



# Félix Dujardin (1801–1860) and His Contributions to Protistology

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## FROM THE ARCHIVES

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### 4 **Félix Dujardin (1801-1860) and His Contributions to Protistology**

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## Introduction

Félix Dujardin is well known as a key figure of 19th century protistology. He is credited with two major advances: 1) recognizing the true nature of foraminifera and grouping them with others in a new group called "*rhizopodes*", and 2) disputing Ehrenberg's characterization of protists as "Polygastrica" i.e., possessing many stomachs and other organs (e.g. Cole 1926; Corliss 1978). His 1841 monograph of nearly 700 pages, "*Histoire naturelle des Infusoires*" is generally named as his major contribution (e.g. Kudo 1954; Manwell 1968). Dobell stated that the foundation of modern protozoology rests on Ehrenberg's 1838 monograph and Dujardin's 1838 and 1841 'devastating corrective' of it (Dobell 1932). Not very well known is the interesting story of his life and professional career, the full extent of his publications on protists, or his technical contribution to microscopy. Here first will be given an account of Dujardin's life and professional career, followed by an annotated list of his publications on protists, and finally an account of his technical contribution to microscopy, invention of the first microscope condenser.

There are several articles on Dujardin's life and his scientific contributions in French (Fauré-Fremiet 1935; Huard and Théodorès 1959; Joubin 1901; Malgutti 1866; Rideau 2010), one in Spanish (Beltran 1941) and one in English (Geison 1971). As Geison points out, the early and by far most detailed account of Joubin (1901) is essentially an uncritical tribute: "*At the time he wrote this paper, Joubin held the chair at Rennes once occupied by Dujardin, and it was his clear intention to bestow on his predecessor all the honor he had been denied in life*" (Geison 1971). Unfortunately, all subsequent accounts of Dujardin,

54 including Geison's, rely heavily on that of Joubin (some to the point of near  
plagiarism). Consequently, the image of a modest man beset by unfair  
56 professional setbacks dominates the biographies of Dujardin. The biographies  
listed above are largely the basis of the account given of Dujardin's life and  
58 career here. However, some events not mentioned in previous accounts of his life  
are given, and based on them, another view of Dujardin's personality will be  
60 proposed.

## 62 **The Life and Career of Félix Dujardin**

Félix Dujardin was born April 5th, 1801 into a middle class family in the city of  
64 Tours, in the center of France. His father and grandfather were watchmakers.  
However, he was apparently uninterested in continuing the family business. As  
66 an adolescent, he had two interests, art and chemistry. At age 17, he attempted  
and failed the entrance exam for the '*Ecole Polytechnique*' in Paris with the goal  
68 of pursuing chemistry. His parents subsequently sent him to Paris to follow  
classes in mathematics and French to bolster his chances at another attempt.  
70 However, he spent much of his time in the studio of Gérard, the preeminent  
portrait artist of his time. He returned to his parent's home in 1820, now living in  
72 Deux-Croix, and convinced them to let him try his hand at agriculture but soon  
afterwards returned to Tours once again and began working as a tutor. He was  
74 hired as an engineer to oversee construction of hydrological installations in  
Sedan, in the Northeast of France. There he met and married Clémentine  
76 Grégoire in 1823. From Sedan the young couple moved to Paris where Dujardin  
worked as a lithographer. By 1824, the couple returned to the region of Tours for  
78 the birth of their first child Albert-Félix. On the birth certificate, Dujardin gave



his occupation as 'painter'. In Tours he made his living managing a bookstore  
and tutoring and by 1826 he was employed by the city to give classes to  
workmen in mathematics and industrial chemistry. From 1826 to 1834, he  
apparently lived from teaching and tutoring and occasional work as an engineer  
as no other jobs are mentioned in the biographies.

Dujardin's official entrance into the scientific community of France  
appears to have been in 1828, the year his name appears as a corresponding  
member of the *Société d'Histoire Naturelle de Paris* (front matter, 1828 *Mémoires  
de la Société d'Histoire Naturelle de Paris*). At that time membership in the *Société*  
was limited to a chosen few (Roux 1924). His nomination was likely due to his  
first publication on the geology of region of Tours (Dujardin 1828a). The  
membership was of some importance to Dujardin as his second publication  
(Dujardin 1828b), also on geology of the region, he signed as "*Correspondant de  
la Société d'Histoire Naturelle de Paris*". Nonetheless, Dujardin did not neglect  
local scientific societies. In 1828 he also became a member of the *Société  
d'Agriculture, Sciences, Arts et Belle Lettres de Touraine* and in 1830 held the  
office of Secretary of the Section of Sciences, his first office in a scientific society.  
In 1833 Dujardin became a member of the *Société Géologique de France* (front  
matter, 1833 *Mémoires de la Société Géologique de France*). In 1835 he proposed  
his candidacy (Anon. 1835a) and was elected vice secretary (front matter, 1835  
*Mémoires de la Société Géologique de France*). Notably, in the next membership  
listing of 1838 (front matter, 1838 *Mémoires de la Société Géologique de France*)  
Dujardin's name no longer appears. His relatively substantial but brief  
involvement in the *Société Géologique de France* is not mentioned in any previous  
accounts of Dujardin.

104 In 1833 Dujardin was offered a teaching job in a secondary school in  
Tours if he could obtain the diplomas needed to qualify for the job. The offer  
106 spurred him to sit for examinations. In rapid succession, he obtained a  
*Baccalauréat* in Letters in Orléans on March 28, a *Baccalauréat* in Science and  
108 Mathematics in Paris on April 1st and a *Licence* (Bachelor's degree) in Physics on  
April 5 in Paris. However, friends advised him that if he wanted a real career it  
110 would have to be in Paris. Apparently, that is what he desired; in June of 1834 he  
set off with his family for Paris. Shortly after installing his family in Paris,  
112 Dujardin left for Toulon on the Mediterranean coast to collect and make  
observations of what would later come to be known as rhizopods. Curiously,  
114 none of the accounts of Dujardin mention what motivated his seemingly sudden  
intense interest in examining living foraminifera, sponges and corals, nor if his  
116 family accompanied him or not during his month's long stay in Toulon. Also  
curious is that he was already known, or made himself known, in scientific  
118 circles of Paris in 1834. A notice appeared in '*L'Echo du Monde Savante*', a  
scientific newspaper, concerning his activities since his arrival in Paris. It stated  
120 that Dujardin had passed most of the summer and autumn on the Mediterranean  
coast observing 'zoophytes' and that his drawings would soon appear (Anon.  
122 1834). Dujardin was soon formally involved in yet another scientific society, if  
only for a short time.

