



Paleontology in France: 200 years in the footsteps of Cuvier and Lamarck

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SUMMARY

Due to its richness in fossil localities and Fossil-Lagerstätten, France played a major role in the 18th and 19th centuries in establishing paleontology and biostratigraphy as scientific disciplines. The French naturalist and zoologist Cuvier (1769-1832) established the fields of comparative anatomy and paleontology, and proposed the concept of 'catastrophism' in geology. The naturalist Lamarck (1744-1829) is considered the founder of invertebrate paleontology and biostratigraphy and an early pioneer in the studies of evolution, developing the idea of 'transformism' and creating the word 'fossil', while his successor Blainville (1777-1850) was the first to use the word 'paleontology'.

Based on this rich heritage, numerous French scientists strengthened paleontology as an important discipline during the 19th and 20th centuries. Paleontology was present at the universities of most major French cities, as documented by the rich collections in over 50 natural history museums and university collections. The most significant paleontological collection is that housed in the *Muséum National d'Histoire Naturelle* (MNHN) at Paris that currently hosts the largest research unit in paleontology of France with over 100 scientists, curators and technicians. The second largest collection (and the largest in terms of invertebrate fossils) is housed at the University of Lyon1, where the most important university paleontology research team is present. About 250 professional paleontologists are currently working in research units that are

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mostly affiliated to the *Centre National de Recherche Scientifique* (CNRS), in public or private museums, or in the numerous natural parcs.

A significant generation change took place in the early 2000s, with the retirement of the paleontologists recruited in the 1960s and 1970s, that were often specialized in alpha-taxonomy and stratigraphy, and the arrival of a young generation of scientists that attempts to answer more 'modern' questions, such as global (climate) change, biodiversity, or evolution. This new generation of paleontologists faces modified funding schemes with project-based supporting structures in a more and more competitive environment.

In the present paper we attempt to summarize the current situation of paleontology as a discipline in the very complex academic and scientific context of France. After a short overview on the history of French paleontology in the last centuries, a synopsis on institutions and funding agencies is presented briefly. The major research departments and their research themes are then described, together with the most important collections, the paleontological associations, journals, and databases, etc. Paleontological training possibilities and job opportunities, in particular in academia, are next documented, concluding with a summary of the prospects of the discipline.

HISTORY OF FRENCH PALAEOLOGY

Fossil localities in France

France is often considered as the birthplace of paleontology (not only by the French!), with Georges Cuvier as the founding father of the discipline. The large number of important fossil localities that were easily accessible to the first natural scientists was of great importance for the early development of paleontology as an independent scientific field. Outcrops of a wide variety of geological epochs, comprising all intervals of the stratigraphic column from the Precambrian to the Quaternary, can be found in France, although Precambrian sedimentary rocks are poorly preserved and therefore Precambrian paleontology never really developed. The first French geoscientists concentrated on spectacular fossil localities, including many Fossil-Lagerstätten, mostly from Mesozoic and Cenozoic rocks (Figure 1). Among the most famous Konservat-Lagerstätten are those of Montceau-les-Mines (Upper Carboniferous), La Voulte-sur-Rhône (Middle Jurassic), Canjuers and Cerin (Upper Jurassic), and the Cenozoic sites of Creil, Menat, Coiron and Sansan.

The abundant presence of fossils in a large number of localities of the Paris Basin, easily accessible from Paris and other major French cities, allowed the early development of French geology and paleontology beginning in the 16th century, and its growth in the late 18th and the 19th centuries. Many international geological series and stage names have been defined in France: the term Jurassic comes from the French-Swiss Jura Mountains, the Devonian stage of the Givetian has been defined from the French-Belgian Ardennes

Mountains. Many Mesozoic and Cenozoic standard stages were named after French localities bearing numerous fossil groups useful for stratigraphy, notably due to the seminal work of Alcide d'Orbigny (1802-1857). Among them are in the Jurassic: Hettangian, Sinemurian, Toarcian, Bajocian; in the Cretaceous: Berriasian, Valanginian, Hauterivian, Barremian, Aptian, Albian, Cenomanian, Turonian, Coniacian, Santonian, and Campanian; and in the Cenozoic: Lutetian, Aquitanian, and Burdigalian.

There is no doubt about France having played a prominent role in the early history of paleontology as a scientific discipline. As early as in the middle of the 16th century, the famous Renaissance potter Bernard Palissy (c. 1510 - c. 1589) was among the first to understand the nature of fossils and enunciate their origin: "*Pourquoi trouve-t-on tant de fragments de coquilles entre deux couches de pierres, sinon parce que ces coquilles déjà déposées sur la plage y furent recouvertes d'une terre rejetée par la mer, laquelle terre est venue ensuite à se pétrifier?*" (*Récepte véritable*, La Rochelle, 1563).

