Chapter 10
BERLIN: From Humboldt to HVac—The Zoological Collections of the Museum für Naturkunde Leibniz Institute for Evolution and Biodiversity Science in Berlin

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Abstract The zoological collections of the Museum für Naturkunde comprise historic specimens predating the founding of the institution, series of well-dated specimens collected over its 200-year history as well as modern additions such as tissue samples and sound recordings of animals. Overall, the zoological collections are estimated to hold more than 25 million specimens that are accessed by scientists from the Museum für Naturkunde and from around the world for research mainly in systematics and evolution. The zoological collections of the Museum für Naturkunde have their roots in the Berlin University, which—founded in 1810—had included a zoological museum from the start. After a period of growth as the principal zoological museum in Prussia, this and other museums from the Berlin University were united under the roof of a purpose-built building in 1889. This new "Museum für Naturkunde" underwent enormous growth in the following years, stemming both from expeditions and from acquisitions from the colonies. In World War II, the museum was affected by an air raid that left the eastern wing in ruins. This lasted until the bicentennial anniversary in 2010, when the eastern wing was reopened, now specially equipped for safely storing the vast wet collections in conjunction with a spectacular public insight into the collections. The reconstruction of other parts of the building will follow to provide up-to-date public galleries in conjunction with excellent storage for the invaluable collections. Being an institution that has combined scientific work with education and public outreach from the start, the zoological collections in the Museum für Naturkunde with its numerous international relations and projects will serve these purposes in the future as a backbone of an excellent research museum.

Collection Acronym: ZMB for most zoological collections

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The Collections of the Museum für Naturkunde at a Glance

30 million zoological, paleontological and geological specimens:
25,894,000 zoology:

more than *15,000,000 insects*, 10,000,000 other invertebrates
674,000 vertebrates, 80,000–100,000 embryological specimens
120,000 animal sound recordings

3,075,000 fossil specimens:

1,500,000 vertebrates
1,300,000 insects and invertebrates
268,000 plants
49,000 microfossils

331,000 minerals and rocks
6000 meteorites

10.1 The Museum für Naturkunde: An Overview

Inevitably, a visitor will look up when entering the Museum für Naturkunde. It is one of the historic buildings typical for the late nineteenth century: tall columns, huge windows, high ceilings and a large glass-roofed central hall producing a cathedral-like atmosphere (Fig. 10.1). “Ah!” is what follows when the visitor stands at the entrance to the central hall, having a first glance at the huge mounted *Brachiosaurus* and its companions presented there.

The Museum für Naturkunde is not the center of Berlin, but it is situated in the very heart of the city, just a 15-min walk from the main station and the Reichstag building. Following visitors’ surveys, it is one of most popular museums and a must see in Berlin.

Not many visitors, however, are aware that behind the historic façade and behind the scenes of the public galleries, a modern research institution forms the backbone of the institution with expertise in fields like systematics, phylogeny, biogeography, evolution, impact of environmental changes and catastrophes, and citizen science. Its core research areas—biodiversity and evolutionary studies—are based on more than 30 million objects ranging from zoology, palaeontology and mineralogy. Comprising almost 26 million objects (including more than 15 million insects), the zoological collections are by far the largest part of it (see Box, http://www.naturkundemuseum-berlin.de/en/insights/collections/). However, no one will ever be able to count them, and an inventory of all specimens is in far reach. In total,

Fig. 10.1 Façade of the Museum für Naturkunde with main entrance (with permission from: Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: A. Dittmann)

280 staff are working at the museum (see Annual Report 2014, http://www.naturkundemuseum.berlin/sites/default/files/jahresbericht_mfn_2014.pdf). Many of these, ranging from technicians to scientists, take care of collections, curate them, digitize them, or provide service to the annually 700 external scientists and making sure that the collections remain accessible and are available for even more research.

Founded in 1810 as part of the university, research and academic education have been central tasks of the museum from the very beginning. With the first museum building and the quickly growing collections over the course of the nineteenth century, exhibitions became the third dimension, a process that can also be found in other natural history museums in Europe. In Berlin, however, history has it that a dispute between traditional and modern views left traces in the architecture of the building (see Sect. 10.3 for details).

Outstanding Specimens in the Zoological Collections of the Museum für Naturkunde

- *From notable collectors*: Collections of Marcus Elieser Bloch (1733–1799; fish collection) and Albertus Seba (1665–1736; herpetological collection), mineralogical specimens from Alexander von Humboldt (1769–1859)

(continued)

- *From extensive national expeditions*: German Deep Sea Expedition (1898–1899), Antarctic Expedition (1938–1939), Tendaguru Expedition (1909–1913)
- 177,000 *Type specimens*, including mountain gorilla and forest elephant

The most extensive growth of the collections was linked to the numerous expeditions starting in the early nineteenth century and the later colonial expansion in Imperial Germany (see Sect. 10.2). Consequently, focal areas of the collections were Africa and Southeast Asia. Until today, these collections build a solid ground for further research in these regions. Several of the museum's icons originate from this period (see box). The most famous is the mounted *Brachiosaurus* in the central dinosaur hall, dug out during the Tendaguru expedition to former German East Africa, today Tanzania (1909–1913, Fig. 10.2). Also, much of the scientifically important material dates back to this period. Others are even older than the founding date of the museum, e.g. objects from the collections of Albertus Seba or Marcus Elieser Bloch. Items collected by Alexander von Humboldt and Charles Darwin (1809–1882) show the close link to our cultural heritage (see box). Apart from outstanding individual objects found throughout the museum, some collections are exceptional, e.g. the embryological collection (see Sect. Vertebrate Collections in the appendix) and the animal sound archive which are unique for the zoological collections of the Museum für Naturkunde.

Key Networks and Consortia of Natural Science Collections

As an Integrated Research Museum of the Leibniz Association, the Museum für Naturkunde is both a research institution—as one of 89 within the *Leibniz Association* (http://www.leibniz-gemeinschaft.de/en/home/) that range from the natural, engineering and environmental sciences via economics, spatial and social sciences to the humanities—and a museum with public galleries and public outreach. As a museum, the Museum für Naturkunde is member of the *International Council of Museums (ICOM, http://icom.museum/*) and its German branch, the German Museums Association (*Deutscher Museumsbund, DMB, http://www.museumsbund.de/en/*). Whereas ICOM and DMB are associations concerned with different aspects of professional museum activities, the following are centered on the scientific collections housed in natural history museums.

The *Deutsche Naturwissenschaftliche Forschungssammlungen (DNFS*, http://www.dnfs.de/) is a German consortium of nine institutions holding the most comprehensive scientific research collections in Germany. It includes the working group on natural science collections in the DMB. Joint efforts and common approaches of the members of the DNFS help to

(continued)

answer the challenges and political and societal requests natural science collections are facing.

CETAF is the *Consortium of European Taxonomic Facilities*, http://cetaf.org/: a European network of 33 natural science museums, natural history museums, botanical gardens and biodiversity research centres with their associated biological collections and research expertise. CETAF aims to promote training, research and understanding in systematic biology and palaeobiology, and facilitate access to information (collections) and the expertise of its member institutions across Europe.

