from *neuro*psychology to *meta*psychology occurred via an intermediate step, represented by the drawings in plates 32-39 below. These are a series of rough diagrams that Freud prepared for his friend Wilhelm Fliess (including those for the famous manuscript known as the "Project for a Scientific Psychology"). Here, as he did in his work on the neuropsychology of language, Freud attempted to infer the neural arrangements that produce other complex mental functions. However, for these functions, anatomical and physiological knowledge was entirely lacking. This was because the clinical phenomena from which Freud inferred things like repression – unlike the language disorders that Freud had studied previously – were not caused by structural lesions of the brain. The only way that he could infer such mechanisms, therefore, was directly from clinical observation. There was no pathological anatomy and therefore no empirical basis for discovering the neural vehicles of such functions. This led Freud, reluctantly, to abandon conventional neuroscientific ground.

This was the breakthrough into psychoanalysis proper. But a comparison between Freud's last neuropsychological drawing (plate 39) and his first metapsychological one (plate 40) reveals unequivocally that little had really changed. The drawings were almost identical;

the systems of "neurons" were merely re-named "mental" systems. The drawings still depicted the same thing, namely, the succession of changes that occur during processing of stimuli, as they proceed from the perceptual to the motor end of the apparatus.

The method by which Freud inferred these processes was now the psychoanalytic method. But for him this new method was not fundamentally different from the microscope, as regards its scientific aims. The rationale behind both methods was to extend as far as possible the observational capacities of our senses (for outer and inner perception respectively) in order to provide the deepest basis for making inferences about underlying functions – which, in themselves, can never be observed directly.

Freud was only too aware that, proceeding in this way, he would never be absolutely sure that his conclusions were correct. This, too, applies to all science. Certainly, the more complex the phenomena under study, the less secure the inferences as to underlying mechanisms. But this is no basis for limiting science to the study of simple things. Science must study nature as it is and remain appropriately modest about its powers – especially in our own time, when we seem to believe that we can control everything, know everything and have everything; when we are told by social scientists that we have reached "the end of history"[4] and by natural scientists that we will shortly "know the mind of God."[5] It is fitting to celebrate the life of a scientist who, although no less curious about the ultimate nature of things, was still willing to admit that "reality in itself will always remain unknowable."[6]

Between the transient superficies of the senses on the one hand and the false certainties of religion on the other, lies the uncertain path of the truth-seeking scientist. These unique drawings are signposts along the path taken by one such person.

1. Sigmund Freud, "Case 5: Fräulein Elisabeth von R." (1895) in Studies in Hysteria (1893-95), *The Standard Edition of the Complete Psychological Works of Sigmund Freud*, trans. James Strachey (London: Hogarth Press, 1953-74), vol. 2. p. 160.

2. Sigmund Freud, "An Autobiographical Study" (1925), *Standard Edition*, vol. 25, p. 9.

3. E. Du Bois-Reymond (1842) Zwei grosse Naturforscher des 19. Jahrhunderts: Ein Briefwechsel zwischen Emil Du Bois-Reymond und Karl Ludwig. (Leipzig: Barth, 1927).

4. Francis Fukuyama, *The End of History and the Last Man* (New York: Free Press, 1992).

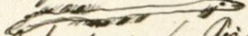
5. Stephen W. Hawking, *A Brief History of Time* (London: Bantam Books, 1988).

6. Sigmund Freud, *The Interpretation of Dreams* (1900), *Standard Edition*, vol. 5, p. 613.

ILLUSTRATIONS

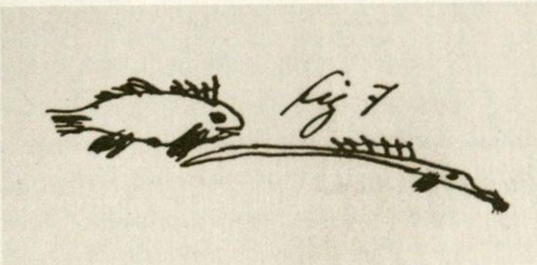
The translation of Freud's legends for the drawings and the comments on the drawings are by Mark Solms.

Die Würmer u. Krebse mein College Grobben (Crustaceus fecit
illa) fig. 8.  die Ascidien sammelt mein zweiter
College, um ihnen die Flöhe abzusuchen; sogenannte
kleine Krebse die parasitisch in ihnen leben.
 fig. 9. Mollusken haben bis jetzt keinen Abnehmer
gefunden, nur die wunderbar schönen
Tintenfische die immer andere Farben kriegen
wenn man sie ärgert, sind noch ohne [struck out]
Liebhaber. fig. 10  Der letzte Teil kleiner Tiere wird
von den Echinodermen eingenommen.
fig. 11 

Was da gefischt wird sind aber meist kleine Dinge.
Jeden Morgen kommt außerdem vom Fischmarkt eine
Sendung von Fischen für mich, Rochen für
die anderen, die uns den ganzen Tag über be-
schäftigen. So bekomme ich ~~[struck out]~~ Haie, Rochen,
Aale u. andere Bestien täglich, die ich allgemein
anatomisch oder mit Bezug auf einen besonderen
Punkt untersuche. Dieser Punkt ist folgender.
Ihr kennt den Aal fig. Lange Zeit hindurch
war von dieser  Bestie nur das
Weibchen bekannt, schon Aristoteles wusste
nicht, woher diese die Männchen nehmen,
und ließ deshalb die Aale aus dem Schlamm ent-
stehen. Durchs ganze Mittelalter u. die Neu-
zeit hindurch wurde eine förmliche Hetzjagd
auf die Aalmännchen angestellt. In

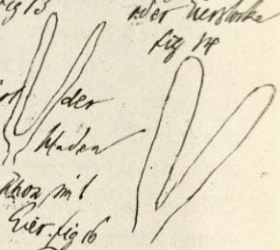
1a.

1. Zoological drawings in a letter Freud wrote from Trieste to Eduard Silberstein, April 5, 1876, Figs. 7-12. Sigmund Freud Collection, Library of Congress.



1b.

der Zoologie wo es keine Geburtsscheine gibt. der Fisch
nach Rarets Ideal – handelt ohne was gelernt
zu haben, weil man nicht was Männchen oder Weibchen
ist, denn die Thiere nicht äusserliche Geschlechtsunter-
schiede haben. Daß gewisse Merkmale Geschlechts
unterschiede sind, muss erst nachgewiesen
werden, das kann nur der Anatom, da die
Aale keine Tagebücher schreiben, aus deren
Orthographie man begreiflich auf das Geschlecht
schließen kann, er reißt sie, findet
entweder Hoden fig 13 oder Eierstöcke fig 14



Der Unterschied beider Organe ist der,
unter Mikroskop zeigen die Hoden
Samenthierchen, die Eierstöcke schon mit
fig 15 freiem Auge Eier. fig 16

Vor kurzem hat ein triester Zoologe wie er sagt
die Hoden, somit die Männchen der Aale
aufgefunden aber weil er, wie es scheint, nicht weiss
was ein Mikroskop ist keine genaue Beschreibung
davon gegeben. Ich plage mich nun, die
Aale seine Aalmännchen wiederzufinden,
aber vergebens, alle Aale die ich aufschneide
sind vom zarteren Geschlecht fig 17
Mehr erfährst Du diesesmal nicht von
mir. Lebe wohl, und

werde bald gesund [illegible]
(Herzig, wenn Du ihn siehst, ich habe keine Zeit zu schreiben,

[illegible]

2.

2. Zoological drawings in a letter Freud wrote from Trieste to Eduard Silberstein, April 5, 1876, Figs. 13-17. Sigmund Freud Collection, Library of Congress.

EXTRACT FROM FREUD'S LETTER:

"I obtain sharks, rays, eels and other creatures daily [Figs. 7-11], which I investigate first from the general anatomical viewpoint and thereafter with regard to one particular problem. This problem is the following. You know the eel. [Fig. 12] Of this creature, since time immemorial, only the female has been recognized; even Aristotle did not know where the male of the species was, and thus how the eel was able to rise from the primal mud. Through the whole of the middle ages and throughout modern times a formal hunt has been on for the male eel. In Zoology, where there are no birth certificates and the beasts behave in accordance with Paneth's ideal – without training – one does not know which is male and which is female when the animal does not possess external sexual differences. That certain distinguishing features are indeed sexual differences must also first be demonstrated, and that is up to the anatomist (since eels do not keep diaries from the orthography of which one may deduce gender); he therefore dissects them and discovers either testicles [Fig. 13] or ovaries [Fig. 14]. The difference between the two organs is this: under the microscope the testicles contain spermatozoa [Fig. 15] and the ovaries – even to the naked eye – contain eggs [Fig. 16]. Not long ago a Trieste zoologist discovered, he says, the testicles, and thereby the male eel; but since it seems he does not know what a microscope is, he did not provide a detailed description of them. Now I am toiling to re-discover this eel, his male eel; but in vain, all the eels which I cut open are of the fairer sex [Fig. 17]. On this occasion you shall learn nothing more from me."

