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► **To cite this version:**

John R Dolan. Félix Dujardin (1801–1860) and His Contributions to Protistology. *Protist*, 2021, 172 (4), pp.125821. 10.1016/j.protis.2021.125821 . hal-03318807

HAL Id: hal-03318807

<https://hal.science/hal-03318807>

Submitted on 22 Aug 2023

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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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14 Submitted April 26, 2021; Accepted June 8, 2021

Monitoring Editor: B. S. C. Leadbeater

16

Running title: Félix Dujardin (1801-1860)

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20 **Key words:** History of Protistology; foraminifera; cercozans; microscopy;
Gromia.

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Introduction

30

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.

46

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,

52

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
80 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
82 apparently lived from teaching and tutoring and occasional work as an engineer
as no other jobs are mentioned in the biographies.

84 Dujardin's official entrance into the scientific community of France
appears to have been in 1828, the year his name appears as a corresponding
86 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*
88 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
90 membership was of some importance to Dujardin as his second publication
(Dujardin 1828b), also on geology of the region, he signed as "*Correspondant de*
92 *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*
94 *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.
96 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
98 his candidacy (Anon. 1835a) and was elected vice secretary (front matter, 1835
Mémoires de la Société Géologique de France). Notably, in the next membership
100 listing of 1838 (front matter, 1838 *Mémoires de la Société Géologique de France*)
Dujardin's name no longer appears. His relatively substantial but brief
102 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
130 (Anon. 1835c), without however any explanation. This second very brief but
substantial involvement in a new scientific society is also absent from previous
132 accounts of Dujardin's career.

It was in 1835 that Dujardin first began publishing on protists and his
134 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*
136 *de France*. On the January 23 of 1835 meeting he read a paper entitled "*Sur les*
prétendues Céphalopodes microscopique". This first protistological presentation
138 of his was actually quite important. Dujardin revealed that forms that had been
classified as microscopic cephalopods, based on gross morphology of the shells
140 (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
142 (now classified as cercozoans). He declared them to be organisms unlike any
known and proposed the name "*Symplectomères*", as the cell contents appeared
144 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
146 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
148 unclear which appeared first, the texts are identical.

By April 1835, he was on his way back again to Toulon to continue his
150 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*'.
152 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 Academie
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 *Hérmès* 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, *Hérmès*, appeared on May 4th, 1836. It was in competition with established scientific newspapers and was absorbed by one of its competitors by October 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 considered a waiting room for those hoping to join the *Académie des Sciences* (Chappey 2010). Dujardin resumed his geological studies, traveling across 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 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 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 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 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 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 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.

234

236 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.

244

Figure 3 here please

246 **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).

248

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
286 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.
288 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
290 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
292 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
294 rather being of a modest nature as portrayed in the biographies Malgutti (1867)
and Joubin (1901), he was an ambitious man.

296 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
298 (*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*).
300 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
302 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
304 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
306 *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.

308 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,

310 ranked as a top candidate, and according to an apologetic letter from the
secretary of the *Légion d'honneur*, mysteriously overlooked (Joubin 1901). He
312 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
314 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
316 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
318 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.

320

Dujardin's Protist and Microscopy Publications

322

Dujardin's scientific contributions ranged across a wide variety of fields from
324 geology to microscopy. His scientific output was considerable, totaling well over
100 works (excluding hundreds of entries he wrote for the encyclopedic
326 *Dictionnaire Universel d'Histoire Naturelle*). The temporal distribution of his
works parsed into broad subject areas shows that his interests varied with time
328 (Fig. 4). Based on his publications, his scientific career can be roughly divided
into three major subject periods, albeit with considerable temporal overlap. He
330 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
332 invertebrate and vertebrate, with an emphasis on parasitology (1837-1852).

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

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

336

Figure 4 here please

338

Figure. 4. The number of publications by Dujardin (articles and books) by year
340 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
342 to be missing, or incorrectly attributed to Dujardin, in his Dujardin bibliography.

344 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
346 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
348 the *Dictionnaire Universel d'Histoire Naturelle* between 1841 and 1848 (dated
according to Sherborn and Palmer 1899). Most entries are short, simple
350 definitions; they do include some substantial, multi-page entries cited by others
(e.g. Bütschli 1880-1882). The publications on protists and microscopy which
352 Dujardin listed in 1850 in his career summary (Dujardin 1850), published
presumably for his 1852 attempt to be elected to the *Académie*, are indicated.

