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Short Communication

NATURAL HISTORY MUSEUMS IN THE UNITED STATES AND CANADA: A REVIEW OF THEIR SCIENTIFIC COLLECTIONS, RESEARCH, EDUCATIONAL, AND CONSERVATION SIGNIFICANCE

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ABSTRACT

Globally, Natural history museums are major scientific, educational, and cultural institutions that document the diversity, evolution, geology, and environmental history of the Earth. Their collections of plants, animals, fossils, minerals, rocks, meteorites, and associated cultural materials provide irreplaceable evidence for understanding biodiversity and environmental change through time. The United States of America and Canada possess some of the world's most prominent natural history museums, including the Smithsonian National Museum of Natural History, American Museum of Natural History, Field Museum of Natural History, California Academy of Sciences, Houston Museum of Natural Science, Royal Ontario Museum, and Canadian Museum of Nature. This review examines the historical development, major collections, scientific research, public education, digitization, and conservation roles of these institutions. Attention is given to the Smithsonian National Museum of Natural History and American Museum of Natural History because of their exceptional international significance and large research collections, while the Field Museum of Natural History, California Academy of Sciences, and Houston Museum of Natural Science represent important regional and multidisciplinary institutions in the United States. In Canada, the Royal Ontario Museum and Canadian Museum of Nature are highlighted for their extensive natural history collections, research programs, and public engagement. Collectively, these museums function as repositories of biological and geological information, centres for taxonomic and evolutionary research, platforms for environmental education, and increasingly important resources for biodiversity conservation and climate-change research. Their future scientific value will depend substantially on continued specimen preservation, digitization, international collaboration, ethical collecting, Indigenous engagement, and integration of museum collections with modern molecular and ecological research.

Keywords: Biodiversity, natural history collections, fossils, taxonomy, museums, research.

INTRODUCTION

Natural history museums have long served as vital institutional bridges between scientific discovery and public understanding. The first university museum opened in Basel in 1671, followed closely by the Ashmolean Museum in Oxford, which was established as the first public natural history museum in 1683 (Barrett and McManus, 2007).

Today, as global ecosystems face unprecedented ecological crises, natural history museums find themselves tasked with a new mandate: transforming historical collections into active tools for modern environmental advocacy and conservation literacy.

Worldwide more than 1,000 natural history museums and herbaria are estimated to exist, collectively preserving an enormous archive of biological, geological, paleontological, and anthropological specimens. A global survey of 73 of the world's largest natural history museums and herbaria in 28 countries documented more than 1.1 billion objects, demonstrating the extraordinary scientific value of these collections (Johnson *et al*., 2023).

Natural history museums occupy a distinctive position at the intersection of science, education, conservation, and public culture. Unlike museums devoted primarily to art or social history, natural history museums maintain physical evidence of the natural world, including preserved plants and animals, fossils, minerals, rocks, meteorites, anatomical materials, tissues, DNA samples, and other scientific specimens. These collections provide chronological and geographic records against which changes in biodiversity, species distributions, morphology, genetics, climate, and ecosystems can be investigated (Suarez and Tsutsui, 2004; Meineke *et al*., 2018).

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The scientific importance of natural history collections extends far beyond their exhibition value. A specimen collected decades or centuries ago can provide information about species occurrence, phenology, morphology, environmental contamination, disease, and genetic variation. Recent modern analytical techniques have further increased the value of historical specimens because preserved tissues and other materials can sometimes be examined using molecular, isotopic, genomic, and chemical methods. Consequently, natural history museums increasingly serve as long-term biological observatories and repositories of environmental information (Lister *et al*., 2011; Meineke *et al*., 2018).

The United States of America and Canada contain several internationally recognized natural history institutions. Among the most prominent are the Smithsonian National Museum of Natural History (NMNH) in Washington, D.C.; American Museum of Natural History (AMNH) in New York; Field Museum of Natural History in Chicago; California Academy of Sciences in San Francisco; Houston Museum of Natural Science in Houston; Royal Ontario Museum (ROM) in Toronto; and Canadian Museum of Nature (CMN) in Ottawa and Gatineau. These institutions differ in history, collection emphasis, architecture, research organization, and educational programs, but they share the fundamental objectives of documenting nature, advancing scientific knowledge, and communicating science to society.

The Smithsonian National Museum of Natural History is particularly significant because it maintains more than 148 million specimens and cultural objects and has scientific departments covering Anthropology, Botany, Entomology, Invertebrate and Vertebrate Zoology, Mineral Sciences, and Paleobiology (Smithsonian Institution, 2025). The museum describes its collections as the largest natural history collection in the world. Its research addresses biodiversity, climate change, molecular systematics, ecosystem processes, human evolution, and other major scientific questions (Smithsonian Institution, 2025).