Comment:

The initial phase of Freud's scientific activity was devoted to histology. His first piece of research was a study of the sexual anatomy of the eel. Freud's search for the testicle of the eel was conducted at the University of Vienna's biological station in Trieste. In this extract from a letter to a childhood friend, he caricatures his scientific efforts.

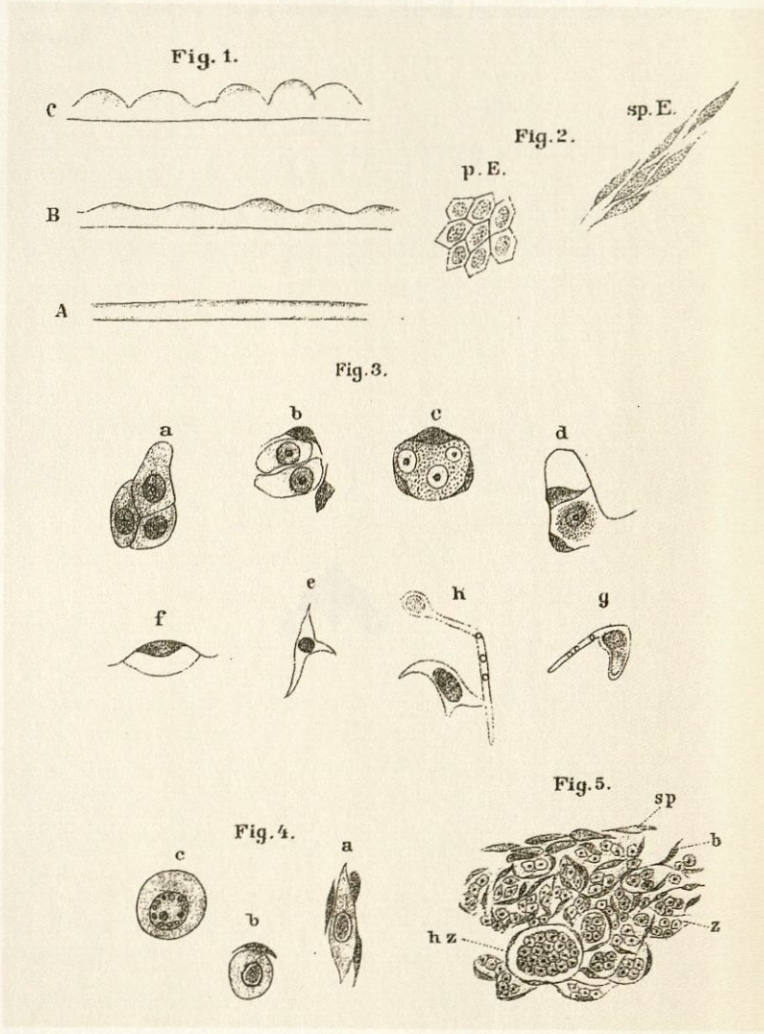


Fig. 1.
C
B
A
Fig. 2.
p. E.
sp. E.
Fig. 3.
a
b
c
d
f
e
h
g
Fig. 4.
c
b
a
Fig. 5.
sp
b
z
h z

3. "Über das Syrskische Organ" (On the Origin of Syrski's Organ), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXV. Band. I. Abtheilung (1877).

Fig. 1. The main forms of the lobular organ. Schematic drawing.

A = organ without lobules.

B = organ with thin hyaline lobules.

C = mature lobular organs.

Fig. 2. Isolated epithelia of the lobular organ fixed in Muller's fluid.

p.E. = polygonal epithelia.

sp.E = spindle-cell epithelium.

Fig. 3. Content-cells and connective tissue elements of the isolated lobular organ fixed in Muller's fluid.

Magnified after Hartn[ack] 4/8.

a = three content cells.

b = two cells surrounded by connective tissue elements.

c = nuclei in finely granulated protoplasm enclosed by connective tissue bodies.

d = two connective tissue elements linked together with bracket-shaped processes framing a cell.

e = connective tissue cell within a large area of protoplasm.

f = connective-tissue cell with ring-shaped bracket.

g = connective tissue element with bracket-like process.

h = unusual form of connective tissue elements with an angular bracket.

Fig. 4. Unusual cells from a small lobule. a and b fixed in Muller's fluid, c fixed in superosmic acid; the cells are surrounded by spindle-shaped bodies.

Fig. 5. View of a small piece from the margin of the lobular organ between two lobules.

sp. spindle cell.

b. connective tissue element.

z. cells of the lobular organ.

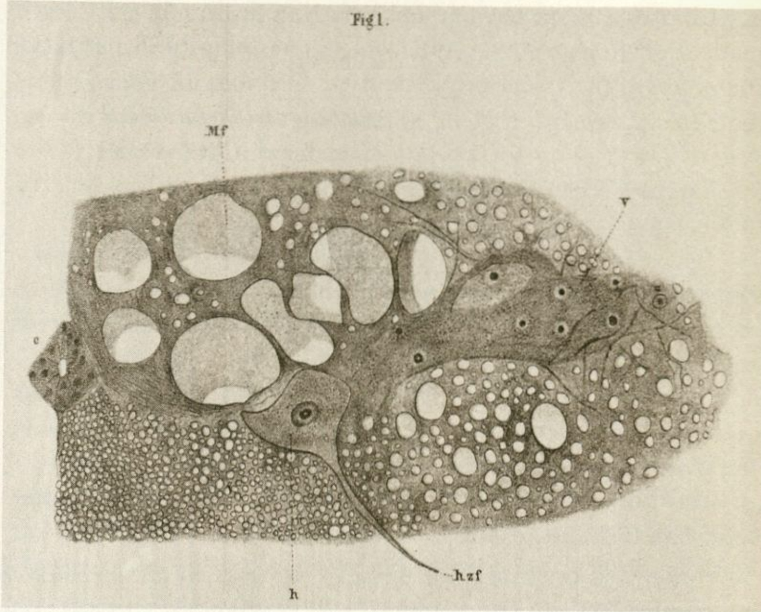
hz. cells of the lobular organ arranged in small clusters.

Comment:

The testicles of the eel had been a puzzling anatomical problem for centuries, for no one could find them – and this made it difficult to imagine how the species reproduced. In this study Freud dissected, in 400 specimens, a lobular organ which a colleague had identified as a likely candidate. In the end, to his disappointment, he could not definitely decide whether this organ was the elusive testicle or not. We now know why: the primitive form of the animal that he dissected was *intersexual* (having both male and female characteristics). Is it not remarkable that the future discoverer of the castration complex began his scientific career by searching, without success, for the missing testicles of the eel?

The lobular organ is seen in Fig 1. Figs. 2-5 depict the cellular structure of its outer layer and its inner contents.

"Über den Ursprung der hinteren Nervenwurzeln im Rückenmark der Petromyzon von Ammocoetes (Petromyzon Planeri)" (On the Origin of the Posterior Nerve Roots in the Spinal Cord of Ammocoetes (Petromyzon Planeri)), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXV. Band. I. Abtheilung (1877).