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

described rhizopods as mischaracterized by d'Orbigny, the cellular material of
360 protists "*sarcode*", his studies revealing how ingested matter is processed in
protists, and his critiques of Ehrenberg's polygastrica theory as well as
362 Ehrenberg's characterization and classification of many taxa. These topics have
been dealt with at length previously (Fauré-Fremiet 1935; Dragesco 1961) and
364 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
366 condenser, to focus light on the microscope stage and the other was a practical
manual of microscopy. While the microscopy contributions did not address
368 protists, it is commonly recognized that advances in protistology often followed
advances in microscopy. The importance of Dujardin's device is detailed in the
370 last section.

Table 1 and notes here please

372

Table 1. Works on protists and microscopy by Félix Dujardin

374 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;
376 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
378 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
380 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.
382 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.

384

Year	Title	Note	Journal
1835a	Observations nouvelles sur les Céphalopodes microscopiques	1	BSSNF
1835b	Observations nouvelles sur les Céphalopodes microscopiques	1	ASN
1835c	Observations nouvelles sur les prétendues Céphalopodes microscopiques	2	ASN
1835d	Sur les rhizopodes ou prétendues céphalopodes microscopiques	2	Institut
1835e	Observations sur les Rhizopodes et les Infusoires	3	Institut
1835f	Observations sur les Rhizopodes et les Infusoires	3	CRAS
1835g	Recherches sur les organismes inférieurs	4	ASN
1836a	Note sur les Infusoires	5	Institut
1836b	Note sur les Infusoires	5	CRAS
1836c	Sur les infusoires munis d'un filament flagelliforme locomoteur et sur les expansions filiformes de quelques autres espèces.	6	ASN
1836d	Rhizopodes	7	Institut
1836e	Rhizopodes	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	Sur une nouvelle espèce de Gromia et sur les Difflugies	11	ASN
1838a	Animaux microscopiques	12	Institut
1838b	Animaux microscopiques	12	SP
1838c	Sur le Volvox végétant de Müller (Anthophysa Bory)	13	ASN
1838d	Sur les Monades à filaments multiple	14	ASN
1838e	Modifications du microscope	15	Institut
1838f	Nouvel appareil pour éclairer les objets vus au microscope par transparence	15	CRAS
1838g	Mémoire sur l'organisation des Infusoires	16	ASN
1838h	Observations sur la substance glutineuse qui constitut en grande partie le corps des animaux inférieurs et sur la manière de l'étudier au microscope	17	AFE
1839a	On the digestive organs of infusoria	18	ANH
1839b	Mémoire sur la substance charnue glutineuse des animaux inférieurs, pour laquelle a été proposé le nom de sarcode	19	AFE
1839c	Sur les Systolides ou Rotifères	20	AFE
1839d	Sur les infusoires proprement dits	21	AFE
1840a	Infusoires	22	Institut
1840b	Mémoire sur une classification des infusoires en rapport avec leur organisation	22	CRAS
1841	<i>Histoire naturelle des zoophytes</i>	23	book
1843	<i>Nouveau manuel complet de l'observateur au microscope</i>	24	book
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 "sarcodes" (Dujardin 1835e,f)

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

illustration; introduction of term "sarcodes"; 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 "sarcodes" (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

436

In 1825 Alcide Dessalines d'Orbigny presented to the *Académie des Sciences* his
438 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
440 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
442 remarkable resemblance of some microscopic shells to the multi-chambered
shell of the *Nautilus*, he placed them among the cephalopods, calling them
444 "*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
446 him rapidly to the conclusion that they were quite unlike cephalopods. He widely
publicized his findings on the "supposed" microscopic cephalopods (Dujardin
448 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
450 rapidly and graciously accepted not only by d'Orbigny (Lipps 2002) but almost
unanimously (Galloway 1928).

452

Figure 5 here please

454

Figure 5. Plate 9 from Dujardin 1835g showing *Gromia oviformis* (fig. 1), its shell
456 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
458 cephalopods by d'Orbigny because their shell resembled microscopic *Nautilus*
shells and he had never seen them alive with their pseudopods.