The American Museum of Natural History in New York is another internationally prominent institution. Established in 1869, it combines extensive scientific collections and research with large-scale public exhibitions, scientific education programs, and planetary science facilities. Its exhibits on dinosaurs, mammals, biodiversity, human origins, Earth science, and astronomy have made it one of the best-known natural history museums in North America (American Museum of Natural History, 2025).

Natural history museums also play an important role in communicating environmental issues. Biodiversity loss, habitat degradation, climate change, invasive species, pollution, and wildlife exploitation are increasingly important global concerns. Museum collections provide historical baselines against which contemporary environmental conditions can be evaluated, while exhibitions and educational programs can translate scientific knowledge into accessible information for students, teachers, policymakers, and the public (Suarez and Tsutsui, 2004; Meineke *et al*., 2018). The present review therefore examines selected major natural history museums of the USA and Canada, emphasizing their historical development, collections, scientific research, education, digitization, and conservation significance.

DISCUSSION

Smithsonian National Museum of Natural History, Washington, D.C

The Smithsonian National Museum of Natural History, USA is one of the world's most important natural history institutions. The museum opened in its present National Mall building in 1910 and is administered by the Smithsonian Institution. Its mission is to increase knowledge and inspire learning about nature and culture through research, collections, exhibitions, and education (Smithsonian Institution, 2025).

The scale of its collections is exceptional. The museum currently reports more than 148 million specimens and artifacts, covering the geological history of Earth, biological diversity, human evolution, and cultural heritage. Its scientific organization includes departments of Anthropology, Botany, Entomology, Invertebrate and Vertebrate Zoology, Mineral Sciences, and Paleobiology (Smithsonian Institution, 2025). In 2024, its scientific staff produced hundreds of scholarly publications and reported the discovery of numerous new species, illustrating the continuing research value of museum collections.

The museum's public exhibitions include the National Fossil Hall, Hall of Human Origins, Ocean Hall, mammal galleries, and mineral and gemstone displays. Its fossil exhibitions provide an extensive interpretation of evolution and geological time, while its biological collections support research on biodiversity and systematics.

The Smithsonian's educational role is also substantial. Academic programs provide students with direct opportunities to examine specimens and interact with scientists. The museum also provides digital resources and virtual experiences that extend access beyond Washington, D.C (Smithsonian Institution, 2025). Thus, the institution represents an integrated model in which collections, research, exhibitions, and education reinforce one another.

Based on the reported number of specimens and objects in their collections, the Smithsonian National Museum of Natural History (NMNH), Washington, DC is the world's largest natural history museum, with more than 148 million specimens and objects. While the Natural History

Museum, London, UK, ranks among the largest comparable institutions, with more than 80 million objects. The museum states that its collections constitute the largest and most comprehensive natural-history collection in the world. Its collections include more than 34 million insects and arachnids, more than 29 million zoological specimens, about 6 million botanical specimens, and more than 7 million fossils (Natural History Museum, 2025).

American Museum of Natural History, New York

The American Museum of Natural History (AMNH) is one of the best-known natural history museums in North America. Established in 1869, it has developed into a major scientific and educational institution encompassing Anthropology, Biodiversity, Evolutionary Biology, Paleontology, Geology, Zoology, Astronomy, and Earth Sciences.

The museum is particularly famous for its Dinosaur and fossil exhibitions, mammal dioramas, biodiversity displays, and Hayden Planetarium. Its exhibitions communicate complex scientific concepts through specimens, reconstructions, dioramas, interactive displays, and digital technologies. The museum's public profile is reinforced by its location in Manhattan and its extensive education and visitor programs (AMNH, 2025).

The scientific importance of the American Museum of Natural History is equally significant. Its research collections support taxonomic, evolutionary, ecological, anthropological, and paleontological studies. Collections-based research allows scientists to investigate changes in species distributions and morphology and to compare historical specimens with modern populations.

The museum also contributes to public understanding of evolutionary biology and environmental science. Its exhibitions demonstrate relationships between organisms and their environments and provide accessible explanations of evolutionary processes, geological history, and planetary science.

Field Museum of Natural History, Chicago

The Field Museum of Natural History (FMNH) in Chicago developed from collections associated with the World's Columbian Exposition and was established in 1894. Its present building opened to the public in 1921. The institution has subsequently developed into a major centre of natural history and anthropology.