124 In January of 1835 the *Société d'Histoire Naturelle de Paris*, with its strictly  
limited membership, transformed itself into a new open membership society,  
126 replacing in its name "*de Paris*" with "*de France*". Dujardin stood as candidate in  
the new *Société* and was elected vice-Secretary and editor of a new publication,  
128 the *Bulletin de la Société Naturelle de France* (Anon. 1835b). In May he abruptly

resigned from the *Société*, an event reported on page 1 in the scientific press  
(Anon. 1835c), without however any explanation. This second very brief but  
substantial involvement in a new scientific society is also absent from previous  
accounts of Dujardin's career.

It was in 1835 that Dujardin first began publishing on protists and his  
reports were based on his work in 1834 in Toulon. His first protistological  
presentation was at one of the first meetings of the *Société des Sciences Naturelles*  
*de France*. On the January 23 of 1835 meeting he read a paper entitled "*Sur les*  
*prétendues Céphalopodes microscopique*". This first protistological presentation  
of his was actually quite important. Dujardin revealed that forms that had been  
classified as microscopic cephalopods, based on gross morphology of the shells  
(i.e., d'Orbigny 1826), were in reality not cephalopods at all. Dujardin, unlike  
d'Orbigny, observed live the forms we know now as foraminifera and gromids  
(now classified as cercozoans). He declared them to be organisms unlike any  
known and proposed the name "*Symplectomères*", as the cell contents appeared  
to be composed of 'folding parts'. A summary of his presentation was published  
twice. Once in the March 1835 issue of the *Bulletin* of the society (Dujardin  
1835a) and also in the *Annales des Science Naturelles*, labeled as an extract from  
the *Bulletin* but it appeared in the February issue (Dujardin 1835b). While it is  
unclear which appeared first, the texts are identical.

By April 1835, he was on his way back again to Toulon to continue his  
studies (Anon. 1835d). In late June, Dujardin sent letters from Toulon, describing  
his results, to the *Académie des Sciences* and to a scientific newspaper, '*L'Institut*'.  
At that time, the proceedings of the meetings of the *Académie des Sciences* were  
not published. However, they were covered in detail in the scientific newspaper,

154 'L'*Institut*', which had been created largely for that purpose (Arnault 1833). In  
his letter, Dujardin gives a new name to his *Symplectomères*, he now calls them  
156 "*Rhizopodes*" meaning root-feet. In his view, their branching cell projections or  
feet, used for both motility and prey capture, resembled roots. He also described  
158 the first species named as a rhizopod, *Gromia oviformis*. Dujardin's sending a  
copy of his letter to *L'Institut*, was a shrewd move. It was published on June 24,  
160 1835 in *L'Institut* (Dujardin 1835d) while the actual report made to the  
*Académie*, describing the contents of Dujardin's June letter, was not read to the  
162 *Académie* until a month later on July 27 1835, and would not be published by the  
*Académie* until 1922 when proceedings from meetings prior to August 1835  
164 were published. It was only from August 1835 on that proceedings of the  
meetings, held on Mondays, were regularly published, and rapidly, appearing on  
166 the following Saturday (pers. comm., Isabelle Maurin-Joffre, *Archiviste Académie  
des Sciences*).

168 It is unclear when Dujardin returned to Paris. However, he presented  
further observations on rhizopods to the *Académie* in November. It is also  
170 unclear how Dujardin made his living at this time. The biographies mention only  
translation work and writing for periodicals. In May of 1836 he launched a new  
172 scientific newspaper. According to the accounts of Malgutti (1866) and Joubin  
(1901), it was created by Dujardin to make money, and he wrote all the contents.  
174 The source of the capital used to create the newspaper is not known. The paper  
should have appeared unlikely to succeed as a profitable enterprise, given the  
176 competition. It was called *Hérmès*, subtitled a journal of scientific news (Fig. 1)  
and appeared on Wednesdays and Saturdays, priced at 22 francs per year.  
178 Dujardin's venture into journalism competed with well-established, well-known,

and similarly priced science newspapers. *L'Echo du Monde Savante*, in its third

180 year, appeared on Thursdays and Sundays and was priced at 20 francs per year.

*L'Institute* which Dujardin had used to publish his observations on rhizopods the

182 year before, was also in its third year, was priced at 30 francs per year, and it

appeared on Wednesdays. Perhaps predictably then *Hérmes* ceased publication

184 after a few months, absorbed by *L'Echo du Monde Savante* by October of 1836.

186

figure 1 here please

188

**Figure 1.** The first issue of Dujardin's ill-fated foray into scientific journalism,  
190 *Hérmès*, appeared on May 4th, 1836. It was in competition with established  
scientific newspapers and was absorbed by one of its competitors by October  
192 1836 (Anon. 1836).

194 While his newspaper attempt failed in 1836, there were brighter events.  
He was named a member of the prestigious *Société Philomathique*, long  
196 considered a waiting room for those hoping to join the *Académie des Sciences*  
(Chappey 2010). Dujardin resumed his geological studies, traveling across  
198 Europe collecting fossils. However, according to one account (Rideau 2010) his  
finances were in such poor shape by 1838 that he had to sell some of the family  
200 silverware and one of his microscopes. In May of 1839 he was appointed to the  
Chair of Geology at the University of Toulouse, in the south of France about 150  
202 km inland from the Mediterranean coast. His tenure though was short. Dujardin  
was offered and accepted a Chair of Zoology and a deanship in a newly created  
204 Faculty of Sciences in Rennes, about 70 km inland from the coast of the English  
Channel. He left Toulouse for Rennes in November of 1839. It is unclear if  
206 abandoning his chair in Toulouse after only a few months was motivated by a  
desire to be a zoologist rather than a geologist, or the prestige of a deanship, or  
208 both. As it turned out, he was not welcome in Rennes. The faculty members held  
against Dujardin the fact that local candidates for the Chair of Zoology had been  
210 ignored and that Dujardin was named Dean, but did not hold the terminal  
diploma of "*Aggregation*" as did other faculty. Between the ill feelings of the

212 faculty and organizational problems, he nearly lost both the chair and the  
deanship. In 1842 he was summoned to Paris and told by the Minister of  
214 Education that he would no longer be Dean but he would retain his Chair of  
Zoology. While Dujardin's career in academia was tumultuous, his scientific  
216 career advanced significantly.