460 **Dujardin's Critique of Ehrenberg's Polygastrica and Classifications**

462 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,
464 Ehrenberg divided them into two large groups, Rotifera and Polygastrica. While
distinguishing them from rotifers, he believed that all protists, and most
466 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
468 characterization was based on experiments with ciliates fed carmine particles. A
few years later, Ehrenberg published his monumental 1838 monograph of 547
470 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
472 contribution, his view of the cellular structure of protists was imaginary.

Ehrenberg's interpretation of how ingested matter is processed in ciliates
474 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
476 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
478 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,
480 Ehrenberg described, in English for the first time, ciliates as having a fully
formed alimentary canal connecting the mouth to the anus with stomachs
482 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
484 miniature organs to protists has been put forward.

486 Figure 6 here please

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

490

Dujardin disputed Ehrenberg's views early on beginning with a critique of his
492 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
494 tract, and multiple stomachs (Dujardin 1835g). Dujardin's arguments were based
first on his observations of ingestion by his rhizopods which have no mouths.

496 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
498 object to polygastrica, citing Bory de Saint-Vincent (1831). According to Dujardin
(1836c), Ehrenberg wrote to the *Academie des Sciences* reaffirming his
500 observations and suggesting that perhaps Dujardin's microscope was of a lesser
quality than his own. Dujardin shortly (Dujardin 1837c) thereafter defended his
502 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 (Fig
504 7).

506

508 figure 7 here please

510 **Figure 7.** From Plate 9 accompanying Dujardin 1837c, d. His illustrations of
small flagellates (10-20 μm long). He named one as *Diselmis viridis* (unlabeled
512 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
514 unnamed but depicted in detail attesting to the quality of Dujardin's microscope
allegedly belittled by Ehrenberg.

516

In 1838 came Dujardin's full frontal attack on Ehrenberg's views of the
518 cellular structures and features in infusoria and his classification scheme in
"Mémoire sur l'organisation des Infusoires". While Dujardin in his *"Mémoire"*
520 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
522 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
524 classification scheme, resting in part on grouping organisms based on dubious
cellular structures, consequently required revision. Dujardin's article ends with
526 the single sentence paragraph below leaving no doubt as to the central message
of his *"Mémoire"*:

528

"The eggs of infusoria, their genital organs, organ of senses, as well as their canals
530 *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
532 *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
534 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,
536 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
538 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
540 classification schemes, how to culture and techniques for microscopic
measurement. The second section was a classification of all of what were
542 considered infusorian forms at the time. His scheme separated one-celled
organisms, 'Infusoria', from the multicellular rotifers and tardigrades into what
544 could be considered as two separate phyla: *Infusoria* and *Systolides*. Infusoria
were grouped in four Orders: 1) 'Asymmetrics' composed of forms now known
546 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
548 *Ceratium*, seemingly all forms which were not obviously ciliates, and 4)
'Echélyens' grouping all the ciliates. The *Systolides*, composed of rotifers and
550 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
552 infusoria by other authors". This included the diatoms and desmids that Dujardin
considered as obviously plant-like, not animal-like, and also sperm cells.

554

556

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

560 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
562 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
564 light condenser. In the 19th century it was widely recognized as a significant
improvement providing a far clearer image (Brooke 1854). All later achromatic
566 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
568 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
570 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
572 credits Dujardin with the invention of the achromatic condenser in 1838
(Bradbury 1967). Shown in Figure 8 is the illustration of his condenser from
574 Dujardin's 1843 microscopy manual and a later manufactured version from Van
Heurck's microscopy manual (Van Heurck 1878).

576

Figure 8 here please

578

Figure 8. A. The illustration of Dujardin's illumination device from his 1843
580 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
582 Dujardin condenser by French microscope maker Gillet with a wheel providing
different diaphragms (as fig. 56) and other condensers made by two English
584 microscope makers: Reade, and Ross.