The mission of the *Scientific Collections International (SciColl, http://scicoll.org/*) is to increase the use and impact of scientific collections for interdisciplinary research and societal benefits to expand the access, awareness and appreciation of scientific collections. The aim of this international organization is to increase the return on investment that countries and institutions make in their scientific collections by catalyzing international and interdisciplinary collaboration, e.g. by research on major challenges and by new and more cost-effective management and use of collections in all disciplines.

For further information on networks, initiatives and projects see Quaisser and Woog (2011).

Although organized in separate institutional structures for most of its history, the zoological, palaeontological and mineralogical collections have always been hosted under one common roof. Only in 2009, almost 200 years after its foundation, the Museum für Naturkunde became an independent research institute and merged all management structures into one new organization led by a director general. In the same process, the museum became a member of the Leibniz Association, and as such it is financed jointly by federal and state funds. Today, the Museum für Naturkunde works towards an integrated research museum, emphasizing once again the close connection and finally the integration of research, collections and public engagement with science. It is a strong partner in many national and international consortia and initiatives, such as DNFS, CETAF and SciColl (see box). Though often closely cooperating in research initiatives, the Botanischer Garten und Botanisches Museum Berlin-Dahlem (BGBM) took quite a separate development in Berlin from the beginning. Only during the German separation, when the BGBM was in West Berlin (West Germany) and the Museum für Naturkunde in the East, Recent botany became part of the Museum für Naturkunde. After reunification, botanical specimens were transferred to the *Herbarium Berolinense* housed in the BGBM (Greuter et al. 1994; Köhler 2010).

Fig. 10.2 Skeleton of *Brachiosaurus brancai*, one of the icons of the museum (with permission from: Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: A. Dittmann)

10.2 Origins

The origins of the zoological collections reflecting the animal diversity known at the time is strongly linked to the opening of the *Alma Mater Berolinensis*, the Berlin University, in 1810. Suggested by Wilhelm von Humboldt (1767–1835) as part of his education reform following the new humanism ideal, it exemplified a new type of university with didactic *and* research components—as had been stipulated in von

Humboldt's text *Über die innere und äußere Organisation der höheren wissenschaftlichen Anstalten in Berlin* (http://edoc.hu-berlin.de/miscellanies/g-texte-30372/229/PDF/229.pdf). This unfinished and undated manuscript can likely be dated to 1810 (Paletschek 2007) and must be seen in a context of contemporary thinkers in education such as philosopher Johann Gottlieb Fichte and theologian Friedrich Schleiermacher. This university, endowed by King Frederick William III of Prussia, incorporated several previous institutions and organizations that were suitable to assist in the education of students. Collections were one essential part of this, as Article 1 of the preliminary regulations for the Berlin University indicates (http://edoc.hu-berlin.de/miscellanies/g-texte-30372/251/PDF/251.pdf). This article states, that "...the University is in connection with the two aforementioned Academies of Sciences and Arts as well as with institutions and collections with which it forms an organic whole" (translation by PG). The zoological collections now housed in the Museum für Naturkunde were no exemption and with reference to his much revered *Muséum National d'Histoire Naturelle* in Paris, Alexander von Humboldt supported the ideas to include a similar institution in the new university (Geus 1998). More explicitly, an outline of the museum was devised in a memorandum from 1810 by Johann Karl Wilhelm Illiger (1775–1813), which stated that a zoological museum was needed both for research and education (Jahn 1985). He was seconded by Johann Centurius Hoffmann Graf von Hoffmannsegg, an entomologist and botanist with a wide interest in zoology, who had visited the museum in Paris en route to his second collecting trip to Portugal (Eckert 2010). Like Alexander von Humboldt, he was impressed by the dual function of this museum (cf. Eckert 2010).

Von Hoffmannsegg was an avid collector of natural history specimens. After having combined his specimens with those from Braunschweig-based Professor Hellwig, they jointly owned the largest entomological collection of the time (Eckert 2010). Apart from this, Hoffmannsegg also owned many botanical specimens and a zoological collection including numerous animals collected by his servant and preparator Friedrich Wilhelm Sieber in Brazil (cf. Göllner-Scheiding 1972). He donated (according to Jahn 1985: sold) this collection of birds, mammals and amphibians to the Prussian State to form the base of the new museum, and, before moving on to Dresden in 1816, he also sold his entomological collection [Göllner-Scheiding (1972), but also see Jaeger and Uhlig (2010), who state an extended date for the transfer until 1820].

It was agreed to hire the entomologist Illiger as head of the new museum following a suggestion by von Hoffmannsegg, who had known Illiger from his time in Braunschweig. There, he had sorted and supervised the vast entomological collection of Hoffmannsegg and Hellwig (Eckert 2010). Other collections that formed the founding stock of the zoological museum were according to Jahn (1985) relocated from the "Academic Museum" of the Academy of Sciences with specimens that originally stemmed from the *Königlich Preußische Kunstkammer* (Royal Prussian Art Collection) and from several founding members of the *Gesellschaft Naturforschender Freunde zu Berlin* (Berlin Society of Friends of Natural

Science, founded in 1773). According to Geus (1998), these included the founder of the society, Friedrich Heinrich Wilhelm Martini (1729–1778, "conchyological" collection), Marcus Elieser Bloch (1723–1799, ichthyological collection), Friedrich Wilhelm Herbst (1743–1807, entomological collection) and Johann David Schoepf (1752–1800, herpetological collection). Until Bauer and Günther (2013) associated several reptilian specimens of the herpetological collection with Albertus Seba (1665–1736) and dated them to 1734 (possibly earlier, Fig. 10.3), the Bloch collection contained some of the oldest specimens of the zoological collections of the Museum für Naturkunde. This collection mainly is known for its fish specimens that soon were joined by Siberian fish specimens from Peter Simon Pallas (1741–1811), who had died shortly after the museum came into existence (Jahn 1985). Despite his support for inclusion of collections into the new university, Alexander von Humboldt did not contribute to the zoological collection initially. He remained mostly in Paris during the first decades of the nineteenth century to work on the report of his journey to South America and to get his biological specimens analysed by local experts. They then received most of his South American collection of botanical and zoological specimens. Nevertheless, apart from his pet parrot, which is now in the bird collection (Fig. 10.4), he gave his collection of minerals and the specimens of the later expedition to Russia to the Berlin museum.