The FMNH maintains nearly 40 million specimens and objects, including material from Botany and Mycology, Zoology, Geology, Anthropology, and related disciplines (Field Museum, 2025). More than 99% of these collections are maintained behind the scenes rather than displayed in public galleries, demonstrating the difference between the visible museum and the much larger scientific infrastructure supporting research. The collections include fossils, minerals, plants, insects, mammals, birds, and cultural materials. The museum's research program includes biodiversity discovery, taxonomy, evolutionary biology, conservation, ecology, and environmental research. The FMNH scientists conduct research in many parts of the world, while collections provide reference material for studies of species and ecosystems.

An important contemporary development is the digitization of museum collections. Digitization allows researchers and the public to access specimen records without physically visiting collection facilities. Community scientists have also contributed to digitization projects, illustrating how museums can involve the public directly in scientific documentation (Field Museum, 2024). The Field Museum therefore demonstrates the continuing transformation of natural history museums from traditional exhibition institutions into global research and data centres.

California Academy of Sciences, San Francisco

The California Academy of Sciences (CAS), established in 1853, is a distinctive multidisciplinary scientific institution in San Francisco. Its public museum opened in 1874, while its current facility in Golden Gate Park opened in 2008. Unlike conventional natural history museums, CAS integrates a natural history museum, aquarium, planetarium, scientific research facilities, and living collections within a single institution.

Its scientific significance is closely associated with biodiversity research. The institution maintains research collections that support studies of botany, zoology, entomology, geology, and related fields. Its location in California and its extensive research activities provide opportunities to investigate biodiversity across terrestrial and marine ecosystems. The Academy's combination of museum displays and living biological systems provides an effective platform for environmental education. Aquarium exhibits can demonstrate marine ecosystems directly, while natural history displays place contemporary biodiversity within an evolutionary and geological context. This integrated approach is particularly relevant to contemporary conservation science because it links specimen-based research with living organisms, ecosystem interpretation, and public environmental awareness.

Houston Museum of Natural Science, Houston

The Houston Museum of Natural Science (HMNS) established in 1909 (current name adopted: 1960) is one of the major natural science museums in the United States of America and an important educational institution in Texas. Its programs encompass paleontology, geology, astronomy, zoology, anthropology, and other natural sciences.

The museum is particularly recognized for Dinosaur and fossil exhibitions, mineral and gemstone collections,

wildlife displays, and astronomy-related programs. Its exhibits introduce visitors to geological time, biological evolution, Earth systems, and human interaction with the natural environment. The institution demonstrates the importance of regional natural history museums in communicating science to large urban populations. Although its collection scale differs from that of the Smithsonian and AMNH, its educational reach and multidisciplinary exhibitions contribute significantly to public scientific literacy.

Royal Ontario Museum, Toronto, Canada

The Royal Ontario Museum (ROM) established in 1914 is Canada's largest and most comprehensive museum, combining natural history, art, and world cultures. The ROM has developed into an internationally recognized research and educational institution (Royal Ontario Museum, 2025).

The museum reports a collection of approximately 18 million artworks, cultural objects, and natural history specimens. Its natural history collections include plants, minerals and gems, rocks and ores, meteorites, insects and arachnids, reptiles and amphibians, fishes, invertebrates, mammals, fungi, birds, and vertebrate fossils (Royal Ontario Museum, 2025).

The scale and taxonomic breadth of the collections make the ROM particularly valuable for biodiversity research. For example, its natural history holdings include more than 10 million insect and arachnid specimens and more than 1.5 million fish specimens. These materials provide reference resources for taxonomy, evolutionary biology, biogeography, ecology, and conservation research.

The ROM also conducts research on species diversity, evolutionary relationships, geographic distributions, and conservation of living organisms. Its paleontological research includes important fossil localities such as the Burgess Shale, while its collections of minerals, meteorites, and rocks support research in Earth and planetary sciences.

An important modern development is the digitization of collections. The ROM's online collections provide access to thousands of objects and specimens, allowing researchers, educators, and members of the public to examine collection information remotely (Royal Ontario Museum, 2025). This expansion of digital access strengthens the museum's role as a global scientific resource.

Canadian Museum of Nature, Ottawa and Gatineau, Canada

The Canadian Museum of Nature (CMN), located in Ottawa and Gatineau, Canada, traces its institutional origins to 1856 and opened its exhibitions to the public in Ottawa in 1912. The institution adopted its present name, the Canadian Museum of Nature, in 1988 (Canadian Museum of Nature, 2024 [Accessed Sept 20, 2025]). As Canada's national museum of natural sciences, CMN maintains the country's national natural history collections and operates a major research and collections campus in Gatineau, Quebec (Government of Canada, 2025).

