

AAM's 19th Annual Excellence in Exhibition Competition

1. Entry Form

San Diego Natural History Museum

Museum Name

P.O. Box 121390

Address

San Diego, CA 92112-1390

City/State/Zip

619-255-0174 / nrenner@sdnhm.org

Phone/Email

Nancy Owens Renner, exhibit developer

Contact Person

Fossil Mysteries / Misterios fósiles

Exhibition Title

Date exhibition opened to the public: July 1, 2006

Date exhibition closed or will close: tbd

Institution's operating budget for the most recently completed fiscal year: \$10,783,894

Type of exhibition: Permanent

Is your institution a 501c-3? ___yes___

Are you a member of AAM? ___yes_____

Fossil Mysteries was developed by the San Diego Natural History Museum. Major funding provided by the California Cultural and Historic Endowment; National Science Foundation; Stephen and Mary Birch Foundation; an anonymous donor; and generous support from the J. W. Sefton Foundation; the San Diego Foundation: Weingart-Price Fund and Carol and Henry F. Hunte Fund; San Diego County Supervisors Pam Slater-Price, Ron Roberts and Greg Cox; The Legler Benbough Foundation; The Parker Foundation: Gerald and Inez Grant Parker; Thomas C. Ackerman Foundation; Charmaine and Maurice Kaplan; Carol and Dennis Wilson; Rice Family Foundation; Samuel and Katherine French Fund; Ellen Browning Scripps Foundation; and Sony Electronics Inc.

2. Institutional Profile

Our community holds the San Diego Natural History Museum in high esteem.

The San Diego Natural History Museum (SDNHM), established in 1874, is one of California's oldest and most respected cultural institutions.

Our mission:

- To interpret the natural world through research, education, and exhibits;
- To promote understanding of the evolution and diversity of southern California and the peninsula of Baja California; and
- To inspire in all people respect for the environment.

We strive to make our programs relevant and accessible to all members of our diverse Southern California community. The Museum, a 501(c)(3) non-profit corporation, is visited by more than 250,000 residents and tourists annually and serves an additional 100,000 children and adults each year through public education and community outreach programs.

SDNHM makes plans and takes action strategically.

The Museum's first ten-year strategic plan, developed in 1992, resulted in \$48 million dollars of support for the Museum and produced the following major achievements:

- A **major capital campaign** that added 90,000 square feet of new space and renovated 60,000 square feet of existing space in the Museum's Balboa Park facility.
- Creation of the **Biodiversity Research Center of the Californias (BRCC)**. The BRCC engages in collaborative research on the evolution and diversity of our binational region.
- Creation of the **Environmental Science Education Center (ESEC)**. With expanded programming for K-12 students and adults, ESEC's robust program provides classes for students and teachers, both in-house and through outreach, lectures, field trips, travel opportunities, and environmental science training for teachers in Baja California, Mexico. Special funds support access for underserved communities.
- Creation of a **Master Plan for Future Permanent Exhibitions** focused on regional natural history. The master plan defines the goals, content, and visitor experience for four primary galleries: *Fossil Mysteries* (9,000 sq.ft.completed), *Habitat Journey* (10,000 sq. ft.), regional biodiversity and research exhibits (3,000 sq. ft.), and a family-oriented discovery room (3,500 sq. ft.). All permanent exhibitions present bilingual information. An ambitious plan for two to three temporary exhibitions per year will elevate the profile of the Museum in the region and the nation.
- **Future Initiatives:** We developed our current 2002-2012 strategic plan with the input from over 200 community members. This plan is serving as a roadmap to guide the Museum's scientific research, exhibition, and education operations through 2012.

SDNHM occupies a wonderful building on the museum campus of Balboa Park.

Public access to the 150,000-square-foot facility includes viewing exhibitions on five floors of the building; theater films, lectures and discussions held in our 300-seat theater; education

classes in the Museum's four classrooms; opening reception parties and special events throughout the year.

Museum employees share the Museum's mission.

The Museum has 75 dedicated full-time employees and 76 part-time employees who staff the building 363 days a year. More than 760 volunteers support the Museum. They contributed 71,939 hours last year, the equivalent of 34+ full-time employees.

3. Narrative

***Fossil Mysteries* employs best practices to create an excellent exhibition and meaningful visitor experiences.**

While planning *Fossil Mysteries*, the SDNHM team studied and applied various models of exhibition excellence. AAM's *Standards for Museum Exhibitions and Indicators of Excellence*, Beverly Serrell's *Judging Excellence in Exhibition*, and Deborah Perry's *Designing Exhibits that Motivate* provided guidance and support through the process. In addition, core team members traveled to museums across the country to admire and critique exhibitions in various disciplines. We interviewed colleagues at these institutions, finding inspiration and advice. Ultimately, *Fossil Mysteries* represents a model of integration. At every level, from the big picture to the details, *Fossil Mysteries* integrates specimens, images, sculpture, environments, and ideas in coherent contexts. Attention to visitors' personal and social needs permeate the interpretation and design. A fresh, inquisitive, passionate perspective nurtures visitors' curiosity, integrating visitor action and intrinsic reward.

Learning is the central goal of *Fossil Mysteries*.

Our planning team defines learning broadly to include cognitive, sensory, and affective learning. Below we'll elaborate on our philosophy and strategies to catalyze learning in the Museum. In addition to a focus on visitor learning, we also embraced our own learning as a team, documenting our questions and outlining our thought processes along the way. Based on summative interviews with team members, our evaluation consultant compiled a report of lessons learned. We share some documents (or excerpts) that represent this rigorous process here, as they reveal our collaboration and learning, as well as the content and form of the exhibition. A brief exhibition overview, which captures the spirit of *Fossil Mysteries*, follows.

Exhibition Content, Interpretation, and Visitor Focus

Fossil Mysteries

Solve them if you can!

Fossil Mysteries, a highly interactive exhibition, explores big themes in science: evolution, extinction, ecology, and Earth processes. Abundant fossils, models, murals, and dioramas offer unique multi-sensory experiences. You'll see the world—past and present—in a whole new way.

Look at and touch real fossils and rocks—the clues to solve countless mysteries.

Explore our region's changing history over the past 75 million years—from dinosaur times to the Ice Ages.

Assemble a story about a dinosaur's life, death, burial, and discovery.

Examine and identify microfossils.

Move like an animal or build an animal!

Make the Earth change shape by moving interactive models.

Imagine prehistoric plants and animals that lived in southern California and Baja California.

Find survivors from the past.

Ponder mysteries such as:

Where are the dinosaurs in our region?

How did mass extinction reset the world stage?

How did our region take shape?

How did prehistoric animals evolve?

How did they live, move, and interact?

What did they eat?

Why did some animals become extinct?

How do fossils relate to our lives today?

***Fossil Mysteries* models object-based inquiry and the scientific process.**

Science is a process of asking questions and seeking answers through experience. Questions underlie our fossil mysteries and present an inherent challenge—can *you* solve the mystery? What information is needed? Rocks and fossils hold abundant information; you only need to decode that information.