The first head of the zoological collections (i.e. the "Zoological Museum Berlin", later and still using the acronym "ZMB" for most of its collections) in the new university, Karl Illiger, had devised a system for mammals and birds of his own (Illiger 1811), and the collections were ordered accordingly. After Illiger's early death in 1813 at age 37, Hinrich Martin Lichtenstein (1780–1857), the first

Fig. 10.3 *Python sebae* ZMB 1478, a specimen traced back to the collection of Albertus Seba. (with permission from: Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: F. Tillack)

Fig. 10.4 ZMB_Aves_14578, *Coracopsis vasa vasa*, the pet parrot of Alexander von Humboldt (with permission from: Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: C. Radke)

professor of zoology at the new university, succeeded him as head of the museum (cf. Lichtenstein 1816). To have a professor of zoology in its own right and not as part of medicine is another progressive feature of the *Alma Mater Berolinensis*. Lichtenstein had spent several years in South Africa as a private teacher (and physician) and explored the natural history of the area (Landsberg 2010). The position had been offered to von Hoffmannsegg, but he declined after his demands for more personnel, for an own library, and for funds to carry out collecting expeditions were turned down (Jahn 1985). If not realized for the hiring of von Hoffmansegg, these ideas were accomplished over time, and the Zoological Museum Berlin became the primary Prussian zoological collection; all others were entitled only to the acquisition of "duplicates" (Jahn 1985). However, the initial mistake not to include the Anatomical-Zootomical Collection, which held material for comparative vertebrate anatomy, was not corrected until 1889 (see Sect. 10.2.1).

Initially, the museum was expected to auction off "duplicates" from the collection and from collecting expeditions to finance both itself and further collecting trips. For this purpose, catalogues of *Doubletten* (duplicates) were printed and distributed, e.g. on mammals, birds, amphibians and fishes (Lichtenstein 1823). However, the surplus was soon used to buy missing species so that around 1850, the Zoological Museum Berlin could be compared to the largest European collections

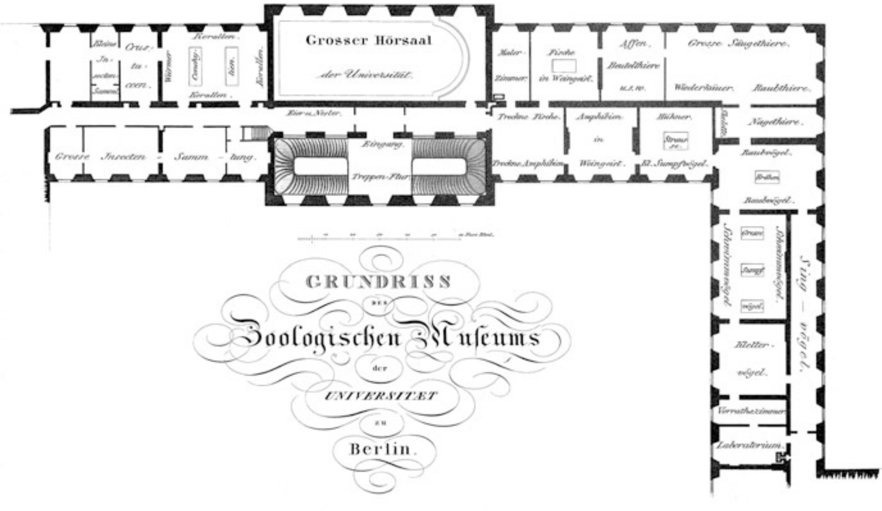

Fig. 10.5 Layout of the Zoological Museum Berlin in the building of the Berlin University around 1830 (with permission from Museum für Naturkunde Berlin) (© with Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science. Museum für Naturkunde Berlin, Historische Bildů. Schriftgutsammlungen (Sigel: MfN, HBSB), Bestand: Zool. Mus., Signatur: S I/Grundriss/1830)

of Paris, Wien, Leiden and London (Jahn 1985). This rapid growth can be seen in the number of rooms allocated to the museum in the university building (still the headquarters at *Unter den Linden 6*): it started out with nine rooms in the east wing, it occupied 22 rooms of the second floor after setting up the insect collection in 1825 (cf. Fig. 10.5), and in 1842 it extended over the entire third floor of the building (Jahn 1985).

The detrimental practice of selling off "duplicates" was continued until Wilhelm Carl Hartwig Peters (1815–1883) became director of the Zoological Museum Berlin in 1858, after Lichtenstein's death. He only allowed the sale of "duplicates" after his consent and generally reduced the number of sales considerably (Jahn 1985). Gradually, the storage facilities in the *Unter den Linden* location filled up, so that around 1870 most of the building was occupied with natural history collections, triggering complaints that teaching was impeded by collection objects obstructing access to lecture halls (Köstering 2010; Damaschun and Landsberg 2010). This led to a formal request for a different location for the vast collections and eventually, a decision was made to construct a new museum building at its present location, *Invalidenstraße 43*. This site, the former location of the Königliche Eisengießerei (Royal Prussian Foundry) had only been incorporated into the city boundaries of Berlin for a few decades, when the museum relocated there in 1889. The controversy about the new building with its dual arrangement in a traditional museum-type building is depicted in Sect. 10.3. Initially, this building with its total combined collection and exhibition space of 20,950 m^2 was large enough to house the collections of the *Unter den Linden* location. However, the collections grew steadily due to a worldwide network of collectors (see Angermann 1989) and due to an increase in the number of expeditions (e.g. Gazelle, Deutsche Tiefsee-Expedition, see Sect. 10.2.2) that in part were furbished by the museum. Another factor that considerably contributed to this growth around the time of the move to the new location was the shift in the policy towards the acquisition of colonies of the unified Germany in 1884. Germany then intensified government involvement in formerly purely trade activities of German companies in Africa and Southeast Asia and Oceania. Ensuing were colonies in what today is Namibia, Cameroon, Tanzania, New Guinea and several of the Oceanic Islands. These colonies provided numerous specimens, and the museum issued instructions for collectors (*Anleitung zum Sammeln, konservieren und Verpacken von Tieren für das Zoologische Museum Berlin*) for the zoological collections in several editions dated 1896, 1902 and 1907 (Jahn 1985). The numbers in the new building rose dramatically and within a few decades and despite the space-saving effect of the dual arrangement (specialized public exhibition and scientific collections locked away behind the scenes with study skins rather than mounted specimens, especially in birds and mammals), the need to build an extension for the collections became evident. The northern addition to the building was finished as one of only a few buildings in the war year 1917. At the time of completion of this wing, the colonies were no longer German, but the growth in the collections only slowed down, and up to now, many specimens are added to the zoological collections every year.

