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A TOOL TO PROMOTE EXPERIMENTAL ZOOLOGY AT THE END OF THE 19TH CENTURY: THE CREATION OF THE "*ARCHIVES DE ZOOLOGIE EXPÉRIMENTALE ET GÉNÉRALE*"

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HENRI DE LACAZE-DUTHIERS
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ABSTRACT. – 1872, France. An eminent zoologist of the time, Henri de Lacaze-Duthiers, realises one of his most important goals: he creates a new journal, focused on zoological discoveries, which he calls "*Archives de Zoologie Expérimentale et Générale*". His motivations were threefold. The first was to participate in the intellectual reconstruction of France, humiliated by the defeat against Prussia in 1871. The second was to promote a new way of conceiving and doing zoology: zoology should be approached through experience (and not just observation), and it should be general, including everything related to animal life (embryology, physiology, histology, ecology). The third was to acquire freedom and autonomy by liberating himself from the conservative journal that had a quasi-monopoly on zoology at the time, "*Les Annales de sciences naturelles*". The *Archives*, which had a difficult start, had an impressive success, revealing young talents from all over Europe and reporting on major discoveries, until their last issue in 1981. This article recounts their adventure.

INTRODUCTION

"*Embryo Anemia Research*", "*Critical study of embryogenic works relating to the kinship of Vertebrates and Tunicates*", "*Contribution to the study of the development of the cerebral lobes of primates*", "*Of the nervous system of aquatic Pulmonary Gastropod Molluscs and of a new organ of innervation*", but also "*The luminous organs and the light of the Pennatula*", "*The skin of the bat's wing, especially the endings of its nerves*" or "*Preservation of microscopic preparations with potassium acetate*" (Dareste 1872, Giard 1872a, Hamy 1872, Lacaze-Duthiers 1872a, Panceri 1872, Schöbl 1872, Schultze 1872)… Edmond Perrier (1844-1921), Ernst Haeckel (1834-1919), Camille Dareste (1822-1899), Henri de Lacaze-Duthiers (1821-1901), Alfred Giard (1846-1908), Hermann Fol (1845-1892), Paolo Panceri (1833-1877) or Franz Eilhard von Schulze (1840-1921)… What do all these disparate titles and authors of very diverse nationalities and specialties have in common? In 1872, they published their work in the first volume of a new scientific journal, the "*Archives de Zoologie Expérimentale et Générale*" and unknowingly they laid the groundwork for what was to become an exceptional scientific adventure of more than a century. Begun in 1872 at the end of the French-Prussian war of 1870 and ended in 1981, this journal, created by an eminent marine zoologist of the 19th century, founder of the marine stations of Roscoff and Banyuls-sur-Mer, Henri de Lacaze-Duthiers, had a considerable influence on biology during all these years.

Since the year 2021 marked the bicentenary of the birth of its founder, Henri de Lacaze-Duthiers, it is interesting to revisit its creation and operation. Indeed, these *Archives* are both a manifesto and a tool: a manifesto in favor of a certain vision of zoology, seen as an experimental science just as much as physiology (to the great displeasure of some representatives of this scientific discipline, as we will see below) and a tool in favor of the rebirth of France hardly hit by the defeat of the war of 1870 partly attributed to the weakness of the training of intellectual elites. Scrutinizing the genesis and the growth of this journal is to penetrate into the workings of biology at the end of the 19th century, to meet its most illustrious representatives and to soak up the debates which were theirs at the time and which, we will have the surprise of noticing it, remain of a burning topicality.

LACAZE-DUTHIERS IN 1872

In 1872, who was Henri de Lacaze-Duthiers? He was a well-established scientist, 51 years old, just elected to the French Academy of Sciences. Graduated in medicine in 1851, holder of a PhD in Sciences in 1853, professor of zoology at the Faculty of Sciences of the university of Lille (whose Dean was Louis Pasteur) in 1854, he became in 1865 professor at the National Museum of

Natural History in Paris and, in 1868, he was appointed as professor of zoology and comparative physiology at the Sorbonne. Even if Lille and Paris are not seaside towns while Lacaze-Duthiers field was marine zoology, he was nevertheless never very far from the coast. As an active promoter of field expeditions, he multiplied from 1853 the trips on the coasts of France but also in the Balearic Islands and in Algeria. In 1864 he published what is probably his magnum opus, the "*Histoire Naturelle du Corail*" which remains an important step in our knowledge of these organisms (Vielzeuf *et al*. 2022). In these very prolific years, he multiplied the discoveries on marine invertebrates, especially but not exclusively, molluscs: he became and remained throughout his life an undisputed malacologist. As we will see below, in 1868 he engaged in a vigorous debate with one of the stars of the French science at the time, the physiologist Claude Bernard (1813-1878), the champion of the experimental method.

But these overflowing activities marked a pause in 1870 because of the war with Prussia declared in July 1870 and quickly lost by France. The second empire collapsed: the emperor Napoleon III abdicated, and the third republic was proclaimed on September 4. This was followed by the siege of Paris in January 1871 with its associated bombardments and privations, followed by the entry of Prussian troops and the troubles of the "*Commune de Paris*" and the "bloody week" in May 1871. This series of disasters deeply marked a whole generation which at the same time wanted to rebuild the country and to understand the causes of the defeat in order not to reproduce the mistakes of the past. These causes are not only to be found in the lack of preparation of the French army, but also in the weakness of the training of the French intellectual elites compared to Germany's major investment in its universities. French writers, philosophers, artists as well as scientists were traumatized and understood that they had to rebuild an intellectual space (Digeon 1959).

We have testimonies of the extent of the trauma in several texts by Lacaze-Duthiers but also in his correspondence. Thereby, in the introduction (called "*Avertissement*", *i.e.*, "Warning") to the first volume of the *Archives* published in 1872, he spoke of this period as a "*huge upheaval of all things*[1]" and added "*when one reflects coldly on the events which have just taken place, when one studies the causes and that without bias, without political concern, try to discern what the effects may be, when on the other hand, we see after so many misfortunes a vitality and a wealth as great as those of which France gives proof, discouragement, inseparable from a terrible crisis like the one we have just gone through, soon gives way to hope and a deep sense of confidence*[2]" (Lacaze-Duthiers 1872b). In a letter dated May 1872 to Albert Kölliker (1817-1905), a Swiss zoologist who worked extensively on jellyfish and cephalopods and who maintained genuine friendships with Lacaze-Duthiers, he spoke of "*these deep feelings, these ulcerations, these pains, these patriotic shocks, so immense that we, French people, suffer. If you knew what a soul who loves his country, who feels humiliation and the heel of the conqueror, feels pain, you would understand that one can fall into a state that nothing is capable of translating*[3]" but he adds further "*France takes back its heart and its soul, our youth will recover, it recovers* […]*, these misfortunes* […] *will be the cause of our recovery*[4]". We thus see him strongly affected but combative and vibrant with energy. He wanted to contribute to the recovery of France. The implementation of innovative experimental approaches in zoology, the dissemination of scientific results through the creation of the *Archives* and the foundation of the first European marine station in Roscoff in 1872, then another in Banyuls-sur-Mer in 1882, in which modern experimental science could be practiced and students trained, were its contribution to this effort.

THE CONTROVERSY WITH CLAUDE BERNARD

The creation of the "*Archives de Zoologie Expérimentale et Générale"*, but also that of the Roscoff biological station, originally called the "*Laboratoire de Zoologie Expérimentale"*, occurred in the context of a vigorous debate that had been raging since 1867 (Dayrat 2016). That year, the renowned physiologist Claude Bernard published a founding text, the famous "*Report on the progress of general physiology in France*", which aimed to promote his vision of physiology but also to provide him with financial government support (Bernard 1867). In this text, Claude Bernard wrote in particular: "*We shall demonstrate that physiology is not a natural science, but rather an experimental science*. […] *All natural sciences are sciences based on observation, that is, contemplative*

[1] "*un immense bouleversement de toute chose*", *our translation*.

[2] "*quand on réfléchit froidement aux évènements qui viennent de s'accomplir, quand on étudie les causes et que sans parti pris, sans préoccupation politique, on cherche à discerner quels peuvent en être les effets, quand d'un autre côté, on constate après tant de malheurs une vitalité et une richesse aussi grande que celles dont la France donne la preuve, le découragement, inséparable d'une crise terrible comme celle que nous venons de traverser, fait bientôt place à l'espérance et à un profond sentiment de confiance*", our translation.

[3] "*ces sentiments profonds, ces ulcérations, ces douleurs, ces ébranlements patriotiques, si immenses que nous autres français nous subissons. Si vous saviez ce qu'une âme qui aime sa patrie, qui sent l'humiliation et le talon du vainqueur, ressent de douleur, vous comprendriez qu'on puisse tomber dans un état que rien n'est capable de traduire*", our translation. Letter to Kölliker, May 6, 1872. Archives de l'Académie des Sciences (Paris).

[4] "*la France reprend son cœur et son âme, notre jeunesse se relèvera, elle se relève* […]*, ces malheurs* […] *seront la cause de notre redressement*", our translation. Letter to Kölliker May 6, 1872. Archives de l'Académie des Sciences (Paris).

of nature, which can only lead to predictions. All experimental sciences are explanatory, which go beyond sciences based on observation. […] *No doubt all biological sciences share the same trunk, since the living being is their common object of study, but* […] *experimental sciences [i.e., physiology] constitute a more advanced scientific stage than natural sciences*[5]". It must of course be understood that it was therefore preferable to support experimental and explanatory physiology rather than descriptive natural sciences, but to avoid any misunderstanding Claude Bernard was very explicit: "*For its importance physiology also deserves attention and protection, because it is likely meant to become the most useful science to humanity, in being the scientific basis for agriculture, hygiene, and medicine, etc*.[6]"

This position was obviously unacceptable for zoologists, botanists and other supporters of the natural sciences. Therefore, Victor Coste (1807-1873), an eminent marine biologist, founder of the first French marine station in Concarneau in 1859 with the aim of improving fish farming techniques, personal physician of Empress Eugénie and member of the French Academy of Sciences, like Claude Bernard, reacted. In 1868, he published a vigorous response in the "*Comptes Rendus Hebdomadaires de l'Académie*". He wrote: "*I give the proof that the sciences of observation are, to the same degree as the experimental sciences, but with more certainty, explanatory of the phenomena of life and conquerors of living nature, and that consequently, contrary to the opinion of M. Claude Bernard, general physiology is both a natural science, that is to say a science of observation, and an experimental science*[7]" (Coste 1868). He then provided many examples and ended by icing the cake: "*The authors of the Dictionary of the French Academy did not make this mistake when they defined the spirit of observation: knowing how to notice causes and effects of phenomena. Then sciences which take account of the causes and effects of phenomena are, for that very reason, sciences essentially explanatory and conquering of nature*[8]". Cut to the quick, Claude Bernard responded by accusing his opponent of "*quoting experiments to which he gives the name of observations, and vice versa*" and in doing so of introducing "*complete confusion*" into the debate (Bernard 1868). He defined what he called a "*provoked observation*" which is basically an observation that "*did not arise spontaneously*", a sort of intermediate category in a way. He ended by reiterating that "*experimental physiology is therefore a modern science advancing to conquer the knowledge which remains to be acquired on the mechanisms of the various phenomena of life*[9]" and that it is therefore "*more active and more conquering than the observational sciences which, moreover, pursue other problems*.[10]" (Bernard 1868).