While questions, investigation, and inquiry form the conceptual frame for *Fossil Mysteries*, object literacy—learning to look—and critical thinking flesh out the experience. Based on observed behavior and exit interviews, visitors to *Fossil Mysteries* do look closely at the fossils. They ask questions aloud, share observations, and draw conclusions.

The exhibition demonstrates how scientists use physical evidence to explore questions. Hence the Museum's collection of rock and fossil specimens form the heart of *Fossil Mysteries*. These specimens, unique to our Museum and our region, provide the keys to discovering Earth's history. The exhibition doesn't just tell visitors the significance of these specimens. Instead, visitors are guided to see and discover important features for themselves. By looking at specimens (sometimes through magnifying glasses and view rings), and interpretive graphics, models, video, and animations, visitors learn how to see. And the displays empower them to learn from looking.

The rocks and fossils might seem immutable, but over time we may learn to see better what they hold. So the exhibition shows how, as more evidence becomes available, our ideas about the history of Earth and life may change. On the other hand, some mysteries may never be solved, until more evidence and information comes to light.

Questions invite visitors to explore and solve mysteries. Exhibits challenge, encourage, and support visitors with intellectual scaffolding to answer questions—large and small—and apply their own critical thinking skills. Various displays offer opportunities to do what scientists do: piece together the history of one particular fossil and imagine how the animal died and was preserved, examine microfossils and determine their identity, compare fossil plants with modern plants to deduce ancient climate conditions, figure out how a prehistoric animal moved or what it ate based on its bones.

Some exhibit planners believe exhibits should only pose questions that mirror visitors' questions. Our team agrees that visitors' questions should be honored, but we decided to expand our exhibit questions based on research in inquiry education. By asking interesting questions, the exhibits model the kinds of questions that can be asked and explored through looking. Visitors might not think of some of these questions on their own, but the questions provoke thought, stimulate curiosity, and open up a world of inquiry within our reach.

***Fossil Mysteries* tells stories to reveal a regional history of dramatic change.**

Inquiry defines the spirit of *Fossil Mysteries*, and storytelling forms the body. The backbone of the exhibition is chronological, running from 75 million years ago in the late Cretaceous Period up to 10,000 years ago, the end of the Ice Ages or Pleistocene Epoch. Our region of interpretation, southern California and Baja California, holds a wealth of fossils from this period in Earth history. *Fossil Mysteries* tells a story of change over time, focused on our region with connections to global events.

Each gallery represents a snapshot of a different time period. Since visitors choose their own path through this exhibition, each gallery, or elements within, can be read to great effect separately. And taken together, they reinforce messages and resonate with deeper meaning, yielding a rich and interesting picture of one place through time.

Each gallery represents both a moment in time in our region and a major theme. Our team chose themes which our fossils illustrate best. Overarching questions, or mysteries based in time, relate to the themes and play off the fossils.

TIME	THEME	MYSTERY (not exhibit text)
Cretaceous Period 144-65 million years ago	Earth Processes: How fossils form	Where are the dinosaurs in our region?
Cretaceous-Tertiary (K-T) Boundary 65 million years ago	Extinction	How did mass extinction reset the world stage?
Eocene Epoch 55-34 million years ago	Evolution	How did these animals evolve?
Oligocene Epoch 34-24 million years ago	Evolution	How does form relate to function?
Miocene Epoch 24-5 million years ago	Earth Processes: Plate Tectonics	How did our region take shape?
Pliocene Epoch 5-1.8 million years ago	(Paleo)Ecology	Fossils from a prehistoric San Diego Bay— how do they fit together?
Pleistocene Epoch 1.8 million-10,000 years ago	Extinction	Ice Age animals—where did they go? And why? How does it relate to today?

In keeping with good storytelling technique, each gallery has an ensemble of interesting characters. The animal sculptures and fossils act as icons within the space and anchor the exhibition in time. We strove to satisfy our visitors' agenda up front by delivering dinosaurs at the south entrance. Fortunately, we have dinosaurs in our regional fossil record! We begin with dinosaurs, pterosaurs, and mosasaurs and proceed to brontotheres, crocodiles, tree-climbing primates, and other exotic-looking mammals. A giant shark, walrus, whales, and huge sea cows inhabit an underwater habitat. Finally, mastodons, a saber-toothed cat and ground sloth (among others) occupy the Ice Ages. Throughout the exhibition, familiar faces greet visitors and invite them to explore the unfamiliar.

Fossil Mysteries tells stories within stories. For example, when you arrive at the Ice Ages and face the mystery "Where have all the mammoths gone?" you are confronted with the theme of extinction. Each display within the gallery tells an extinction story focused on a particular animal or set of animals, revealing relationships and larger processes of cause and effect.

Integrated elements communicate concrete details, big ideas, and new perspectives.

Fossil Mysteries teaches visitors how to interpret the detailed features of fossils, draw conclusions, and assemble bigger pictures related to important themes such as evolution, extinction, ecology, and Earth processes. In a sense, visitors can see inside the minds of paleontologists, who draw on vast prior knowledge. In *Fossil Mysteries*, visitors physically see what paleontologists see in their minds' eyes. Through specimens, models, images, video, sound, and environments, visitors put together a rich and complex understanding of the past and see how the pieces fit in context. "Entry-level" visitors take away a simple, yet profound message: Life and landscapes change. These specific plants and animals (crocodiles, primates, giant sea

cows, etc.) lived right here in our region in the past. Visitors with more prior knowledge make connections of greater sophistication or subtlety. An emphasis on integration, where many elements align in concept and design, allows visitors to shift focus between parts and wholes, and facilitates a broader understanding of their interconnection. Integrated elements facilitate reinforcing experiences and allow multiple entry points, offering ample opportunities for personalized meaning-making and new perspectives.

***Fossil Mysteries* makes the most of tradition and innovation.**

Despite countless attractions and competition for the public's leisure time, people still visit museums to see and do things they can't see and do anywhere else. Our tradition of displaying authentic and unusual objects continues to draw visitors. And we've learned that object displays alone are not enough to satisfy visitors. Visitors need integrated context to glean meaning from rocks and fossils.

Current best practices in exhibit-making represent the evolution of traditions, both new and old. The *Fossil Mysteries* team embraced the old tradition of displaying well-curated specimens of both scientific and aesthetic value. Every specimen is labeled with information relevant to the novice and the expert, organized in a way that does not overwhelm visitors. Our team also embraced the newer tradition of creating an exhibition with the exhibit-user at top of mind, so visitor studies and evaluation played a critical role to inform our decisions. Visitors' interest, prior knowledge, learning preferences, and desire for bilingual labels shaped the interpretation of the content. Even so, our team did not sacrifice intellectual rigor for accessibility. Profound ideas, new perspectives in science, controversial topics, and cutting-edge scientific research imbue the presentation with a sense of importance, relevance, and immediacy. These are not the same old fossil stories you've seen on the television or in other museums. And yet, *Fossil Mysteries* does not have a know-it-all attitude. We sprinkle the text with interesting unsolved mysteries, acknowledging limits to our knowledge and explaining why these gaps exist. Based on our summative evaluation, visitors read more labels than in other exhibits, they find the labels very interesting, and most say the quantity of information is just right. Spanish readers applaud the quality of the Spanish text. As the intellectual content serves the varied needs of visitors, so does the physical design. Every gallery employs beautiful colors, forms, materials, and sound. Visitors find an ample number of benches, and all elements meet or exceed ADA requirements. We elaborate on design details below.