In 1838 Dujardin published his first overview of protists in an 85-page  
218 article "*Mémoire sur l'Organisation des Infusoires*" (Dujardin 1838g) based on his  
doctoral thesis (university unknown). It contained a scathing critique of  
220 Ehrenberg's *Polygastrica* and his characterizations of many taxa. A summary of  
the article in English appeared in the *Annals and Magazine of Natural History*  
222 (Dujardin 1839a). In 1840 Dujardin's classification of protists was published in  
the proceedings of the Academy (Dujardin 1840a). In 1841 appeared his  
224 "*Histoire Naturelle des Zoophytes Infusoires, comprenant la Physiologie, et la*  
*Classification des ces Animaux et la Manière des les Etudier à l'Aide du Microscope*".  
226 It was accompanied by an "*Atlas*" of 22 color plates and even the plates were  
used to criticize Ehrenberg (e.g., Fig. 2.). The appearance of the 1841 monograph  
228 marked the end of his studies of protists with the single exception of an 1852  
paper. For the remainder of his life he focused on invertebrate zoology. It is only  
230 from this later period that we have illustrations of Dujardin himself, one a  
miniature painting by his daughter from about 1844 and another, a portrait by  
232 Roy from about 1853 (Fig. 3). Félix Dujardin died only a few years later on April  
8th, 1860, at the age of 59 from an unnamed but long-endured disease.

Figure 2 here please

**Figure 2.** Plate 8 from the Atlas of Dujardin's 1841 *Histoire Naturelle des Zoophytes*. In the plate, the figure 5 is a *Paramecium* feeding on carmine particles and figures 6a and 6b are the same cell in decomposition, extruding 'sarcode', cytoplasm. Dujardin pointed out in the plate legend that the star-shaped structures in fig. 6a, recognizable today as contractile vacuoles (Lloyd and Beattie 1928), of a decomposing *Paramecium* were described by Ehrenberg as seminal vesicles.

Figure 3 here please

**Figure 3.** Félix Dujardin at about age 43 from a miniature painting by his daughter, Louise (A) and about age 52 by the portrait artist Roy (B).

Dujardin's landmark book on protists was dedicated to Henri Milne Edwards with whom he had a puzzling relationship. In Dujardin's time, Milne Edwards was a powerful scientific figure. He was elected a member of the *Académie des Sciences* in 1838, named Professor at *Muséum d'Histoire Naturelle* in 1841, and in 1849 named Professor and Dean of the Faculty of Science in Paris (Berthelot 1904). According to Joubin (1901) Dujardin believed Milne Edwards turned against him in 1839, for unknown reasons, and subsequently worked against Dujardin's advancement, for example preventing him from obtaining any position in Paris. However, Milne Edwards was also the long-time editor of the *Annales des Sciences Naturelle, Zoologie* in which Dujardin published most of his important articles on protists including the long critique of Ehrenberg's



260 Polygastrica in 1938. Perhaps because of this he dedicated his major work on  
protists to Milne Edwards. While it is not possible to know if Milne Edwards  
262 actually did harbor ill feelings towards Dujardin, Milne Edwards repeatedly  
ignored Dujardin's work on protists.

264 Milne Edwards authored important texts laying out the official national  
curriculum for zoology in all the secondary schools of France. In the first 1841  
266 edition, the short sections concerning infusoria refer to them as having many  
stomachs and thus often termed *polygastrica* (Milne Edwards 1841). In a 'new'  
268 edition published in 1847, infusoria are not referred to as polygastrica but are  
described as having several stomachs (Milne Edwards 1847). Only in the 1853  
270 edition of the manual were infusoria not described as multi-stomached (Milne  
Edwards 1853). Years later, Milne Edwards was tasked by the Ministry of  
272 Education with writing a comprehensive report summarizing recent progress in  
zoology in France. In the report he mentions at some length Dujardin's later  
274 work on parasitic worms, echinoderms, and insects (Milne Edwards 1867). The  
only mention of protists is a short statement concerning his contribution to  
276 knowledge of the 'organisation' of foraminifera and citations of only two of  
Dujardin's early articles in the *Annals des Sciences Naturelles*. Thus, 7 years after  
278 Dujardin's death, Milne Edwards continued to ignore Dujardin's major works on  
protists.

280 In addition to ignoring Dujardin's work, perhaps Milne Edwards did work  
against him. Dujardin attempted and failed twice to obtain a faculty position at  
282 the *Muséum d'Histoire Naturelle* in Paris, first in 1844 and again in 1855.  
Dujardin also attempted twice to be elected to the *Académie des Sciences* by  
284 nominating himself. In Dujardin's time candidatures and election results of the

*Académie* were very public affairs. Thus, in 1844 it was reported in the press that

Dujardin had received the votes of only 3 of the 54 members of the *Académie*, coming in last (Anon. 1844a,b). The 1852 attempt was if anything worse.

Although ranked first among 3 candidates in committee evaluations according to the press (Anon. 1852a), he finished third, receiving but a single vote in the second tally (Anon. 1852b). Given the dismal results and their public nature, one cannot help but wonder why Dujardin persisted, especially if he believed that Milne Edwards, who was well-established at the *Muséum d'Histoire Naturelle*, and in the *Académie des Sciences*, did work against him. One explanation is that rather being of a modest nature as portrayed in the biographies Malgutti (1867) and Joubin (1901), he was an ambitious man.

A chronology of his scientific career does not easily fit the profile of a modest man. He submitted candidatures for office in a scientific society in 1830 (*Société d'Agriculture, Sciences, Arts et Belle-Lettres de Touraine*), and in twice in 1835 (*Société de Géologie de France* and *Société d'Histoire Naturelle de France*). He single-handedly created a scientific newspaper in Paris in 1836. In 1839 he accepted a Chair of Geology at the University of Toulon and a few months later left it to become Dean and to occupy a chair of Zoology in Rennes. In 1844 he applied for a Chair at the *Muséum d'Histoire Naturelle* in Paris and for membership in the *Académie des Sciences*. In 1852 he again posed his candidature for the *Académie des Sciences* and in 1855 again for a Chair at the *Muséum d'Histoire Naturelle* in Paris. The chronology is one of someone who was both ambitious and persistent; such personalities can foster hostility in others.

He was only rather begrudgingly given recognition and this suggests that he was not popular. He was first proposed for the *Légion d'honneur* in 1847,

ranked as a top candidate, and according to an apologetic letter from the secretary of the *Légion d'honneur*, mysteriously overlooked (Joubin 1901). He was elected in 1850 at age 49 but with his service to public education was given as the basis, not his scientific contributions. His son Albert-Félix was elected at age 32 in 1856 to the *Légion d'honneur* as a military physician and teacher. Dujardin did eventually join the ranks of the *Académie des Sciences*, but only as a corresponding member in 1859, two years before his death when he died at the relatively young age of 59 years. The cause of death was described only as a disease that had weakened him for many years. The portraits shown in Fig. 2 do suggest a rapid aging from 42 to age 53 years of age.

### **Dujardin's Protist and Microscopy Publications**

Dujardin's scientific contributions ranged across a wide variety of fields from geology to microscopy. His scientific output was considerable, totaling well over 100 works (excluding hundreds of entries he wrote for the encyclopedic *Dictionnaire Universel d'Histoire Naturelle*). The temporal distribution of his works parsed into broad subject areas shows that his interests varied with time (Fig. 4). Based on his publications, his scientific career can be roughly divided into three major subject periods, albeit with considerable temporal overlap. He began with geology that in 19th century included what we now call paleontology (1828-1838), then turned to protists (1835-1841), followed by zoology, both invertebrate and vertebrate, with an emphasis on parasitology (1837-1852).