Cuvier and Lamarck

In the late 18th century, as the bases of modern scientific concepts were established, France benefited from and contributed to the large cultural and intellectual exchanges within western Europe. It was Georges Cuvier (Jean Léopold Nicolas Frédéric Cuvier (1769-1832); Figure 2), born in Montbéliard (a French speaking city in eastern France that was at the time of Cuvier's birth part of the German duchy of Württemberg) who is today generally considered as the founder of comparative anatomy and paleontology as scientific disciplines. After studying theology at the University of Tübingen



FIGURE 1. The "dalle à ammonites" is the most famous fossil locality of the Réserve Naturelle Géologique de Haute Provence. A slab of 320 m² shows 1550 ammonites of the species *Coroniceras multicosatum*, up to 70 cm in diameter, indicating an early Jurassic age. Photograph by Taniel Danelian.

gen (Germany), he left for Stuttgart where he studied natural sciences. He moved to France where he got a professorship at the *Muséum National d'Histoire Naturelle* (MNHN) in 1802. He presented his first paleontological studies at the *Académie des Sciences* since 1796, establishing the widely used concept of "catastrophism". With his four volumes on the *Recherches sur les ossements fossiles de quadrupèdes*, published in 1812, Cuvier can be considered as the originator of vertebrate paleontology. It was also Cuvier who first defined the Jurassic as a geological period.

Jean-Baptiste Pierre Antoine de Monet de la Marck (1744-1829; Figure 3), considered as one of the founders of biology as life science, was not only the father of "transformism" (a pre-Darwinian evolutionary concept), but he was also the founder of invertebrate paleontology. It was also Lamarck who created the word *fossile* as it is generally used and accepted today. Lamarck was a student at Paris of Bernard de Jussieu (1699-1777), and he also benefited from the protection of Georges-Louis Leclerc, comte de Buffon (1707-1788). He was surrounded by the most important French natural scientists of the 18th century and as the first scientist working on the evolution of life was also

the precursor of Charles Darwin (1809-1882). In his *Système des Animaux sans vertèbres* (published in 1801) Lamarck introduced the classification of numerous fossil invertebrates, and he published subsequently the series of *Mémoires sur les fossiles des environs de Paris*. All these studies made him also one of the first scientists working on biostratigraphy and paleoclimatology.

The 19th century: France as a center of paleontological research in the world

Henri-Marie Ducrotay de Blainville (1777-1850) was a student of both Cuvier and Lamarck, but also of the famous zoologist Etienne Geoffroy Saint-Hilaire (1772-1844). Blainville took over the chair of Cuvier at the museum in Paris in 1832, who in turn became his biggest scientific enemy. It was Blainville who created the word *paléontologie* in 1822 to design the new scientific discipline dedicated to fossil organisms.

Marin Jacques Louis DeFrance (1758-1850) collaborated with the above mentioned scientists. He established important palaeontological collections from Normandy and from the Paris Basin and was one of the first to investigate the conditions of *fossilisation*.



FIGURE 2. Jean Léopold Nicolas Frédéric CUVIER, known as Georges Cuvier (1769 Montbéliard - 1832 Paris), who established the scientific disciplines of comparative anatomy and paleontology. Portrait by Matheus van Bree.

Alexandre Brongniart (1770-1847) was a mineralogist, geologist, zoologist and paleontologist, and is considered, together with Cuvier, as one of the founders of stratigraphic paleontology. His son, Adolphe Théodore Brongniart (1801-1876) is clearly considered to be the originator of the discipline of paleobotany in France, as he followed and adapted the studies of Kaspar Maria Sternberg (1761-1838) in Bohemia and Ernst Friedrich von Schlotheim (1765-1832) in Germany. A.T. Brongniart published the first classification and distribution of fossil plants, with comparisons to their nearest recent relatives, in his *Histoire des végétaux fossiles* (1828-1837).

Alcide Dessalines d'Orbigny (1802-1857) had a specific interest in marine organisms; he coined the term “*foraminifères*” (foraminiferans) in 1825. D'Orbigny started the ambitious publication *Paléontologie française*, a series containing over 4000 pages and 1440 lithographic plates. He is considered to be the founder of micropaleontology and he promoted not only biostratigraphic paleontology (*Prodrome de Paléontologie Stratigraphique*, 1849) but also paleogeography, in particular for the Mesozoic.



FIGURE 3. Jean-Baptiste Pierre Antoine de Monet, chevalier de LAMARCK, known as Jean-Baptiste de Lamarck (1744-1829), who contributed to the classification of invertebrates, a term he coined, and an early proponent of evolutionary studies. Statue by Léon Fagel in front of the Place Valhubert entrance of the Jardin des Plantes in Paris.