Lacaze-Duthiers, who knew very well both Claude Bernard and Victor Coste could not stay silent in this debate. After more than 20 years of zoological studies, he became convinced that animals must be studied by following morphology, anatomy, physiology, knowledge of the environment (we would say now ecology), all of this carried out on embryonic, larval and adult forms. He insisted that observations must be carried out on living animals and must be done in the field. But after him, observing the morphology, anatomy and development of a living being was not enough to understand its functioning and its interactions with the environment. Indeed, the scientist must manipulate the animal, modify some of its parameters to study the consequences and, for Lacaze-Duthiers, this was an experimentation. This is why building modern experimental laboratories by the sea was essential. The *Archives* were therefore viewed as a tool to promote this vision as well as the results of this new science performed in marine laboratories. In the first issue, he published a text of 64 pages entitled "*Direction of the zoological studies*[11]" for promoting his vision of experimental and general zoology (Lacaze-Duthiers 1872c). In this text, he fiercely attacked Claude Bernard by putting him in front of his own contradictions, including his more

[5] "*Nous établirons tout d'abord que la physiologie n'est point une science naturelle, mais bien une science expérimentale.* […] *Toutes les sciences naturelles sont des sciences d'observation, c'est-à-dire des sciences contemplatives de la nature, qui ne peuvent aboutir qu'à la prévision. Toutes les sciences expérimentales sont des sciences explicatives, qui vont plus loin que les sciences d'observation.* […] *Sans doute toutes les sciences biologiques procèdent d'un même tronc, puisque l'être vivant est l'objet commun de leur étude ; mais* […] *les sciences expérimentales représentent un état scientifique plus avancé que les sciences naturelles*". Translation of Benoît Dayrat (Dayrat 2016).

[6] "*Par son importance la physiologie mérite encore qu'on lui accorde intérêt et protection, car elle est certainement appelée à devenir la science la plus utile à l'humanité, en servant de base scientifique à l'agriculture, à l'hygiène et à la médecine, etc*.". Translation of Benoît Dayrat (Dayrat 2016).

[7] "*Je donne la preuve que les sciences d'observation sont, au même degré que les sciences expérimentales, mais avec plus de certitude, explicatives des phénomènes de la vie et conquérantes de la nature vivante, et que par conséquent, contrairement au sentiment de M. Claude Bernard, la physiologie générale est à la fois une science naturelle, c'est à-dire d'observation et une science expérimentale*", our translation.

[8] "*Les auteurs du Dictionnaire de l'Académie française n'ont pas commis cette faute quand ils ont défini l'esprit d'observation : savoir remarquer les causes et les effets des phénomènes. Or des sciences qui tiennent compte des causes et des effets des phénomènes sont, par cela même, des sciences essentiellement explicatives et conquérantes de la nature*", our translation.

[9] "*la physiologie expérimentale est donc une science moderne marchant en avant à la conquête des connaissances qui nous restent à acquérir sur les mécanismes des divers phénomènes de la vie*", our translation.

[10] "*plus active et plus conquérante que les sciences d'observations qui poursuivent d'ailleurs d'autres problèmes*", our translation.

[11] "*Direction des études zoologiques*", our translation.

ancient texts : "*Let M. Cl. Bernard allow me first of all to tell him: he is too exclusive; he assigns and distributes roles to the various branches of science with great authority, no doubt, but a little too arbitrarily. Also, I ask him to allow the circle in which experience moves to be enlarged and, without absolutely excluding Zoology, to grant it a place, however modest it may be*.[12]" This important text that influenced the way the school of Lacaze-Duthiers, *i.e.*, himself and his numerous students and proteges, performed zoological research, is in fact divided in 3 parts that explain "*What zoology must have been primitively*", "*What zoology still is for many zoologists*" and "*What zoology must be and become*.[13]" It is of course in this last part that he addressed the controversy with Claude Bernard. He opposed Bernard's vision on two points. The first is, of course, that zoology is an experimental science and not just an observational science. The second is that zoology is not only experimental but also general, which means that it includes anatomy, morphology, embryonic and larval development AND physiology! There is therefore no reason to make physiology a separate and more important science than the other so-called natural sciences, since it is integrated into them as a component of knowledge of animals and is just as experimental as the others. He ended up his demonstration by a vibrant coda in which we can easily discern the spirit of the Eco-Evo-Devo field (Lacaze-Duthiers 1872c):

"*Descriptive zoology has passed its time: it is now only one of the parts, indispensable, it is true, but insufficient of the GENERAL ZOOLOGY. Also, to have an undisputed value, its results must be:*

Based on the precise laws of MORPHOLOGY;

Deduced from the most meticulous research of HISTOLOGY;

Demonstrated by the long and continuous studies of EVOLUTION;

Subjected to the CONTROL OF EXPERIMENTATION, which must always prepare, help and lead the studies of MORPHOLOGY and EVOLUTION.

They must be such, in one word, that GENERAL ZOOLOGY still deserves the name of EXPERIMENTAL ZOOLOGY."[14]

This controversy remained lively for many years. About 10 years later, in 1883, the French newspaper *Le Soir* reported a "*lively discussion*" at the *Académie* between Lacaze-Duthiers and Louis Pasteur (1822-1895) about the "*experimental method*". In this report for the general public, an incisive Lacaze-Duthiers replied to a defensive Pasteur: "*Zoology therefore admits the experimental method as well as the other natural sciences*[15]". In 1872, the Danish malacologist Rudolf Bergh commented on Lacaze-Duthier text in the *Archives*: "*I do not know the struggles which will have* […] *taken place, nor the* […] *occupations* […] *of M. Claude Bernard which provoked your recriminations in the introductory article, but I know very well the dispositions of physicians who are unfavorable to zoology and their inclination for the flag of immediate utility*[16]", which was another discordance of views between physicians and naturalists that goes beyond the notion of experimentation. Let us remember that Claude Bernard was a medical doctor, and that Louis Pasteur was working on human infectious diseases. After them, physiology should have a prominent place because of its usefulness for human health, whereas the natural sciences only provide general knowledge. In short, the latter are basic sciences, of which Lacaze-Duthiers will be an ardent promoter throughout his life. We sometimes wonder if, in France, it is not yet still relevant today…

THE CREATION OF THE "*ARCHIVES DE ZOOLOGIE EXPÉRIMENTALE ET GÉNÉRALE*"

The creation of the *Archives* took place in the context of this intellectual debate. However, the date of their first issue, 1872, should not mistake us as it has been delayed almost two years by the Prussian war. Without the war, the *Archives* would have been created in 1870, that is just after the climax of the Bernard-Coste controversy. Actually, the desire of Lacaze-Duthiers to create this journal is clearly expressed in his correspondence from 1867. Let add that this decision was part of a specific context:

[12] "*Que M. Cl. Bernard me permette tout d'abord de le lui dire : il est trop exclusif ; il donne et distribue les rôles aux diverses branches de la science avec une grande autorité sans doute, mais un peu trop arbitrairement. Aussi, je le lui demande, qu'il laisse élargir le cercle où se meut l'expérience, et que, n'en excluant pas absolument la Zoologie, il lui accorde une place, quelque modeste qu'elle soit*", our translation.

[13] "*Ce qu'à du être primitivement la zoologie*", "*Ce qu'est encore la zoologie pour beaucoup de zoologistes*", "*Ce que doit être et devenir la zoologie*", our translation.

[14] "*La Zoologie descriptive a fait son temps : elle n'est plus que l'une des parties, indispensables, il est vrai, mais insuffisantes de la Zoologie générale. Aussi pour avoir une valeur indiscutable, les résultats que celle-ci enregistre doivent être :*
Appuyés sur les lois précises de la Morphologie ;
Déduits des recherches les plus minutieuses d'Histologie ;
Démontrés par les études longues et continues de l'Évolution ;
Soumis au contrôle de l'expérience, qui doit toujours préparer, aider et conduire les études de Morphologie et de l'Évolution.
Ils doivent être tels en un mot que la Zoologie générale mérite encore le nom de Zoologie expérimentale.", our translation.

[15] "*la zoologie admet donc aussi bien que les autres sciences naturelles la méthode expérimentale*", our translation (*Le Soir*, 26 November 1883).

[16] "*Je ne connais pas les luttes qui auront (?) eu lieu, ni les (?) occupations (?) de M. Claude Bernard qui ont provoqué vos récriminations dans l'article d'introduction, mais je connais fort bien les dispositions des médecins peu favorables pour la zoologie et leur inclination pour le drapeau de l'utilité immédiate*.", our translation. Letter from Rudolph Bergh to Lacaze-Duthiers, 1872. Archives de l'Académie des Sciences (Paris).

France was experiencing a new publishing economy, with the beginnings of the industrialization of book manufacturing, the change in book format, the evolution of the publisher's profession. Lacaze-Duthiers was very conscious of this and was eager to grasp these opportunities (Chartier & Martin 1984).

His will to create and bring to life these "*Archives de Zoologie Expérimentale et Générale*" came mostly from the decision to promote a school of thought, namely experimental zoology, as defined above. But the wish to create a new zoology journal was also motivated by the desire to escape the control of the leading zoology journal that had the monopoly at that time, the "*Annales de sciences naturelles, section de zoologie*". Before the creation of the *Archives*, Lacaze-Duthiers, as all other French naturalists, published mainly in the "*Annales de Sciences Naturelles*", a journal created in 1824 and which, for its zoological part, was held by his former mentor, Henri Milne-Edwards, Professor at the National Museum of Natural History. This journal did not accept papers from young scientists and was not open to foreign science. More, it promoted very descriptive zoological studies. Let us let Émile Baudelot (1834-1875), Professor at the Faculty of Sciences of Nancy and close friend of Lacaze-Duthiers, express his vision of the "*Annales de sciences naturelles*" in a letter written to Lacaze-Duthiers in 1868[17]: "*You told me about your intention to publish a journal. Are you still thinking about it? If so, let me know; I have several things to publish, I could keep them for you for some time. Please answer me about this. For some time now, the Annals* [Annales de sciences naturelles] *have become unbearably bland; one can only see parrot bones or other fossils, and it will soon be a journal of comparative anatomy, if things go well. As I have been known to push open doors, I do not feel obliged to provide this journal with more substantial and philosophical food. What do you say to that?*". Motivated by the promotion of a modern experimental zoology, Lacaze-Duthiers obviously wanted to escape the conservatism of this journal. He therefore had the firm resolution to have a journal in which, as he wrote in 1868 to Émile Baudelot, he could do "*Zoology as you and I understand it*[18]". At the same time, and the two ideas are linked, the *Archives* were designed from their creation as a natural outlet for the work carried out in the marine stations funded by Lacaze-Duthiers, first Roscoff in 1872 and 10 years later Banyuls-sur-Mer. The title of the journal, almost identical to the name of Roscoff's first laboratory, sounded like a proclamation: Lacaze-Duthiers wanted to promote the zoology of the future, as important as the physiology of Claude Bernard and which must be submitted "*to the control of experience*" by combining these experiences with work in the field and by embracing the entire life cycle, and even the living conditions of organisms. Finally, the dissertation theses of Lacaze-Duthiers' students, all of course carried out according to the master's experimental methods, were to be published in priority and in full in the *Archives*. All this approach was therefore coherent and ambitious: Lacaze-Duthiers wanted to spread out, push his ideas and obtain the means for his ambitions. Marine stations, training of young scientists and the *Archives* were thought as complementary tools to reach this goal. The least one can say *a posteriori,* is that they were very effective tools indeed….

Lacaze-Duthiers seriously considered creating a publication in the mid-1860s. In 1868, he contacted publishers, Baillière but also Hachette, by avoiding one of the most powerful of the time, Masson, because he was the editor of the "*Annales des sciences naturelles*" with which he was going to compete head-on. But "*they refused me, telling me that there would be a loss*". He regretted it and added "*This is obvious but, I believe that I would have made with a few names of young teachers a small nucleus which would have made its way. It is not said that I do not think of doing the thing alone.* […] *It is an idea that I have had in mind for two years. If family matters did not hold me* [his father just died]*, I would be determined and I would engage in the fight.*[19]" We can therefore see that, from the start he knew that the game will not be easy. In 1872, he therefore launched the publication of the first volume of the *Archives* with no financial support other than his own funds. The paternal inheritance allowed Lacaze-Duthiers to make this investment, but he could not ensure further publications. The publisher was the librarian Germer-Baillère who had not put a cent in the publication. This first volume was very well received by the French and European scientific community. But many

[17] "*Vous m'avez manifesté votre intention de faire paraître un journal. Y pensez-vous encore ? Si oui, dites-le moi ; j'ai plusieurs choses à publier, je pourrais les garder quelque temps encore à votre intention. Veuillez me répondre à ce sujet. Les* Annales *depuis quelque temps sont devenues d'une fadeur insupportable ; on n'y voit plus que des os de perroquets ou autre fossile, ce ne sera plus bientôt un journal d'anatomie comparée pour peu que les choses aillent en progressant. Comme on m'a reconnu l'aimable faculté d'enfoncer des portes ouvertes, je ne me crois nullement tenu de fournir à ce journal une nourriture à la fois plus substantielle et plus philosophique. Qu'en dites-vous ?*", our translation. Letter from Émile Baudelot to Lacaze-Duthiers, July 5, 1868. Bibliothèque du Laboratoire Arago, Sorbonne Université.