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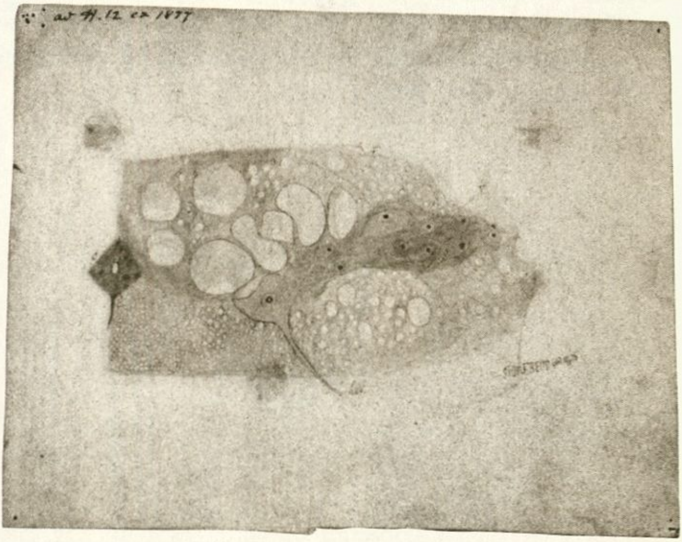
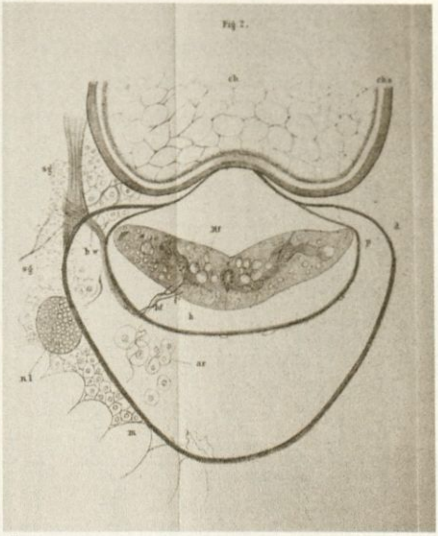


Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

4. "Über den Ursprung der hinteren Nervenwurzeln im Rückenmark der Petromyzon von Ammocoetes (Petromyzon Planeri)" (On the origin of the Posterior Nerve Roots in the Spinal Cord of Ammocoetes (Petromyzon Planeri)), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXV. Band. I. Abtheilung (1877). The New York Academy of Medicine.

Fig. 1. Half of a transverse section of the spinal cord of the Ammocoetes, fixed in Muller's fluid. A segment is missing from the anterior, external corner [top right].

c. = central canal.
h. = posterior cell.
hzf. = posterior-cell process.
M.f. = Muller's fibre.
v. = anterior horn.



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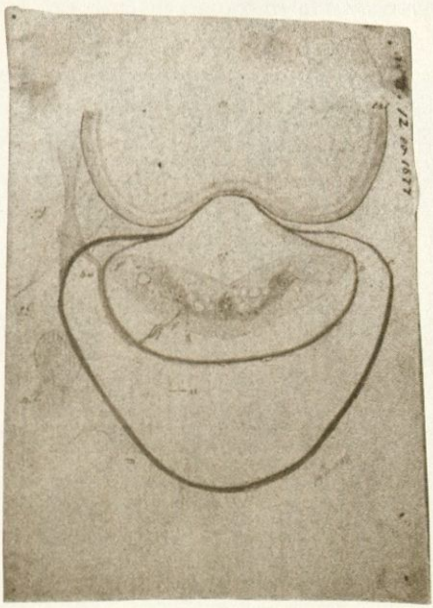


Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

5. "Über den Ursprung der hinteren Nervenwurzeln im Rückenmark der Petromyzon von Ammocoetes (Petromyzon Planeri)" (On the Origin of the Posterior Nerve Roots in the Spinal Cord of Ammocoetes (Petromyzon Planeri)), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXV. Band. I. Abtheilung (1877). The New York Academy of Medicine.

Fig. 2. A transverse section through the whole of Ammocoetes; chromic acid preparation. The tissues surrounding the central canal are incompletely drawn.

ch. = chorda dorsalis.
chs. = the three layers of the internal chordal sheath.
d. = dura mater.
p. = pia mater.
ar. = cells and elastic fibres in the arachnoid space.
m. = muscle segments
n.l. = transverse section of the nervus lateralis
M.f. = Muller's fibre.
c. = central canal.
h. = posterior cell.
h.f. = posterior-cell fibre.

Adjacent are other root fibres.

f. = which cannot be followed as far as the posterior cells.
h.w. = posterior root.
s.g. = surrounding fatty tissue within which the cartilaginous skeleton of the Petrmomyzon is embedded.

Comment:

The study for which these drawings were prepared was Freud's first neuroscientific publication. This study (which continued into the following two) was concerned with the histology of the nerve cell – the basic element of nervous tissue. The drawings show sections through the spinal cord of a primitive fish called Petromyzon or Ammocoetes, commonly known as the lamprey. Freud's scientific task was to describe the structure of particular nerve cells and fibers in the spinal cord of this species, and discuss them in relation to others. The nerve cells are indicated in both drawings by the letter h. The fibers attached to the cell bodies (axons) are indicated by the letters hf and hzf.

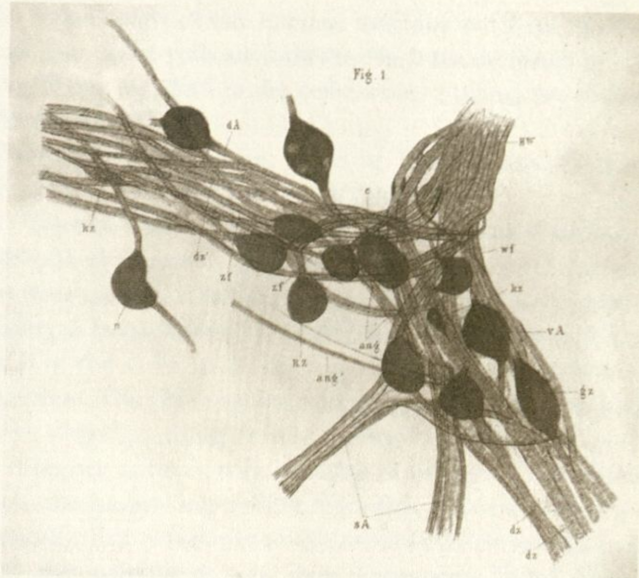
The following quotation, made in 1953 by Freud's biographer Ernest Jones, describes the broader context:

> "Together with the problem of the intimate structure of nervous elements … [there was the] question of whether the nervous system of the higher animals is composed of elements different from those of the lower animals, or whether both are built of the same units. This topic was highly controversial at that time. The philosophical and religious implications seemed to be very disturbing. Are the differences in the mind of lower and higher animals only a matter of degree in complication? Does the human mind differ from that of some mollusc – not basically, but correlative to the number of nerve cells in both and the complication of their respective fibres? Scientists were searching for the answers to such questions in the hope of gaining definite decisions – in one way or another – on the nature of man, the existence of God, and the aim of life." (*Sigmund Freud: Life and Work* [London: Hogarth Press, 1953, p. 51]).

To this vast and exciting field of research, these early studies of Freud's belong.

"Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878).

Plates I–IV



6.

Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

6. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate I

Fig. 1. Spinal ganglion of Petromyzon, gold stain, drawn with Hartnack Ocular 3, objective 8 and X, magnification 520.

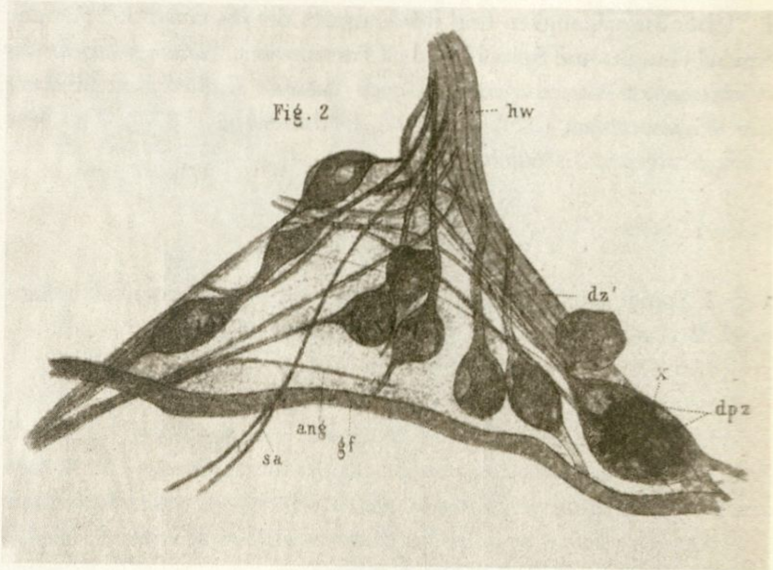
Spinal ganglion with 15 cells, five larger and one small cell in ventral branch, eight medium-sized and one small cell in dorsal branch. The differences in size between dorsal and ventral cells are not great. Both processes of all 13 cells of the first and second magnitude can be traced. In the dorsal branch is a Ranvier cell *RZ*. The last dorsal cells somewhat displaced.