While protists and microscopy were among his many research interests, and he

published on these topics over a relatively short time span, he produced a considerable number of publications, especially on protists.

Figure 4 here please

**Figure. 4.** The number of publications by Dujardin (articles and books) by year and by subject area. The bibliography used was that in Joubin's biography of Dujardin (Joubin 1901) except for the Protist works, some of which were found to be missing, or incorrectly attributed to Dujardin, in his Dujardin bibliography.

Table 1 lists Dujardin's publications on protists and microscopy and the notes provide bullet descriptions of the publications. The works are given in the presumed chronological order of appearance. Excluded from Table 1 but given in the supplementary file, are the 54 entries by Dujardin on protists published in the *Dictionnaire Universel d'Histoire Naturelle* between 1841 and 1848 (dated according to Sherborn and Palmer 1899). Most entries are short, simple definitions; they do include some substantial, multi-page entries cited by others (e.g. Bütschli 1880-1882). The publications on protists and microscopy which Dujardin listed in 1850 in his career summary (Dujardin 1850), published presumably for his 1852 attempt to be elected to the *Académie*, are indicated.

The publications are likely to be those he considered to be his major contributions. They were works in which he contested prevalent views put forward by important figures of his time, Alcide Dessalines d'Orbigny and Christian Gottfried Ehrenberg. The works Dujardin wanted the *Académie* to consider with regard to his candidacy are those in which he recognized and

described rhizopods as mischaracterized by d'Orbigny, the cellular material of  
protists "*sarcode*", his studies revealing how ingested matter is processed in  
protists, and his critiques of Ehrenberg's polygastrica theory as well as  
Ehrenberg's characterization and classification of many taxa. These topics have  
been dealt with at length previously (Fauré-Fremiet 1935; Dragesco 1961) and  
will be reviewed briefly below. Dujardin's list also included his two publications  
on microscopy. The first was the description of a device now known as the  
condenser, to focus light on the microscope stage and the other was a practical  
manual of microscopy. While the microscopy contributions did not address  
protists, it is commonly recognized that advances in protistology often followed  
advances in microscopy. The importance of Dujardin's device is detailed in the  
last section.

Table 1 and notes here please

**Table 1.** Works on protists and microscopy by Félix Dujardin

Journal abbreviations: AFE=Annales Françaises et étrangères d'anatomie et de physiologie, ser. 2, Zoologie; ANH=Annales of Natural History; ASN=Annales des Sciences Naturelles, ser. 2, Zoologie; BSSNF=Bulletin de la Société des Sciences Naturelles de France; CRAS=Comptes rendus hebdomadaires des séances de l'Académie des sciences; Institut=L'Institut: journal général des académies et sociétés scientifiques de la France et de l'étranger; SP=Société Philomathique de Paris, Extraits des Procès-Verbaux des Séances. Articles and books are listed in presumed chronological order; shown in bold are the works Dujardin listed in his 1850 career résumé (Dujardin 1850) presumably for his candidature for membership in the Academy of Sciences. Dating details and protist entries in the *Dictionnaire Universel d'Histoire Naturelle* are given in the supplementary file "DujardinRefs.xlsx". Notes on contents are given in the next section.

Year	Title	Note	Journal
1835a	Observations nouvelles sur les Céphalopodes microscopiques	1	BSSNF
1835b	<b>Observations nouvelles sur les Céphalopodes microscopiques</b>	1	ASN
1835c	<b>Observations nouvelles sur les prétendues Céphalopodes microscopiques</b>	2	ASN
1835d	Sur les rhizopodes ou prétendues céphalopodes microscopiques	2	Institut
1835e	Observations sur les Rhizopodes et les Infusoires	3	Institut
1835f	<b>Observations sur les Rhizopodes et les Infusoires</b>	3	CRAS
1835g	<b>Recherches sur les organismes inférieurs</b>	4	ASN
1836a	<b>Note sur les Infusoires</b>	5	Institut
1836b	<b>Note sur les Infusoires</b>	5	CRAS
1836c	<b>Sur les infusoires munis d'un filament flagelliforme locomoteur et sur les expansions filiformes de quelques autres espèces.</b>	6	ASN
1836d	<b>Rhizopodes</b>	7	Institut
1836e	<b>Rhizopodes</b>	7	SP
1836f	Infusoires fossiles	8	Institut
1836g	Infusoires fossiles	8	SP

1837a	Sur un Infusoire de la matière verte	9	Institut
1837b	Sur un Infusoire de la matière verte	9	SP
1837c	Sur les infusoires muni d'une double filament locomoteur	10	ASN
1837d	<b>Sur une nouvelle espèce de Gromia et sur les Difflugies</b>	11	ASN
1838a	Animaux microscopiques	12	Institut
1838b	Animaux microscopiques	12	SP
1838c	<b>Sur le Volvox végétant de Müller (Anthophysa Bory)</b>	13	ASN
1838d	Sur les Monades à filaments multiple	14	ASN
1838e	Modifications du microscope	15	Institut
1838f	<b>Nouvel appareil pour éclairer les objets vus au microscope par transparence</b>	15	CRAS
1838g	<b>Mémoire sur l'organisation des Infusoires</b>	16	ASN
1838h	<b>Observations sur la substance glutineuse qui constitut en grande partie le corps des animaux inférieurs et sur la manière de l'étudier au microscope</b>	17	AFE
1839a	On the digestive organs of infusoria	18	ANH
1839b	<b>Mémoire sur la substance charnue glutineuse des animaux inférieurs, pour laquelle a été proposé le nom de sarcode</b>	19	AFE
1839c	Sur les Systolides ou Rotifères	20	AFE
1839d	Sur les infusoires proprement dits	21	AFE
1840a	Infusoires	22	Institut
1840b	<b>Mémoire sur une classification des infusoires en rapport avec leur organisation</b>	22	CRAS
1841	<b><i>Histoire naturelle des zoophytes</i></b>	23	<b>book</b>
1843	<b><i>Nouveau manuel complet de l'observateur au microscope</i></b>	24	<b>book</b>
1852	Les infusoires vivant dans les mousses et dans les jungermannes humides, et particulièrement sur une amibe revêtue d'un tégument membraneux	25	ASN

386 **Notes on Dujardin's protist publications: bullet description of contents**

1: Foraminifera are not molluscs nor infusoiria but members of a new group

388 "symplecomères" (Dujardin 1835a,b)

2: Text description of *Gromia oviformis*, introduction of term 'rhizopodes' to

390 replace 'symplecomères' (Dujardin 1835c,d)