Many other important paleontologists worked during the same periods and in the following decades. It is impossible to provide here a comprehensive list, and the reader is referred to Gayet and Babin's (2007) alphabetical index of key paleontologists to have a more complete view. Among the significant names of the early 19th century that must be mentioned, Hardouin Michelin (1787-1867) worked on several invertebrate fossil groups and co-founded the *Société géologique de France* in 1830, of which he was the first treasurer. Marcel de Serres (1780-1862) was a professor of geology at the University of Montpellier, working on human paleontology and fossil mammals. He was one of the scientists who defined the Quaternary system. Edouard Lartet (1801-1871) was a pioneer in pre-history and human paleontology, finding the first fossil primate in 1837 (*Pliopithecus*, middle Miocene of Sansan, SW France), subsequently proving that men lived together with extinct mammals (Aurignac Cave, SW France; *Nouvelles recherches sur la coexistence de l'homme et des grands mammifères fossiles*, 1861), and discovering the first Cro-Magnon skeletons in Les Eyzies, SW France.

Lartet is also known as the founder of the term *Néolithique*.

The 20th century

The 19th century was the period when most professor chairs were founded at the major university towns in France. But it was only in the 20th century, and particularly during the 1960s that university research was promoted extensively, with the creation of numerous universities in almost all major towns in France. This development was clearly based on the rapid and enormous economic growth in western Europe that is today paralleled in China with the current development of paleontology in that country (Shuhai Xiao et al., 2010). Geology courses were launched at most public universities, and paleontology classes were established in almost all university towns. In the last part of the 20th century, paleontology strongly shifted from geology departments to biology and life science departments. Classical geological questions (such as biostratigraphy) became less attractive, and have been replaced by more modern questions about global (climate) change or (erosion of modern) biodiversity and evolution linked to human pressure.

It is impossible to list all major actors of French paleontology of the 20th century, and only a few names are given here: Georges Deflandre (1897-1973) was clearly the most important micropaleontologist, working on almost all fossil groups and considered a pioneer in using the Scanning Electron Microscope as early as 1952. Jean Cuvillier (1899-1969) was an important biostratigrapher who founded in 1958 the journal *Revue de Micropaléontologie*. Jean Piveteau (1899-1991) was one of the most important vertebrate paleontologists, working also extensively on human origins. He coordinated between 1952 and 1961 the ten volumes of the *Traité de Paléontologie*. As a collaborator of Piveteau and his *Traité*, Léon Moret (1890-1972) published the textbooks *Manuel de Paléontologie Animale* between 1940 and 1966 and *Manuel de Paléontologie Végétale* between 1943 and 1964. These are important textbooks that were known and extensively used by most paleontology students of these years. Henri Tintant (1918-2002) was also a major invertebrate paleontologist. He started his career at Montpellier, but worked most of the time at the University of Burgundy at Dijon, where he developed the studies of quantitative paleontology, starting the "Dijon school" on biometrical studies.

In the field of paleobotany, France also became a leading actor. At the turn of the twentieth century, Bernard Renault (1836-1904), François Cyrille Grand-Eury (1838-1917), René Zeiller (1847-1915) and the Bertrands, father and son, (1851-1917 and 1879-1944) counted among the best paleobotanists of their time. B. Renault realized some of the finest anatomical studies of petrified plants and fungi from Paleozoic fossils he collected in his native region of Autun. He deserves special mention regarding the poor conditions under which he accomplished his research at the *Museum d'Histoire Naturelle de Paris*. More recently, Edouard Boureau (1913-1999) edited the four volumes of the "Traité de Paléobotanique" (1964-1975). He is also known for his work on wood anatomy and later in his career, on Precambrian microfossils. He contributed to the foundation of the International Organisation of Palaeobotany. Jeanne Doubinger (1921-1994) can be considered being one of the French pioneers of paleopalynology, working on Upper Paleozoic spores and pollen. A more complete history of paleobotanical and (paleo-)palynological studies in France has been presented by Alpern et al. (1968).

INSTITUTIONS

Natural History Museums and the *Muséum National d'Histoire Naturelle*

The rich collections of the French paleontologists, collected from France and from many foreign countries, are housed in a great number of places, among them not only public museums, but also universities and private collections.

The most important collection of fossils is clearly the one housed in the *Muséum National d'Histoire Naturelle* (MNHN) at Paris, one of the most prominent collections in the world, together with those from the *Natural History Museum in London* or the *Naturkundemuseum* in Berlin. The MNHN is a member of the national museums of France and has a particular status.

Most of the other "Natural History Museums" are not national museums, but mostly directed by the towns or the political departments or regions. They therefore depend on the budget of local or regional councils. There are over 50 such local or regional museums, present in many French cities. Some of these museums house large animal and/or mineral collections, but only very few fossils (the museum at Chartres has only a single type specimen, for example), whereas others store tens of thousands of fossil specimens, that are more or

less well curated and stored. Among the most important “city museums” are those of Lille, Lyon and Toulouse, with large paleontological collections. The keepers in these museums are mostly trained curators with a background in natural sciences, sometimes with a Master or even a PhD degree in paleontology. The main objective of these “city museums” is the exhibition of parts of the collections to the public. Scientific research is usually limited in these collections, but they are, however, open to the scientists who wish to consult the specimens.