Fossil Mysteries exemplifies innovation with its extraordinary integration of content, including opportunities to examine objects and ideas at many different scales. Sometimes the integration of content is obvious, other times the interweaving of content holds surprises waiting to be discovered. The Eocene forest immersive diorama represents the greatest (and most expensive) expression of integration. Visitors walk through a 45-million-year-old forest populated by animals hunting, eating, interacting. A laminated field guide card invites visitors to find and identify the various animals and the plants which envelope them. The animals make sounds, some activated by the presence of visitors. Fossil displays communicate that this habitat reconstruction is firmly based on fossil evidence. Some fossils are large, some are quite small, enhanced by magnifying glasses and microscopes. Due to the high degree of integration, visitors immediately understand this space. They spend a lot of time there, deeply engaging physically and socially.

In another gallery, a life-size touchable armored dinosaur sculpture sits in the visitor space. Nearby, the armored dinosaur fossil specimen invites visitors to look for clues to its identity, life,

and death. A small bronze sculpture of the dinosaur sits on the reading rail, allowing visitors to figure out how the incomplete fossil fits with the animal's whole body. To the left, visitors can assemble a four-part story that covers 75 million years, illustrating the dinosaur's life, death, burial, and discovery. In addition, visitors can find the dinosaur living on a landscape with other dinosaurs in a mural on the left. They can also find the dinosaur's bones resting on the seafloor, colonized by clams and oysters in a mural on the right. Docents enjoy pointing out the interconnected layers of visual information to visitors' delight.

We strive for integration of information by providing context for everything. Some examples on a grand scale include three full skeletons with sculpted flesh on one side, showing the relationship between the internal structure and the external appearance of the animal. In other cases, our fossil skeleton is incomplete so we mounted the fossil pieces in a metal armature that defines the shape of the animal's body. On graphic panels, illustrated bones sit upon a silhouette of the body form. In murals, illustrations, and dioramas, we put animals in the context of their environment.

Comparison provides meaningful context in some displays. When looking at a deer's skeleton, superbly adapted to a running lifestyle, visitors can compare a human skeleton and see the similarities and differences in the shape and placement of the bones. In another display, two skulls—one from a meat-eater and one from a plant-eater—sit side by side. Visitors compare the shape and location of their teeth. Visitors also move levers to see and compare how the jaws move. These two skulls then serve as context to compare with a fossil skull. Visitors can solve the mystery: What did this fossil animal eat?

A primary focus of our remediation efforts is to provide greater context where context is lacking. Two mechanical models illustrate the different form and function of a running animal's arm and a climbing animal's arm. The models were simplified abstractions with a textual explanation. Because visitors could not immediately apprehend the visual context, they found the models confusing and did not read the text to seek understanding. In the new version, the models are shaped more like bones and they sit on a drawing of the animal's skeleton in the appropriate place. We will observe visitor behavior to assess the addition of more concrete visual context.

Finally, our team employed innovation in our approach to evaluation. Working with Paul Gabriel, we invited people with learning differences (i.e., learning disabilities) to evaluate *Fossil Mysteries*. We hypothesize that people with attention deficit disorder and/or dyslexia serve as early and reliable indicators for the effectiveness of learning environments which require focused attention and reading. We share more on this subject below in the section about evaluation.

Exhibition Design, Aesthetics and Function

***Fossil Mysteries* represents an artful balance with design for people and collections.**

When designing the physical aspects of *Fossil Mysteries*, we confronted the clashing wants and needs regarding collections and visitors. We need to protect the specimens, yet we want to afford maximal access. We want to show objects in abundance, yet we need space for people and furniture. We want to display a rich variety of specimens, yet we don't want to overwhelm visitors. The first step in mediating any conflict is to recognize the issues.

Our team acknowledged that exhibit design requires creative balancing. We eschewed the *either/or* mentality and embraced the concept of *and*. We learned how to reach consensus, sometimes simply by answering the question "Can I live with it?" Team members with varying

perspectives and values engaged in spirited dialog. We used models, plans, prototypes, and mockups to explore options and examine strengths and weaknesses of different solutions. What may have felt like compromises then, now represent intelligent design solutions, with wants and needs satisfied to the greatest degree possible.

Fossil Mysteries displays specimens from a research collection, so our team agreed on the importance of protecting the specimens. We mounted our fossils and rocks to withstand earthquakes, and most are behind plexiglass cases or glass walls. The fossils are impervious to light damage yet sensitive to humidity fluctuations, so the cases protect the fossils from the elements and from potential damage by visitors. Since we know that visitors learn through touch, numerous touchable objects (real fossils, rocks, casts, models, and sculptures) populate the galleries.

To avoid visual overload, we grouped fossil specimens to provide conceptual organization and to limit the number of discrete chunks. Sometimes the groupings follow a family line: fossil primates occupy one case, carnivores in another. Or they may be organized spatially: a case of marine invertebrates (clams, snails, crabs) align with their habitat association from shallow water to deep. We learned through our summative evaluation that visitors with attention deficit disorder reach short-term memory overload when viewing a few of our fossil display cases. At present, we're reflecting on these results and pondering how we might still edit these displays and break the visual and verbal information into fewer, bigger chunks. Most team members and visitors feel that we've displayed the perfect quantity of fossils, although a few fossil aficionados still want more. We plan to add new fossil discoveries over time.

***Fossil Mysteries* attends to visitors' physical and sensory needs and desires.**

Visitors stay and learn in *Fossil Mysteries* because they find the space comfortable and functional, heightening enjoyment and diminishing fatigue. We've heard numerous anecdotes of parents leaving the exhibition dragging children who don't want to leave. Our designers and fabricators paid attention to human needs, abilities, and limitations designing for comfort and social interaction. They created spaces and elements with beautiful variety, yet continuity.

Each of the seven galleries has a distinct look and feel consistent with its theme and message. For example, the Cretaceous gallery with large dinosaur skeletons, big life-size models, and murals has an expansive feel with blue walls, natural light, and a soaring 20' ceiling. The end-Cretaceous extinction gallery feels more constricted. Images and sculptures representing this major chokepoint in Earth history are reinforced by a lower 12' ceiling, red lights, and eerie sounds like wind through Tibetan sounding bowls. Continue walking and enter the Eocene forest immersive diorama, where the tree of life flowers with wonderful diversity. Spacious, verdant, and richly textured with plants, animals, and sounds, this gallery shows how life survived and evolved, although very different than before the mass extinction. The Oligocene gallery, focused on form and function, features bright warm colors and skeletons with parts that move. Activity fills this space, where visitors can move their own bodies or build animals and imagine their ability to survive. Some fossil mysteries can only be explained by Earth's plate movements, so the Miocene plate tectonics gallery has deep earthy rock-like tones, numerous moveable geologic models and interactives, and touchable rocks. Our Pliocene Bay (which once covered the Museum's location) makes you feel like you're underwater, surrounded by walruses, sea cows, and whales, large murals, and blue and green walls and floor. Once again above sea level, the Pleistocene extinction gallery lends a feeling of nostalgia for wonderful mega-beasts such as mammoths and mastodons, which lived in this very spot.