3: Uses term rhizopodes/describes but not names "sarcode" (Dujardin 1835e,f)

392 4: Uses term rhizopode; gives a full *Gromia oviformis* description with

illustration; introduction of term "sarcode"; critique of Ehrenberg's Polygastrica

394 (Dujardin 1834g)

5: Describes finding flagella and cilia on various forms; cells of various forms

396 (ciliates, monads) as capable of changing shape; states cell contents are without

membrane covering; no mention of "sarcode" (Dujardin 1836a,b)

398 6: Description of four new genera *Trinème*, *Pleuronema*, *Pryonème*, *Cremenula*

(Dujardin 1836c)

400 7: Describes showing living *Arcella* to members of the Société Philomathique de

Paris (Dujardin 1836d,e)

402 8: Describes showing with microscope infusoirian fossils (not named) to

members of the Société Philomathique de Paris (Dujardin 1836f,g)

404 9: Describes *Microglena monadina* as having 2 flagella in contrast to Ehrenberg's

original description with no flagella (Dujardin 1837a,b)

406 10: Renames *Microglena monadina* as *Diselmis viridis* (Dujardin 1837c)

11: Description of *Diffflugia globulosa* and *Gromia fluvialis* and first depiction of

408 *Diselmis viridis* (Dujardin 1837d)

12: Short text description of *Gromia fluvialis* (Dujardin 1838a,b)



410 **13:** Describes *Volvox vegetans* as similar to other Volvox, not a micro-plant  
(Dujardin 1838c)

412 **14:** Describes new genus *Hexamita* a form with six flagella, depiction (Dujardin  
1838d)

414 **15:** Describes achromatic illumination device for microscope, precursor to  
condenser (Dujardin 1838e,f)

416 **16:** Detailed critique of Ehrenberg's Polygastrica (Dujardin 1838g)  
**17:** Describes how to isolate and microscopically examine "sarcode" (Dujardin  
418 1838h)

**18:** English translation of *Mémoire sur l'organisation des Infusoires*, see note 16  
420 (Dujardin 1838g)

**19:** Describes "sarcode" as a homogenous substance endowed with vital  
422 chacteristics, found in all animals at some point in development (Dujardin  
1839b)

424 **20:** Rotifers are not infusorians but lower animals (Dujardin 1839c)  
**21:** Diatoms and closterids are close to plant realm and should be considered  
426 distinct from infusoria (Dujardin 1839d)

**22:** Presents orders and families of infusoria based on body form, symetry, and  
428 possession of flagella or cilia (Dujardin 1840a,b)

**23:** Monographic treatment of infusoria with 146 new species described (see  
430 supplementary file for list of new species) (Dujardin 1841)

**24:** Complete introduction to microscopy, but very little on infusoria (Dujardin  
432 1843)

**25:** Describes new genus of amoeba *Corycie* (Dujardin 1852)

434

## Dujardin's Critique of D'Orbigny's Microscopic Cephalopods

In 1825 Alcide Dessalines d'Orbigny presented to the *Académie des Sciences* his classification of *céphalopodes* in which he sought to give a home to the organisms responsible for the myriad forms of microscopic shells forming the sands of some localities. It was published in 1826 (d'Orbigny 1826). He united them under the name '*Foraminifères*', due to the many holes in shells. Based on the remarkable resemblance of some microscopic shells to the multi-chambered shell of the *Nautilus*, he placed them among the cephalopods, calling them "*Céphalopodes microscopiques*". D'Orbigny had never seen his foraminifera alive. Dujardin's observations of live organisms when he was in Toulon in late 1834 led him rapidly to the conclusion that they were quite unlike cephalopods. He widely publicized his findings on the "supposed" microscopic cephalopods (Dujardin 1835a,b,c,d,e,f,g). The revelation of foraminifera having pseudopods rather than tentacles (Fig. 5), and actually representing a new group of organisms, was rapidly and graciously accepted not only by d'Orbigny (Lipps 2002) but almost unanimously (Galloway 1928).

Figure 5 here please

**Figure 5.** Plate 9 from Dujardin 1835g showing *Gromia oviformis* (fig. 1), its shell opening (fig. 2) and *Miliola vulgaris* (fig. 3) and an enlargement of its pseudopods (fig. 4). Foraminifera, such as *Milola vulgaris*, had been placed among the cephalopods by d'Orbigny because their shell resembled microscopic *Nautilus* shells and he had never seen them alive with their pseudopods.

## Dujardin's Critique of Ehrenberg's Polygastrica and Classifications

In 1830 Ehrenberg presented a new classification of 'infusoiria', organisms previously organized in a variety of manners since the time of O.F. Müller. First, Ehrenberg divided them into two large groups, Rotifera and Polygastrica. While distinguishing them from rotifers, he believed that all protists, and most obviously ciliates, possessed a mouth and an alimentary canal similar to metazoa but with many stomachs and thus the organisms should be called polygastric. His characterization was based on experiments with ciliates fed carmine particles. A few years later, Ehrenberg published his monumental 1838 monograph of 547 pages of text and 64 plates. In it he refined his classifications and placed all known forms within it. While Ehrenberg's monograph was a very important contribution, his view of the cellular structure of protists was imaginary.

Ehrenberg's interpretation of how ingested matter is processed in ciliates was illustrated in the figure accompanying an 1839 note Ehrenberg sent to the *Annals of Natural History*, defending his characterizations (Fig. 6). The note was sent in reaction to the publication of a report on the 1838 meeting of the British Association for the Advancement Science in the newspaper *The Athenaeum* that included very brief remarks critical of his presentation with regard to the polygastric nature of infusoria (Anon. 1838). In his 4-page note of defense, Ehrenberg described, in English for the first time, ciliates as having a fully formed alimentary canal connecting the mouth to the anus with stomachs branching off as appendices. Other than observations such as 'one finds what one is determined to find', to date, no explanation for Ehrenberg's attribution of miniature organs to protists has been put forward.

Figure 6 here please

**Figure 6.** Ehrenberg's depiction of the polygastric *Loxodes bursia* from his note in the *Annals of Natural History* (Ehrenberg 1839).