The MNHN plays a particular role. This very old institution (Cuvier, Lamarck and many other scientists worked here) not only houses the largest paleontological collection, but it also hosts the largest research unit dedicated to paleontology in France, with over 100 scientists, curators and technicians. The MNHN includes different departments. The Earth History Department, currently directed by a paleontologist, integrates the Geology, Paleontology, and Cosmochemistry sections, that house the geological/paleontological, paleontological and meteorite collections, respectively near the *Jardin des Plantes*.

The collections related to human paleontology are housed in another department and another institute (*Institut de Paléontologie Humaine*) in a remote building.

The collections of the paleontology department of the MNHN are the most important collections in France for vertebrate paleontology, and although the research team of the museum (currently grouped with the paleontology department of the University Pierre et Marie Curie, UPMC, Paris 6) includes all sub-disciplines of paleontology (micropaleontology, paleobotany, palynology, invertebrate paleontology, etc.), a major research focus of the MNHN paleontological team is the study of vertebrate paleontology, with a very high international visibility on early vertebrates (including jawless fish and early tetrapods), mammals, and phylogenetics.

University departments and the CNRS

The universities of most major cities included departments of geology and paleontology. Many of these departments had professorships in paleontology. Most of these universities are public universities, but some are private institutions, mainly engineering schools.

Many of these universities established their own collections. Some of these “university collec-

tions” are today very important in term of number of fossils. The most important university collection is that of the University of Lyon¹, which is in fact the most important collection of invertebrate fossils in France (see below). Some “university collections” are no longer curated, because paleontologists are no longer active in these institutions. This has let in the past and may lead in the future to serious preservation problems, as many universities do not understand the value of the paleontological collections. Some of these collections are housed in private universities, and are thus not necessarily accessible to the scientists who wish to consult the type specimens.

The *Centre National de la Recherche Scientifique* (CNRS) was founded in 1939 to boost research in French universities. It covers almost all fields of scientific research and employs about 30000 people, with over 10000 research scientists on permanent positions. Many university research departments include “mixed research units” (*Unité Mixte de Recherche*, “UMR”) linked to the CNRS. These research units are mixed in the sense that they are constituted of both university and CNRS staff (both depending on the Ministry of Research and Higher Education). In this way, many university departments house both teaching and research staff (*professeurs* and *maîtres de conférences*) and CNRS scientists (*directeurs de recherche* and *chargés de recherche*), but also research technicians, engineers and administrators from both the university and the CNRS.

The re-organisation of the CNRS in the late 2000s let to the situation that the paleontologists are today affiliated with at least three distinct CNRS institutes: the *Institut National des Sciences de l'Univers* (INSU, with special focus on Earth and Planetary Sciences), the *Institut Ecologie et Environnement* (INEE, a highly multidisciplinary Institute dedicated to research on Biodiversity and Ecological-Environmental questions), and the *Institut des Sciences Humaines et Sociales* (INSHS). The creation of larger mixed research units (“UMR”) in the last decades resulted in many smaller paleontology research units disappearing in the same interval.

For various reasons, it is difficult to explain the organization of paleontological research in all the French CNRS and university teams, and only a very simplified description is provided here. In addition, the affiliations and the boundaries of each research unit move constantly as all research departments are evaluated every four or five years;

the picture below is thus only a momentary snapshot.

Currently, six CNRS research units host teams that include more than ten paleontologists. Two of these units are affiliated to both the INEE (primary affiliation) and the INSU (secondary affiliation) of the CNRS:

- The largest paleontology research unit, based at the MNHN and at the University Pierre et Marie Curie (Paris 6), covers almost all scientific fields of paleontology (see above);
- The research unit “*Biogéosciences*” at the University of Burgundy at Dijon has a tradition in Mesozoic and Quaternary paleontology; it is specialized in “macroevolution” and is clearly a world-leading group in quantitative paleontology.

Two other larger research units are affiliated to the INSU (with a second affiliation to the INEE), and particularly related to its Earth Science division:

- The Earth Science department of the University of Lyon1 and of the *Ecole Normale Supérieure (ENS) de Lyon* hosts the largest paleontological research team in a French geology department. The paleontologists from this department are micropaleontologists and invertebrate paleontologists, but also vertebrate paleontologists, and palaeobotanists, working traditionally in close collaboration with sedimentologists. Because the Lyon1-ENS earth science department is a world leading research unit on geochemistry, the biogeochemical applications in paleontology did particularly well develop at Lyon during the last decades. The university Lyon1 houses the largest collection of fossil invertebrates in France. This collection is even larger than the collection of Paris (MNHN) and one of the top-20 fossil collections in the world.
- The *Géosystèmes* research unit of the University of Lille1 and the *Université Catholique de Lille* is a research unit focused on sedimentary environments with a large paleontological team specialized on Paleozoic rocks (historically based on the paleontology of Carboniferous coal beds), but covering also the Precambrian, Mesozoic, Cenozoic and Quaternary, with

a special expertise in Paleozoic paleobiogeography and paleoclimate evolution.