The color palette throughout uses rich jewel earth tones. In the words of our lead exhibit designer Michael Field, “Like Fiesta ware plates, these rich saturated colors are timeless. They energize the space without irritating anyone.” Curved walls, soffits, and hanging walls define galleries while maintaining an open floor plan. This plan allows social groups to meander, divide, and rejoin without losing each other, fostering a sense of personal choice and control.

Attention to lighting adds to the comfort of the space. A combination of dramatic lighting in places, bright lighting in others, and natural sunlight creates a pleasant ambiance with welcome variety. *Fossil Mysteries* straddles our historic building and our building addition, with some galleries open to the new bright sunlit atrium. To address the lighting imbalance in these two spaces, we maximized the sunlight in the historic building by demolishing a wall which blocked sunlight through beautiful arched windows at the entrance, uncovering an additional window, removing the black drop ceiling, and restoring the historic white, sculpted concrete ceiling. We also applied a neutral-density filter film to the windows to limit glare yet retain optimal color rendering. Increasing the light input also helps eyes to adjust when entering from the bright historic entrance with southern exposure. Renovation of this space included reconfiguring unsightly HVAC ducts, now hidden strategically in soffits, thus reducing visual clutter.

Fossil Mysteries’ space design accommodates visitor flow. Large displays have ample area so visitors can get the full view. Optimally, we put 7-8' distance between displays. At a minimum, we allow 5' between displays, so two strollers can pass each other. Tabletop interactives and reading rails at the appropriate height invite visitors in wheelchairs to pull right up to the display. Rounded edges and corners allow toddlers to bounce around without injury. Padded benches and moveable stools in every gallery accommodate visitors’ need to rest, relax, and reflect.

To make viewing easy and comfortable, we display wall mounts and pedestal cases lower than typical museums. We hang wall displays at 56" on center and pedestal tops are 30" high. This meets the viewing needs of visitors of varying heights, wearing bifocals or not, in wheelchairs or in strollers. All text is sized for readability, with ample contrast between text and background. We established a clear pattern for the treatment of bilingual text (English/Spanish), which visitors easily identify. Satin plexiglass reduces glare on wall displays and graphic panels.

***Fossil Mysteries* will stand the test of time with the use of durable materials.**

Metal frames for wall panels and vitrines, and metal rails and posts sport a handsome dark coffee, chocolate powder-coat finish, which wears gracefully, taking on the patina of a paleontologist’s beloved tool. Walnut details, domestic and sustainably harvested, will only improve with oils from the human touch. Forbo laminate—also a “green” material made of linseed oil, cork, and mineral pigments—used on tabletops and floors withstands tremendous foot traffic. Nubbly flecked carpet hides wear and tear while absorbing sound in high-energy areas. And with energy-efficient lighting, accountants paying the bills will thank our designers for years to come.

4. Exhibition Staff

Tom Deméré, Ph.D., curator of paleontology

Tom brought his deep knowledge of regional geology and paleontology to the project and insisted on scientific precision and integrity. He shaped the conceptual framework of the exhibition, emphasizing big themes in the natural sciences and the myriad questions that can be asked of fossils. Tom also supervised the selection and preparation of fossil specimens for display.

Michael Field, lead exhibit designer

Michael designed beautiful, functional, comfortable spaces for visitors to view fossils, interact with exhibits, and learn in social groups. Through a highly iterative process, Michael generated models, floorplans, perspective and elevation drawings, and detailed plans for construction. Michael also selected the color scheme, finish materials, and supervised construction and installation.

Lynett Gillette, content developer

Lynett researched our fossil stories, finding rich content in brand new research as well as historical themes. Lynett's passion and experience infused the project, sometimes challenging the team to make the arcane accessible and interesting. Lynett selected fossils, worked with preparators, fed information to the wide array of artists on the project, developed concepts for graphic panels, and co-wrote exhibit text.

Mick Hager, Ph.D., president

Mick led the complicated fundraising effort to finance the exhibition with funds from the federal government (National Science Foundation), the state of California (California Culture and Humanities Endowment), and private donors.

Jim Melli, exhibit designer and artist

Jim gave physical form to the exhibition's plants, animals, and environments, sometimes reconstructing fossil organisms for the first time in history. Through countless drawings and models, Jim communicated anatomy, posture, color, and design intent to numerous sculptors, painters, and diorama builders. Jim supervised fabrication of animal sculptures and dioramas to ensure scientific accuracy and artistic excellence.

Mary Lou Morreal, art director

Mary Lou designed the graphic elements of the exhibition, including the treatment of bilingual text. She also supervised the immense task of graphic production.

Dolores Monterrubio Alvarez, educator

Dolores advised the team on fundamental theories of learning and bilingual education. Her constructivist approach inspired the development of *Fossil Mysteries*. Dolores also taught classes for museum staff focused on Spanish language and communication strategies.

Tim Murray, director of exhibits

Tim served as project manager, coordinating in-house efforts with various contractors. He kept an eagle eye on the schedule and budget, making sure the project was done on time and on budget. Tim quietly and steadfastly supported the team, encouraging and empowering them to move forward, helping when necessary.

Nancy Owens Renner, exhibit developer

Nancy focused on integrating content and design to create meaningful experiences for a diversity of learners. She fostered collaboration and pushed for clarity in communication, recording team decisions in documents, content outlines, exhibit descriptions, email, and finally exhibit text. Nancy held the role of audience advocate and coordinated exhibit evaluation.

Jim Stone, vice president of public programs

As an administrator, Jim smoothed the way for work to happen. He oversaw contracts and provided documentation to funding agencies to keep the money flowing. Jim trained the team in consensus building, skills which the team had ample opportunity to practice.

Marianna Adams, Ed.D., evaluation consultant—Institute for Learning Innovation

Marianna designed front-end, formative, and summative evaluations to address the team's questions about visitors' interest, knowledge, understanding, and the exhibits' functionality. Marianna encouraged museum staff to participate in visitor studies, thus building capacity within the institution.

Robert Garfinkle, project leader—Science Museum of Minnesota

When the Science Museum of Minnesota joined the *Fossil Mysteries* project, Robert critiqued the exhibit plan, urging team members to clearly articulate learning intent, behavioral expectations, and means of execution. Other project leaders gracefully stepped in later, guiding as the project required.

Ken Kornack, project production manager—Science Museum of Minnesota

During planning, Ken played the critical role of Mr. Reality-Check. He created a budget and workplan that frightened the team into working with great intensity over the long haul, avoiding the need to work excessive overtime as opening day approached. Ken passed the torch to other capable production managers after making his invaluable contribution.