10.2.1 Zoology vs. Medicine

In its first decades, the Zoological Museum Berlin had difficulties to set itself apart from the medical faculty. It was intended by the university founders to include zoology in its own right in the faculty of philosophy—which succeeded by providing Hinrich Lichtenstein with the first chair of zoology in Berlin in the philosophical faculty (Damaschun and Landsberg 2010). However, despite Illiger's outline for the collections of 1810 (which explicitly included anatomical specimens) and the support of von Hoffmansegg in his concept of rules and regulations for the new museum, the collection profile was challenged for specimens by the collection of comparative anatomy ("Anatomisch Zootomische Sammlung") which demanded all skeletal material of vertebrates (Jahn 1985). Unfortunately, Illiger's and von Hoffmannegg's suggested outline of the collection was reviewed by Karl Asmund Rudolphi (1771–1832), first full professor of the medical faculty and head of the Anatomical-Zootomical Museum, who opposed these views (Jahn 1985) with regard to the Paris Muséum National d'Histoire Naturelle—where these objects are still in different locations today. In a decision by the Prussian administration dated 28 January 1811 (cited in Jahn 1985), a compromise was found in that both collections have separate administrations but remain together and could be used in the same manner. This separation resulted in the unfortunate situation that mammal specimens were divided between the two collections: the skeleton was given to the

Anatomical-Zootomical Museum and the skin to the Zoological Museum Berlin for mounting. The decision by the Prussian administration was kept up throughout the working lives of Rudolphi and his successors, Johannes Müller (1801–1858) and Karl Bogislaus Reichert (1811–1883) despite various attempts to incorporate the Anatomical-Zootomical Museum into the Zoological Museum. Only after a simultaneous vacancy of both the zoological and anatomical-zootomical chairs in 1883, a reorganization of the museums within the Berlin University was achieved, and the new director of the Zoological Museum Berlin was also appointed to supervise the Anatomical-Zootomical Museum in 1887–1888, and an integration of the latter into the Zoological Museum Berlin was decided in 1888 (Jahn 1985). With the move into the new building at the current location of the Museum für Naturkunde in 1889, the two collections were eventually combined (Jahn 1985), but the confusion stemming from the separation of the same specimen into two collections (along with two unrelated specimen numbers) remains until today, and the identification of matching skin and bones still can be an extremely time-consuming task for the collection personnel of the mammal collection (Angermann 1989).

10.2.2 Expeditions

The collections of the Museum für Naturkunde gained from several expeditions outfitted by government authorities and public funding. The first substantial expedition linked to the new museum took the young scientists Friedrich Wilhelm Hemprich (1796–1825) and Christian Gottfried Ehrenberg (1795–1876) to northern Africa and the Middle East. In 1820, the Prussian Academy of Sciences proposed to the Prussian Ministry that Hemprich and Ehrenberg accompanied an expedition of General Minutoli (1772–1846) to Egypt and Northern Africa in order to collect and record natural history objects. This expedition soon broke up and Hemprich and Ehrenberg continued to accomplish the tasks outlined in instructions by the Academy independently (cf. Stresemann 1954). Unfortunately, nine of the expedition members died for various reasons en route (see Ehrenberg 1828), including Hemprich, who died from malaria in June of 1825 (see Anonymus 1827). After the return of Ehrenberg to Europe late in the same year, Alexander von Humboldt gave a concise account of the voyage for the Academy in 1826 and recorded the scientific gains of the expedition beyond the 114 crates sent back to the museum with a total of 34,000 zoological and 46,000 botanical specimens (von Humboldt 1826).

Another Prussian expedition prior to German unification in 1871, the Royal Prussian Expedition to East Asia (1860–1862), was accompanied by Carl Eduard von Martens (1831–1904), curator of malacology and marine invertebrates at the museum, who besides his own interest in molluscs (von Martens 1867) collected animals in general, including mammals (von Martens 1876; Angermann 1989). Whereas the purpose of this expedition to Japan was mainly political, the focus shifted back to science in the following expedition of the "S.M.S. Gazelle"

(1874–1876), which was accompanied by zoologist Theophil Rudolf Studer (1845–1922) from Berne who included Berlin-based zoologists in the analysis of the material (Studer 1889). This frigate of the Prussian Navy was used for an expedition to the Kerguelen Islands in the southern Indian Ocean to contribute to the international effort in recording a transit of Venus at different remote stations. This was followed by two expeditions with a marine biological focus: the Plankton Expedition of 1889 (mainly funded by the Alexander von Humboldt Foundation for Nature Research and Travel) as a counterpart to the British Challenger Expedition (1872–1876) and the German Deep Sea Expedition (1898–1899) using the specially outfitted steamer "Valdivia" (Fig. 10.6). Whereas the Plankton Expedition was initiated by Kiel-based Victor Hensen (1835–1924), the head of the Prussian *Meereskommission* (Commission for the Seas), the German Deep Sea Expedition was led by Carl Friedrich Chun (1852–1914), whose scientific estate is kept at the Museum für Naturkunde in Berlin. Other noteworthy expeditions that contributed to the wealth of zoological specimens in the collections were the German Sunda Expedition (1929–1931), the German Expedition to Tibet (1938–1939) organized and led by Ernst Schäfer (1910–1992) and the Cuba Expedition (1967) led by Hans-Eckard Gruner (1926–2006), then in the middle of his 40 years as curator of the crustacean collection (Coleman 2007). The latter two exemplify expeditions that were constrained by ideological ties of their time which, in Schäfer's case, who was an SS officer, were prevalent in the participants themselves. The Cuba Expedition differs from other scientific expeditions carried out by staff members of the

Fig. 10.6 Steamer "Valdivia" on the German Deep Sea Expedition (1898–1899) (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science. Museum für Naturkunde Berlin, Historische Bildŭ. Schriftgutsammlungen (Sigel: MfN, HBSB), Bestand: Zool. Mus., Signatur: B VI/3164)

museum in socialist German Democratic Republic as it was accompanied by media coverage that enabled participation of the general public in the exotic world which was out of reach for the vast majority of the population—not only for financial but also for political reasons. This is especially true for the coral reef that was disassembled and boxed up for transport to Berlin with the help of amateur divers who reported from the field (e.g. Wagner 1967). Using this material, a new diorama was created with the scientific expertise by the curator of marine invertebrates, Dietrich Hans Hermann Kühlmann (1927–2014), who continued to publicize these efforts (Kühlmann 1980). Parts of these corals are currently on display again. Today, expeditions are project based and, like the Cuba Expedition, in collaboration with host institutions in partner countries. In times of access and benefit sharing (see Chap. 5), this is a prerequisite for successful collecting of biological specimens (i.e. “genetic resources”).

10.3 Spirit, Culture, Science and Technology

As outlined above, the Zoological Museum Berlin together with other natural history collections of anatomy, mineralogy, geology and palaeontology represented an integral part of the Berlin University in 1810. Two hundred years later, the Museum für Naturkunde has developed into one of the largest and most active integrated research museums of natural history in Europe and is an independent institution of the Leibniz Association. However, war action and inadequate building maintenance in the following 60 years have left their mark on the shell of the museum so that major reconstruction was needed. Following decades of limited repairs and provisional additions of infrastructure, the first phase of reconstructing the building was completed in 2010, still under the lead of the expert staff of the Humboldt University (Bartsch and Neuhaus 2011). After completion of the modernization of part of the galleries in 2007, which resulted in almost a doubling of the public visitor numbers to 500,000 per year, the first large scale reconstruction programme aimed particularly at rebuilding the eastern wing which had been destroyed by a bomb hit in February of 1945 (Fig. 10.7).