The two last larger (> 10 permanent scientists) paleontology research units are affiliated to the INEE, working more (but not entirely) on biological questions:

- the *Institut des Sciences de l'Evolution de Montpellier (ISE-M)* is a large CNRS research unit working on biodiversity and evolution from various perspectives. It hosts a large group of vertebrate and invertebrate paleontologists, but also paleobotanists and palynologists. The expertise concentrates on upper Mesozoic/Cenozoic vertebrates and Quaternary paleontology, but also the Paleozoic, in a lesser extent. A small but internationally highly visible group of paleobotanists is active at the CIRAD at Montpellier.
- The *Institut de Paléoprimateologie, Paléontologie Humaine: Evolution et Paléoenvironnements (IPHEP)* at the University of Poitiers is focused on human evolution and vertebrate paleontology of the Cenozoic, with a special emphasis on Africa and South Asia. This research unit is internationally recognized due to the discovery of early humans, such as Abel or Toumaï.

A high number of more or less isolated paleontologists work in numerous other departments that are affiliated either to the INEE, the INSU or the INSHS. Among the larger groups (with more than three paleontologists), the paleontology teams of Bordeaux, Toulouse, Rennes and Brest should be mentioned.

The University of Bordeaux integrates a mixed University-CNRS research team focused on marine sciences and marine geology with a significant group of micropaleontologists and palynologists focusing on Quaternary climate evolution but also other aspects of Mesozoic and Cenozoic paleontology.

The small and relatively young research team at the University Paul Sabatier at Toulouse focuses on invertebrate paleontology and its impact on climate evolution and climate modeling. A strongly visible group of microbiologists and micropaleontologists, in particular foraminifers, is very active at the University of Angers.

An important paleontology research team formerly existed in Normandy and Brittany. This team,

which traditionally worked on Paleozoic paleontology, existed until the mid-1990s. It was based in the cities of Rennes and Brest (Brittany) and Caen (Normandy). Whereas the retired paleontologists at Caen have not been replaced, the paleontologists of Brest are now integrated in the marine geoscience department of the University, while the paleontologists of Rennes are affiliated to the large “*Géosciences Rennes*” department of the University of Rennes¹, where they built a strongly visible research group on Mesozoic (Cretaceous) paleontology, with a leading role in the investigation of amber.

Several geology or biology departments also include specialists who teach paleontology classes at other universities, such as Marseille, Nancy, Nice, or Strasbourg, and other cities. A total of about 200 to 250 paleontologists are currently working as university assistants, university engineers and professors or CNRS research associates, research engineers and research directors in the different departments that are linked to French universities or the MNHN.

Among other institutions including professional paleontologists, one may mention the *Ecole Pratique des Hautes Etudes* (EPHE) that hosts scientists in different research teams, notably at Paris, Dijon, Bordeaux, and Montpellier. The *Collège de France* also hosts several professionals, mostly focused on human paleontology. As indicated above several city museums (Toulouse, Marseille, Lyon, Lille, Orléans, and others) include trained paleontologists who occupy the roles of directors, curators and/or preparators.

National parks, private museums

Due to its outstanding historical-paleontological heritage, the French territory shelters many geological reserves aiming to protect the strato-types and associated fossils. Protected areas and national parks include national, regional or local natural parks, among them are about ten geological parks (*Réserves Naturelles Géologiques*), the most important of which are those of Saucats-La Brède, Île de Groix, de la Falaise du Cap-Romain, Thouars (*Réserve Naturelle du Toarcien*), Digne-les-Bains (*Réserve Naturelle de Haute Provence*), Apt (*Réserve Naturelle du Lubéron*), Vireux-Molhain, Hettange-Grande, Essonne, Pointe de Givet, etc.

A few private museums and non-profit organisations (with public fundings) exist in France, such as the “*Musée des dinosaures*” (Espéraza), “*Rhinopolis*” (Gannat) or the “*Plage aux Ptérosaures*”

(Crayssac). They primarily focus on a given period or taxonomic group, alongside a paleontological locality of outstanding interest.

Both of the above-mentioned national parks and private museums host trained paleontologists, usually with short-term contracts.

FUNDING AND RECRUITMENT

Public and private funding

There is a general impression among French scientists that the budget dedicated to public research has significantly decreased in recent years, which is mainly due to the fact that the distribution of governmental support has drastically changed in the last decade.

A major change is the modification of the university law in 2007 (*La loi relative aux libertés et responsabilités des universités*, LRU), each university being now responsible in terms of its budget and all recruitments. The university council now freely decides if a position is to be (re)opened or if a department or research unit is getting financed or closed.