5. Exhibition Walkthrough

Please see accompanying PowerPoint presentation.

6. Floor Plan

Please see attachment and pdf document.

7. Exhibition Budget Worksheet

Fossil Mysteries Budget San Diego Natural History Museum

Direct Exhibition Costs

Fabrication and Installation \$4,100,000

(includes construction of all exhibit elements as well as prototypes, media, interactives, painting, photo reproduction, lighting supplies, and similar costs)

Staff expenses \$1,000,000

(includes travel, books, office supplies, etc. -- excludes salaries)

Collections \$1,000,000

(includes conservation, shipping, loans, storage and other related expenses)

Consultants \$1,000,000

(includes fees and expenses related to content experts, designers, evaluators, etc.)

Total Direct Exhibition Costs \$7,100,000

Additional Project Costs

Educational Programs and Materials \$90,000

(includes presenters' honoraria and expenses, printing, curriculum materials, etc.)

Publications \$180,000

(includes print and electronic materials including catalogs, gallery guides, websites)

Marketing \$630,000

(includes advertising, publicity, and related costs)

Total Additional Project Costs \$900,000

GRAND TOTAL

\$8,000,000

(Direct Exhibition Costs + Additional Project Costs)

8. Audience Awareness and Evaluation

Specific questions shaped the evaluation process and helped us know our audience.

Working on *Fossil Mysteries*, we learned how to “think evaluatively,” i.e. to consider our audience, what information we need from them to make progress, how we will use that information, and what is the most efficient way to get that information. Through front-end, formative, and summative evaluation, we have a better understanding of our audience and how our unique offerings can serve their needs. Our current audience is diverse in ethnicity, social background, educational experience, and prior knowledge. We serve students, families with children, and individuals of all ages. Our target audience matches our current audience, except that we are always trying to attract and better serve visitors of ethnic diversity. San Diego County has a high percentage of Latino residents and visitors from Mexico; some speak mostly Spanish and many are bilingual with varying degrees of English expertise. Strategic planning, bilingual interpretation, targeted marketing, and demographic realities have resulted in a higher number of Latino visitors to the Museum. An interest in the natural world unifies our diverse audience. Through our exhibitions, we seek to nurture that interest, to stimulate curiosity, and foster a love of learning about and connecting with nature.

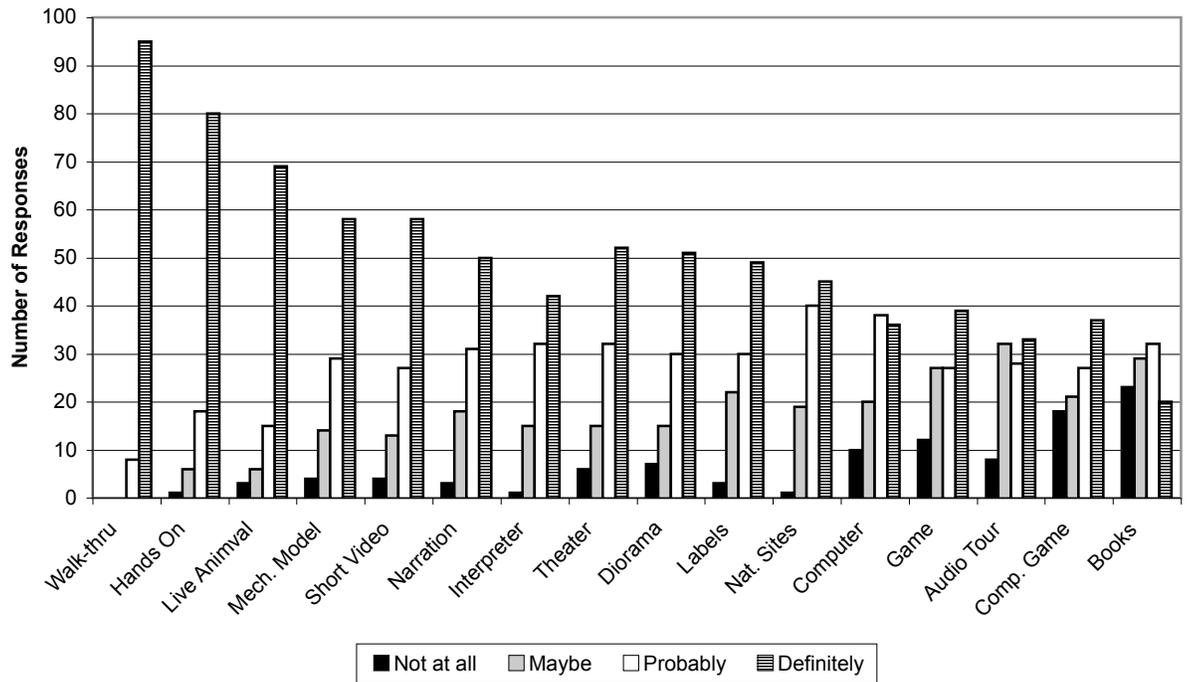
During front-end evaluation, we explored visitors’ motivation for visiting the Museum.

We also inquired about their prior knowledge, interests, and expectations regarding the primary themes of the exhibition. We conducted interviews using an engaging card-sorting technique that enabled visitors to organize their thoughts and provide precise responses. We also queried visitors about their learning preferences, which yielded valuable information and enabled us to allocate resources strategically. For example, based on visitor studies, we decided to complete the design and fabrication of *Fossil Mysteries* first in our strategic plan for new permanent exhibitions. Visitors expressed a yearning for information on our region’s prehistory, content which they couldn’t find anywhere else. In another example, some team members wanted to provide greater depth of information for visitors at computer kiosks. Through various studies, triangulated results confirmed that our visitors don’t want to use computers in the traditional Web-based format to access additional information while at the Museum. Below are excerpts from the final front-end evaluation report, which served as the foundation for our own learning as an institution.

Visitors were asked why they came to the Museum. Their responses, categorized across five dimensions, make clear that visitors hold multiple motivations. They seek education *and* entertainment at our Museum.

EDUCATION Seeking a learning experience, want information (general or specific) or cultural content	41% (41)
PLACE A destination or attraction; To see something specific such as the new building or the <i>Epidemic</i> exhibition	35% (35)
ENTERTAINMENT Seeking fun, an enjoyable thing to do	32% (32)
SOCIAL EVENT An outing with friends and/or family	27% (27)
PRACTICAL In the area, had the time	16% (16)

Preference for Exhibit Formats: “Would you use this in a museum exhibit?”



Preference for Exhibit Formats Weighted Mean

Ranking	Format	Score
1	Walk-through Scenes	3.9
2	Hands-on Demonstrations	3.7
3	Live Animals	3.6
4	Mechanical Model Short Video Listen to Narration Talk with Interpreter	3.3
5	Theater Presentation Diorama Read Labels Get Information About Natural Sites	3.2
6	Get Information from a Computer	3.0
7	Play a Game with Family or Friends Audio Tours	2.9
8	Play a Computer Game	2.8
9	Read Books in Museum for Information	2.3

During formative evaluation, we investigated visitors' response to various titles, big mysteries representing each time period, and ways of expressing time.