The museum's collections encompass animals, plants, fossils, minerals, rocks, and other components of Canada's natural heritage. Its research activities are particularly important for Canadian biodiversity, Arctic science, taxonomy, species discovery, and conservation. The museum has reported a national natural history collection containing more than 14.6 million natural history specimens, including extensive holdings representing Canada's biological and geological diversity (Canadian Museum of Nature, 2024). Its National Biodiversity Cryobank of Canada is particularly significant because frozen tissues and biological samples can provide material for genomic research.

The Canadian Museum of Nature has a strong emphasis on Canada's Arctic environments. Arctic collections are important because the region is experiencing rapid environmental change associated with climate warming. Historical specimens can provide baseline information against which contemporary ecological changes can be assessed.

The museum also plays an important national educational role through exhibitions, public programs, travelling exhibitions, digital resources, and scientific communication. Its position as Canada's national natural history museum gives it a special responsibility for documenting and interpreting the country's biodiversity and geological heritage.

Scientific Importance of Natural History Museums

The major museums reviewed here differ in size and specialization, but several common characteristics are evident (Table 1). The Smithsonian and American Museum of Natural History are especially important for their international research scope and enormous collections. The Field Museum has exceptional strength in collections-based biodiversity and anthropological research. The California Academy of Sciences is notable for combining natural history collections with aquarium and planetarium facilities. The Houston Museum of Natural Science emphasizes public science education and multidisciplinary exhibitions.

Table 1. Selected major natural history museums in the United States of America and Canada and their principal scientific characteristics.

Museum	Location	Major scientific strengths	Approximate collection scale / characteristic
Smithsonian National Museum of Natural History	Washington, D.C., USA	Zoology, botany, entomology, paleobiology, mineral sciences, anthropology	>148 million specimens and artifacts
American Museum of Natural History	New York, USA	Zoology, paleontology, anthropology, biodiversity, Earth and space sciences	Major international research collections
Field Museum of Natural History	Chicago, USA	Zoology, botany, geology, anthropology, conservation	Nearly 40 million specimens and objects
California Academy of Sciences	San Francisco, USA	Biodiversity, zoology, botany, marine science, aquarium science	Integrated museum, aquarium and planetarium
Houston Museum of Natural Science	Houston, USA	Paleontology, geology, astronomy, zoology, anthropology	Major multidisciplinary public science museum
Royal Ontario Museum	Toronto, Canada	Zoology, botany, paleontology, geology, mineralogy	18 million total artworks, cultural objects and natural history specimens
Canadian Museum of Nature	Ottawa/Gatineau, Canada	Biodiversity, Arctic science, botany, zoology, geology, paleontology	>14.6 million natural history specimens

Sources: Smithsonian Institution (2025); American Museum of Natural History (2026); Field Museum (2025); Royal Ontario Museum (2025); Canadian Museum of Nature (2024).

In Canada, the Royal Ontario Museum combines natural history with art and cultural collections, while the Canadian Museum of Nature has a distinctive national mandate focused on Canada's natural sciences.

Natural History Museums Collections as Scientific Archives

A central conclusion emerging from this review is that the scientific importance of natural history museums resides primarily in their collections rather than solely in their public galleries. A specimen represents a physical record of a particular organism or geological material at a specific location and time.

For biodiversity scientists, these records can reveal historical distributions of species. Comparison of historical and modern specimens can help identify range contractions, expansions, local extirpations, morphological changes, and responses to environmental change. Such information is particularly valuable when long-term ecological monitoring data are unavailable (Suarez and Tsutsui, 2004).

Museum collections can also support disease research. Preserved specimens may contain evidence of pathogens, parasites, contaminants, or physiological changes. Similarly, historical tissues can sometimes provide genetic information that helps scientists reconstruct changes in populations.

The importance of such collections is increasing as biodiversity loss accelerates. Species may disappear from local environments before their biology is adequately documented. Natural history museums therefore provide a permanent scientific archive of biodiversity.

Digitization and Open Scientific Access

Digitization is transforming the accessibility and scientific usefulness of natural history collections. Digital photographs, specimen databases, georeferenced records, taxonomic information, and tissue databases allow researchers to investigate collections without travelling to museum facilities. The Royal Ontario Museum, for example, has expanded its online collection resources, while the Field Museum has undertaken large-scale digitization projects involving staff and community scientists (Royal Ontario Museum, 2025; Field Museum, 2024).