In addition, several drastic changes took place with the creation of a national research agency (*Agence Nationale de Recherche*, ANR). Similarly to the *Deutsche Forschungsgemeinschaft* (DFG) in Germany or the *National Environment Research Council* (NERC) in the United Kingdom, the ANR is a national agency that provides project-based funding to advance French research in selected scientific fields. The ANR was established by the French government in 2005 to fund research projects, based on competitive schemes.

The national evaluation agency (*Agence d’Evaluation de la Recherche et de l’Enseignement Supérieur*, AERES) is an independent administrative authority set up in 2007. It evaluates research and higher education institutions, research organisations, research units, but also higher education programmes and training degrees.

With these changes during the last decade, it became evident that French public research would be more and more project-oriented now, with a much stronger evaluation than until the end of 20th century. This has major impacts on the funding of research projects and research departments, but also on the recruitment of professors, scientists, and technical staff.

Today, at a national scale, funding support mainly originates from the ANR (that includes salaries for PhD’s or post-doctoral students) and from the CNRS through INSU/INEE research pro-

grammes. At a local scale, the French universities and the MNHN support research projects through the “*Bonus Qualité Recherche*” (Research Quality Bonus; BQR) project funding scheme. The Foreign Affairs Ministry also provides funding for field expenses, in particular for projects related to international collaboration, through different research programmes. This support is particularly important for projects related to human evolution. Also, at the international level, French paleontological projects are more and more supported by the European Research Council (ERC). In addition, several French foundations (e.g., the *Fondation Singer-Polignac*, the *Fondation des Treilles*, the *Fondation Marcel-Bleustein-Blanchet pour la Vocation*, or the *Fondation de France*, etc.) provide also individual grants to post-graduate, Ph.D. or post-doctoral students. As a result, the French paleontologists are now becoming more and more active to search support from the numerous and various budget lines.

Recruitment and generation change

Many permanent positions opened in the ‘golden years’ of the 1960s and 1970s, i.e. a period when a high number of paleontologists got recruited. Most of these scientists were university-based, working in research units that were affiliated to the CNRS. This generation of paleontologists recently retired and a very important generation change is currently taking place.

The situation in France is probably less dramatic than in Germany (Kießling et al., 2010), where many paleontology departments closed and many retiring paleontologists did not get replaced. In France, numerous young scientists got recruited in paleontology departments, in particular in the large departments.

Néraudeau (2010) counted that about 260 students followed the three major paleontology master courses “*Pal & Sed*” (Dijon, Lyon, Marseille, Reims, Toulouse), “*Paléontologie*” (Paris, Montpellier, Poitiers, Rennes) and “*Océanographie et Micropaléontologie*” (Bordeaux) between 1986 and 2000. About 150 of these students subsequently achieved a PhD in French research units, and about 110 of those got permanent positions in research departments, 70 of them within France (many other got positions abroad, partly in their home countries). About 50 young scientists are now holding positions in universities, while about 20 got recruited by the CNRS.

These numbers (that do not take into account some of the smaller master course programs)

clearly indicate that the success rate for the recruitment of paleontologists on permanent positions was relatively high in the last decade. These numbers will surely drop significantly in the next years, because only few positions will become available due to a limited number of retirements.

In addition to the permanent positions in academia, numerous paleontologists found permanent or short-term jobs in national or regional parks (as curators or guides) and in regional and local museums (as curators, technicians and guides), funded by city councils, or at the level of the French administrative departments or regions. Quite a few paleontologists also got positions in industry or consulting agencies (especially micropaleontologists). A great number of trained paleontologists are currently school teachers or college professors, some left France (and got permanent positions abroad), and others no longer work in the field of paleontology.

A significant generation change took place in France at the turn of the 21st century. While during the 1960s and 1970s most paleontologists were working on alpha taxonomy and biostratigraphy, and after a period of only very few recruitments in the 1980s and 1990s, paleontologists are now working on scientific questions typical of the 21st century: climate and global change, (paleo) biodiversity, paleobiology, paleoenvironments, etc. The new generation publishes almost exclusively in English, in contrast to the previous generation that published mainly in French. Scientific articles are more and more multi-authored, due to the changing evaluation criteria that consider highly impacted (ISI) research being high quality research. After a “publish-or-perish” period (with a French evaluation system that mostly counted the number of publications of scientists), most paleontologists now take care about the impact factor of the journals and the number of citations of their articles.

Another important change is the integration of most scientists in interdisciplinary teams working in larger departments, in comparison with isolated scientists working in many different universities during the 1960s to 1990s.

ASSOCIATIONS, JOURNALS, DATABASES

Associations

With the increasing number of paleontologists recruited in academic positions, the number of active specialists became significant in the second half of the 20th century, which in turn allowed the creation of an independent paleontological associ-

ation. One of the objectives was to be recognized as a group of scientists distinguished from the very large geological society (*Société Géologique de France*, created in 1830, see above). Many paleontologists no longer wanted to be considered as simple data providers for geologists that used the paleontological results as (mostly stratigraphical, but also paleogeographical) proxies. In this context, and similarly to the *Palaeontological Association* that was created in the UK in 1954, the *Association Paléontologique Française* (APF) was created in 1979 (i.e., a quarter of a century later than the British association), just before the International Geological Congress of 1980 for which the APF was one of the main organizing associations. The APF is a corporate member of the International Paleontological Association (IPA) and for the International Zoological Congress which was held in 2008 in Paris, APF participated actively by organizing 2 paleontological sessions.