We also tested exhibit ideas in the form of drawings, verbal descriptions, and prototypes, enabling us to identify what visitors found compelling, barriers to their understanding, and mechanical problems. We explored the notion of object literacy with elementary school children. In this case, the students chose a fossil on display to write about, responding to various questions as if they were journalists. We also interviewed children while looking at fossils. These studies reaffirmed that visitors look at objects very concretely. Novice learners do not engage in abstract thinking or conceptual encoding with novel objects. The continual challenge to exhibit planners is to begin with the concrete object, not overlook the obvious, and carefully bridge the object with abstract concepts. We constructed a Web-based questionnaire to solicit feedback on our exhibit plan from exhibit planners and content experts. Their invaluable input helped us cull the best aspects of *Fossil Mysteries* and edit out the non-essential.

Below is an excerpt from one of our formative evaluation reports. It clearly expresses our effort to identify the critical questions in order to make progress toward satisfying visitors' needs and interests.

Fossil Mysteries Formative Evaluation Summary Report

September 2003

To inform the development of *Fossil Mysteries*, the San Diego Natural History Museum (SDNHM) worked with the Institute for Learning Innovation and student interns from the University of California, San Diego (UCSD) to evaluate various aspects of the exhibit plan.

Evaluation Agenda

The exhibit team generated an evaluation agenda to address the following questions. Completed studies (listed below) may require ongoing investigation.

- **Title(s)** (DONE)
Does the title entice and communicate? How do people understand the title and advanced organizer?
- **Fossil Mysteries / Questions** (DONE)
Do the questions engage people and inspire curiosity? Which questions need more work?
- **Prior knowledge** (DONE)
What do visitors already know? What preconceptions and misconceptions do they have?
- **Depth** (DONE)
Who wants depth? How much? What is the best way to deliver depth?
- **Bilingual label design** (DONE)
What is the best way to differentiate languages and facilitate communication, limit visual overload, and maintain positive feelings toward the Museum?
- **Prototype** (ONGOING)
Do the exhibits work and communicate as intended?
- **Bilingual text** (ONGOING)
Does the text communicate intended messages? What is the appropriate amount and complexity of information?

Visitor Studies Completed to Date

A workplan emerged based on immediate needs and opportunities, e.g., availability of participants and volunteer data collectors. The following studies were undertaken. A summary of results follows. Detailed reports are on file under *Fossil Mysteries* Evaluation Reports.

- **Title Testing/Region/Time/Framework of Questions**
Interviews (n=52)

- **Pliocene and Eocene: Interest in Content and Activities**
Focus groups with fifth graders (n=40)
Focus group with home-school families (n=6)

- **Bilingual Labels: Amount and Organization of Information**
Group interview with Spanish speakers (n=4)
Written survey with Spanish speakers (n=39)
Interviews with English speakers, three label versions (n=139)

- **Focus Mystery Stations: Preliminary Prototype Testing**
SDNHM staff focus group (n=20)
Kids focus groups (n=24)

- **Prior Knowledge of Exhibit Themes**
Personal Meaning Mapping Interviews (n=126)

Summative evaluation focused on how *Fossil Mysteries* stimulates learning and nurtures curiosity in our visitors.

Focused observations (tracking and timing) and exit interviews explains how and why the exhibition is successful with visitors. In comparison with Beverly Serrell's data in *Paying Attention: Visitors and Museum Exhibitions*, we found that *Fossil Mysteries* visitors spend more time and read many more labels than in most exhibitions. Beyond the numbers, we also measured the quality of visitors' physical and social engagement and found patterns in visitors' behavior. Exhibits designed to encourage social interaction and that are immersive and/or interactive with multiple outcomes elicit the deepest engagement for the greatest number of visitors. Other elements yield deep engagement for fewer visitors, primarily based on visitors' interest in the subject matter. *Fossil Mysteries* successfully provides a menu of options for visitors—there is something for everyone, though not everyone will do everything.

Using a novel approach, the Museum worked with Paul Gabriel to facilitate an evaluation of *Fossil Mysteries* by invited guests with dyslexia and/or attention deficit disorder. This study reinforced our findings in other studies and in the literature: Text should not be used as the exclusive gateway to meaning. Objects and ideas presented in a well-integrated, accessible context offer the greatest opportunities for meaning-making. Exhibits with ready access and complex outcomes engage visitors in the deepest ways. To quote Paul, we have to make the exhibit answer these questions in an intuitive and immediate way: "What is the game? What are the rules? How can I play?"

Diverse visitors respond with great enthusiasm to the overall quality of the exhibition, fascinating content, fun social activities, and beautiful and comfortable environments. The result: tremendous increases in attendance, visitor satisfaction, membership, positive word-of-mouth, and extraordinary media exposure.

The exhibit team continues to work on improving *Fossil Mysteries*. For example, we feel that visitors do not sufficiently use the title-wall advance organizer and time-and-place markers throughout the exhibition. We are rewriting the text and redesigning the graphics. We are also modifying a couple other graphic panels and two mechanical models, which were too abstract and created confusion for some visitors.

Our summative evaluation also included a series of interviews with core team members to investigate our collective lessons learned about the exhibit development process. Below is an excerpt from the final report written by Dr. Marianna Adams of the Institute for Learning Innovation.

The museum practitioners identified a range of points that hampered the exhibition development process. These included the ambiguity of roles and responsibilities and individuals' uncertainty as to the role of other team members, repeated incidents of having to redo designs and fabrications slowing the process, and uncertain funding for several years of the project.

Despite periods of frustration with the project and difficulty in keeping the energy and commitment strong over such a long time, practitioners could articulate ways in which the process benefited the SDNHM. The themes that emerged from this discussion are that the collaborative process resulted in a larger sense of ownership of the exhibition across the museum staff; how the establishment of collaborative ways of working can be drawn upon in the future; and the exhibition itself and the research that took place in order to create it provides a greater level of visibility in the local community, the country, and in academic circles. With benefits come the inevitable drawbacks. Staff identified the prolonged investment of time and energy in the lengthy exhibition development period as the major drawback. The protracted pace of the project led to alternating waves of burnout and the feeling of "being stuck," overcome through immense effort, persistent will, and strong commitment to the museum's mission.

As part of the role-clarifying task, it is clear that the SDNHM must select an on-site project leader with sufficient time to commit to the project, convey authority for creative decision-making along with responsibility to develop the exhibition. It appeared that much valuable time and energy was wasted by not having a consistent project leader.

Another task related to clarity is to agree upon your organizational beliefs regarding visitors and learning in museums. Develop an interpretive plan that articulates your philosophy about learning in museums and provides clear guidelines for such components as printed text, video development, and interactive design.

Although our team did have an interpretive plan, we didn't have the knowledge, experience, or *hutzpah* to assert that the plan was a kind of contract that all team members needed to agree to or amend. Making *Fossil Mysteries* allowed us to develop the skills to advocate, negotiate, think divergently, and build consensus. In the six months since *Fossil Mysteries* opened, we have been planning two major exhibition projects with great efficiency and creativity, drawing from our hard-won experience.