[18] " *Zoologie, comme vous et moi l'entendons*.", our translation. Letter from Henri de Lacaze-Duthiers to Émile Baudelot, July 23, 1868. Bibliothèque du Laboratoire Arago, Sorbonne Université.

[19] "*Cela est évident mais, je crois que j'aurais fait avec quelques noms de jeunes professeurs un petit noyau qui aurait fait son chemin. Il n'est pas dit que je ne songe à faire tout seul la chose* […] *C'est une idée que j'ai en tête depuis deux ans. Si des affaires de famille ne me tenaient… je serais décidé et j'engagerais la lutte*". Letter from Henri de Lacaze-Duthiers to Émile Baudelot, July 23, 1868. Bibliothèque du Laboratoire Arago, Sorbonne Université.

of Lacaze-Duthiers' friends were anxious. As an example, let's cite the veterinary and geologist Philippe Thomas (1843-1910) who wrote him in 1872: "*I have received and read your latest issue of the* Archives. *No need to compliment you on the importance of the content (to others more authorized the care and pleasure of doing it) for me I can only express the interest that I found. Your publication is very beautiful, a fine example, a fine model – and an honor for France; it is very sad that with such merits, it cannot live an independent life. Your letter tells me only too well what it is, and I was alarmed at the figure of your deficit. No matter how great your dedication to science, you cannot continue to make such sacrifices. Your ruin would be at the end.*[20]" Indeed, the subscriptions, essential to the continuation of the journal, were not forthcoming. Everything threatened to stop there.

Fortunately, at the end of 1872, one of his colleagues, the chemist and geologist Édouard Collomb (1801-1875), introduced him to the librarian and editor Charles Reinwald (1812-1891). Charles Reinwald had specialized in the publication of scientific works and general science. He was also one of the few to publish translations of scientific works (he was the first to publish the works of Darwin in France). His address book abroad was a considerable asset in obtaining subscriptions throughout Europe and the United States. Importantly, he agreed to invest funds in the creation of the *Archives*, although for years Lacaze-Duthiers also continued to finance the publications. Reinwald and Lacaze-Duthiers were bound by a written contract that they renegotiated every two to three years. It took at least five years for the affair to be financially balanced. Upon the death of Reinwald in 1891, his business was taken over by his adopted grandsons, the Schleicher brothers, who continued to publish the *Archives*. In 1873, the second volume of the *Archives*, edited by Charles Reinwald, also received two other important contributions: the support of the "French Association for the Advancement of Sciences"[21] and of the Ministry of Public Instruction. Indeed, the Director of Higher Education, Armand du Mesnil (1819-1903), took subscriptions for the French Faculties of Sciences, quickly followed by the Ministry of Agriculture. All this saved the journal and allowed it to start up until it reached a financial balance. Indeed, little by little, the situation stabilized but it had been very demanding years. In 1883, celebrating the 10 years of the *Archives*, Lacaze-Duthiers wrote: "*More than once, I have felt this beginning of failure which forces ready to be exhausted give birth to.* […] *The deficits of the first days were painful to bear, because they were considerable.* […] *But I had confidence, and hope never abandoned me, despite passing moments of discouragement.*[22]" (Lacaze-Duthiers, 1883). The highly favorable opinion of foreign colleagues such as Rudolf Bergh (1824-1909): "*It is true that considering the territorial size of France and its intellectual importance, one is surprised at the very limited number of French natural history journals, much fewer in fact than expected, especially good journals which left the rut of the naturalists to engage in the truly scientific furrow*[23]"; or the Swiss anatomist Albert Kölliker: Lacaze-Duthiers thanks him in a letter in May 1872: "*You were one of the first subscribers to my archives. Thank you. The undertaking is heavy, everything is at my expense. But in all branches, work, work, make an effort. French Zoology has its quarters of nobility and nobility obliges.*[24]"; or another Swiss zoologist, Carl Vogt (1817-1895), who took a subscription as early as 1872, surely contributed helping him maintaining his effort throughout these demanding first years.

THE DAY BY DAY OF A SCIENTIFIC JOURNAL AT THE END OF THE 19TH CENTURY

It has been clear since the beginning, the *Archives* were the natural outlet for the work carried out in the marine stations directed by Lacaze-Duthiers, as well as the thesis works of his students and all the studies carried out by

[20] "*J'ai reçu et lu votre dernier numéro des Archives. Inutile de vous faire mes compliments sur l'importance du contenu (à d'autres plus autorisés le soin et le plaisir de le faire) pour moi je ne peux que vous exprimer l'intérêt que j'ai trouvé. Votre publication est bien belle, un bel exemple, un beau modèle – et un honneur pour la France ; c'est bien triste qu'avec de tels mérites, elle ne puisse pas vivre d'une vie propre et indépendante. Votre lettre ne me dit que trop ce qu'il en est, et j'ai été effrayé du chiffre de votre déficit. Quel que grand que soit votre dévouement à la science, vous ne pouvez pas continuer à faire de tels sacrifices. Votre ruine serait au bout*", our translation. Letter from Philippe Thomas to Henri de Lacaze-Duthiers, December 31, 1872. Bibliothèque du Laboratoire Arago, Sorbonne Université.

[21] "*L'association française pour l'avancement des sciences*" is a non-profit association founded in 1872 by several renowned scientists, including Louis Pasteur, to bring scientists into contact with each other.

[22] "*Plus d'une fois, j'ai ressenti ce commencement de défaillance que font naître des forces prêtes à s'épuiser.* […] *Les déficits des premiers jours furent pénibles à supporter, car ils étaient considérables.* […] *Mais j'avais confiance, et l'espérance ne m'abandonna jamais, malgré des moments passagers de découragement*", our translation.

[23] "*C'est vrai qu'envisageant la grandeur territoriale de la France et son importance intellectuelle on s'étonne du nombre très restreint de journaux français d'histoire naturelle, beaucoup moindre à vrai dire qu'on ne l'attendait, surtout de bons journaux qui ont quitté l'ornière des naturalistes pour s'engager dans le sillon vraiment scientifique*.", our translation. Letter from Rudolph Bergh to Lacaze-Duthiers, May 5, 1872. Archives de l'Académie des Sciences (Paris).

[24] "*Vous avez été l'un des premiers abonnés à mes archives. Je vous en remercie. L'entreprise est lourde, tout est à ma charge. Mais dans toutes les branches, travaillez, travaillez faire des efforts. La Zoologie française a ses quartiers de noblesse et noblesse oblige*", our translation. Letter from Lacaze-Duthiers to Albert Kölliker, May 6, 1872. Archives de l'Académie des Sciences (Paris).

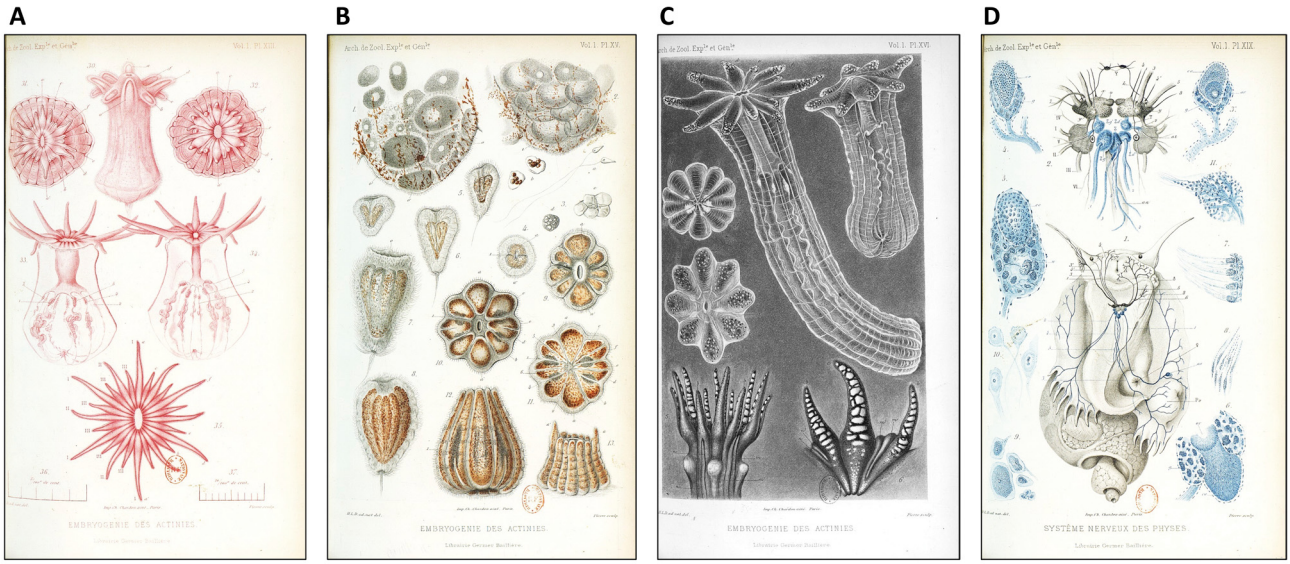

Fig 1. – Four plates by Lacaze-Duthiers published in the 1st volume of the *Archives* in 1872. A, B and C are from the article "*Développement des coralliaires. Premier mémoire. Actiniaires sans polypiers*". D comes from the article "*Du système nerveux des Mollusques Gastéropodes Pulmonés aquatiques et d'un nouvel organe d'innervation*". The drawings are from Lacaze-Duthiers, the engraver is M. Pierre, the printer is Charles Chardon aîné. **A**: Development of *Actinia mesembryanthemum*, between 12 and 24 division cycles. In the original legend, Lacaze-Duthiers mentioned: "*However lightly the engraving was done in some parts, it would have been much better to represent the outer layer and the vibratory cilia with a neutral tint. The idea of naturalness will be obtained in all these plates by replacing by the imagination the red colour with a light wash of neutral tint.*" ("*Quelque légère qu'on ait fait la gravure dans certaines parties, il eût été bien préférable de représenter la couche externe et les cils vibratiles par une teinte neutre. On aura dans toutes ces planches l'idée du naturel en remplaçant par la pensée la couleur rouge par un léger lavis de teinte neutre.*", our translation). **B**: Development of the *Sagartia bellis*. Portion of ovaries, spermatozoa, embryos at different developmental stages and a young *Sagartia* already fixed are represented, on this two-colors plate. **C**: Development of the *Bunodes gemmacea*. Embryos and different stages of the development of this sea anemone are represented, in black and white. In the original legend, Lacaze-Duthiers mentioned: "*The beauty of the colours, the transparency of the tissues of the embryos in this period make the study both attractive and easy.*" ("*La beauté des couleurs, la transparence des tissus des embryons dans cette période rendent l'étude aussi attrayante que facile.*", our translation). **D**: Nervous systems of *Physa fontinalis* et *Physa acuta*. © Source gallica.bnf.fr / Bibliothèque nationale de France

the lecturers and assistant-professors of his laboratories (in Paris, Roscoff and Banyuls). In fact, because of this eminent position, Lacaze-Duthiers knew in advance the work that will be sent to the *Archives*. The scientists who visited his stations were either his students and members of his laboratories, or former pupils or colleagues from various French Faculties of Sciences, or foreign scientists (with the exception of Germans who were not admitted). They came for several weeks or months, sometimes several consecutive years and then continued to work in their respective institutions, in France or abroad, on the material collected in the stations. All of them were obliged to tell Lacaze-Duthiers the subject of their studies before coming or at the beginning of their stay, and to provide him with a summary of their work when they left. They also had to request permission to take biological material with them at the end of their stay, specifying the species concerned and the use they wanted to make of it. An absolute obligation was to publish their results in the *Archives*, to the exclusion of any other journal. A translation could then be given to other foreign journals. The time for writing and drawing came several months, or even years, after the first stay in the station. There were no classical referees as in the modern journals but as we have seen, Lacaze-Duthiers was already aware of all the results compiled in the article that was sent to him and checked beforehand the interest and quality of the work. Moreover, he sometimes urged the authors to write and send their article more quickly. He was indeed in constant contact with the authors, as evidenced by his extensive correspondence. Then, everything needed the "*imprimatur*" of the master! Along with the authors, Lacaze-Duthiers also proofread the manuscripts, especially the quality of the drawings or got help from his collaborators, lecturers, assistant professors or even his "*préparateurs*" who were his PhD students, hired as assistants. He sometimes proposed changes, but these were rather cosmetic, concerning the quality of the drawings, or the clarity and consistency of the language. Everything was published in French. This was a challenge for the many foreign authors who published in the *Archives* (English, Belgian, Dutch, Danish, Swedish, German Swiss, Spanish, Romanian, Russian, American, etc.). In fact, most of them spoke and wrote extremely good French! They often had their texts corrected by a translator in their country of origin. Occasionally, a collaborator of Lacaze-Duthiers who knew a foreign language well (Aimé Schneider (1844-1932) for German, Lucien Joliet (1854-1887) for English, for example) would correct or, more rarely, translate *in extenso* an article by a foreign author. It should be noted that Laca-

ze-Duthiers was not familiar with any foreign language except for a little Spanish!