More space for the crowded collections was and still is needed urgently along with a higher security standard for the sensitive material part of zoological collections. From the very beginning in 2005, the project aimed at a safe storage of the 279,000 lots of the wet collection, the glass jars of alcohol-preserved zoological specimens. These amount to about 80 t of highly flammable fluid, and fire protection requirements demanded that they must be separated from the bulk of the dry collection. As such, it seemed to be shaped into a rather straightforward and clear-cut project with concordant aims of fire safety and an improvement of collection care. This included cooling and stable air-conditioning (HVac), an automatic fire-extinguishing system, laboratory space for handling, conservation and scientific use combined into a new replacement building of the eastern wing. The hope was that these measures would get rid of most of the immense and permanent task of refilling

Fig. 10.7 Ruined eastern wing in 2006 (with permission from: Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: C. Radke)

evaporated alcohol under the changing temperature conditions of the previous collection halls for wet specimens (Fig. 10.8), which ranged from 13 °C in winter to 30 °C in summer. At the same time, the internal, rather traditional procedures for conservation were reviewed, which was accomplished within a project for improving the curation of wet collections funded through the KUR—Programme for the Conservation of Moveable Cultural Assets by the German *Kulturstiftungen* (Neuhaus et al. 2012).

The logistics of disparate collections of hazardous materials originally forming historically grown entities and arranged according to biological systematics can be a problem for research availability and are a horror for the collection personnel and the fire marshal alike. To complicate matters, the remains of the eastern wing, the partly preserved façades and the head buildings of the building listed as a monument had to be preserved.

10.3.1 Building History

What about this monumental architectural heritage? It is simply marvellous. It is open, spacy, with large windows, inviting the public and with the stringency and Prussian austerity of a functional building at the same time. But, for a large museum of natural history with a huge influx of research collections during colonial times, it

Fig. 10.8 The fish collection in the old collection hall (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: H.J. Götz)

had been an outdated near misconception already when it was opened in 1889. August Tiede (1834–1911), the architect of the building, a thoughtful specialist in museum construction (Tiede and Kleinwächter 1891; Tiede 1898), had originally envisioned a building with a separation of collection space and public access (dual arrangement), as it had been developed in Great Britain at that time. Thus, he seemed not to be wholly convinced of his construct that encompassed the demands of the director W.C.H. Peters and the authorities who had dismissed all his innovative plans from 1873 onward (Helbig 2010). They wanted to keep the entire collections open for public access as it had been in the original location in *Unter den Linden* and thus, the new building was designed along these lines. In a quirk of history, the successor of W.C.H. Peters, Karl August Möbius (1825–1908), who was the first director in the new building, supported the dual arrangement. Since the new building was devoid of capacious magazine areas for the ever growing zoological, palaeontological, geological and mineralogical collections, he directed that the grand staircases (Fig. 10.9) and the upper floors were closed to public access in order to gain collection space. Nevertheless, due to the growing collections, a northern wing soon had to be added—the construction lasted from 1913 to 1917. This was purposely built as collection and office space with a lower ceiling, thus accommodating two additional floors in the same building height. The dual arrangement also allowed Möbius to implement the new concept of public education with specially designed galleries incorporating didactic needs on the ground floor (Möbius 1884a, b; Jahn 1989).

Fig. 10.9 Internal stairs intended for visitors' access to the upper floors (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: H.J. Götz)

What did this mean for the project of the reconstruction of the eastern wing and the ongoing restoration programme? The architect, Roger Diener, had immediately grasped the aesthetic potential of the thousands of glass jars of the zoological wet collections and the necessity of physically separating the walkway of visitors through the eastern wing on the ground floor from the collection space. After some disputes over the dominance of research and curation pragmatics over aesthetic demands, it was quickly understood that placement of an authentic research collection into the public gallery in a natural continuation of the old building concept is somewhat irritating yet highly attractive and appreciated by an educated citizen of today.

Accordingly, the high ceilings of the old building were continued into the new part, which essentially is a concrete box with wall-cooling set into the framework of the remnant façades of the original eastern wing (Fig. 10.10). The shelf system of the wet collection is 5–6 m high per floor, separated by integrated grid levels. At the intersection between original building and the later added northern wing, virtually no levels correspond. Even in the ground floor galleries, these parts are separated by several steps preventing wheelchair access. In the upper floors, internal ramps render internal transport of materials difficult; however, in 1913, with many cheap hands available, probably nobody thought of the internal logistics or barrier-free access. Now a large transport elevator with 13 stops provides access to all floors and is publicly accessible on the two ground floors. Since this transport facility had to be built in anyway, it was also decided to place the taxidermy, dissection and preparation laboratories on top of the new eastern wing. Instead of the usual basement situation for these facilities, this provides high ceilings with natural lighting.

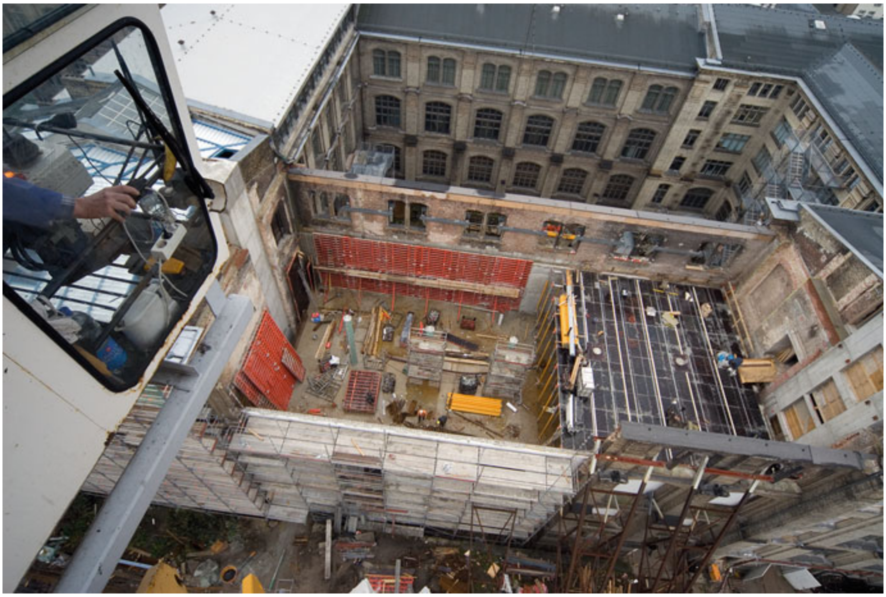

Fig. 10.10 New eastern wing under construction in 2008 (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo C. Radke)

In the restored northern head building of the eastern wing, it was possible to construct offices and laboratories for most of the scientific and technical staff working with the larger wet collections, which at the same time are quite close to the corresponding dry collections. No work spaces are allowed in the wet collection itself for safety reasons. Other safety requirements of the new collection space include temperature control that cools it down to 15–18 °C (i.e. below the flashing point of 70 % ethanol), an explosion-protected electrical system, a high air exchange to prevent the accumulation of alcohol vapours and a gas fire-extinguishing system based on nitrogen. Access into the collection halls is only permitted for trained personnel. Work time is limited within the collections and examinations of the specimens, or conservational measures must be carried out in the laboratories of the northern head building.