Dujardin disputed Ehrenberg's views early on beginning with a critique of his classification grouping naked and testate amoeba with diatoms, and then a direct attack on his declarations that infusoria all have a distinct mouth, an alimentary tract, and multiple stomachs (Dujardin 1835g). Dujardin's arguments were based first on his observations of ingestion by his rhizopods which have no mouths. Dujardin has been credited with being the first to contest the views of Ehrenberg (Churchill 201). However, Dujardin himself noted that he was not the first to object to polygastrica, citing Bory de Saint-Vincent (1831). According to Dujardin (1836c), Ehrenberg wrote to the *Academie des Sciences* reaffirming his observations and suggesting that perhaps Dujardin's microscope was of a lesser quality than his own. Dujardin shortly (Dujardin 1837c) thereafter defended his observational skills, and the quality of French microscopes, by reporting on the presence of flagella in very small forms where Ehrenberg had not seen them (Figure 7).

figure 7 here please

**Figure 7.** From Plate 9 accompanying Dujardin 1837c, d. His illustrations of small flagellates (10-20  $\mu\text{m}$  long). He named one as *Diselmis viridis* (unlabeled and 4 b) saying it was probably what Ehrenberg had call *Microglena monadina* but Ehrenberg had not seen the flagella. The others (5a, 5b, and 5c) were unnamed but depicted in detail attesting to the quality of Dujardin's microscope allegedly belittled by Ehrenberg.

In 1838 came Dujardin's full frontal attack on Ehrenberg's views of the cellular structures and features in infusoria and his classification scheme in "*Mémoire sur l'organisation des Infusoires*". While Dujardin in his "*Mémoire*" reviewed critically many previous observers of infusoria, he took special aim at Ehrenberg and mentions him 73 times in his 84-page article. Besides pointing out that no one else ever observed an alimentary canal, Dujardin notes the same applies to Ehrenberg's descriptions of ovaries, testes, and eyes. Ehrenberg's classification scheme, resting in part on grouping organisms based on dubious cellular structures, consequently required revision. Dujardin's article ends with the single sentence paragraph below leaving no doubt as to the central message of his "*Mémoire*":

*"The eggs of infusoria, their genital organs, organ of senses, as well as their canals can not be found and this leads one to think that these animalcules, while well-endowed with a degree of organization commensurate with their lifestyle, cannot have the same system of organs as that of the higher animals. "* (my translation)

In Dujardin's 1841 book "*Histoire Naturelle des Zoophytes*" many of the same issues as those in his "*Mémoire*" were treated and expanded upon. Ehrenberg is

mentioned 334 times in Dujardin's book, usually in a negative fashion. However,  
his book was much more than a rebuttal of Ehrenberg's views. It was a  
comprehensive treatment of organisms known then as infusoria. It was divided  
into 5 large sections. The first of was 'General Observations' and covered broad  
topics such as those he addressed in his "*Mémoire*", to anatomy, historical  
classification schemes, how to culture and techniques for microscopic  
measurement. The second section was a classification of all of what were  
considered infusorian forms at the time. His scheme separated one-celled  
organisms, 'Infusoria', from the multicellular rotifers and tardigrades into what  
could be considered as two separate phyla: *Infusoria* and *Systolides*. Infusoria  
were grouped in four Orders: 1) 'Asymmetrics' composed of forms now known  
as bacteria, 2) 'Rhizopods' composed of naked and testate amoeba, as well as  
foraminifera, 3) 'Monads', grouping a large variety of forms from *Volvox* to  
*Ceratium*, seemingly all forms which were not obviously ciliates, and 4)  
'Echélyens' grouping all the ciliates. The *Systolides*, composed of rotifers and  
tardigrades, were divided into four orders and were treated in sections 3 and 4  
of his book. The last section was entitled "Diverse microscopic objects taken for  
infusoria by other authors". This included the diatoms and desmids that Dujardin  
considered as obviously plant-like, not animal-like, and also sperm cells.

#### **The Early Condenser for the Microscope: *Eclairage Dujardin***

In 1838 Dujardin presented to the *Académie des Sciences* his invention of a device composed of three lenses and a diaphragm to focus light on the stage of microscope. It came to be known as '*eclairage Dujardin*' or the "*concentrateur de Dujardin*" (Coze and Feltz 1866; Moitessier 1866). It was the first achromatic light condenser. In the 19th century it was widely recognized as a significant improvement providing a far clearer image (Brooke 1854). All later achromatic condensers were said to have been based on the principles described by Dujardin (Plumer 1864). Dujardin was then known in the 19th century as the inventor of the condenser (Van Heurck 1878). This is rarely recognized in histories of microscopy (e.g. Weise 1961). Today, commonly, the invention of the condenser is attributed to Ernst Abbe in the 1870's (e.g. Manwell 1968). A singular exception is Bradbury's 1967 '*The Evolution of the Microscope*' that credits Dujardin with the invention of the achromatic condenser in 1838 (Bradbury 1967). Shown in Figure 8 is the illustration of his condenser from Dujardin's 1843 microscopy manual and a later manufactured version from Van Heurck's microscopy manual (Van Heurck 1878).

Figure 8 here please

**Figure 8. A.** The illustration of Dujardin's illumination device from his 1843 microscopy manual; in the figure 'A', 'B', & 'C' are 3 lenses, 'D' is a diaphragm. **B.** From Van Heurck's microscopy manual (Van Heurck 1878), shown are the Dujardin condenser by French microscope maker Gillet with a wheel providing different diaphragms (as fig. 56) and other condensers made by two English microscope makers: Reade, and Ross.

## Conclusion

Here is exposed the remarkable life of Félix Dujardin, in his youth a would be painter or chemist, first a geologist, then a biologist and a would be journalist. His first academic appointment was a Chair of Geology, and second was a Chair of Zoology and Dean of a Faculty of Science in Rennes, with the Chair of Zoology as his final appointment, despite attempts to obtain a chair at the *Muséum d'Histoire Naturelle* in Paris. Here also is an attempt to catalogue all of Dujardin's contributions to protistology. His works included books for the general public on natural history (Dujardin 1833), insects (Dujardin 1838i), and microscopy (Dujardin 1843) as well his classic treatises on protists (Dujardin 1841), helminth parasitic worms (Dujardin 1845) and a posthumous treatise on echinoderms (Dujardin and Hupé 1862). He was apparently the first to have observed foraminifera alive, correctly identify them as related to amoeboid organisms, and gave rhizopods their name. While Dujardin was not the first nor alone in disputing Ehrenberg's view of protists as having structures such as stomachs and ovaries (e.g., Bory de Saint-Vincent 1831, Meyen 1839a,b) his critique as described by Dobell (1932) was devastating. As a final note, Dujardin's technical contribution to the development of microscopy is documented.

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## NOUVELLES.

— L'Académie des sciences a décidé que, pour remplacer l'analyse de ses travaux, qu'elle distribuait autrefois à l'époque de la séance publique, elle publierait tous les deux ans un résumé des travaux faits, pendant les six années précédentes, dans une section sciences dont elle s'occupe. De la sorte, le résumé des sciences physiques alternant avec les deux autres, serait fait tous les six ans.

— Un bâtiment à vapeur vient, pour la première fois, d'entrer à Caen. Son tirant d'eau est de quatre pieds, et l'expérience ayant réussi, d'autres steamers vont être construits, qui remonteront l'Orne avec un égal succès.