Digitization also facilitates integration of museum collections with geographic information systems (GIS), biodiversity databases, climate datasets, and molecular research. The future value of natural history museums will therefore depend not only on physical preservation but also on the quality, accessibility, and interoperability of digital collection data.

Conservation of Biodiversity and Natural History Museums

Natural history museums have become increasingly important to conservation biology. Their collections can provide baseline evidence for species distribution and abundance before major environmental changes occurred. This information can be compared with contemporary surveys to identify population declines and changes in geographic range.

Museum scientists also participate directly in biodiversity inventories and conservation projects. Field Museum research, for example, includes documenting species and ecosystems and applying scientific knowledge to conservation (Field Museum, 2025).

Similarly, the Canadian Museum of Nature's collections and research contribute to knowledge of Canada's biodiversity, including Arctic ecosystems. The Smithsonian's research addresses biodiversity, climate change, ecosystem modelling, and conservation (Smithsonian Institution, 2025). Thus, natural history museums should increasingly be viewed as conservation infrastructure rather than simply cultural attractions.

Education and Public Scientific Literacy

Another major function of natural history museums is science education. Their specimens provide visual and physical evidence that can make abstract concepts such as evolution, geological time, extinction, adaptation, and biodiversity understandable to students and general visitors.

Large Dinosaur skeletons, fossil plants, mounted mammals, insect collections, minerals, meteorites, and marine specimens provide opportunities for experiential learning. Modern museums increasingly combine these traditional specimens with interactive technologies, digital media, virtual tours, educational laboratories, and online collections.

The educational significance of these institutions is especially important at a time when societies must make informed decisions concerning climate change, biodiversity conservation, sustainable development, pollution, and natural-resource management.

Future Challenges and Opportunities

Despite their importance, natural history museums face several challenges. Maintaining millions of specimens requires substantial financial resources, specialized storage, conservation facilities, trained taxonomists, collection managers, and research infrastructure.

Another challenge is the decline in taxonomic expertise in some biological disciplines. Large collections cannot reach their full scientific potential without specialists capable of identifying and interpreting specimens.

Museums must also address the ethical history of collecting, particularly where specimens and cultural materials were acquired during periods of colonial expansion. Contemporary museums increasingly recognize the importance of consultation, repatriation where appropriate, Indigenous participation, shared authority, and respectful interpretation.

Climate change presents both a research opportunity and a conservation challenge. Historical specimens provide evidence for reconstructing past environments, but museum facilities themselves must be protected against increasing risks from heat, flooding, humidity fluctuations, and extreme weather.

The integration of genomics, artificial intelligence (AI), imaging, machine learning, geographic information systems, and digital databases offers substantial opportunities to expand the scientific value of collections. Future natural history museums will likely function simultaneously as physical repositories, genomic resources, biodiversity data centres, research laboratories, and public science institutions.

CONCLUSION

Natural history museums in the United States of America and Canada represent some of the world's most important repositories of biological, geological, and anthropological knowledge. The Smithsonian National Museum of Natural History, American Museum of Natural History, Field Museum of Natural History, California Academy of Sciences, Houston Museum of Natural Science, Royal Ontario Museum, and Canadian Museum of Nature collectively preserve enormous scientific collections and provide important platforms for research, education, conservation, and public engagement.

The Smithsonian and American Museum of Natural History demonstrate the international scientific importance of large multidisciplinary museums, while the Field Museum illustrates the continuing value of collections-based biodiversity research. The California Academy of Sciences provides an integrated model involving museum collections, living organisms, aquarium science, and planetary science. The Houston Museum of Natural Science demonstrates the importance of large regional institutions in public scientific education. In Canada, the Royal Ontario Museum represents a major multidisciplinary institution with extensive zoological, botanical, geological, and paleontological collections, whereas the Canadian Museum of Nature has a distinctive national responsibility for documenting Canada's natural heritage.

The scientific value of these museums extends far beyond their exhibitions. Their specimens constitute irreplaceable records of biodiversity and environmental history. Increasing digitization is making these collections more accessible to researchers and the public, while molecular and genomic technologies are creating new possibilities for studying historical specimens. At the same time, museum collections can provide critical baseline information for understanding species declines, climate change, habitat transformation, and other environmental pressures.

For these reasons, natural history museums should be recognized as essential components of modern biodiversity science and conservation infrastructure. Continued investment in collection preservation, digitization, taxonomic expertise, ethical collecting, Indigenous collaboration, interdisciplinary research, and public education will ensure that these institutions continue to contribute to scientific knowledge and environmental stewardship for future generations.

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