Energy consumption of the new facility is moderate but much higher than the original building with its passive ventilation similar to that of a termite mound. Building large compartments reduced construction costs and optimized storage volume for the collections, thus allowing for 20 % growth. After overcoming initial technical problems, the museum staff are still quite content with the functionality of the building after five years—and this is perhaps the best compliment for everyone involved in the design and construction of this specialized collection space. With the fascinating insight for the public (Fig. 10.11) and the equally spectacular façade reconstruction (Fig. 10.12), the eastern wing represents a highly esteemed example of good architecture, almost—a piece of art.

Fig. 10.11 Eastern wing ground floor with visitor walkway (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: C. Radke)

In essence, the close cooperation between architect, construction team and users, respecting the demands of the building monument as well as the functionality of the research facility, led to a synergetic effect rather than compromise (Diener 2010). For the remaining part of the highly needed reconstruction, it is planned to continue in this way by making use of the large room volumes for suitable collections,

Fig. 10.12 Partly destroyed façade of eastern wing supplemented by concrete casts (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: H.J. Götz)

incorporating the high climate inertia of the thick walls of the building, applying loam rendering to the walls preventing drastic changes in relative humidity, tightening the old double box windows, diminishing energy consumption and carbon footprint by geothermic heating and cooling, and, at the same time, providing more room, more access and more insight for the interested public in the upper floors, rather than pressing all collections into the overloaded existing building (Bartsch et al. 2013). Taking into account the numerous collection storage areas outside the original building, it is not possible to accommodate all collections in the existing building effectively. This is especially true for the quickly growing and particularly fragile, yet frequently accessed entomological collections that according to current conservation standards (see standards) require strict pest management and climate control, and this is also true for the particularly heavy parts of mineralogy and palaeontology collections which currently amount to a load of 808 t. Thus, after 200 years of growth, a new on-site collection building is needed to reconcile the needs for increased space for public galleries in the original building and the need to accommodate the collections in an energy efficient building incorporating all conservation requirements.

10.4 Collections and Public Galleries

The collections were initially intended for student education and scientific research but soon were opened to the general public. As Lichtenstein (1816) notes, the ordering and preparatory work started by Illiger in 1810 had by 1814 advanced far enough that limited access to the halls of the museum could be granted. Since no differentiation between public displays and collection specimens was made at that time, the entire collection served as galleries. This only changed with the directorship of Möbius (see above), who separated collections from galleries with their specialized didactic displays, thus transforming the museum to one of the most advanced of its kind. This status slowly diminished over time, but, with the reconstruction of the public galleries that opened in 2007, international recognition was regained (Moldrzyk 2015). In his review, Moldrzyk (2015) explained that this was achieved by careful planning after an analysis of the shortcomings of the exhibition concepts in the previous decades. It was understood that the focus of the exhibitions should shift from education towards raising interest by focussing on the fascinating facts and remarkable stories rather than trying to explain biological processes or complex systems. This generates a comfortable situation for visitors and makes them more receptive for natural history issues. Therefore, object aesthetics, scenography and the display of the objects are in the focus of exhibition planning while content overload is avoided. Yet, in a second step, a wealth of information is offered to the interested public. Important conclusions drawn by Moldrzyk (2015) include the insight that original items from the collections should be preferred over casts, models or reconstructions and that content should focus on the research of the museum's scientists, especially on evolution and biodiversity. He states that more than 40 scientists were involved in creating the new permanent exhibitions that display thousands of collection specimens. A special case in this context is the fish wet collection in the east wing which serves as active collection space but nevertheless can be viewed by the public (see above). Following the insight that original specimens from the collections are the key to success, future concepts must allow visitors to have a closer look at the collections. In a way, this resembles the initial concept of the Zoological Museum Berlin as implemented 200 years ago by Lichtenstein (1816).

10.5 Collections and Research

Scientific curiosity has always been the driving force behind the development of natural history collections, especially zoological collections, and the collections of the Museum für Naturkunde reflect this. In the same way as research moved from descriptive biology to morphological studies, molecular genetics and ecological research over the course of time, collecting and consequently the character of collections changed. Starting with "cabinets of curiosities", the focus moved to

Fig. 10.13 Series of study skins in the bird collection (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: H.J. Götz)

"complete" collections at the beginning of the nineteenth century and further to whole series of specimens of specific taxa in order to understand their morphological variability (see Sect. 10.2 and Fig. 10.13).

Today, the Museum für Naturkunde takes an interdisciplinary approach to study biological and geological/palaeontological issues. With partners around the world, zoologists, palaeontologists and geoscientists work closely together on the discovery of microevolutionary mechanisms of population differentiation, on speciation, evolutionary genetics and biodiversity. The work covers the entire time frame from the birth of the solar system via the present to the modelling of future scenarios. Processes of diversity dynamics are also investigated based on changes of ecosystems in time and space.

10.5.1 New Collections

The collections support this research and, in turn, are complemented by newly acquired materials. Along with the arrival of new technologies like DNA sequencing, new collection types such as DNA and tissue collections arose. Especially in vertebrate zoology, scientists now take blood and tissue samples instead of whole organisms, or, if so, they take special care that the preservation of voucher specimens will not destroy the genetic resources. The DNA and tissue collection of the Museum für Naturkunde is one of the youngest collections of the institution with a history of only 30 years. In 2015, about 30,000 DNA samples and another 3000 tissue samples were stored in freezers at the Museum für Naturkunde, mainly from mammals, amphibians, molluscs, insects and crustaceans. Each new research question is translated into the growth of this collection.

Another relatively new facet in natural history collections are the fast-growing digital collections. Based on both digital access to specimen information and to digital representations of it, digitization and new scanning facilities facilitate access to the specimens, speed up processes and enable new ways of research. On the other hand, this leads to an impressive amount of digital data that need their own management strategies, access and curation. In 2015, about 4 % of all collections objects were accessible through central databases and management systems.

Outstanding in this context is the animal sound archive. It is one of the largest collections of animal sounds, consisting of about 120,000 analogue and digital bioacoustical recordings comprising almost all groups of animals. The animal sound archive is basis for a whole range of research projects and educational programmes, from behavioural studies to bioacoustic monitoring of birds and the detection of bioacoustical patterns. Almost all recordings are digitized and available online, see www.tierstimmenarchiv.de.

10.5.2 Collection-Based Research

Collections are especially relevant for taxonomic research and the entire field of biodiversity discovery, and they play an important role in many areas of evolutionary studies. There is an impressive record of good examples of collection-based research at the Museum für Naturkunde. Snapshots from recent years will give an impression of the variety of this research conducted by scientists of the museum.

Between 2009 and 2011, scientists of the Museum für Naturkunde discovered and described almost 500 new taxa which is about 1 % of all taxa described in this period. One of the most impressive findings is probably the giant wasp, *Megalara garuda*, a new genus and species of larrine wasps from Indonesia (Larrinae, Crabronidae, Hymenoptera). Collected on the Indonesian island of Sulawesi in 1930, it remained hidden in the collection for about 80 years. Only then the curator Michael Ohl stumbled over two specimens in his collection that caught his eye by their sheer size. Very quickly it became clear that this extraordinary sphecid species had never been described. The description of the Giant Wasp (Kimsey and Ohl 2012) caught the attention of hundreds of newspapers and journals all around the world (Fig. 10.14).