The central process of cell *n* torn off. The only visible nucleus is on cell *c*. The other nuclei cannot be recognized due to excessive staining of cells.

Two broad, through-going fibres *dz* in the ventral branch. Many medium-sized through-going fibres in both branches.

Anaclitic fibres clear at *ang*. Two sympathetic fibres are present.

HW = posterior root.
vA = ventral branch.
kz = small cell.
dA = dorsal branch.
gz = large cell.
zf = cell fibres.
ang = anaclitic fibres.
sA = sympathetic branch.
dz = broad through-going fibre.
dz = medium-sized through-going fibre.
wf = fibre twisting round root.
RZ = Ranvier cell.



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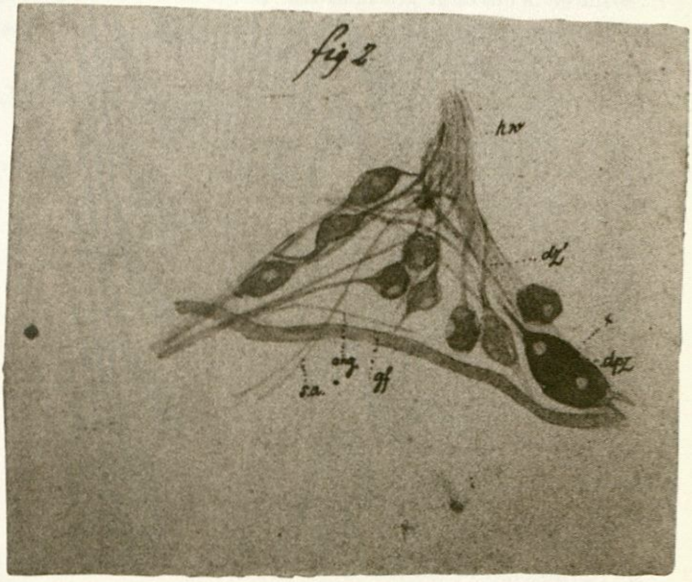


Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

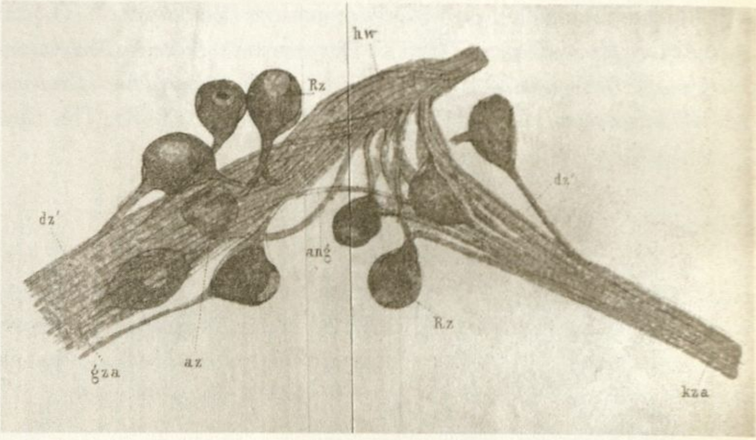
7. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate I

Fig. 2. Spinal ganglion of Ammocoetes, gold stain, drawn with Hartnack 2/8, obj. X could not be used. Several cells appear, therefore, unipolar. On squashing the spinal ganglion it could be seen that all cells, with the exception of the double cell *dpz*, were bipolar.

After isolation, the double cell displayed at *x* a second central process. Magnification 305.

gf = vessel.
sa = sympathetic branch.
dz = mass of through-going fibres.
hw = posterior root.
ang = anaclitic fibres.



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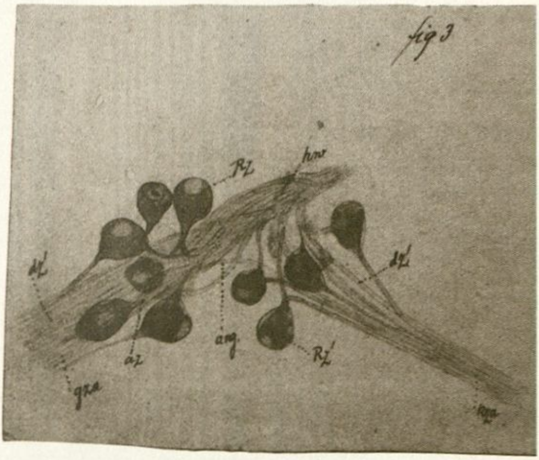


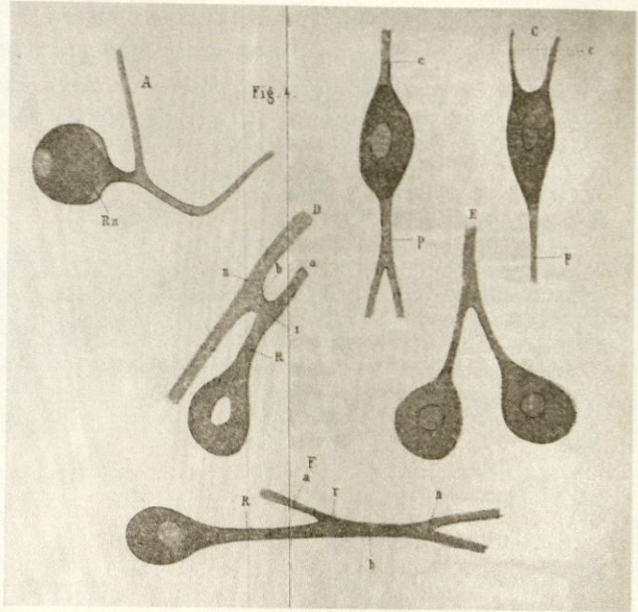
Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

8. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate I

Fig. 3. Spinal ganglion, gold stain, drawn with Hartnack 2/8, obj. X could not be used. On squashing the slide, one could see the two processes of the cell *az* which previously appeared apolar. Two Ranvier cells *Rz* and *Rz'*. The latter with very short process. Magnification 435

HW = posterior root.
gza = branch of large cell.
dz = through-going fibres.
kza = branch of small cell.
Rz, Rz' = Ranvier cells.
az = cell apparently without process.
ang = anaclitic fibres which describe an arc from the ventral to the dorsal branch.



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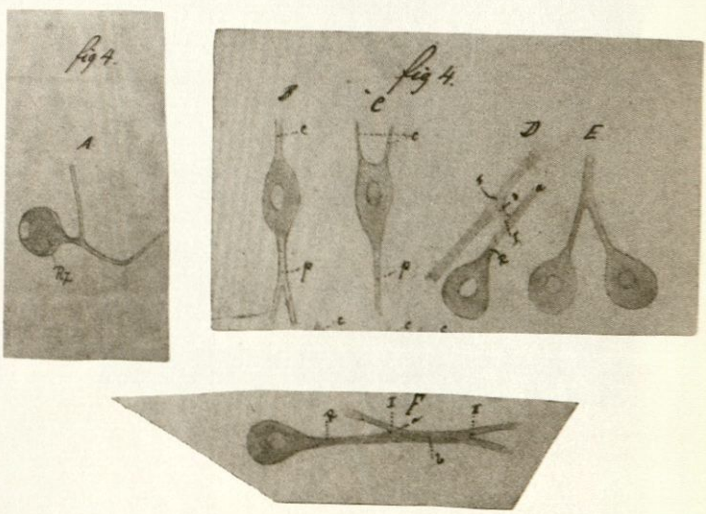


Freud's original drawings (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

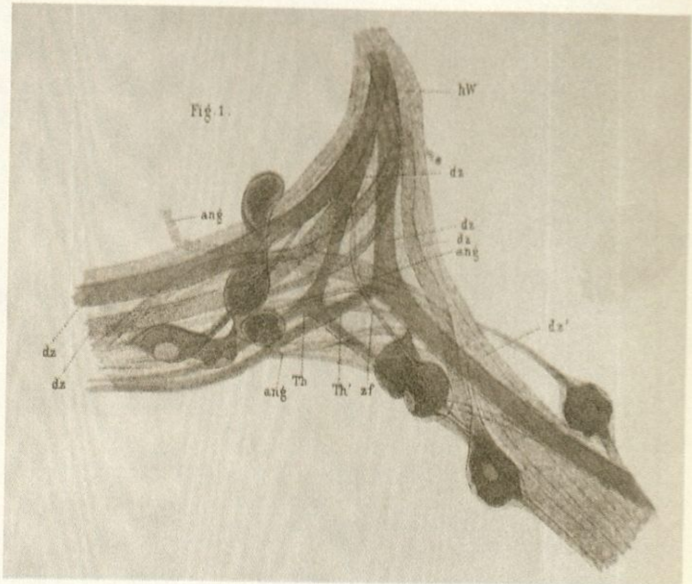
9. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate I

Fig. 4. *A.* Ranvier cell from one of the last spinal ganglia, gold stained.