## CHIMIE.

**DECOUVERTE DU FLUOR.** — L'annonce faite à la société philomatique par M. Pelouze, d'un procédé pour isoler le fluor, a déterminé M. Baudrimont à faire connaître lui-même les moyens qu'il avait employés d'abord, et ceux qu'il emploie aujourd'hui pour obtenir ce corps simple.

Déjà en décembre 1854, M. B. avait indiqué, dans un dictionnaire de physique générale, les propriétés du fluor en ces termes : « Le fluor est gazeux, brun-jaunâtre très foncé, son odeur a beaucoup d'analogie avec celle du chlore et avec celle du sucre brûlé; il est sans action sur le verre, il décolore l'indigo et se combine directement avec l'or. » Les deux flacons adressés par lui à l'Académie des sciences paraissaient contenir en effet un gaz brunâtre, mais non très foncé; on reconnaissait d'ailleurs qu'il n'avait pas d'action sur le verre, puisque les parois ont conservé leur transparence. Il ne pouvait donc être mêlé tout au plus que de gaz fluorosilicique.

M. Baudrimont l'avait préparé tout simplement en traitant, par l'acide sulfurique, un mélange de fluorure de calcium (*spath-fluor*) et de peroxyde de manganèse, dans une fiole de verre; l'excès de l'une des substances employées devait donner ou de l'oxygène ou de l'acide fluorhydrique, et ce dernier, par son action sur le verre, se serait changé en gaz fluorosilicique.

Sa première méthode d'extraction consistait à décomposer le gaz fluoroborique par le minium chauffé au rouge, et donnait le fluor moins pur.

Le procédé indiqué par M. Pelouze est tout différent, car il se borne à décomposer le fluorure d'argent dans l'eau, par le chlore, et, dans ce cas, suivant M. Baudrimont, on doit avoir un mélange d'acide hypochloreux et d'acide fluorhydrique.

On doit remarquer, en tout cas, combien le Fluor ainsi obtenu diffère de ce qu'on eût pu supposer être le radical de l'acide fluorique ou fluorhydrique, connu généralement par son action puissante sur le verre, et qui paraît plus énergique et plus délétère que les autres hydracides. On doit donc espérer de le voir bientôt mieux connu que l'acide fluorique lui-même, qu'on ne pouvait préparer ou conserver dans des vases de verre.

## PHYSIQUE.

**EFFETS DE LA FOUDRE.** — Un fait curieux a été signalé à l'Académie des sciences par M. Baric-Delahaye, au sujet de l'effet produit par la foudre sur un peuplier de l'avenue du château de Comacre, en Touraine. Cet arbre, frappé en juillet 1835, eut seulement alors quelques branches cassées. Le courant électrique, après avoir suivi la tige, même sans endommager l'écorce, pénétra dans le sol et souleva quelques grosses mottes au pied de l'arbre. Depuis cette époque, le peuplier a surpassé du double en accroissement les autres arbres de l'avenue, et il est résulté de ce développement excessif une crevasse par où la sève s'écoule en abondance.

**OPTIQUE.** M. Cauchy a écrit de Prague, à M. Libri, une lettre communiquée à l'Académie des sciences, sur les propriétés de la lumière réfléchie par un milieu constamment opaque, ou par un métal après avoir été déjà polarisé par une première réflexion; il démontre, par ses formules, que la lumière, après un nombre assez considérable de réflexions par ces surfaces, finira par être complètement polarisée dans le plan d'incidence. Il annonce, en outre, devoir déduire de ces mêmes formules générales, dans une autre lettre, un grand nombre de conséquences également d'accord avec les résultats obtenus par M. Brewster.

**MESURE DE LA TERRE.** M. Puissant, dans un Mémoire sur une nouvelle détermination de la longueur de l'arc de méridien compris entre Montjouy et Formentera, établit que la longueur réelle de celui qui s'étend du parallèle de Greenwich à Formentera, dépasse de 90 toises 271 la longueur donnée par Delambre. Par conséquent le mètre, dont la valeur avait été fixée à 3 pieds 11 lignes, et 296 millièmes de ligne, devrait être augmenté de 72 millièmes de ligne, ou d'environ un sixième de millimètre, pour être exactement, comme on le voulait, la dix-millionième partie de distance de l'équateur au pôle.

## ZOOLOGIE.

**QUADRUMANES.** ORANG-OUTAN VIVANT, A LONDRES. M. de Blainville a communiqué à l'Académie une lettre de M. Marion de Procé au sujet d'un orang-outan dont on voudrait faire l'acquisition pour le jardin du roi. Ce jeune singe, âgé de neuf mois, a été apporté de Sumatra: son front très élevé et bombé dans la ligne médiane de manière à simuler assez bien le front de certains hommes, est tout à fait dépourvu de longs poils ainsi que le reste de la face, sauf les côtés des joues. Son nez ne fait point de saillie, ses yeux ont une expression d'intelligence et de douceur remarquable. Les paupières sont garnies de longs cils, le museau n'est point proéminent; mais les lèvres sont très mobiles et peuvent s'allonger de deux pouces environ. Les oreilles ressemblent à celles de l'homme si non qu'elles ne sont pas terminées de même par un lobule. Il a la face d'une couleur ardoisée, et manque tout à fait de queue. Les pouces sont très petits comparativement aux autres doigts, dans les quatre mains. Tout le corps, à l'exception de la face et de la partie antérieure du cou est couvert de longs poils roux, et ceux de la tête dirigés en avant font l'effet d'une perruque.

Les dents offrent l'apparence de celles de l'homme si ce n'est que les racines sont plus allongées.

2.

3.

5.

1.

4.

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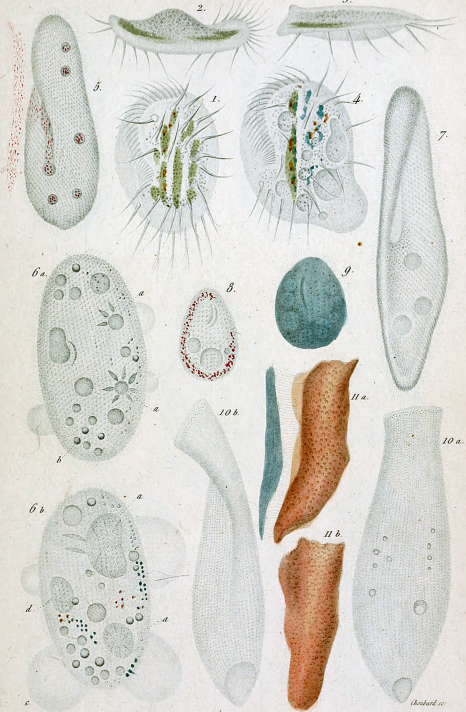
11a.

10a.

6b.

11b.

Chesnut sc.