How to Name a Wasp

In a unique process of describing a new species, public visitors to the museum had the chance to vote and consequently decide on the scientific name of a

(continued)

new digger wasp (Ampulicidae, Hymenoptera). As guidance, they were provided with a description of biology and behavior of the new species and a selection of four names based on peculiarities of the species. As the result most visitors selected the name “dementor” (full name *Ampulex dementor* Ohl, 2014). This name, derived from the “soul-sucking” dementors from the popular Harry Potter books is an allusion to the wasps’ behavior to selectively paralyze its cockroach prey. In this example, public voting on a scientific name has been shown to be an appropriate way to link museum visitors emotionally to biodiversity and its discovery (Ohl et al. 2014).

In another example, molecular as well as anatomical analyses revealed new evolutionary relationships between very similar-looking African rainforest frogs specialized on waterfalls and rapids. It turned out, that Eastern and Central African frog species were closely related. However, the West African frogs represented an evolutionary lineage of their own, branched off from all other extant frogs as early as the Cretaceous, a period when dinosaurs still roamed the earth. Furthermore, the new discovery has anatomic features not found in other frogs (long, pointed and backward-bending teeth in the upper and massive fangs in the lower jaw, Fig. 10.15), underpinning the evidence for the discovery of a new frog family. This finding has not only academic and scientific value but is also relevant for conservation and underlines the necessity to protect the unique and species rich forests of West Africa (Barej et al. 2014).

Fig. 10.14 Pinned specimens of the giant wasp *Megalara garuda* and other species of Hymenoptera (with permission from Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science; photo: C. Radke)

Fig. 10.15 Visualization of the skull and teeth of *Odontobatrachus natator* (ZMB 78203) from μCT data, lateral aspect (with permission from Museum für Naturkunde Berlin—Leibniz Institute for Evolution and Biodiversity Science, visualization by M. Barej, μCT scanning by K. Mahlow)

The combination of taxonomic expertise, comprehensive collections and complementary fieldwork builds a solid ground for the documentation and description of biodiversity and biogeography. Not surprisingly, several scientists from the Museum für Naturkunde are authors of comprehensive monographs on specific taxonomic groups, including recent works on bugs (Wachmann et al. 2004–2008; Deckert and Göllner-Scheiding 2006), poisonous snakes (Sharma et al. 2013) and sawflies (Koch 2005; Koch et al. 2015a, b). Others are involved in national programmes for marine exploration on research vessels such as the "Sonne" which results in the description of new species from the deep sea (e.g. Logan et al. submitted). Some of this work is linked to long-term national research projects such as BIOTA and maritime research programmes, e.g. with the research vessel "Sonne" in the Indian and Pacific Oceans.

In 2014, the German National Academy of Sciences Leopoldina published a review of taxonomic research in the era of OMICS technologies. This milestone document on the future of taxonomic research in Germany was coauthored by colleagues of the Museum für Naturkunde (C. Häuser, C. Lüter in Nationale Akademie der Wissenschaften Leopoldina 2014, http://www.leopoldina.org/uploads/tx_leopublication/2014_Stellungnahme_Taxonomie_LANG_final.pdf). As part of the recommendations, three areas for future collaborative projects were proposed: the description of all species in Central Europe supported by new high-throughput methods and technologies, an internal revision of the collections and the future development of taxonomy especially with regard to new standards and rules.

Recommendations and results have a direct influence on strategies and priorities of taxonomic research at the Museum für Naturkunde. The development of efficient methodology for recording and analysing biodiversity changes (taxa, ecosystems and timescales) is one of the strategic aims of the museum (https://www.naturkundemuseum.berlin/en/insights/about-us) and is realized, e.g. in the joint project Indonesian biodiversity discovery and information system (INDOBIOSYS, http://www.indobiosys.org/). This project develops and provides core components for a knowledge-based functional screening approach employed to the discovery of new anti-infective compounds from Indonesian organisms. This comprises (1) a novel integrated high-throughput biodiversity discovery pipeline for sampling, identification and provision of target groups from areas with a high level of biodiversity and (2) setting up a digital Indonesian Biodiversity Information System. The combination of primary biodiversity data and relevant metadata supporting an innovative approach towards the discovery of active compounds creates a novel platform that allows a targeted, efficient and sustainable exploitation of biological resources in Indonesia. The approach is accompanied by an internal revision of existing material in the collections, e.g. of the Museum für Naturkunde.

The research on microevolution focuses on gradual evolutionary changes within organisms that can lead to the emergence of new forms over extended periods of time. The research on evolutionary morphology is concerned with the evolution of genetic blueprints and characteristic complexities and builds a bridge between deep time and Recent biodiversity. Various methods are used, including modern imaging procedures and different types of digitization, as well as molecular biological approaches. Collections are playing a key role in many of the research projects in these fields. Outstanding in this context is the Embryological Collection with approximately 600 vertebrate species in more than 3000 alcohol jars and around 80,000 histological preparations of developmental stages of vertebrates and their reproductive organs (cf. Richardson and Narraway 1999). Originating mainly from the historical collections of Ambrosius Arnold Willem Hubrecht (1853–1915) and James Peter Hill (1873–1954), it is the largest and most significant collection of its kind. Recent publications on the basis of this specific collection include Ashwell et al. (2012) and Koyabu et al. (2014).

One of the focal research areas at the Museum für Naturkunde is the evolution of tetrapods and more specific the evolution and development of the vertebrate body plan and the relationship between ontogeny and phylogeny throughout the evolutionary history of tetrapods and patterns of phylogenetic and morphological diversification. In an integrative approach data from both fossil records and extant taxa are combined including fresh material as well as collections objects (Müller et al. 2010; Fröbisch et al. 2015).

In many other cases, collection specimens support the work on specific research questions by providing essential details or missing links. At the same time, collections benefit from the research input and the acquisition of new collection material through expeditions and research work. This is not only true for research fields mainly based on collections like taxonomy, systematics and biogeography but also for evolutionary studies and research on diversity dynamics, covering the entire time frame from deep time to the present situation. In 2014, research at the Museum für Naturkunde resulted in 208 scientific publications, 115 of them in ISI-listed journals (see Annual Report 2014, http://www.naturkundemuseum.berlin/sites/default/files/jahresbericht_mfn_2014.pdf).

10.5.3 Training

The collections also build the ground and are the resource for manifold educational activities, ranging from student courses to training workshops for collection management staff.