Fig. 4 *B-F.* Isolated cells from spinal ganglia drawn from pencil sketches of the slides.

B = bipolar cell with division of the peripheral process.
C = Similar forms found in the spinal cord.
D = Ranvier cell; the process of cell *R* divides at *I.* Of the two branches, branch *b* divides again in the shape of a T at *II.*
E = Two apparently unipolar cells, the processes of which unite.
F = Ranvier cell; the process of cell *R* divides for the first time at *I,* one of the two branches (*b*) divides again, fork-shaped, at *II.*



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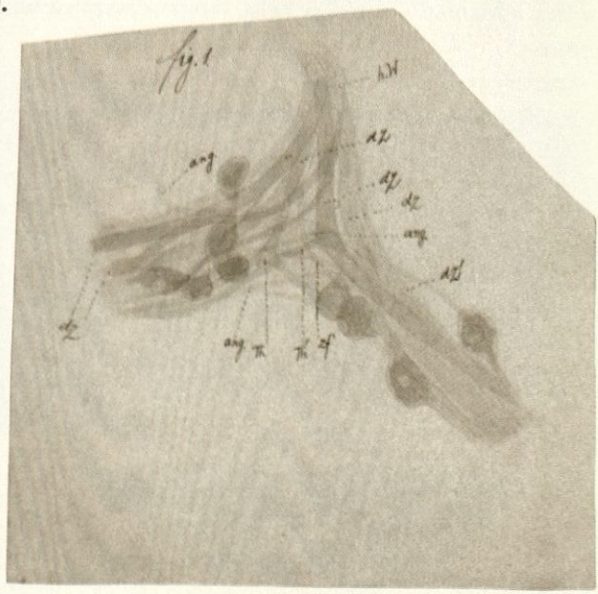


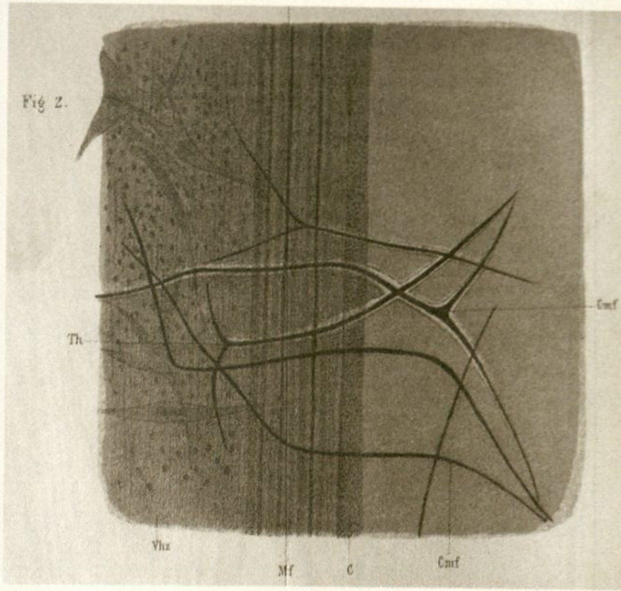
Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

10. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate II

Fig. 1. Spinal ganglion, gold stained. Drawn with Hartnack 3/8. Magnification 435. Several broad through-going fibres, some of which divide.

HW = posterior root.
dz = broad through-going fibre.
dz = through-going fibre.
zf = cell fibre.
Th = division of fibres.
Th = division of broad fibre into two branches of different width.
ang = anaclitic fibre.



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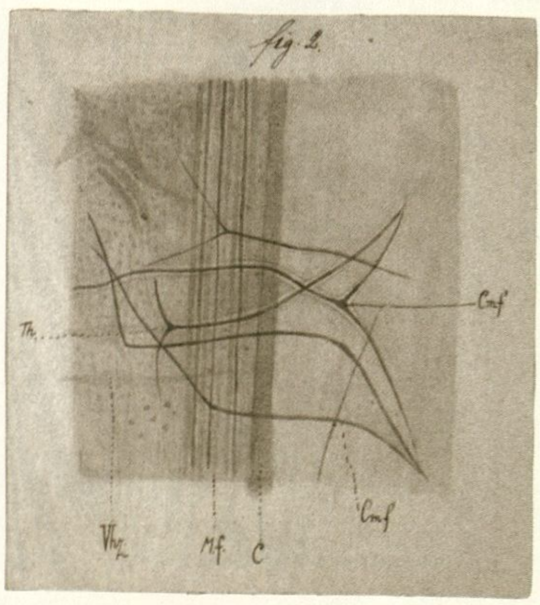


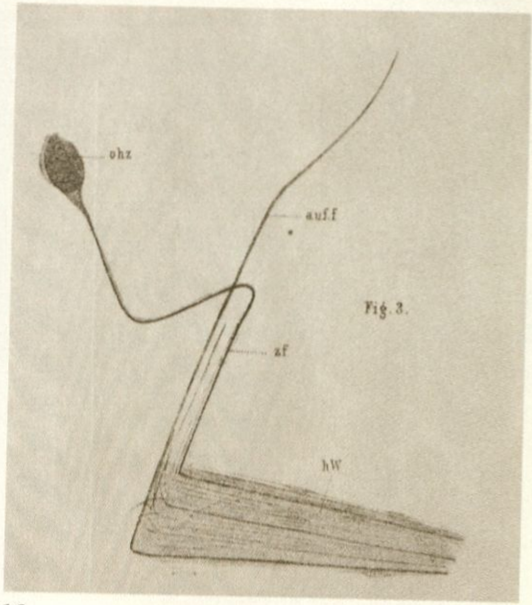
Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

11. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate II

Fig. 2. Spinal cord of Petromyzon marinus. Viewed from anterior surface. Alcohol and carmine preparation. Magnification 115. Anterior superficial decussation of fibres.

C = central canal.
Mf = Müller's (calossal) fibre.
Vhz = anterior horn cells.
Cmf = anterior decussation of fibres.
Th = division of fibres.



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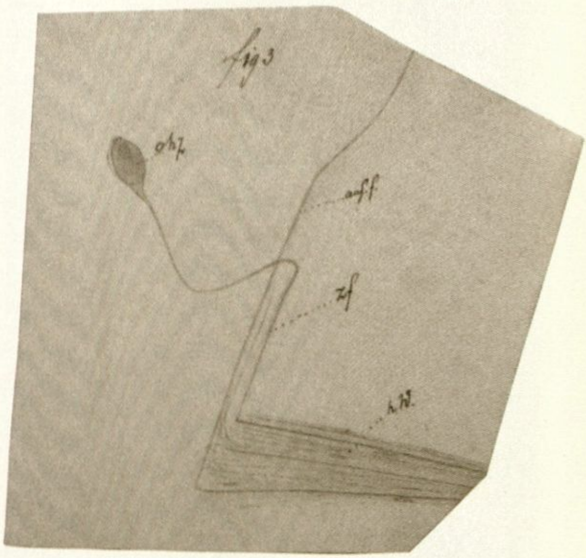


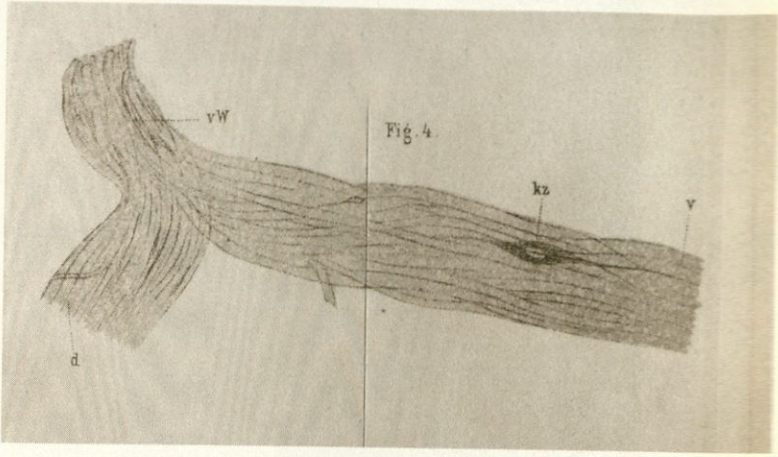
Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

12. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate II

Fig. 3. A posterior root with superficial posterior cell on *pia mater.* Alcohol carmine preparation. Magnification 220.