One of the most important aspects of the *Archives* was of course the plates that contained most often color drawings associated with the main papers. The stage of elaboration of the plates was the most difficult, the longest and the most expensive (Fig. 1). Everything started with the drawings made directly by the authors (ink or pencil). Not all of them had the artistic talent of Lacaze-Duthiers, and they sometimes took a very long time to produce drawings that satisfied them, that is to say, as close to reality as possible. Many of them colored their drawings, a difficult additional step, all requiring a lot of technique (gouache, watercolor, pastels). These drawings were then sent to an engraver, through Lacaze-Duthiers and Reinwald. Depending on the quality and precision expected, the engravings were made on wood (for the roughest drawings), or on stone or on metal. A first impression, a proof, was made and sent back by Reinwald and/or Lacaze-Duthiers to the author who indicated the corrections to be made. The engraver made the changes and usually only one proof was needed. But demanding authors, like Hermann Fol, requested a second set of proofs. This slowed down the publication and increased the prices! Then came the application of colors. Of course, black and white was the most economical solution, and the more colors there were, the more expensive it became. Again, for the colors, a set of proofs was circulated. At the end of the process, the engravings were printed (Fig. 1) in the same number as the volumes of the *Archives* that were to be published, with the addition of prints for the reprints intended for the authors: 25 free of charge, the rest to be paid by the authors. The text was printed separately by the printer-typographer Alexandre Hennuyer.

The question of the quality of the engravings and their price was recurrent. The first problem was the availability of engravers. Good engravers were rare. And the more the years passed, the more expensive they became. In 1900, the Schleicher brothers wrote about the engraver Lartaud, whose prices were becoming excessive: "*You know that the race of copper engravers is gradually dying out, and those who remain – sadly – all seem to have the motto "*Quo non ascendam*"* [literally: "where will I not go up", meaning: in terms of prices!]. *We are visited by many artists every day: there is not one as a copper engraver. It would be good to spare the only one left, while stopping his enthusiasm* [in terms of prices] *from time to time*."[25]

Lacaze-Duthiers constantly made the bitter reflection of it, jealous of the German engravers whom he considered better craftsmen and much cheaper. Besides, he had to stay within his budget. He regularly refused colors to authors, except if they took charge of the expenses. Faced with these concerns, the authors reacted differently. Some were ready to pay for the colors, as for example Lucien Joubin (1861-1935), ex-lecturer of Lacaze-Duthiers and then Professor at the Faculty of Sciences of Rennes, who wrote in 1883 to Lacaze-Duthiers: "*You told me that the budget of your Archives did not allow you to give me the color of my plates. It will be at my expense, and despite the meagerness of my purse, I will find, I hope, to borrow from the paternal fund enough to pay this sum.*[26]" Others, having a personal fortune like Hermann Fol, preferred to hire an engraver of their choice and sent already engraved plates for printing. This was a solution that Lacaze-Duthiers reluctantly accepted, only from some foreign authors, like Hermann Fol, Émile Yung (1854-1918) or Carl Vogt, because he then lost some control over the publication! Others, gifted with a certain talent, had initiated themselves to engraving, and even to colorization, in order to provide plates to Reinwald. This was a rare case, and again not much appreciated by Lacaze-Duthiers, but Aimé Schneider, very close to Lacaze-Duthiers, obtained this permission, which allowed him to make substantial savings. Sometimes, the authors were unhappy of the quality of the plates and complained bitterly. This added a lot to the burden of managing the *Archives*. This is the case of the embryologist Edouard Gerard Balbiani (1823-1899), famous for his Balbiani rings in puffing insect chromosomes, who in 1900, unhappy of the reproduction of his figures complained to Lacaze-Duthiers: "*I have never seen a slaughterer like this XX. The modeled figures (?) of the 1st plate are of a loose and flat work where there is not the shadow of artistic effect. But what is more serious, badly copied details are absolutely confusing*." and then, about cell nuclei: "*It looks like musical notes out of scope wandering through histological figures*[27]"!

Publishing in the *Archives* was essentially free for the authors, unless they wanted reprints in addition to the 25

[25] "*Vous savez que la race des graveurs sur cuivre s'éteint petit à petit, et ceux qui restent – hélas – semblent avoir tous pour devise "*Quo non ascendam*". Nous avons chaque jour la visite de nombreux artistes : il n'y en a pas un comme graveur sur cuivre. Il serait bon de ménager le seul qui nous reste, tout en arrêtant son élan de temps à autre*.", our translation. Letter from the Schleicher brothers to Lacaze-Duthiers, January 23, 1900. Bibliothèque du Laboratoire Arago, Sorbonne Université.

[26] "*Vous m'avez dit que le budget de vos* Archives *ne vous permettait pas de me donner la couleur de mes planches. Ce sera à ma charge, et malgré la maigreur de ma bourse, je trouverai je l'espère à emprunter à la caisse paternelle de quoi payer cette somme*", our translation. Letter from Louis Joubin to Lacaze-Duthiers, November 1883. Archives de l'Académie des Sciences (Paris).

[27] *…jamais je n'ai vu un massacreur comme ce XX. Les figures modelées (?) de la planche 1ère sont d'un travail lâche et plat où il n'y a pas l'ombre d'effet artistique. Mais ce qui est plus grave, des détails mal copiés déroutent absolument*." […] Puis à propos des noyaux des cellules : "*On dirait des notes de musique en rupture de portée se promenant à travers des figures histologiques*.", our translation. Letter from Balbiani to Lacaze-Duthiers, 1899 ou 1900. Archives de l'Académie des Sciences (Paris).

free of charges, or the colorization of their plates. There was no page charge but there was also no retribution to the authors. For this reason, some of them, like the great entomologist Jean-Henri Fabre (1823-1915) who were heavily dependent on the income generated by their books and publications, were therefore unable to publish in the *Archives*: "*I would like nothing better than to publish the results of my research for the sole honor of adding my modest sheaf to the harvest of science; but I have already entrusted it to you, I live little from the work of my pen. To spend my time in writings which would not help me somewhat would be a mad generosity on my part which I would have to suffer seriously. It's annoying, very annoying but what to do about it: the profession must feed its man*[28]".

As we have seen, two people were central to the publication of the *Archives*, Lacaze-Duthiers and Reinwald. The initial manuscripts and drawings were communicated to Lacaze-Duthiers by the authors. He then communicated them (or not!) to Reinwald. The latter coordinated the typographer in charge of the composition and printing of the text, the engravers, and was in direct contact with the authors. He regularly asked for changes due to technical constraints: the manuscript was too long, there were too many plates, the article could be divided into two parts to be published in two successive volumes, etc. But he did not take any decision without the agreement of Lacaze-Duthiers! Lacaze-Duthiers was the real scientific editor, likely to delay the publication of an article to give priority to another more urgent one. The scientific competition was already fierce at that time and the anteriority of the publication a very important element. For this to work, Reinwald and Lacaze-Duthiers were in constant contact, either directly when Lacaze-Duthiers was in Paris, or by mail: at least one letter a week, or even one every 2-3 days, or even every day at the time of the closing of the volumes! Let's add that Lacaze-Duthiers always refused to delegate any of his duties and had the responsibility to sign all the administrative acts related to the publication, from the printing orders to the requests for authorizations to the Prefecture of Police (the press was under control…). This represented a tremendous amount of work as, between 1872 and 1901 (the year at which Lacaze-Duthiers died), the *Archives* published between 6 (1889 and 1900) and 20 (1879-1880) articles, representing an average of 11 articles per year. These were mostly long articles, sometimes several hundred pages and in overall, each year, these represented 644 pages of text (therefore 58 pages per paper in average).

Despite the fact that Lacaze-Duthiers was central in the decision-making process, to publish or not a paper, it is important to stress that he was in fact very open to divergent opinions and respected the liberty of his collaborators. He was however extremely careful to the quality of the science and was uncompromising on this aspect. The following testimony of Emile Racovitza (1868-1947), a Romanian researcher who will be the founder of biospeleology, provides a nice illustration of this: "*Lacaze-Duthiers was a true master! He knew how to choose and encourage his students, he knew how to inculcate in them the severe discipline of order in research, rigor in observation and experience which he advised repeating before concluding. He* […] *invited them to have confidence only in rigorously established and conscientiously verifiable facts. On the other hand, he never tried to impose his opinions or his theoretical views on the students. This man, yet in other circumstances so well rounded, showed himself to be completely tolerant from this point of view. It suffices, to prove it, to mention the fact that Lacaze was not a transformist and that all his pupils were; some even are militant evolutionists. Wasn't he also one of those who supported Darwin's candidacy for the dignity of correspondent of the Academy of Sciences?*[29]" (Racovitza 1937).

In addition to the regular articles, the *Archives* also contained a very original section called "*Notes et Revues*" which consisted in short notes on important works published abroad, in foreign languages, whose most important points were summarized. The "*Notes et Revues*" also contained news, descriptions of new methods, brief expedition reports, etc. In the two first years, many were written by Lacaze-Duthiers himself with the help of two of his pupils, Edmond Perrier and Alfred Giard. But Lacaze-Duthiers did not read any foreign language (except a few words of Spanish, as already mentioned), so he had to use collaborators who could read and translate the articles (most often from English, German or Russian) in question. Aimé Schneider, Patrick Geddes (1854-1932), a

[28] "*Je ne demanderais pas mieux que de publier les résultats de mes recherches pour le seul honneur d'ajouter ma modeste gerbe à la moisson de la science ; mais je vous l'ai déjà confié, je vis petitement du travail de ma plume. Dépensant mon temps en des écrits qui ne me viendraient pas quelque peu en aide serait de ma part folle largesse dont j'aurais sérieusement à pâtir. C'est fâcheux, très fâcheux mais qu'y faire : le métier doit nourrir son homme*.", our translation. Letter from Jean-Henri Fabre to Lacaze-Duthiers, 1899. Archives de l'Académie des Sciences (Paris).

[29] "*Lacaze-Duthiers était un véritable maître ! Il savait choisir et encourager ses élèves, il savait leur inculquer la sévère discipline de l'ordre dans les recherches, de la rigueur dans l'observation et l'expérience qu'il conseillait de répéter avant de conclure. Il* […] *les invitait à n'avoir confiance que dans les faits rigoureusement établis et consciencieusement vérifiable. Par contre, jamais il n'a essayé d'imposer aux élèves ses opinions ou ses vues théoriques. Cet homme, pourtant en d'autres circonstances si entier, se montra de ce point de vue d'une complète tolérance. Il suffit, pour le prouver, de mentionner le fait que Lacaze n'était pas transformiste et que tous ses élèves l'étaient ; quelques-uns mêmes sont des évolutionnistes militants. N'a-t-il pas d'ailleurs compté parmi ceux qui ont soutenu la candidature de Darwin à la dignité de correspondant de l'Académie des sciences ?*", our translation.