The association has currently about 250 members. It holds a symposium every two years. The most recent meetings took place in 2007 in the natural reservation at Digne-les-Bains (Haute-Provence), in 2009 at the Catholic University of Lille (North), and in 2011 in the local museum of Elbeuf near Rouen (Normandy). The APF tries to bring together all professional paleontologists from France, not only those from academia. The bi-annual symposium is rather a national meeting, in contrast with the international annual meetings of the *Palaeontological Association* and the *Paläontologische Gesellschaft*. The French association distinguishes the best Ph.D. students with a prize. It edits a regular newsletter, distributes news to all members by electronic mail, and sponsors the journal *Annales de Paléontologie* (see below).

A great number of smaller paleontology-related associations have been founded, some of which are no longer active. With the high number of French paleontologists during the 1970s and 1980s, specialist groups have been created for either fossil groups (such as the group of French ostracod workers) or stratigraphical intervals (such as the Cretaceous interval, *Groupe Français du Crétacé*, for example). Among the active groups are the French stratigraphers, mostly but not entirely composed of paleontologists (*Comité Français de Stratigraphie*), that edit the *Carnets de Géologie* (see below), or the *Groupe Français du Paléozoïque*, that organizes excursions to Paleozoic rocks in France and elsewhere in Europe.

The association of paleobotanists (*Organisation Française de Paléobotanique*) is still active but

currently includes a strongly reduced number of specialists that meet at regular intervals.

A sister association of the APF is the APLF (*Association des Palynologues de Langue Française*), that groups together all French speaking palynologists. This association has over 100 members. However, only few paleontologists are currently included in the APLF, as the number of paleopalynologists and stratigraphers has been reduced dramatically in the last 20 years. Most French palynologists currently work on modern palynology, including pollen biology or even forensic palynology or melissopalynology. They are particularly active and visible for their investigations on Quaternary climate reconstructions.

French paleontology journals

A number of scientific journals related to paleontology have been created in France, but only few of them are currently ISI-referenced. Among the 48 journals listed under the subject category “paleontology” in the ISI Web of Science, the *Comptes Rendus Palevol* have a 2010 impact factor (IF) of 1.000, making this journal rank at the 27th position out of 48.

This publication series was originally related to the *Académie des Sciences* at Paris. The journal is followed by *Geodiversitas* (open access; *Publications du Muséum*, considered as a publication of the MNHN) with an IF of 0.986, ranking 30/48, and *Geobios* (the journal from the paleontology department of Lyon¹) with an IF of 0.868, ranking 35/48. The *Annales de Paléontologie* (official journal of the APF) has an IF of 0.778 and is ranked 39/48 of all paleontology journals.

Two other French journals of the subject category “geosciences” are also listed in the ISI Web of Science, the *Comptes Rendus Geosciences* have a 2010 impact factor (IF) of 1.708, with a ranking of this journal at the 62th position out of 167 journals in this category. The journal of the French geological society, the *Bulletin de la Société Géologique de France* is ranked at the 86th position, with an IF of 1.250. Both journals regularly publish paleontology articles too.

Similar to the German journals (see also Kiessling et al. 2010), there is an ISI discrimination of non-Anglophone journals also for the French publication series. French paleontologists are encouraged by their evaluation committees to target American and British journals to increase their indices, and the French journals, including the ISI-referenced publications, are regrettably neglected.

Among the non-ISI-referenced journals that regularly publish paleontological articles, *Revue de Micropaléontologie*, a well-established and international journal dedicated to microfossils. In fact, in 2010, the IF of the journal was 0.8, but for 2011, it is almost 1.0. *Palaeovertebrata* (Montpellier 2 University), *Oryctos* (*Musée des dinosaures*, Espéraza), *Annales de la Société géologique du Nord* (Lille1 University) and *Carnets de Géologie* (Brest University) should also be mentioned.

Databases: Trans'Tyfipal®

Trans'Tyfipal® is the national inventory of all paleontological type and illustrated specimens housed in French universities and museums. This national programme, developed by the paleontology team at the University of Burgundy at Dijon, attempts to provide a complete inventory of paleontological types and illustrated specimens housed in France, that is accessible freely from internet. The institutions with the largest number of type specimens constitute the national steering committee who coordinates the regional network with local data providers (small museums).

TRAINING OF PALEONTOLOGISTS

Paleontology is taught in most French universities, for undergraduate students and future life and earth sciences high school teachers. However, several universities do not host any permanent professorship (for example, Nantes, Clermont-Ferrand, Saint-Etienne, Nice, Besançon) but hire short term assistant professors instead (*Attaché Temporaire d'Enseignement et de Recherche*, ATER), through 6 to 24 month-long contracts.