HW = posterior root.
zf = cell fibre.
ohz = superficial posterior cell.
auff = ascending fibre.



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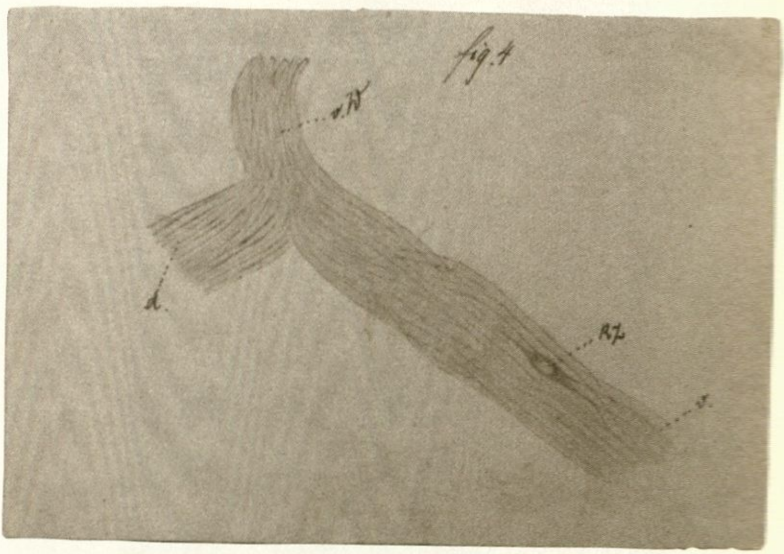
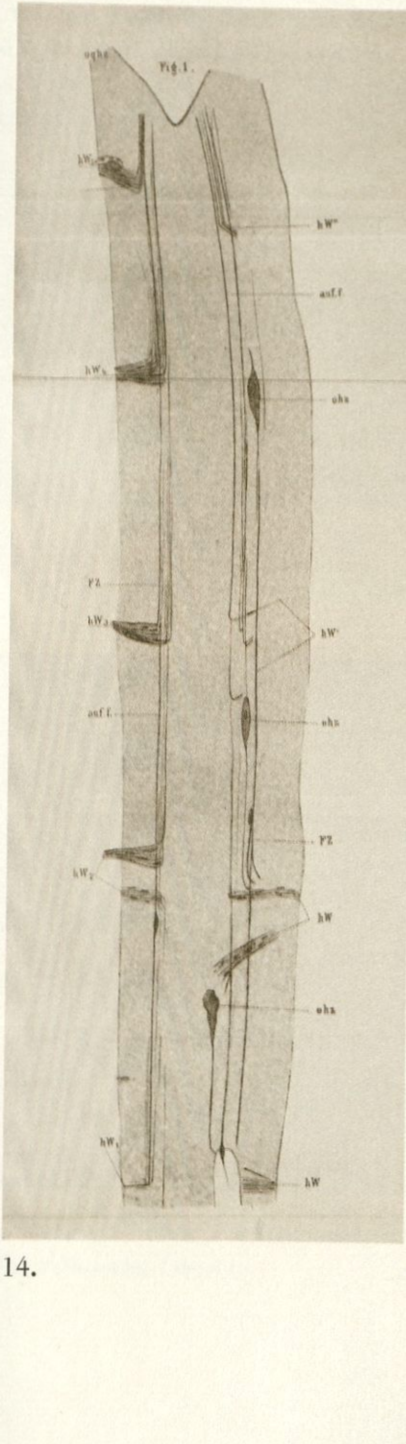


Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

13. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate II

Fig. 4. Anterior root, gold stain, magnification 285.
aW= anterior root.
d= dorsal branch.
v= ventral branch.
kz= small interposed cell.



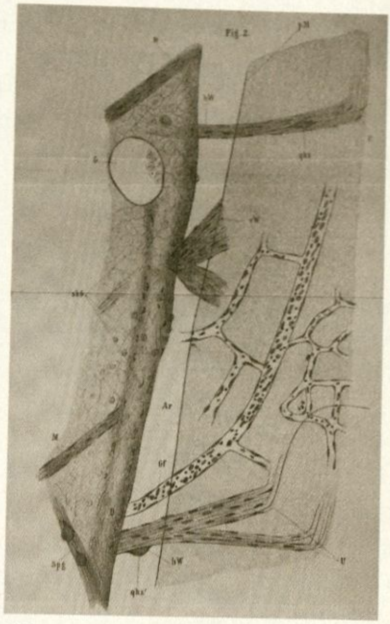
14.

14. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate III

Fig. 1. Flat slice of pia mater with five posterior roots, the superficial fibres and posterior cells. Chromic acid preparation, gold stain. Magnification 50. At *hW2*, hW and *hW'* two half-roots in place of a single one.

*hw*1 - *hw*5 = posterior roots.
ohz = superficial posterior cell.
auf.f = ascending fibres.
qhz = posterior cell lying in the root.
FZ = fibres joining in the course of ascending fibres.



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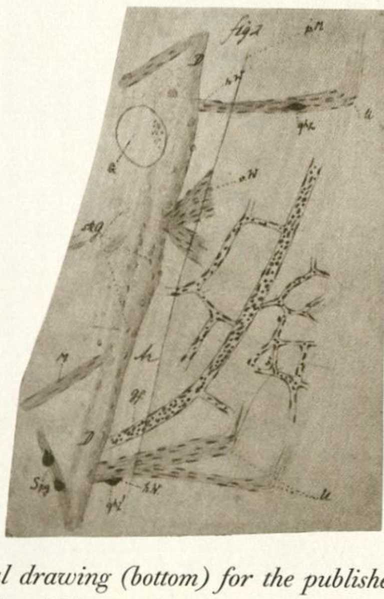


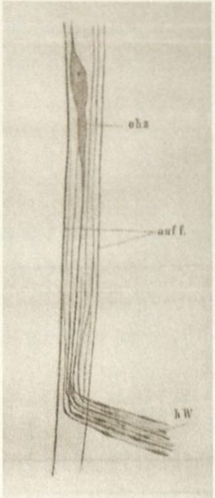
Freud's original drawing (bottom) for the published illustration (top). Ink on paper. Freud Museum, London.

15. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

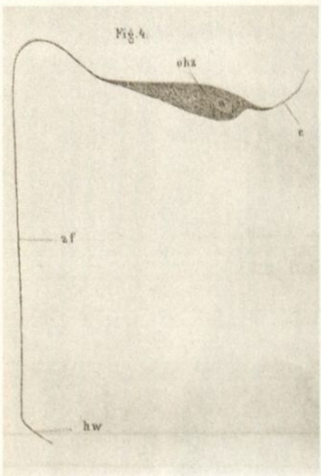
Plate III

Fig. 2. Flat slice (frontal) through pia mater and surrounding tissues. Chromic acid preparation, gold stain. Magnification 105. Cells lying in the transverse course of root *qhz* and *qhz*.

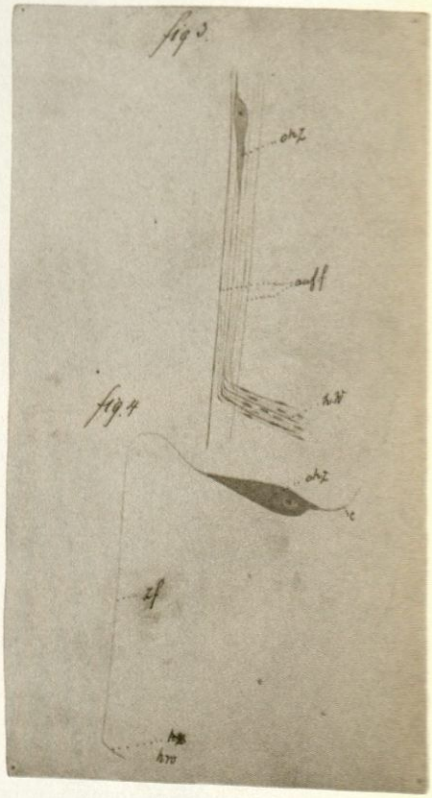
sz G = so-called bone-forming tissue round the vertebral canal.
D = dura mater.
Ar = arachnoidal space.
Spg = spinal ganglion.
G = cross-section of vessel.
M = muscle.
hW = posterior root.
U = bend of posterior root fibres in the spinal cord.
vW = anterior root.
Gf = vessel.
qhz = transverse posterior cells lying in the root.