French-speaking Scottish scientist, and then Lucien Joliet played an important role in these "*Notes et Revues*". Lucien Joliet was almost alone in charge of this section for 11 years, until his death in 1887. From 1898, under the influence of Georges Pruvot (1852-1924), the "*Notes et Revues*" will serve to quickly publish short original articles, thus allowing authors to ensure the anteriority of a discovery particularly important in their eyes. Previously, the anteriority was often acquired by a communication to the French Academy of Sciences, but it was still necessary to go through the goodwill of a friendly academician… This section which thus played the role of a magazine had a considerable importance by making available to French scientists the main discoveries published in foreign countries. We can clearly see here the desire of Henri de Lacaze-Duthiers to contribute in this way to enlighten and inspire French zoology as he conceived it. The deliveries of these "*Notes et Revues*", a real supplement to the *Archives*, were quite irregular no doubt because of the difficulties of finding translators but also because of the cost of the *Archives*, of which it naturally constituted a kind of variable of adjustment, but they continued, with ups and downs until 1965, the *Archives* ceasing to appear in 1981.

Table I provides the integrality of the titles of the "*Notes et Revues*" for the first and the fifth volume of the *Archives* and gives a good idea of the impressive diversity of this section. All taxons were covered and even if there was a clear bias in favor of marine invertebrates, mammals, birds or insects could be discussed. If plants were not discussed (it is, after all, a zoology journal), protists were often covered. This diversity also concerns the scientific disciplines: zoology of course but also geology, paleontology, embryology, histology, cell biology, for the simple reason that Lacaze-Duthiers considered zoology to be general (we would say today "integrative"), as indicated in the title of the journal ("*Zoologie Générale*"), and including all these disciplines. Another important aspect was the expeditions occurring in the world. Only in these two volumes, we travel to Titicaca Lake, the poles, Caspian Sea or on the mythical *Challenger* boat. Last, but not least, the papers of all the scientists of the time were summarized: the work of Ernst Haeckel of course but also Alexander Agassiz (1835-1910), Ray Lankester (1847-1929), Albert von Kölliker, Alexandre Kowalevsky (1840-1901) or Oscar Hertwig (1849-1922) are regularly scrutinized and commented in the "*Notes et Revues*". Indeed, for a French-speaking zoologist of the time, it would have been very interesting to read these short notes to be aware of what was going on over the world!

Among the duties of the Director of the *Archives* was also that of firefighter. Indeed, many authors were dissatisfied with the publications of their colleagues, either because they disagreed with them, or because they considered that their anteriority had not been respected or even frankly that their work had been stolen. By reading the articles of the time, we see that the authors were clearly outspoken and much more vindictive than us today. Anthology: "*The section that Ray Lankester represents is absolutely theoretical and cannot give any idea of what actually exists*[30]" (Perrier 1874). Hermann Fol writes about a report by another author: "*I will abstain from criticizing this singular web of absurdities; that would lead too far*[31]." (Fol 1874). Other authors are not less hard: "*From which we should logically conclude* […] *that no Hydroid has an epithelium, which is absurd*[32]." (Korotneff 1876a). Lacaze-Duthiers himself had difficulties with Alfred Giard whom he accused of having suddenly decided to go it alone on work on sea squirts which had first started as a collaboration. Without ever being vitriolic, you can feel him vibrating with anger when he recounts this episode (Lacaze-Duthiers 1874). Even if he cut all relationships with Giard, he nevertheless let him publish his work in the *Archives*, with a certain elegance (Giard 1872a, b).

But of course, it often degenerated, and the authors then wrote to Lacaze-Duthiers to have him as a witness. Then he analyzed, answered and sometimes arbitrated in the form of a short note or an addendum added at the end of an article to try to calm things down. One of the most violent polemics was the one opposing Ray Lankester and Hermann Fol on the development of molluscs. Henri de Lacaze-Duthiers clearly found himself be caught in the crossfire: Ray Lankester was obviously one of the hugely influential scientists of the time, and Hermann Fol, a former student of Haeckel, was clearly a protege of Lacaze-Duthiers but was known for his strong character. In an article published in the *Archives*, Fol accused Lankester of stealing results from him when they met in Messina in 1874, and then publishing them in October 1874. Lankester was outraged and wrote to Lacaze-Duthiers: "*Allow me to say immediately that Mr. Fol's assertions are the product of a sick imagination. There is not a word of truth in this accusation except that I published a work on the embryogeny of Lymnea in the Quarterly Journal Microsc Sci Oct 74. The facts related in this work were observed by me in Lymnea embryos.* […] *His assertion* […] *is neither more nor less than a falsehood, which I am quite inclined to believe is due rather to the work of an imagination excited by vanity and jealousy, than to a deliberate lie.*[33]" Lacaze-Duthiers tried to calm things down and

[30] "*La coupe que représente Ray Lankester est absolument théorique et ne peut donner aucune idée de ce qui existe en réalité*", our translation. In the same paper (Perrier 1874), Perrier talks about the "*faulty figures*" of Jules d'Udekem.

[31] "*Je m'abstiendrai de faire la critique de ce singulier tissu d'absurdités ; cela nous mènerait trop loin*", our translation.

[32] "*D'où il faudrait logiquement conclure,* […] *qu'aucun Hydraire n'a d'épithélium, ce qui est absurde*", our translation. Korotneff about Kleinenberg's opinion on Hydra.

[33] "*Permettez-moi de dire de suite que les assertions de M. Fol sont le produit d'une imagination malade. Il n'y a pas un mot de vrai dans cette accusation si ce n'est le fait que j'ai publié un travail sur l'embryogénie du Lymnée dans le* Quaterly

Table I. – Titles of the "*Notes et Revues*" of the Volumes 1 and 5 of the "*Archives de Zoologie Expérimentale et Générale*". (a) our translation; (b) Author indicated in the publication. It often corresponds to the author of the original paper that is summarized. (c) The Redactor is the person who read the original article and wrote the actual note. E.P.: Edmond Perrier; A.G.: Alfred Giard; H.L-D.: Henri de Lacaze Duthiers; L.B.: Lucien Brun; L.J.: Lucien Joliet; A.S.: Aimé Schneider; J.F.: Jean Fessenko.

1872 – Volume 1

Title (a)	Author (b)	Length	Taxon	Redactor (c)
I – On the lateral line sense organs in Fishes and Amphibians	Franz Eilhard Von Schulze	4	Vertebrates	E.P.
II – On the organization of sponges and their relationship with the Corallia	Ernst Haeckel	7	Sponges	A.G.
III – Station of *Pentacrinus europaenus* on the coasts of France	Henri de Lacaze-Duthiers	4	Echinoderms	
IV – New Instruments	Henri de Lacaze-Duthiers	4		
V – About the Choetoptera and Myxicoles station on the beaches of Roscoff and Saint-Pol-de-Léon, coasts of Brittany (Finistère)	Henri de Lacaze-Duthiers	8	Annelids	
VI – The luminous organs and the light of the Pennatula	Paolo Panceri, Professore, in Napoli	2	Cnidarians	H.L-D.
VII – Tests of paleontological theories by reality. Trilobites	Joachim Barrande	9	Paléontology Arthropods	
VIII – The skin of the bat's wing, especially the endings of its nerves	Jos Schöbl, in Prag	2	Mammals	H.L-D.
IX – The outer ear of the mouse considered an important organ of touch	Jos Schöbl, in Prag	2	Mammals	H.L-D.
X – Preservation of microscopic preparations with potassium acetate	Max Schultze	2		
XI – The snout of the mole considered as an apparatus of touch	Th. Eimer	2	Mammals	
XII – Amoeboid nature of cilia movement	Ernst Haeckel	2		
XIII – The plastid theory versus the cell theory	Ernst Haeckel	3		
XIV – News	Henri de Lacaze-Duthiers	2		
XV – Memoirs and Works received by the Direction of the *Archives*		2		
XVI – Elections to the Academy of Sciences (Institut de France) in the Section of Zoology	Henri de Lacaze-Duthiers	2		
XVII – Creation of an Experimental Zoology laboratory on the coasts of France	Henri de Lacaze-Duthiers	3		
XVIII – Scientific movement	Henri de Lacaze-Duthiers	2		
XIX – Remarks on note XII relating to the nature of ciliary movements	Henri de Lacaze-Duthiers	5		
XX – Study on the Appendicularians of the Strait of Messina	Fol Hermann	3	Appendicularians	
XXI – On the phosphorescence of marine animals		2		
XXII – News of Mr. Louis Agassiz's trip to South America	Henri de Lacaze-Duthiers	1		
XXIII – No title		2		
XXIV – Memoirs and Works received by the Direction of the *Archives*		2		
XXV – On the nature of sponges	Henri de Lacaze-Duthiers	3	Sponges	
XXVI – Zoological Relationships of Brachiopods	Edmond Perrier	2	Brachiopods	
XXVII – New zoological publications from abroad		1		
XXVIII – Research to serve the history of terrestrial earthworms	Edmond Perrier	12	Annelids	
XXIX – Works and Memoirs received by the Direction of the *Archives*		2		

Table I. – Continued.

1876 – Volume 5

Title (a)	Author (b)	Length	Taxon	Redactor (c)
I – *Neomenia*: new genus of invertebrate	Tycho Tullberg, Stockholm	4	Molluscs	L.B.
II – Sur les poissons électriques et pseudo-électriques	Stefano Sihleanu	4	Fish	L.J.
III – Contribution to the study of Acinetes	Richard Hertwig	4	Protists	A.S.
IV – Swedish polar expedition. New sea cucumber	F. Schulthess	4	Echinoderms	H.L-D.
V – Zoological exploration of the Caspian Sea	Oscar Grimm & Th. Von Siebold	3		A.S.
VI – Developpement of *Podurella*	Oulianine	3	Insects	H.L-D.
VII – *Cyanea* eggs. Zoological notice	P. Harting	3	Cnidarians	
VIII – The animal egg	Oscar Hertwig	6	Echinoderms	A.S.
IX – On the development of sea cucumbers (*Holothuria tubulosa* and *Cucumaria doliolum*)	Emile Selenka	6	Echinoderms	A.S.
X – Instinct (?) in the hermit crab	Alexandre Agassiz	2	Crustaceans	L.B.
XI – On the development and multiplication of infusoria	Th.-W. Engelmann	6	Protists	A.S.
XII – On the structure and affinities of *Heliopora caeruea,* with notes on some species belonging to the genera *Sarcophyton*, *Pocillopora* and *Stylaster*	H.-N. Moseley	4	Cnidarians	L.J.
XIII – Preliminary note on the structure of the Stylasteridae, a group of corals which, like the Milleporidae, are hydroids and not Anthozoa	H.-N. Moseley	2	Cnidarians	L.J.
XIV – Sur la structure d'une espèce de Millepora trouvée à Tahiti	H.-N. Moseley Naturaliste associé à l'expédition du *Challenger*	2	Cnidarians	L.J.
XV – On the production of Cunines by budding at the bottom of the stomach of Geryonids	Oulianine	3	Cnidarians	J.F.
XVI – Hydrographic sketch of Lake Titicaca	Alexandre Agassiz	2	Geology	L.J.
XVII – Remarks on the organization and systematic position of the Foraminifera	Richard Hertwig	3	Protists	A.S.
XVIII – On the *Pelagonemertes rollestoni*	H.-N. Moseley Naturaliste à bord du *Challenger*	1	Nemertans	
XVIX – On the site of the luminous movement in the Campanullaires	Paolo Panceri	1	Cnidarians	L.J.
XX – On *Dendrocometes paradoxus* (Stein), with some remarks on *Spirochona gemmipara* and the contractile vacuoles of Vorticellae.	O.Butschll	5	Protists	A.S.
XXI – On the structure and systematic position of *Stephanoscyphus mirabilis*	Allman	1	Cnidarians	L.J.
XXII – Anatomy of *Caliphylla mediterranea*	Salvatore Trinchese	2	Molluscs	L.J.
XXIII – On the structure and development of the Myriothela	Allman	5	Cnidarians	L.J.
XXIV – Studies on Ligules	A. Donnadieu	2	Platyhelminths	

offered Ray Lankester to publish his version in the form of a Note: "*I will be able at most to allow myself some advice and some indications and in the present case, don't you think that some expressions of your note are very lively and that the debate like science would benefit from seeing them modified*. […] *when you compare the note that hurts you with the answer that you kindly sent me, you will see that the tone of the two is very different.*[34]"

Journal Microsc Sci *Oct 74*. *Les faits relatés dans ce travail ont été observés par moi chez des embryons de Lymnée*." … "*Son assertion… n'est ni plus ni moins qu'une fausseté qui, je suis tout disposé à le croire, est due plutôt au travail d'une imagination excitée par la vanité et la jalousie, qu'à un mensonge de propos délibéré*", our translation. Letter from Ray Lankester to Lacaze-Duthiers, January 5, 1875. Archives de l'Académie des Sciences (Paris).