Well-trained collection management staff is one of the key elements for the management and development of natural history collections. The Museum für Naturkunde is aware of this and has put a special emphasis on staff training. On the way to a career development plan and life-long learning for collection management staff, a lot has already been realized with the support of national and EU projects as well as institutional funding. With focus on the staff of the Museum für Naturkunde, projects and initiatives have always taken a broader approach, including national and international partners and networks. Major achievements are:

– Regular training courses on relevant issues, e.g. Integrated Pest Management, disaster preparedness, collection techniques, legal aspects (partly funded by EU, Synthesys project, http://www.synthesys.info/)
– Staff exchange with EU partner institutions (funded by Leonardo da Vinci, Daubenton project)
– Development of a competency framework for collection management (funded by Leonardo da Vinci, EUColComp project, http://eucolcomp.myspecies.info/)
– Development of a wiki platform for collection management as tool for collaborative work and knowledge pool (funded by BMBF)

10.5.4 Beyond the Traditional Use

Besides the core research areas such as systematics, phylogeny and evolutionary studies, scientists are also facing new research questions. Many of them are linked to the increasingly demanding societal and environmental challenges, e.g. questions regarding food security, natural resources, emerging diseases, biodiversity loss, etc. With more than 200-year history the zoological collections of the Museum für Naturkunde have already proven in many cases that they can assist in answering these questions, and they have the capability to demonstrate their usefulness in these and many other in the future. However, to do so and to remain relevant for science and society, it is essential that institutions holding collections address these challenges in their research strategies and build new and fruitful partnerships not only within the scientific community but also beyond, with the industry and the general public. This is even more important since the valorization of collections and public engagement with science are becoming more and more driving factors in the world of zoological collections.

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Appendix

1. National and international networks
2. Collection use
3. Collection statistics
4. Standards

1. National and International Networks

The collections of the Museum für Naturkunde are part of a dispersed international scientific infrastructure that is linked by joint initiatives, research projects, exhibitions and of course the shared desire among the institutions' directors and scientists that these collections be maintained, utilized, displayed and augmented. These efforts include national and international projects such as the Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB, http://www.bbib.org/), Synthesys (an integrated European infrastructure for natural history collections, http://www.synthesys.info/), Biota (Biodiversity Monitoring Transect Analysis in Africa, http://www.biota-africa.org/) and EDIT (European distributed Institute of Taxonomy, http://www.e-taxonomy.eu/).

2. Collections Use

The zoological collections of the Museum für Naturkunde are not only used by internal scientists but they also provide a huge international research infrastructure for scientists from all over the world. During the 6-year period from 2009 to 2014, an average of 650 external scientists visited the Museum für Naturkunde annually. In 2014, they spent a total of 2408 days working in the collections. Overall, 1764 collection-related enquiries were recorded in 2014, resulting in 47,921 objects on loan. On average, about 33,000 objects were sent on loan to partner institutions and scientists abroad in each of year between 2009 and 2014, and about 1600 scientific inquiries were answered by the collection staff of the museum.

3. Zoological Collections Statistics

a. Vertebrate Collections

The oldest stock of the Vertebrate collection are several newly identified reptilian specimens bought from Albertus Seba and donated to the museum in 1817 by Graf Friedrich Heinrich von Borcke (1776–1825, Bauer and Günther 2013) followed by more than 800 fish specimens from M. E. Bloch and P.S. Pallas (late eighteenth century). The vertebrate collections have a global geographic scope with some emphasis on Africa (e.g. Peters, Pascha, Hemprich and Ehrenberg, Stuhlmann), Japan (Döderlein, Hilgendorf) and Southeast Asia (Day, v. Bork and v. Martens). Considerable contributions derive from the early expeditions of exploration vessels like the “S.M.S. Gazelle” (1874–1876) or “Valdivia” (Deutsche Tiefsee-Expedition 1898–1899), from the former colonies at the end of the nineteenth and beginning of the twentieth century and from land expeditions (e.g. Hemprich and Ehrenberg, v. Humboldt, Temminck, and Mayr). Recent activities include additions to the herpetological collection by R. Günther (New Guinea) and M. O. Rödel (West and Central Africa). As depicted above, the Embryological Collection is the largest of its kind and is specialized in vertebrate developmental stages and reproductive organs (histology and wet specimens). Primary collections are not only from A.A.W. Hubrecht and J.P. Hill but also from A. Dohrn, L. Bolk and experimental work by Mangold, Spemann, Grüneberg and others.

Collection	Skeletal preparation	Wet specimens	Skins and mounted specimens	Other collection material	Types	Estimated number of individuals
Ichthyological collection	1100	130,640	1750		>1,700	134,000
Herpetological collection	500	118,000	1500		2600	155,000
Bird collection	7000	5000	155,000	40,000 eggs 1500 nests	6000	207,000
Mammal collection		35,000 lots			2210	150,000–180,000
Embryological Collection	0	3000 lots	0	80,000–100,000 histological slides	0	ca. 30,000 databank entries

b. Invertebrate Collections (Without Entomology)

The collections comprise all recent invertebrate groups with the exception of insects. Some 6.2 million specimens are systematically arranged and allow for efficient retrieval and curation. The majority of the specimens are preserved in ethanol complemented by dry and microscope slide collections. Most taxa are covered worldwide with rich material from the expeditions of the nineteenth and early twentieth century and from colonial origin. Zoologists such as Kükenthal, von Martens, Döderlein, Arndt, Ehrenberg, Haeckel, Philippi, Dunker, Rudolphi, Blumenbach, Esper, Plate and even Darwin deposited at least part of their material in the Berlin collection. Many of the current marine expeditions by research vessels such as the "Polarstern", the "Meteor" or the "Sonne" are accompanied by the curators of these collections who thus or in other field work contribute to the growth of the collections.

Collection	Taxa	Curatorial units	Types	Estimated number of individuals
Vermes	Platyhelminthes, Nemathelminthes, Nemertini, Sipuncula, Echiuroidea, Chaetognatha, Pogonophora, Annelida	41,159	2150	100,000
Crustaceans	Crustacea	36,500	800	500,000
Chelicerates/ Myriapods/ Onychophorans	Chelicerata, Myriapoda, Onychophora	52,300	5098	250,000
Molluscs	Mollusca	110,000	9000	7,000,000
Marine Invertebrates	Porifera, Cnidaria, Ctenophora, Phoronida, Brachiopoda, Bryozoa, Echinodermata, Pterobranchia, Enteropneusta, Tunicata, Acrania	130,000	3000	350,000

c. Entomology

The insect collections are estimated to count around 15 million predominantly pinned specimens. They have a global geographic coverage with an emphasis in the western Palearctic, Central Asia and the former German colonies and cover approximately 10–30 % of the known insect species. Apart from vast collections of pinned material and a smaller portion of wet specimens, there are several tens of thousands of microscope slides. The oldest specimens date back from at least 1775 and have been part of collections by A. von Humboldt, Pallas, Herbst, Illiger, Gravenhorst, Hellwig, v. Hoffmansegg, Fabricius, Panzer and other eminent entomologists of that time. However, the major part of the collections originates from the nineteenth and early twentieth century and due to collection activities by the curators, they are growing. The insect collections hold an enormous number of type specimens, particularly from the nineteenth century.

Collection	Prepared specimens	Types
Lepidoptera	4,000,000	10,700
Coleoptera	6,000,000	100,000
Hemimetabola	680,000	8800
Hymenoptera	2,227,880	11,700
Diptera and Siphonaptera	1,300,000	21,000
Neuropterida, Orthopteroidea, Sphecidae	350,000	9200
Unprepared material	1,000,000	
Entomology total	15,500,000	161,400

4. Standards

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