16a.



16b.



Freud's original drawing (right) for the published illustrations (left). Ink on paper. Freud Museum, London.

16. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

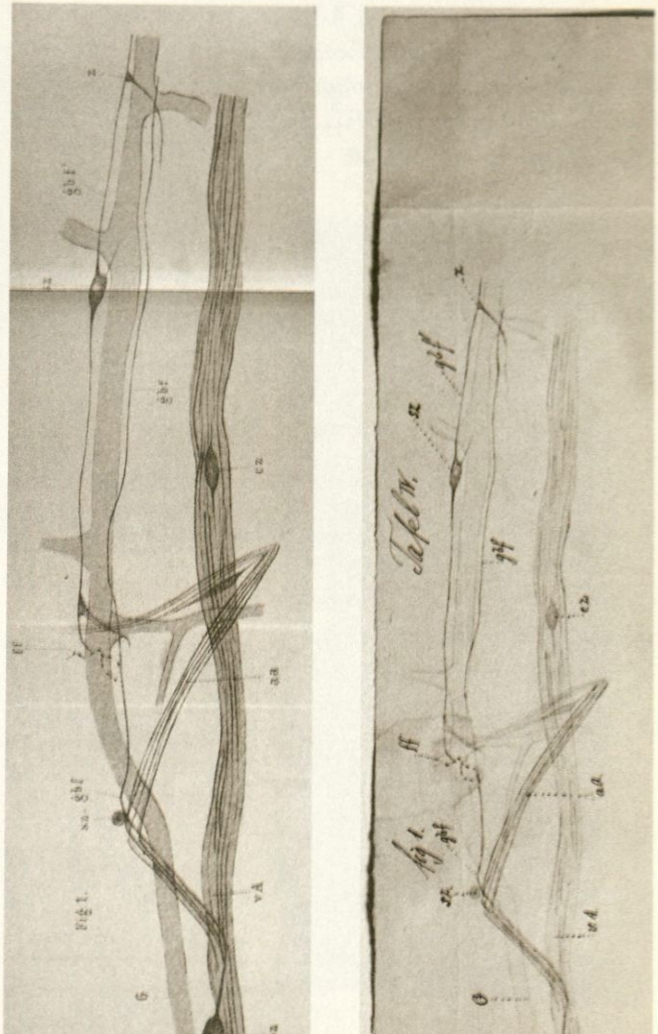
Plate III

Fig. 3. Posterior root with ascending fibre and superficial posterior cell from a flat slice of pia mater. Chromic acid-gold preparation. Magnification 110.

hW = posterior root
auff = ascending fibres from a previous root.
ohz = superficial posterior cell.

Fig. 4. Isolated superficial posterior cell on pia mater. Chromic acid-gold preparation. Magnification 110.

ohz = superficial posterior cell.
zf = its root process.
hw = its bending to posterior root.
c = central process.



17.

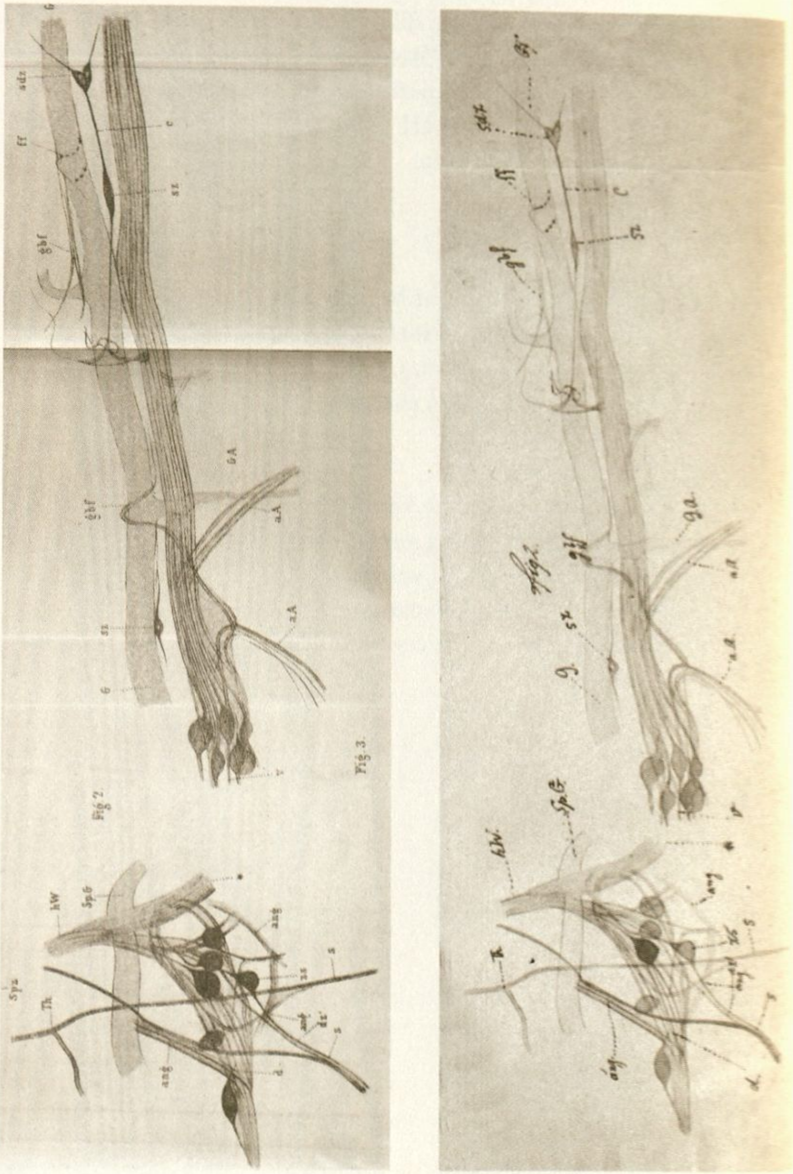
Freud's original drawing (right) for the published illustration (left). Ink on paper. Freud Museum, London.

17. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate IV

Fig. 1. A posterior root's ventral branch with accompanying vessel. One fibre accompanying the vessel *gbf* can be followed into the ventral branch of the posterior root. Gold stain. Magnification 225.

spz = most exterior spinal ganglion cell.
vA = ventral branch.
sz = sympathetic cell.
ez = small cell lying in the ventral branch.
aA = small branch exiting ventral branch.
gbf = fibre accompanying vessel.
z = branch of fibre accompanying vessel.
ff = thin varicose fibre into which the fibre accompanying the vessel merges.



18.