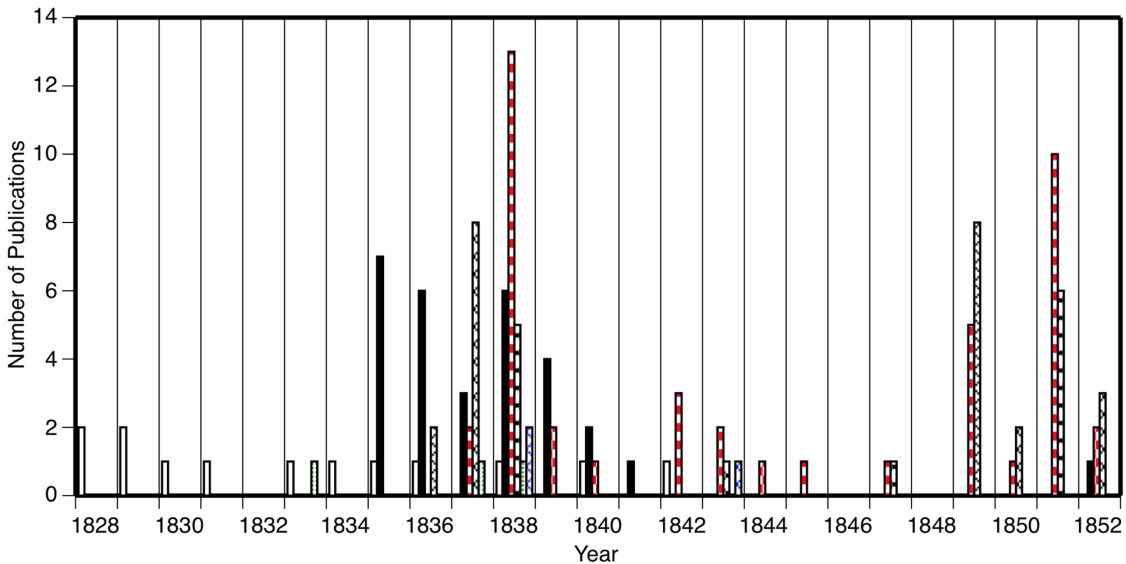




Fig. 1.

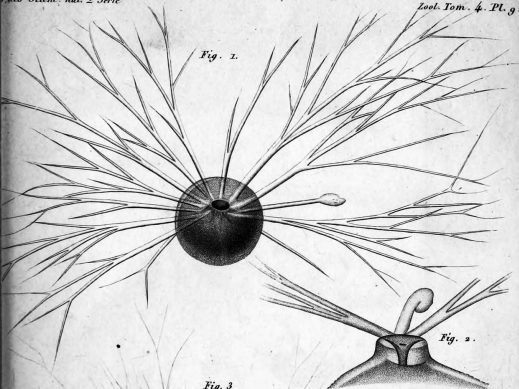


Fig. 2.

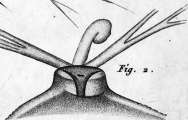


Fig. 3

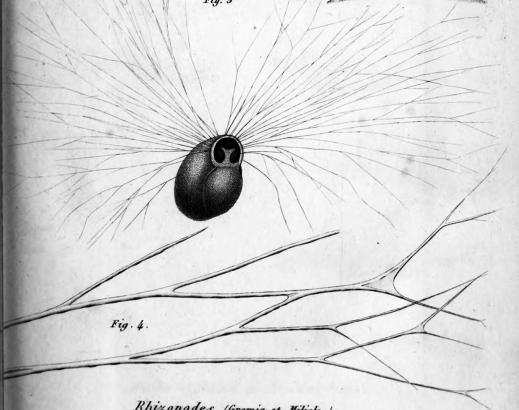
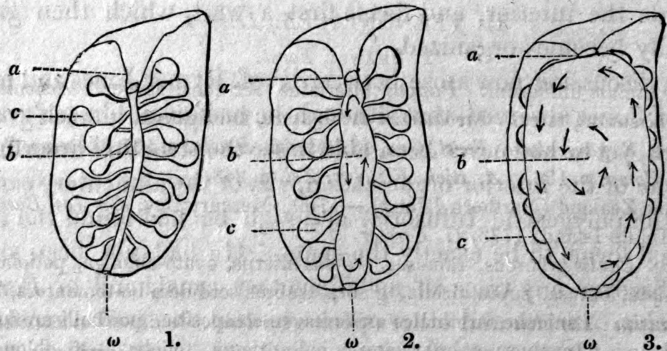


Fig. 4.

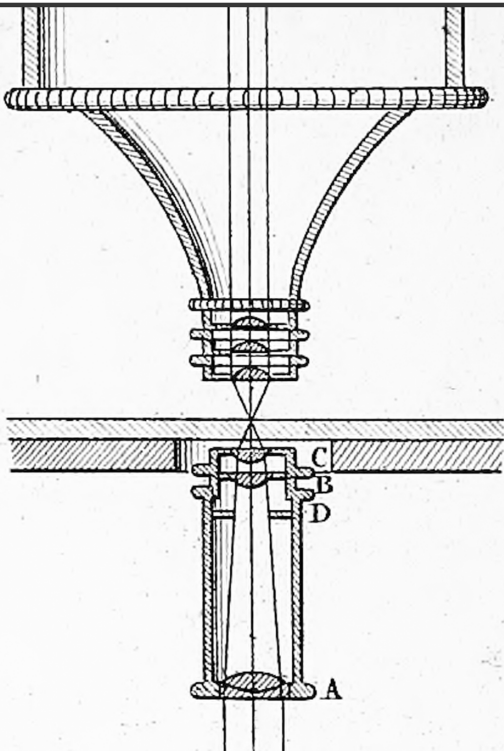
*Rhizopodes. (Gromia et Milioides)*  
gravés au foin



Ideal figures of *Loxodes Bursaria* in various states of the extension of the alimentary canal, and its inner circular motion, not of the ventral sacs, but of the contents of the sacs voided into the canal. *a* the mouth, *b* the alimentary canal, *c* ventral sacs,  $\omega$  anal aperture.

*Fig. 5. a*





**A**

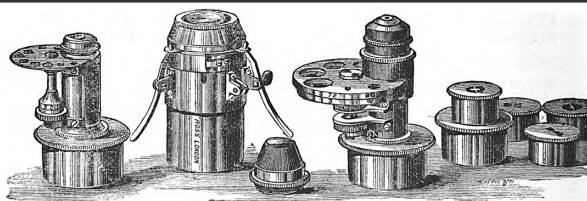


Fig. 56,

57,

58,

59,

60,

56, éclairage Dujardin, modifié par Gillet;

57, condenseur de Reade;

58, petit condenseur de Ross;

59, condenseur 4/10<sup>es</sup> de Ross;

60, oculaires disposés pour servir de condenseur.

**B**