[34] "*Je pourrai tout au plus me permettre quelques conseils et quelques indications et dans le cas actuel, ne trouvez-vous pas que quelques expressions de votre note sont bien vives et que le débat comme la science gagneraient à les voir modifier.* […] *quand vous comparerez la note qui vous blesse à*

Finally, two notes, one from Lankester and one from Fol were published in 1875 in the volume 4 of the *Archives*. This illustrates very well the amount of work that Lacaze-Duthiers had to do to ensure the quality and reputation of his *Archives*. This was not only a question of honor or ego: it was vital for the *Archives* to have as many subscribers as possible to ensure its survival and this would have not been possible without maintaining the quality of the papers and notes published in the *Archives*.

WHO WROTE IN THE "*ARCHIVES*"? WHAT DID THEY PUBLISH ?

If it is difficult given their diversity of topics, structures and affiliations, to make a general analysis of the authors of the "*Notes et Revues*". In contrast, it is possible to do such an analysis for the authors of the main papers that form the core of the *Archives*. Such an analysis revealed that for the period 1872-1914, 9 authors have published more than 5 papers (see Table II, extracted from Debaz 2005).

At the top of these is Lacaze-Duthiers himself. His input is especially impressive because these papers are not small contributions, but most often extensive monographies of several hundred pages. Given that the man was founder and head of two marine stations (one in Brittany and one on the Mediterranean coast close to Spain!) in addition to running his Parisian laboratory, professor at Sorbonne Faculty of Sciences, member of the French Academy of Science and implicated in many aspects of the French scientific policy of the time, this in-depth scientific work is quite impressive. We know from numerous testimonies that Lacaze-Duthiers was a terrific hardworker, but this scientific production indeed speaks for itself.

All the authors who published regularly in the *Archives* were mostly French, were regular visitors of the marine stations and were very often directly connected to Lacaze-Duthiers, being members of his laboratories, former pupils or close colleagues. He had therefore succeeded in his project: to create a school of thought and method, a group of scientists united by the same faith in experimental zoology and who, each on his own research theme, were going to make a career, spread all over France and make their own school. The great success of Roscoff and Banyuls-sur-Mer, which are still known as two of the most prominent French Marine stations (with Villefranche-sur-Mer that was derived from Hermann Fol and Alexis Korotneff (1854-1915), two followers of Lacaze-Duthiers) testifies to the double success of Lacaze-Duthiers. It is interesting to draw some portraits

Table II. – Authors that have published more than 5 articles in the *Archives de Zoologie Expérimentale et Générale* from 1872 to 1914.

Author	Number of papers 1872-1914
Henri de Lacaze-Duthiers	42
Yves Delage	20
Émile Racovitza	14
Edmond Perrier	12
Lucien Cuénot	11
Frédéric Guitel	11
Georges Pruvot	10
Louis Boutan	10
Aimé Schneider	9
René Jeannel	8
Émile Maupas	8
Camille Viguier	8
Émile Topsent	8
Camille Dareste	7
Octave Duboscq	7
Léon Fredericq	7
Louis Joubin	7
Louis Fage	6
Hermann Fol	6
Paul Marchal	6
Henri Prouho	6
Émile Yung	6

of some of these authors and we have chosen 4 of them: Edmond Perrier, Hermann Fol, Yves Delage (1854-1920) and Louis Boutan (1859-1934), which are fairly representative and which we present in boxes 1 to 4. But besides these four scientists and among those who have published more than five times in the *Archives*, many others had interesting scientific trajectories that have been supported by Lacaze-Duthiers. Let us mention two specialists of unicellular eukaryotes: Émile Maupas (1842-1916) who, with very limited means, in Algeria, discovered the mysteries of the sexuality of ciliates; and Aimé Schneider, also with the rather limited means of the Faculty of Sciences of Poitiers, became the pioneer specialist of Gregarines. Let us not forget the young Swiss Émile Yung, Vogt's pupil, very often neglected by his mentor (often on a trip, or busy with political activities, or ill), and who wrote his misfortunes to Lacaze-Duthiers who advised him and opened the doors of Roscoff and the *Archives* to him[35]. A brilliant personality stands out from the list, the Belgian physiologist Léon Frédéricq (1851-1935), also supported by Lacaze-Duthiers as attested by their abundant correspondence, and who discovered in Roscoff, in octopus,

la réponse que vous avez bien voulu m'envoyer, vous verrez que le ton des deux est bien différent", our translation. Letter from Lacaze-Duthiers to Ray Lankester, January 19, 1875. Archives de l'Académie des Sciences (Paris).

[35] This is the early period of Emile Yung's work on the development of animals, before he turned to anthropology and adopted positions that are today qualified as racialist.

the respiratory pigment of many invertebrates: hemocyanin! But also Louis Joubin, former lecturer in Lacaze-Duthiers' laboratory who became an eminent specialist of marine fauna and directed the Oceanographic Institute of Monaco at the request of Prince Albert I; Émile Topsent (1862-1951), a specialist of sponges who determined the sponges of the collections of Prince Albert I of Monaco, a work that served as a basis for the actual classification of sponges; Georges Pruvot, also a pupil of Lacaze-Duthiers and the pioneer of oceanology that will become is successor as Director of the Banyuls-sur-Mer marine station; Émile Racovitza, former student of Lacaze-Duthiers and founder of the biospeleology; Lucien Cuénot (1866-1951), one of the pioneers of genetics, opponent of the transmission of acquired characters dear to Lamarck and fervent supporter of a Darwinian type of evolution; Camille Dareste, the successor of Lacaze-Duthiers in Lille, who was the first embryologist to study the formation of monsters (teratology) and whose work prefigured endocrinological and pharmacological research of the future. And so many others, all of them revealing Lacaze-Duthiers' temperament: he favored free, audacious and curious minds, those who broke with dogma, even if their theories were far from or contrary to his own. By opening his *Archives* to them, he wanted to put forward a new generation of talented free minds.

If French scientists were the most regular contributors of the *Archives*, as expected from a French journal (as we have seen, scientists published in their own languages and therefore in national journals even if there were several ways to ensure the spreading of scientific information, as for the "*Notes et Revues"*). It is therefore interesting to point out names of prestigious colleagues who have chosen to publish original work in French in the *Archives*. This is the case of Alexander Agassiz, the son of the famous ichthyologist Louis Agassiz (1807-1873), who had done a brilliant scientific career and was in constant relationship with Lacaze-Duthiers, with a paper on flounder development in 1877. We can cite also Carl Vogt who published 3 times in 1876 and 1877 on marine worms, and its pupil, Émile Yung (see above); Oscar Hertwig on the fertilization and first division of animal eggs in 1872; Albert Von Kölliker on teeth and bones mineralization in 1873; Elie Metchnikoff (1845-1916) in 1876 on sponge morphology; and of course, Léon Frédéricq, Hermann Fol or Émile Racovitza (see above). It should be noted that although German researchers were not received at the Roscoff and Banyuls stations, which would have seemed an affront following the French defeat in the French-Prussian war in 1870 and was probably forbidden by the French Ministry of Public Instruction that financially supported the Roscoff station, Lacaze-Duthiers was open-minded enough to accept their publications in his *Archives*.

Several important discoveries have been published in the *Archives* and without being exhaustive, it is interesting to cite, for example, the work of Lacaze-Duthiers himself on coral (Lacaze-Duthiers 1872d), the studies on ascidians of Lacaze-Duthiers but also by Alfred Giard (Lacaze-Duthiers 1874, Giard 1872a, b). Other long lasting reports were the work on parthenogenesis by Yves Delage (Delage 1899, 1901, 1902a); the description of the method used to carry out underwater photographs (Boutan 1893, 1898); Camille Dareste's work on avian teratogenesis, of which he was one of the founders, but also on embryonic appendages in birds (Dareste 1873, 1874, 1876a, b); the works on fertilization by Hermann Fol (Fol 1877) and Oscar Hertwig (Hertwig 1876); those of Korotneff on actinia (Korotneff 1876b); and finally the work of Yves Delage on the crab parasite *Sacculina* (Delage 1884). On a more oceanographic point of view, Georges Pruvot, published in the *Archives* his first analysis on the seabed topography and the discovery of the submarine canyons, now known to be so important as biodiversity hotspots. He laid the foundations of underwater phylogeography (Pruvot 1894, 1895, 1897, Pruvot & Robert 1897). All this shows that Lacaze-Duthiers had succeeded in its double bet: promoting the research carried out in "his" marine stations and, at the same time, promoting zoology, modern, of quality, demanding and based on experimental research.

THE DEATH OF LACAZE-DUTHIERS AND THE CONTINUATION OF THE "*ARCHIVES*"

From 1890, Lacaze-Duthiers started thinking about his succession. Even at the age of 70 years, retiring was of course not an option, but he had to think about the future of his laboratories. One, Banyuls, was his personal property. Roscoff was under the administration of the Sorbonne where Lacaze-Duthiers was powerful, which would not necessarily have been the case for his successor. For the marine stations as for the *Archives*, the major fear was that one or the other passed to someone of the Giard clan who was truly, for Lacaze-Duthiers and his school, a fierce adversary, or under the control of the National Museum of Natural History with which Lacaze-Duthiers had a rather uncooperative relationship. In fact, the essential point for Lacaze-Duthiers was that his laboratories, like his *Archives*, should continue to enjoy total autonomy, without coming under the control of an institution such as the Museum or a Faculty, or of an adversary school such as that of Giard.

In 1898, Lacaze-Duthiers enlisted the services of Georges Pruvot who would be his successor in Banyuls and in whom he had full confidence. A little later, in 1900, Georges Pruvot and Émile Racovitza respectively became director and deputy-director of the Banyuls laboratory, although in practice no decision was taken without consultation and agreement with Lacaze-Duthiers. The laboratory was taken over by the Sorbonne, where Georges

Pruvot became a professor, while the Roscoff laboratory, already under the control of the Sorbonne, was directed by Yves Delage. In this way, both laboratories were run by faithful disciples of Lacaze, both of whom were professors at the institution administering them, the Sorbonne. This balanced solution for the two laboratories was not the same for the *Archives*. After the death of Lacaze-Duthiers in 1901, Pruvot and Racovitza, the heads of Banyuls, were alone in command of the *Archives*. From this period, if the *Archives* were still open to work carried out in Roscoff and elsewhere, they were much more centered on Banyuls-sur-Mer. The situation might have been different if the new director of Roscoff, Yves Delage, had joined the Archives' management group. The Pruvot-Racovitza duo remained at the head of the *Archives*, which kept the same format and the same organization, until the end of the 1920s. Then Pruvot, who died in 1924, was replaced by two colleagues, the protistologist Octave Duboscq (1868-1943) (who took over from Pruvot at the Banyuls station and was its director from 1923 to 1937) and Louis Fage (1883-1964), professor of zoology at the Museum who, like Racovitza, was a biospeleologist. The trio presided over the destiny of the *Archives* until the Second World War. The *Archives* were published until 1981, at that time over the patronage of the National Center for Scientific Research (CNRS), but they had largely lost their influence after World War II. The biologists of today can nevertheless dive into the *Archives*, especially those who are addressing biological questions through marine animals. They will measure how their favorite animals were already at the heart of intense research more than 150 years ago. All the *Archives* have been scanned and are publicly available at the Bibliothèque nationale de France (BnF Gallica[36]) or the Biodiversity Heritage Library (BHL[37]).