Perhaps the greatest achievement of the *Fossil Mysteries* evaluation program is that it transformed our museum culture regarding evaluation. Based on some past negative experiences with consultants providing marginally useful and expensive evaluations, upper-level museum staff regarded visitor studies with suspicion. Visitor studies were considered an obligation, a requirement by funders. Thanks to the participatory approach of Marianna Adams and Paul

Gabriel, a concerted effort to involve and inform museum staff and board, and applicable and meaningful results, museum staff now embrace evaluation as a valuable and necessary part of the exhibit development process ensuring wise allocation of time and resources.

9. Educational Approach

***Fossil Mysteries* aligns directly with our Museum's mission.**

Our mission—to interpret the natural world through research, education, and exhibits; to promote understanding of the evolution and diversity of southern California and the peninsula of Baja California; and to inspire in all people respect for the environment—defines every aspect of *Fossil Mysteries*. In the deepest sense, *Fossil Mysteries* cultivates a sense of place, an appreciation for the rich and varied history of our region. This history, which we all can share, engenders respect for the creativity and resilience of life and Earth.

With questions of different scale, *Fossil Mysteries* models and promotes active curiosity. Some questions address big concepts, others focus on smaller details. We structure our exploration of regional change over time through inquiry within interrelated themes: evolution, extinction, ecology, and Earth processes. Richly integrated ideas, images, objects, and media afford multiple avenues of access to fascinating concepts regarding Earth and life. Following a Constructivist philosophy, we acknowledge that visitors will construct their own unique personal experience shaped by their prior knowledge, interests, and interactions with the exhibition. To facilitate optimal personalized meaning-making, we created reinforcing layers of visual and verbal information, accessible for a diversity of learners. Document excerpts below illustrate our effort to create a coherent and reinforcing conceptual framework. Based on exit interviews, the vast majority of visitors articulate in their own words the main messages of *Fossil Mysteries*.

Fossil Mysteries

Conceptual Framework 5/21/04 (excerpts)

Project Goals

Fossil Mysteries will

- Inspire curiosity about the past and how it relates to the present;
- Attune visitors to fossils as physical evidence of Earth and life processes of change;
- Promote inquiry and observational skills;
- Reveal science as a disciplined process of asking and exploring questions that we all can engage in;
- Illustrate the importance of our museum's collection in understanding our world and the history that we all share.

Big Idea

Fossils are physical evidence of enduring processes of change in our region and the world.

Exhibition Themes

- Evolution: Fossils show how life changes over time in response to challenges and opportunities.
- Extinction: Fossils show that whole species can die when environmental changes are too rapid for life to adapt; extinction represents both loss and opportunity.
- Ecology: Fossils show how living communities and environments exist in relationship to each other—in the past as in the present.
- Earth Processes: Fossils show how Earth processes shape life—in living form and in the record that is left behind.

“Take-home” Messages

- Fossils are remains of past life. By looking at them and thinking carefully, we can research lifestyles, behavior, relationships, and past environments.
- Fossils provide a link to the past, and a way of understanding what is here now.
- Fossils record past life and events. They show how Earth and life have changed and are physical evidence for the process of evolution.
- Fossils are relevant to us because they reveal forces of change in the past, which are still at work today.
- The history of this region is complex, and many different life forms have come and gone.
- When life forms go extinct, it doesn't mean that they are not good enough to survive, but their environment has changed and their unique adaptations don't fit the new conditions.
- We don't know everything there is to know about fossils, yet they hold a lot of information and inspire lots of questions.

We considered the complexity of the learning process and sought guidance in learning theory.

We devised an audit process to ensure that *Fossil Mysteries* includes a variety of interactives (whole-body, simple, complex), a balance of experiences (multi-sensory, active, contemplative, quick, in-depth, scientist-like, appealing to preschoolers), and universal access (wheelchair, stroller, visually impaired, hearing impaired.) One team member even carried the torch for color-blind people, raising our awareness of color perception. We made a list of issues related to perceiving, processing, and encoding information to remind us to carefully craft exhibits for a wide range of learners and experiences.

Visitor Experience
High Intensity (Wow)
Medium Intensity
Low Intensity (Contemplative)
Minds-on

Hands-on
Ah-ha
Wow!
Appeals to many ages/types
Learning Styles
Concrete experience (sense, feel)
Reflective observation (watch)
Abstract conceptualization (think)
Active experimentation (do)
Multiple Intelligences (& Sensory)
Naturalist
Linguistic
Logical-Mathematical
Visual-Spatial
Bodily-Kinesthetic
Tactile
Whole-body
Olfactory
Auditory-Musical
Interpersonal
Intrapersonal
Cross-hemispheric Functions
Parts—Wholes
Details—Big Picture
Listening—Telling
Small motor—Gross motor
Vocabulary—Big Idea
Logical Sequence—Imagination
Science Processes
Observe
Communicate
Compare
Organize
Relate

Infer
Apply
Making Connections
Classify
Structure
Describe
Define
Personalize
Regionalize
Globalize
Imagine
Create

We found inspiration in Dr. Deborah Perry's work, *Designing Exhibits that Motivate*. Her model for enhancing intrinsic motivation to learn is outlined below.

Curiosity—The visitor is surprised and intrigued.

Confidence—The visitor has a sense of competence.

Challenge—The visitor perceives that there is something to work toward.

Control—The visitor has a sense of self-determination and control.

Play—The visitor experiences sensory enjoyment and playfulness.

Communication—The visitor engages in meaningful social interaction.

Perhaps it is inherent in human nature, but visitors can't resist a well-constructed challenge. To be successful, the challenge must be clear and readily accessible, the rules for engagement must be intuitive, and the outcome must be satisfying. In *Fossil Mysteries*, we experiment with various challenges to visitors. Although their content and depth varies, our successful challenge exhibits provide guidance and feedback to visitors so they are neither overwhelmed nor bored. The duration of their stay and the depth of engagement indicate the success of our challenges.

Fossil Mysteries goes beyond push-button interactivity. Our interactive exhibits demonstrate relationships between cause and effect. To see and experience this relationship requires—from the visitor—time to engage, and—from the exhibit—a balance between simplicity and complexity. Exhibit planners generated countless iterations of interactive exhibits; many were changed and some discarded because they did not meet the criteria for success. The exhibit team refused gratuitous interactivity. All interactive exhibits had to effectively communicate a message that was part of a larger big idea.

While developing the content, we laid out a plan to effectively deliver information in various formats and to integrate content in different media.