586 **Conclusion**

588 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.
590 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
592 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
594 contributions to protistology. His works included books for the general public on
natural history (Dujardin 1833), insects (Dujardin 1838i), and microscopy
596 (Dujardin 1843) as well his classic treatises on protists (Dujardin 1841),
helminth parasitic worms (Dujardin 1845) and a posthumous treatise on
598 echinoderms (Dujardin and Hupé 1862). He was apparently the first to have
observed foraminifera alive, correctly identify them as related to amoeboid
600 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
602 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,
604 Dujardin's technical contribution to the development of microscopy is
documented.

606

Acknowledgements

608

Martine Fiorini, the librarian of the *Institute de la Mer de Villefranche* uncovered
610 the full name and online location of *L'Institut: journal général des académies et*
sociétés scientifiques de la France et de l'étranger and Isabelle Maurin-Joffre,
612 archivist at the *Académie des Sciences*, patiently dealt with my many inquiries.
Marc Rideau kindly provided copies of rare works. Finally, while the comments
614 and suggestions of the reviewers and Monitoring Editor led to significant
improvements in the text, I retain full responsibility for all errors of fact,
616 omission, or interpretation.

618

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14 fr., 7 fr., 50.**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 alternerait 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 paraissent 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 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-Deulhaye, au sujet de l'effet produit par la foudre sur le peuplier de l'avenue du château de Comacre, en Touraine. Cet arbre, frappé en juillet 1833, 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 Montjoux et Formentera, établit que la longueur réelle de celui qui s'étend du parallèle de Greenwich à Formentera, dépasse de 90 toises 2/10 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.

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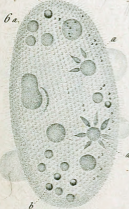


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Ploesconie, Paramccies, Glaucome, Spathidie et Planariole.



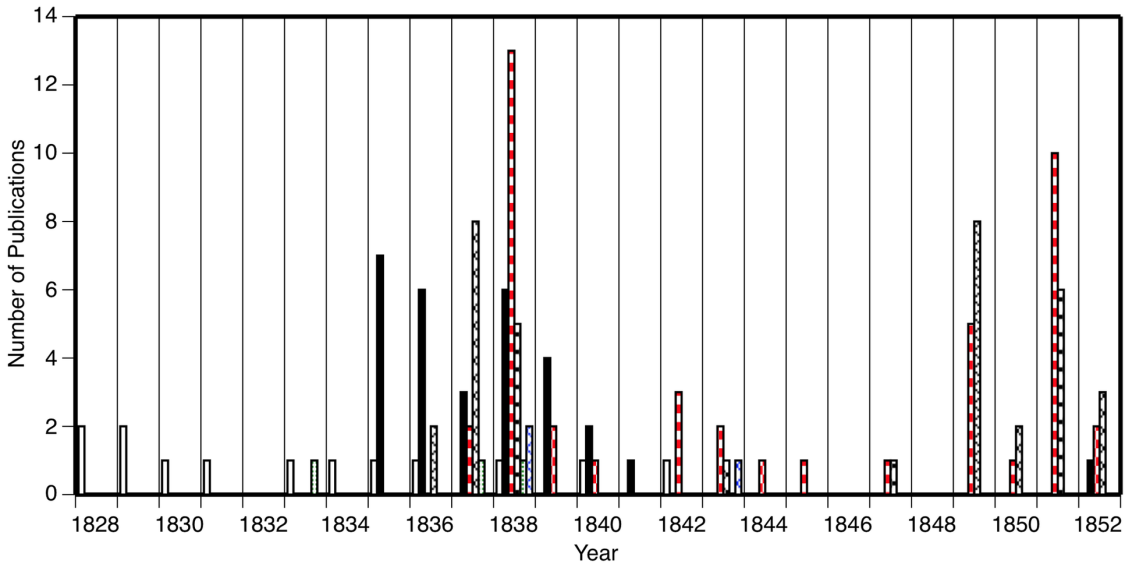


Fig. 1.