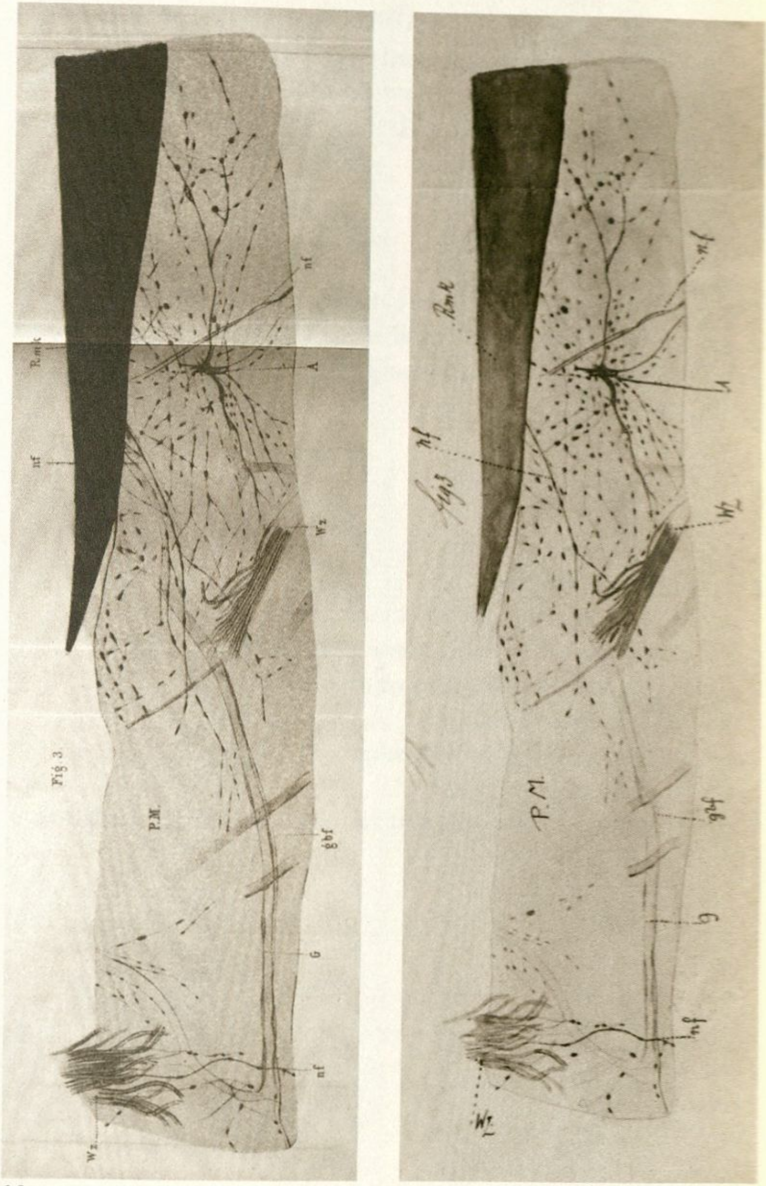
Freud's original drawing (right) for the published illustrations (left). Ink on paper. Freud Museum, London.

18. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate IV

Fig. 2. Spinal ganglion, ventral branch of the posterior root and accompanying vessel. The ventral branch torn before ventral cells enter it. At *C* a commissure between two cells. Gold stain. Magnification 225.

SpG = spinal vessel.
d = dorsal branch.
v = ventral branch.
s = sympathetic branch.
ang = anaclitic fibre.
dz = through-going fibre entering sympathetic branch.
Th = division of a fibre crossing the dorsal branch.
aA = branches exiting the ventral branch.
sz = sympathetic cell.
sdz = sympathetic double cell.
GA = branches of vessel.
zs = spinal ganglion cell emitting its process into the sympathetic branch.



19.

Freud's original drawing (right) for the published illustration (left). Ink on paper. Freud Museum, London.

19. "Über Spinalganglien und Rückenmark der Petromyzon" (On the Spinal Ganglia and Spinal Cord of Petromyzon), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften,* LXXVIII. Band. I. Abtheilung (1878). The New York Academy of Medicine.

Plate IV

Fig. 3. Fine network of varicose fibres on the pia mater. Gold stain. Magnification 185.

PM = pia mater.
Rmk = spinal cord.
Wz = root.
G = vessel in the pia meter.
nf = nerve-fibres which merge into the net of varicose fibres.
A = a point from which the ramifying nerve fibres and the varicose fibres radiate.

Comment:

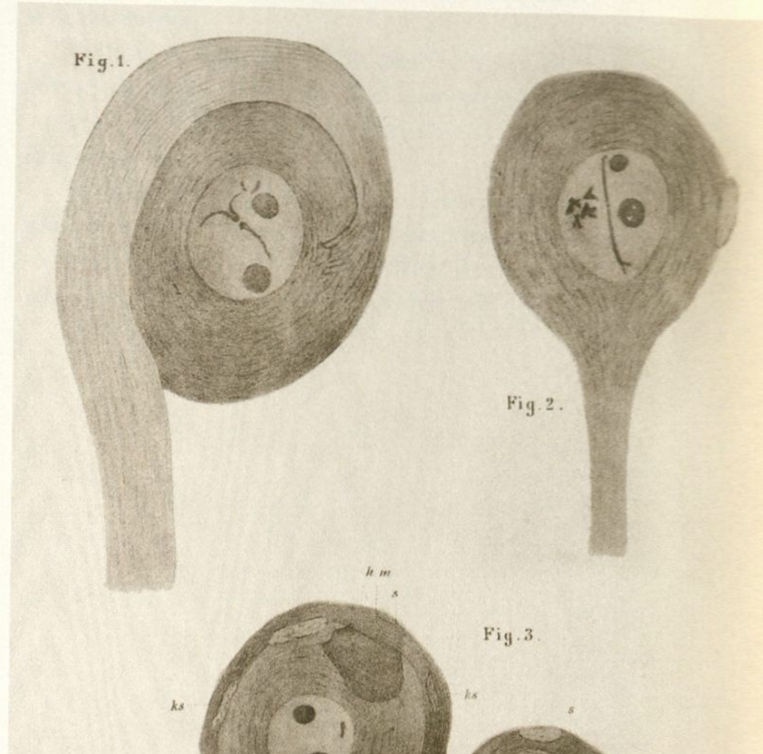
By researching the *genetic migration and transformation* of nerve cells in the spinal cord of Petromyzon (the same lowly species studied in the previous paper), Freud was able to show that a continuous series of subtle changes linked the nervous systems of invertebrates and vertebrates. Previously it was believed that a sharp anatomical division separated these two classes of animal. In other words, Freud discovered something of a "missing link" in this study. He thereby contributed to the great pool of data which finally established in the scientific community the conviction of the evolutionary continuity of all organisms.

Freud also showed in these drawings that along the path originally traversed by its cells through the evolution of the species, some primitive forms had remained behind in the spinal cord of the contemporary animal – fixated, as it were – in their phylogenetic development. We may therefore trace back to these drawings Freud's abiding belief in the *persistence of primitive structures* in the fully developed organism. This connection is underscored by the fact that he later referred to this study when illustrating the concept of fixation in his *Introductory Lectures on Psychoanalysis* (1916-17).

There he wrote:

"... it is possible in the case of every particular sexual trend that some portions of it have stayed behind at earlier stages of its development, even though other portions may have reached their final goal."

We note also, in the legend to these drawings, Freud's first use of the word "anaclytic" – to describe a type of nerve fiber which attaches itself to another fiber that originates in a nerve cell, but is itself independent of that cell.



20.

20. "Über den Bau der Nervenfasern und Nervenzellen beim Flusskrebs" (On the Structure of the Nerve Fibers and Nerve Cells of the River Crayfish), *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften*, LXXXV. Band. III. Abtheilung (1882). The New York Academy of Medicine.

Fig. 1. Nerve cell from the tail ganglion of the river crayfish with a process which clings to the surface of the cell. The nucleus contains, apart from the round nucleoli, several short, thick rods and a nuclear body consisting of two pieces. Drawn with Hartnack 3/8, magnification 360.

Fig. 2. Living nerve cell from an abdominal ganglion with coniform process. The nucleus, which is without a membrane, contains four small particles with multiple peaks and a rod bent at its end and forked. At *k* a nucleus of the covering tissue. Same magnification as Fig. 1.

Fig. 3. Marginal portion of the spindle-shaped gastric ganglion of the river crayfish. Two multipolar nerve cells with their processes, one of which displays a T-shaped partititon. The smaller cell has been drawn with an adjustment near to the surface.

s = thick, concentrically stratified cell-sheath.
ks = nuclei of the above.
hm = strongly shining homogeneous masses at the margin of the cell, but situated interiorly from the cover.
f = fibre from another cell.

his 1895 *Project for a Scientific Psychology* (see Plates 31-33), there was no hint of the fact – which must by then have been clear to him – that he actually played a seminal role in the development of that concept.

In the legend to one the drawings shown here (Fig. 2) Freud mentioned that the cell he depicted was *alive*. He was dissatisfied with the standard technique of observing dead cells under the microscope. His new technique enabled him to directly observe the internal workings of the living cell. A host of structures and processes which had previously been invisible thus suddenly appeared before him. As L. Triarho and M. del Cerro confirm in their 1985 study ("Freud's Contributions to Neuroanatomy," *Archives of Neurology*, 42: 282), this enabled Freud to provide an early account of microtubules (before microtubules were actually discovered) and to unwittingly become the first scientist to report the phenomenon of nuclear rotation of neurons in culture (see legend to Fig. 4). With this new technique, Freud grasped the fact, so important for his later work, that progress in science flows from new methods of observation.