THE LEGACY OF THE *ARCHIVES*

Created to promote both a scientific approach – experimental zoology as defined by Lacaze-Duthiers in his inaugural manifesto (Lacaze-Duthiers 1872b) – as well as the permanent marine stations of Roscoff and Banyuls-sur-Mer, the *Archives* quickly became an essential reference in 19th century zoology. Even more, they have been for many years the place where a real school of thought and methodology could express itself and promote its vision of science. In fact, it can be said that not only have the *Archives* firmly anchored the stations created by Lacaze-Duthiers in the landscape, but they have also largely contributed to expanding and disseminating throughout zoology and marine biology the work of the fervent disciples of this school. Even Alfred Giard himself, having clearly become an enemy of Lacaze-Duthiers and his clan, continued to promote the same ideas in favor of experimental zoology (Giard 1905). We can therefore say that Giard, by creating the marine station of Wimereux in 1874, has undoubtedly contributed, maybe reluctantly, to spread the ideas of Lacaze-Duthiers. In the same way, Yves Delage who was the director of the Luc-sur-Mer marine station (before taking over from Lacaze Duthiers in Roscoff) and his successor, Jean Joyeux-Laffuie (1852-1917), were students of Lacaze-Duthiers and therefore the station of Luc-sur-Mer became part of the network. This is of course also the case of Villefranche, under the double influence of Hermann Fol and Alexis Korotneff, both very close to Lacaze-Duthiers, but also of the Endoume station, near Marseille, whose founder, Antoine-Fortuné Marion (1846-1900) was an admirer of Lacaze-Duthiers' ideas and asked him for abundant advice for the creation of his station; as well as many other places where scientists coming from the Lacaze-Duthiers' school were involved in the fifteen or so marine stations that were created around the French coast before 1900 (Caullery 1950, Dayrat 2016). This dynamism contrasts with other countries, in particular the United Kingdom where a certain delay has been seen from this point of view (see the anonymous article in *Nature*, 1883).

But there is more than that. Even if that would take us too far, it is necessary as a conclusion, to evoke the fact that the very research carried out in the marine stations of Lacaze-Duthiers, including that of Villefranche where Hermann Fol and Alexis Korotneff, both followers of Lacaze-Duthiers' ideas, had a considerable influence, have always retained an experimental specificity. Descriptive science alone (whether zoology, botany or oceanography) has never reigned in these marine stations. There has always been a vocation to understand how things work, to dissect, to visualize processes in action, to explain underlying mechanisms, in short to do experimental science in the sense that Lacaze-Duthiers intended when creating the *Archives*. This approach remained very original, and it still is, even if it is probably less visible today. It probably explains why these marine stations have allowed the emergence over the years of exceptional scientists and today are still internationally renowned.

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[36] https://gallica.bnf.fr/ark:/12148/cb34348221q/date
[37] https://www.biodiversitylibrary.org/

Box 1. The broken former student: Edmond Perrier (1844-1921)

Edmond Perrier was a student of Lacaze-Duthiers. In 1864, he was received at the *École Normale Supérieure* where he was noticed by Louis Pasteur and followed the courses of Lacaze-Duthiers. At the end of his education, in 1867, he was involved, like all the other students of the *École Normale*, in a political affair: they wrote a collective letter of support to the writer Sainte-Beuve, then a senator, who had defended freedom of thought and the right to criticize religion in the National Assembly. All the students, including Perrier, were excluded from the *École Normale*. Lacaze-Duthiers was one of the many who argued for their reintegration, which in fact took place a few months later. After a few brief years as a teacher in Agen, a small town where Lacaze-Duthiers had relatives to whom he introduced Perrier, he became in 1868 assistant-naturalist of Lacaze-Duthiers at the National Museum of Natural History in Paris. There, he completed a PhD under the supervision of Lacaze-Duthiers and signed his first contributions to the *Archives*. Lacaze-Duthiers was appointed professor at the Sorbonne in 1869 and Perrier stayed at the Museum. Nevertheless, he continued to work very closely with Lacaze-Duthiers. In 1872, Lacaze-Duthiers stopped teaching at the *École Normale Supérieure* and used all his energy and political contacts to get Perrier to take over these courses, which was a good financial opportunity for Perrier. The two men were very close, Lacaze-Duthiers clearly representing a paternal figure to whom Perrier confided his professional problems (he was tempted for a long time by a professorship in Montpellier) as well as his personal ones (he was widowed at the end of 1875, at the age of 31, with young children, and it was Lacaze-Duthiers who provided him with a housemaid; he remarried in 1879). Lacaze-Duthiers had a deep affection for him and saw him as a scientific promising young man. He supported his application for a professorship at the National Museum of Natural History, which Perrier obtained in 1876, in charge of molluscs, worms and zoophytes. We can therefore say that Perrier has spent his entire career in the footsteps of that of Lacaze-Duthiers. Nevertheless, in 1879-1880, a violent rupture occurred between the two. Lacaze-Duthiers criticized Perrier's evolution, in particular the decrease in the intensity of his work (he accused him of laziness) and his lectures which were too much based on speculative theories and not enough on biological facts (Perrier developed a theory that all organisms were constructed and functioned like a colony, adopting both Lamarck's and Darwin's ideas). Then three events triggered the rupture: (i) Perrier tried to get in touch directly with the publishers in charge of the *Archives*; (ii) It was reported to Lacaze-Duthiers that Perrier mocked Lacaze-Duthiers' scientific conservatism, saying that he remained attached to Cuvier (which was not true); (iii) Perrier wrote a rather critical PhD report on the work of Aimé Schneider, one of Lacaze-Duthiers' favorite students. Perrier continued to write desperate letters to his master to reconcile with him, to which Lacaze-Duthiers no longer replied, also refusing to receive him. The rupture was completed in 1880 when Lacaze-Duthiers, an academician, refused to communicate a note from Perrier to the French Academy of Sciences. It is at the Museum that the impact of Edmond Perrier was the most lasting. He became its Director from 1900 until 1919 and did everything to preserve the independence of the Museum from the Sorbonne University, rightly fearing the conservatism of the latter.

He specialized in annelids and echinoderms, and he published in this field in the *Archives*. His long-term work on the anatomy of the earthworm as well as its detailed analysis of Stellerids (sea stars and brittle stars) were published in the *Archives*. He took in charge many "*Notes et Revues*" from 1872 to 1875 but this collaboration quickly ceased due to the break with Lacaze-Duthiers. After 1876, his contributions to the *Archives* were very episodic.

Box 2. The protégé, Hermann Fol (1845-1892)

Hermann Fol life was apparently as his character: agitated turbulent, epic! He came from an old and wealthy Geneva family and therefore never had money problems, unlike many of his colleagues. He studied in Jena (Germany) where he was a pupil of Ernst Haeckel who considered him as one of his most intelligent students. Fol accompanied Haeckel on a trip to the Canary Islands where he became interested in molluscs and ctenophores, but he quickly fell out with Haeckel (Richards 2008). He continued to be interested in marine biology and from the early 1870s, he began an assiduous correspondence with Lacaze-Duthiers, essentially based on his scientific observations. Immediately, Lacaze-Duthiers was seduced by the lively intelligence and absolute scientific motivation of Fol. He gave him a lot of advices, invited him to Roscoff (where he reserved the best room for him) and opened the doors of the *Archives* to him. To be honest, he also used Fol as an informer to find out what was going on in Switzerland, around his friend but still competitor Carl Vogt, at the Naples station, and in Germany where Fol had some connections. Hermann Fol set up his own personal laboratory in Messina, in Italy, an area known for its rich marine diversity. He made regular stays at the station of Roscoff, then also at that of Naples. In 1877, he planned to move, by boat, his laboratory from Messina, because the violent currents made it difficult to collect marine animals, to Villefranche, and proposed to Lacaze-Duthiers to join him as a director of this new laboratory. It would have been complementary to the one in Roscoff. Lacaze-Duthiers, who was very attached to his independence and already had the Catalan coast in mind, was not interested in the proposal. No matter, Fol's idea from 1877 became a reality in 1878, with his installation in a private house converted into a laboratory in Villefranche, assisted by a young French lecturer, Jules Barrois (1852-1943), a pupil of Giard in Lille, but angry with the latter. However, Alexis Korotneff, a Russian professor from Kiev and close from Lacaze-Duthiers as well, also intended to set up a marine station in Villefranche, in the former galley buildings belonging to Russia. At first, Korotneff, Fol and Barrois agreed on an arrangement, and from 1881 to 1885, the three of them set up a marine station in the Russian buildings. In fact, Fol was very often absent. From 1878 to 1887, he was professor at the University of Geneva. After a "*regrettable university incident*[1]" (Lacaze-Duthiers & Bedot 1894) (Fol broke with Carl Vogt), he left Geneva to work exclusively in Villefranche. Epic disputes with Korotneff immediately arose. Surprisingly, Hermann Fol never mentioned in his letters to Lacaze-Duthiers the terrible crisis that followed, between 1886 and his expulsion from the buildings in 1888. In contrast, Korotneff multiplied his letters to Lacaze-Duthiers. He needed his support since the French Ministry must choose between Russia and Fol. Curiously, Lacaze-Duthiers, who appreciated Fol's science, did not support him, and it was on his advice that the station became Russian. In fact, Korotneff wanted a French-Russian station with Lacaze-Duthiers as director. Lacaze-Duthiers supported the French-Russian solution but refused this direction and thought to entrust it to the Faculty of Sciences of Lyon. He surely feared too much Swiss, or even Swiss-German, or even German influence by entrusting it to Fol. In the end, the Lyon plan did not materialize and the station became Russian. As a consolation prize, Fol and Barrois were appointed directors of a virtual laboratory in Nice, installed, at Fol's expense, in a private house, which did not satisfy him at all. This episode did not alter the scientific and friendly ties between Fol and Lacaze-Duthiers who resumed a pleasant and lively scientific correspondence. In 1892, Fol disappeared in the mysterious sinking of the *Aster* during an expedition where he wanted to reach the Greek and Tunisian coasts to study sponges.

Fol has clearly been a protege of Lacaze-Duthiers, constantly soliciting him for his support about his articles, for his multiple controversies with other colleagues such as Ray Lankester, Alfred Giard, Ernst Haeckel, Jean Perez (1833-1914), Alexandre Kowalevski, Armand Sabatier (1834-1910) and others, and even for obtaining the "*Légion d'Honneur*"! Hermann Fol was not an easy person and it even happened that his delays in delivering an article led to delays in the publication of an entire volume of the *Archives* (Petit and Theodoridès 1972). Despite this, Lacaze-Duthiers constantly supported him, often defending him publicly, without any doubt because he respected his dynamism and his scientific work. The fact that Fol was, as Lacaze-Duthiers, a malacologist, making great contributions on the embryogenesis and fertilization of molluscs, was also a reason explaining their proximity. Fol also studied echinoderms and he was the first to observe, in a starfish (*Asterias*), the penetration of the spermatozoon into the ovum, thus confirming the observations of Oscar Hertwig in 1875 in the sea urchin. In 1894, after Fol's disappearance at sea, Lacaze-Duthiers published with Maurice Bedot (1859-1927) a necrology of Hermann Fol in which he wrote that he was "*linked by a close friendship and great esteem to Mr. Hermann Fol*" and "*how great was his admiration for Hermann Fol's research*". In one rare expression of personal feeling, he added: "*We can say that he loved in his own way and, if he did not give himself up easily, he nevertheless had very tenacious devotion. One year, I was detained by illness in Périgord; he turned away from his scientific travels to come and see me and inquire about my condition. I have never forgotten his friendly visit and this mark of affection.*[2]" (Lacaze-Duthiers & Bedot 1894). Fol's widow, Emma, wrote several times to Lacaze-Duthiers after the death of her husband, to thank him for his obituary and to invite him to Switzerland to come and take whatever he thought useful among the instruments and collections of Fol, because, she said, Lacaze-Duthiers was the scientist for whom he had the most respect. One of Fol's daughters, Alice, also a malacologist, married Georges Pruvot, the successor of Lacaze-Duthiers in Banyuls-sur-Mer, in 1908.

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[1] *"regrettable incident universitaire"*, our translation.

[2] *"Lié par une étroite amitié et une grande estime à M. Hermann Fol"… "combien grande était son admiration pour les recherches d'Hermann Fol" … "On peut le dire, il aimait à sa façon et, s'il ne se livrait pas facilement, il n'en avait pas moins des dévouements très tenaces. Une année, j'étais retenu par la maladie en Périgord ; il se détourna de ses voyages scientifiques pour venir me voir et s'enquérir de mon état. Je n'ai jamais oublié sa visite sympathique et cette marque d'affection"*, our translation.