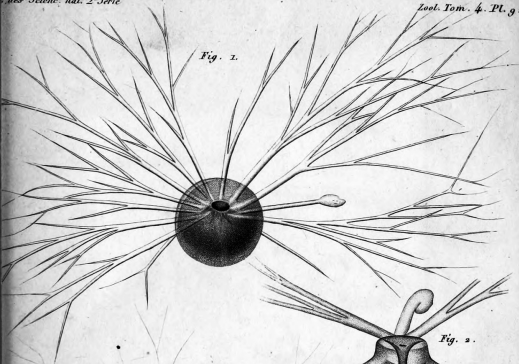


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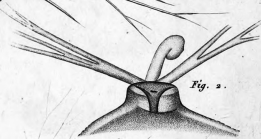


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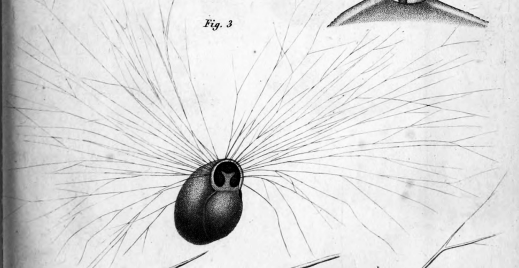
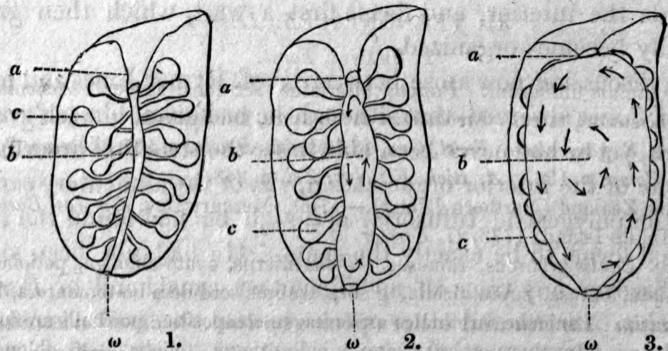


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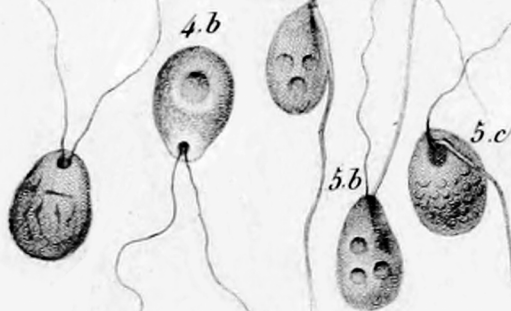


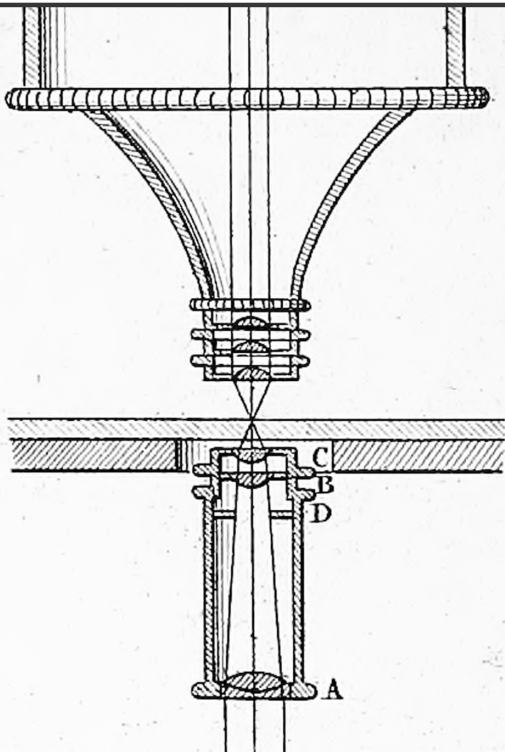
Rhizopodes. (Gromia et Miliola)
gracili 20 fois



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, ω anal aperture.

Fig. 5. a





A

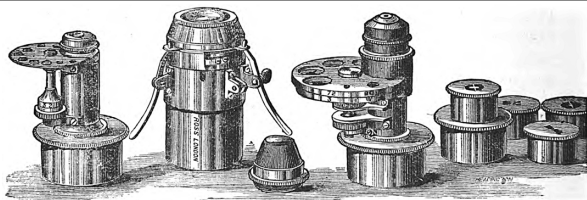


Fig. 56,

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56, éclairage Dujardin, modifié par Gillet;

57, condenseur de Reade;

58, petit condenseur de Ross;

59, condenseur 4/10^{es} de Ross;

60, oculaires disposés pour servir de condenseur.

B