Master courses are now presented at several universities (and at the MNHN). The traditional master courses (see **Recruitment and generation change**) exist in modified versions and are completed by more general master programs at other universities. Currently, the master programs based on research attract fewer students than those based on applied research, mostly because students (are being told they) have much better chances to get positions outside of fundamental research.

The Ph.D. degrees are financed by different means. The "allocations" are the classical Ph.D. grants from the Ministry of Higher Education. Many other grants and Ph.D. salaries now come from the ANR projects, but also from many other sources, including industrial co-financing. Post-doctoral programmes and other short-term contracts were absent for a very long time and have only been

introduced recently, in particular with the creation of the ANR.

The curriculum of French paleontologists is more and more related to life sciences, which contrasts to what occurred until the 1980s (mainly earth scientists, working in alpha-taxonomy in a biostratigraphical perspective). The shift from taxonomic and systematic skills toward more analytical disciplines (e.g., biogeochemistry or molecular phylogeny) in the last decades is clearly a threat for teaching paleontology basics and comparative anatomy for the forthcoming decades.

Today, an average Doctor in Paleontology in France has passed a "*Baccalauréat*" (highschool degree; age 18), a "*Licence*" (B.Sc., 3 years; age 21), a "*Master*" (M. Sc., 2 years; age 23) and a "*Thèse de troisième cycle*" or "*Thèse de Doctorat*" (Ph.D., 3 years; age 26).

PERSPECTIVES AND THE FUTURE OF FRENCH PALEONTOLOGY

In terms of publications, scientific impact and citations in the geosciences, France currently occupies the fourth rank in the world after the USA, the UK and Germany. Based on the analyses of geo-science articles in international journals (data from the ISI Web of Science by Thomson Reuters) it is evident that France occupies one of the higher ranks in scientific productivity and citation impact, with similar values to other countries in Western Europe and North America (Isozaki et al., 2010).

Estimates indicate that about 7000 geoscientists are currently active in France (Blicek et al. 2007), among them up to 150 paleontologists. French paleontologists are also represented in other scientific disciplines, such as biology and life sciences as well as human and social sciences. As in other countries, paleontology is highly interdisciplinary in France, and a rapid summary of the scientific activities of French paleontologists can only be approximate and not comprehensive.

Together with astronomy and volcanology, paleontology is a scientific discipline that fascinates all generations. As in many countries all over the world, paleontology is a common component in French society from mass media to children's toy shops (partly thanks to dinosaurs!). However, alike to the situation of paleontology in Germany (see Kiessling et al. 2010), the discipline lacks a strong academic visibility in France, as paleontology is classically located between geology and biology but also neighbours archeology and other fields. This situation leads to a very weak voice in research councils and academia compared to

physicists, chemists, or biologists. But even amongst geoscientists, paleontologists are in a difficult position when they compete against geophysicists or geochemists (for example in terms of impact and citations). Similarly, in life sciences, paleontologists often have to negotiate research grants and positions together with colleagues working in ecology and biodiversity, but also genetics and other disciplines.

France displays a very active and highly multidisciplinary paleontological community that is strongly implicated in the fields of geological and biological sciences. The French paleontologists with permanent academic positions are much younger than a decade ago, due to the current replacement of recently retired colleagues. A relatively young generation is thus now in place, and the presence of several larger centers should allow French paleontology to remain highly active and visible in the next years. This new generation of scientists must find a unity and create lobbying organisms to ensure financial support for paleontological studies in the new very competitive funding environment.

Different research teams and many individuals are highly visible on the national and international level. All paleontological disciplines are developed, including vertebrate and invertebrate paleontology, micropaleontology and paleobotany. French paleontologists are at the forefront on biometrical studies, but also on paleoclimate modeling, and a strong interface between classical paleontology and geobiology is currently being built. Biogeochemical applications are used for the reconstruction of paleoclimates and paleoenvironments, with French scientists being leaders in these fields. There is also a strong community working on macroevolution and on questions of evolution and development ('EVO-DEVO'), among others. French paleontologists now use modern analytical techniques based on high-resolution equipments (e.g., CT-Scan, Synchrotron, etc.).

However, the expertise in systematical paleontology does no longer cover all fossil groups or all stratigraphic intervals. Classical paleontology, based on taxonomy and biostratigraphy, is more and more abandoned, and there is a clear danger that in a few years the biostratigraphical expertise will no longer be available. There is also a clear

delay in analytical paleobiology in France, and molecular paleontology is not yet very much developed.

A major problem for the next years will be the lack of possibilities to recruit young scientists, as new positions will most probably not become available in larger numbers. Although many children will remain fascinated by the discipline, there is a great danger that it will become more and more difficult to motivate young students to study paleontology.

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