Box 3. The successor at Roscoff, Yves Delage (1854-1920)

Yves Delage was one of Lacaze-Duthiers' favorite students. He followed his teachings at the Sorbonne, visited the Roscoff station during his Bachelor, and as was often the case, studied medicine in parallel. He was Doctor of Medicine in 1880. He was then recruited as "*préparateur*": paid as an assistant to Lacaze-Duthiers while preparing a PhD under his supervision. During the summer of 1881, the running of the marine station of Roscoff was entirely his responsibility as a "*préparateur*", which was not a small task at the age of 27… In 1881, he was Doctor of Science, and in 1882, he became Lecturer in the laboratory of Lacaze-Duthiers at the Sorbonne Faculty of Sciences. Then his career followed the usual strategy of Lacaze-Duthiers: placing his students in various French Faculties of Sciences to disseminate a modern zoology approach. Lacaze had first thought of Clermont-Ferrand to install Delage. The professorship went to someone else, fortunately because it would have been too far from the sea for the poor Delage. Finally, with the strong support of Lacaze-Duthiers, in 1885, Delage was nominated as "*Chargé de conférences*" (kind of professor) at the Faculty of Sciences of Caen (in Normandy) that had the great asset to own a marine station at Luc-sur-Mer, on the Manche, of which he was appointed director. In his correspondence with Lacaze, if he was happy with the biological resources of the coast of Luc-sur-Mer, he complained bitterly of his scientific isolation and of the disappearance of the lively discussions he had with Lacaze-Duthiers and their colleagues in the laboratory. In 1886, the Norman punishment ended. With the support of Lacaze-Duthiers, he became a professor at the Faculty of Sciences of the Sorbonne and took over the management of the Laboratory of Experimental Zoology at Roscoff. Deputy-director in 1899, he became, after Lacaze-Duthiers' death in 1901, director of the Roscoff marine station until his own death in 1920. If, in 1902, he took part in a debate on the Holy Shroud of Turin where he argued in favor of its authenticity, he was one of the founders of modern zoology by introducing experimental approaches in the laboratory, on subjects such as fertilization or parthenogenesis. Very interested in evolution, he remained of a neo-Lamarckian tendency, like Edmond Perrier or Alfred Giard. In the obituary he pronounced at the funerals of Lacaze-Duthiers, he used this as an example to illustrate the broad-mindedness of his master, respectful of the opinions of his pupils even when they did not correspond to his own: "*Prepared by my philosophical tendencies, by reading Büchner's opuscules, fascinated by Darwin's argumentation, I had, like so many others, moved towards evolutionism. Sometime after I was appointed as a "préparateur" in his laboratory, I felt it was my duty to make him aware of this divergence of our views, and to do so I took the opportunity of a discussion which took place at the table one day during a joint excursion to the beach at Trez-Hir. He simply replied: "I knew that a long time ago." And he continued to treat me with the same favour*.[1]" (Delage, 1902b). Settled in Roscoff, he did not hesitate to use his medical skills to treat many of the poorest inhabitants for free. His undergraduate zoology courses and the stays at the Roscoff Station that he organized for students would determine many vocations for marine zoology.

In the *Archives*, Yves Delage has never been a very active contributor of the "*Notes et Revues*" but published many articles. What is striking is the evolution of his interests, thus revealing, over the years, his intellectual development. He began with classical zoological work on crustaceans and in particular on *Sacculina*, his work on the parasite having been the subject of the discussion, mentioned above, between Pasteur and Lacaze-Duthiers on the experimental method. It was a *tour de force* to understand the mechanisms of penetration of *Sacculina* inside its host, requiring the reproduction of the cycle in the laboratory in the dimly lit rooms of Roscoff. The day Delage understood this mechanism, he wrote an enthusiastic letter to Lacaze-Duthiers, full of erasures due to the excitement of his discovery and beginning with a gigantic "Eurêka" written in Greek characters. Here is an extract of this letter that shows Delage's gratitude and admiration for Lacaze-Duthiers: "*It is a very strange story that of this sacculina, and you have well judged the day when you thought that this animal was too singular in the adult state not to present remarkable phenomena in its embryogenesis*. […] *I confess that it is not without a sigh of relief that I see the end approaching. Many times I have been on the verge of discouragement. You have always encouraged me. Today I thank you for that, because the goal has been reached*.[2]" Later, he greatly broadened his contributions, notably by focusing on the inner ear and otocysts, the fluid-folded vesicles that contain otoliths and are important in the auditory apparatus of many invertebrates. From 1899 saw the appearance of his work on fertilization, in particular merogonia and parthenogenesis which remained famous (Fischer 1997).

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[1] *"Préparé par mes tendances philosophiques, par la lecture des opuscules de Büchner, fasciné par l'argumentation de Darwin, j'avais, comme tant d'autres, versé vers l'évolutionnisme. Quelque temps après avoir été nommé préparateur de son laboratoire, je jugeai qu'il était de mon devoir de lui faire connaître cette divergence de nos vues et saisis pour cela l'occasion d'une discussion qui survint à table un jour d'excursion en commun sur la plage de Trez-Hir. Il me répondit simplement : "Il y a longtemps que je le savais." Et il n'en continua pas moins à me traiter avec la même faveur."*, our translation.

[2] *"C'est une bien étrange histoire que celle de cette sacculine et vous avez bien jugé le jour où vous aviez pensé que cet animal était trop singulier à l'état adulte pour ne pas présenter dans son embryogenèse des phénomènes remarquables. […] Je vous avoue que ce n'est pas sans un soupir de soulagement que j'en vois approcher la fin. J'ai bien des fois frôlé le découragement. Vous m'avez toujours encouragé. Aujourd'hui je vous en remercie puisque le but est atteint."*, our translation. Archives de l'Académie des Sciences (Paris).

Box 4. Louis Boutan (1859-1934) and the first underwater photography

In the history of marine stations there are some truly singular characters and, undoubtedly, Louis Boutan is one of them. Indeed, Boutan is the author of the first underwater photo ever made, a photo taken in 1893 in Banyuls-sur-Mer, Henri de Lacaze-Duthiers being director. Louis Boutan studied natural sciences in Paris and was a student of Lacaze-Duthiers. At the age of 20, in 1879, he became "*préparateur-adjoint*" at the Sorbonne. Attracted by distant expeditions, he made in 1880 the first of a long series of travels, in Australia. During this first trip of eighteen months, he wrote long and picturesque letters to Lacaze-Duthiers, describing in a quasi-ethnographic way the habits of Australians, but also his observations on the phylloxera which decimated Australian vines and which he was asked to study. His fascination with Australia did not leave him, and years later, in 1892, he prepared a new travel project to study marsupials. Supported by Lacaze-Duthiers, he applied for multiple grants, was relieved of his courses, and even rejected plans to marry! But he failed in gathering sufficient funds for this expedition which, to his great despair, was not carried out. In 1884, he joined the laboratory of Lacaze-Duthiers to carry out his PhD thesis on a limpet (the fissurelle), a gastropod mollusc, therefore clearly walking in the path of his master. He came each summer to the Banyuls marine station for his PhD work and made extensive use of the laboratory diving suit for his observations in the natural environment. He was Doctor in Science in 1886 and nominated lecturer at the Faculty of Sciences of Lille, still in constant contact with Lacaze-Duthiers. There he met Alfred Giard, who left Lille for Paris in 1887. A loyal disciple of Lacaze-Duthiers, he did not appreciate Giard, with whom he had some clashes. In 1892, he came back to Paris, appointed as lecturer in the Laboratory of Lacaze-Duthiers. He always remained very close to Lacaze-Duthiers, was also a very good friend of Yves Delage and a collaborator of Louis Joubin. In particular, he brought back from an expedition to the Red Sea in 1892 an abundant harvest of molluscs that were analyzed by Joubin. Between 1904 and 1908, he was in charge of an important mission in Indochina, where he explored the fauna, from molluscs to monkeys (he undertook comparative studies of the mental abilities of gibbons and those of children)! Back in France, he became a professor in the Faculty of Sciences of Bordeaux and took over the direction of the marine station of Arcachon. From 1900, he focused on the mechanisms of pearl production by oysters, publishing his first article on the subject in the *Archives* in 1904. Amusingly, the article begins with 3 pages of ironic but sharp dispute with Giard, who denied Boutan's prior discovery about the real origin of pearls (Boutan 1904). He ended his life on the Algerian coast, as professor at the Faculty of Sciences of Alger, director of the agriculture and fisheries station of Castiglione and inspector of fisheries of the General Government of Algeria.

In the 19th century, the observation of marine animals was limited to animals captured and put in aquarium. Given the importance for Lacaze-Duthiers and his followers to see animals in conditions as close as possible to natural conditions, it is not surprising that the invention of diving suits in 1850s opened new possibilities. Indeed, as soon as the Banyuls laboratory was built, Lacaze-Duthiers equipped it with a diving suit and then strongly pushed scientists at the laboratory to use it: "*To control a fact well, it is good to see for oneself*". Although he himself never went scuba diving, probably too concerned about his health to dare take risks! In 1884, soon after his arrival in Banyuls, Boutan learnt to dive. Let him explain his wonder in seeing marine life in real: "*When one has become accustomed to this somewhat cumbersome garment, its heaviness and the persistent rustle of the pump that pushes the air inside the helmet, we manage to worry only about the objects that surround us and we are struck by the beauty and the diversity of the landscapes*[1]" (Boutan 1893).

From 1892, Louis Boutan, now lecturer at the laboratory of Lacaze-Duthiers, had one idea in mind: "*I would have liked to bring back a more tangible memory from these explorations*. […] *I then resolved to try the image photography; since you manage to take a landscape in the open air without difficulty, why, I said to myself, wouldn't you be able to take a photograph at the bottom of the sea?*[2]" (Boutan 1893). Despite his very inventive spirit, his photographic attempts last several years. Lacaze-Duthiers supported his work and built an extension to the Banyuls laboratory to install a photographic workshop. With Joseph David, the mechanic of the laboratory, they made a waterproof box to lower a weighted glass plate camera into the water and place it on the bottom of the sea. After many failures, the very first underwater photo was taken in Banyuls bay, but the mud caused a cloud under the steps of the diver and the very first photograph was very blurred. The first quality photograph was taken in the bay of Troc in 1893 at a depth of 7 meters with a long exposure time. There are other known photos dating from 1898: a self-portrait, a ceramic basin with the inscription "*Underwater Photography*" or a portrait of Joseph David underwater in a diving suit. This success had a considerable impact. From 1896, Boutan launched the project of exhibiting his photos at the Universal Exhibition of 1900, in Paris. He was supported by Lacaze-Duthiers who introduced him to the rich sponsor Raphaël Bischoffsheim (1823-1906). Thanks to these aids and Boutan's persistence, his images were projected on the large screen at the "*Palais de l'Optique*" during the Exhibition. Even though the Eiffel Tower was the absolute star of the 1900 Exhibition, these images made a big impact. It was also in 1900 that Boutan published his reference work, "*La Photographie sous-marine et les Progrès de la photographie*". And it was of course the beginning of a huge adventure that still lasts.

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[1] *"Quand on a pris l'habitude de ce vêtement un peu encombrant, de sa lourdeur et du bruissement persistant de la pompe qui refoule l'air dans l'intérieur du casque, on arrive à se préoccuper uniquement des objets qui nous entourent et on est frappé par la beauté et la diversité des paysages"*, our translation.

[2] *"J'aurai voulu rapporter de ces explorations un souvenir plus tangible. […] Je résolus alors d'essayer l'image photographique ; puisqu'on arrive à prendre sans difficulté un paysage en plein air, pourquoi, me disais-je, ne parviendrait-on pas à faire une photographie au fonds des mers ?"*, our translation.

All this should not make us forget that Boutan was also an excellent scientist who worked on molluscs like his master Lacaze-Duthiers. In the *Archives*, his contributions are varied but of course those on underwater photography are now the best known. He also participated actively in the "*Notes et Revues*".

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