Fossil Mysteries INFORMATION DELIVERY 11/15/04

Format	Unique qualities	Content Notes
Reading rails Exhibit panels	<ul style="list-style-type: none"> Convey main messages—use specimens to illustrate themes Provoke curiosity—ask questions Focus on specimens—guide observation 	
Specimen labels	<ul style="list-style-type: none"> Identify specimens 	Common name, scientific name, cast or actual fossil, age, location, source—SDNHM or other
Electronic media	<ul style="list-style-type: none"> Provide in-depth information, e.g., access to website 	Digital labels were cut from the exhibit plan, based on visitor feedback.
Docents / Interpreters	<ul style="list-style-type: none"> Extend the message—provide information tailored to the audience Provide up-to-date information, recent discoveries, directions to prep lab Provoke curiosity—ask questions Focus on specimens—guide observation 	Consider alternate themes (Dating, Sex and Reproduction, Pathology, Fossilization Process, Geologic Time, etc.)
School programs	<ul style="list-style-type: none"> Promote critical thinking and process skills Engage in meaningful activity where additional materials and adult guidance are required Provide pre-visit orientation, post-visit activities May include self-guided tours, science workshops, standards-targeted curricula 	California State Science Content Standards mapped to exhibition content
Website	<ul style="list-style-type: none"> Make available as in-museum resource Provide online resource for school projects on regional geology and paleontology (include science fair ideas) Link to other Internet resources Exploit data access and digital technology—use specimen database, GIS mapping, etc. 	Content may include: Fossil Field Guide (include new discoveries) Fossil Field Trips Fossils in the Museum Theme-based activities Curricula Learning Resources
Popular book	<ul style="list-style-type: none"> Provide more in-depth treatment of regional geology and paleontology (form to be determined) Complement other available resources 	In process '07

We involved the community in creating *Fossil Mysteries*.

Through an intensive evaluation process, we sought input from museum visitors, members, staff, docents, educators, school children and the general public. We employed many methods to better understand our diverse audience including interviews, games, surveys, observation, and focus groups. For example, 126 visitors completed personal meaning maps, or concept diagrams, to

reveal their ideas, experiences, and questions related to the primary themes of *Fossil Mysteries*. Our extraordinary volunteer interviewer elicited rich responses, providing our exhibit team with a wealth of information. We made a deliberate effort to invite a wide range of people to our numerous focus groups, including the special needs community (visually impaired, physically challenged, learning disabled), migrant worker educators, teachers on Indian reservations, Latinos (with focus groups conducted in Spanish), seniors, families, and youth. Our education staff conducted an extensive review of California State Science Content standards, ensuring that the information presented in the exhibition was mapped to the Standards and would meet the needs of classroom teachers and students.

We engaged the museum community by conducting a Web-based peer review with exhibit planners and content experts across the nation. Through presentations at AAM, we engaged in dialog with other practitioners thus enhancing everyone's learning. Our collaboration with the Science Museum of Minnesota and the Institute for Learning Innovation expanded our community, exposing our team to new ways of doing things. To develop the content, we opened new channels of communication with scientists in our own backyard and around the world. Approximately 100 scientists shared information, images, and objects. To quote content developer Lynett Gillette, "Our fellow researchers were exceptionally generous with our Museum. Their support and interest in our project are a wonderful reminder that this institution participates in a global community committed to natural history research and education." And thanks to the national, state, and local communities, *Fossil Mysteries* was fully funded through public grants and private donations.

Fossil Mysteries represents diverse perspectives as a result of our rigorous effort to listen to many voices. This process, both systematic and organic, informed decision-making throughout the life of the project. The interests, needs, and desires of our visitors and the scientific views of researchers around the world contributed to the making of *Fossil Mysteries*. Our team members, with varied expertise and ways of thinking, sustained the community's diverse perspectives assuring a well-rounded, vibrant presentation.

***Fossil Mysteries* extends beyond the museum walls.**

Museum educators developed a teachers' guide to the exhibition, with a thematic content overview, in-gallery inquiry-based activities and classroom activities.

(www.sdnhm.org/exhibits/mystery/education.html) A well-designed content-rich website, with mysteries to solve and a fossil field guide, serves learners in our region and around the world (www.fossilmysteries.org). Reaching out to the local and national museum communities, we shared what we learned from *Fossil Mysteries* in several presentations with the San Diego Evaluators and Exhibits Group and at AAM annual meetings, and in articles published in NAME's *The Exhibitionist*, *Visitor Studies Today*, and *WestMuse*. And finally, phenomenal media attention reflects public interest and support of *Fossil Mysteries*, spreading the Museum's message far and wide.

10. Labels – photographs in PowerPoint presentation

Visitors experience *Fossil Mysteries* labels in three dimensions.

Fossil Mysteries labels integrate specimens, models, interactives, images, guided observation, and questions that challenge and provoke. Photographs in the PowerPoint presentation illustrate the dimensionality and context of the labels. The English text for those selected labels can be found below. Spanish text is available upon request.

Title wall / Introduction

FOSSIL MYSTERIES bridges our historic building and our new addition, and the architecture demanded an exhibition with two entrances. This necessity offered an opportunity to reassert the primary message of the exhibition—our place has changed, dramatically and beautifully, through time.

Fossil Mysteries

Enter a world of fossils,
discovered and studied by this museum.
Explore 75 million years of change in our region—
southern California and Baja California.

Uncover long buried mysteries of life and death.
Past and present connect and curiosity awakens.
What mysteries will these fossils reveal to you?

Armored Dinosaur

On this label, we exceeded our word count and experimented with a flipbook to tell a deeper story about one of our visitors' favorite subjects—dinosaurs.

Half a fossil tells half the story

This incomplete dinosaur fossil is loaded with information—and mystery.

Look closely at this fossil. You'll see leg bones, hips covered in bony armor, and delicate oddly-shaped teeth.

It's an armored dinosaur, but not all scientists agree on what kind. Without a head or a tail, it's hard to tell.

(with models)

Is it an ankylosaur? Is it a nodosaur?

Fit the fossil model on the dinosaur models to appreciate the dilemma.

(flipbook p.1)

Dinosaurs lived on land. However, this one was buried on an ancient seafloor. Look at the evidence and uncover a story.

(flipbook p.2)

We know these fossil facts:

The dinosaur was found lying on its back, belly up, with many bones connected as they were in life.

Shark teeth, oysters, clams, and snails were found with the dinosaur fossil.

Scientists discovered the dinosaur, preserved in a mudstone layer, 3 miles inland and 200 feet above modern sea level at a roadway construction site.

This evidence suggests what happened to the dinosaur...

(flipbook p. 3)

The cause of death is unknown, but because the skeleton is partly intact, the dinosaur carcass probably didn't travel far before sinking to the seafloor. Pulled by the weight of bony armor on its back, the carcass sank with the belly up.

(flipbook p.4)

Sharks fed on the carcass. The dinosaur bones provided a surface for shells to attach. A reef community thrived. Mud and sand buried the dinosaur remains beneath sedimentary layers, hundreds or thousands of feet deep.

Much later, movement of Earth's crust lifted the 75 million-year-old seafloor above sea level. Erosion followed, making the fossil discovery possible.

(base panel under flipbook)

Are you curious...

How did it die? Was the dinosaur dead or alive when it washed out to sea? What happened to the rest of the body? Was it an ankylosaur with a clubbed tail? Or a nodosaur without a club?

Without more evidence, some mysteries may never be solved.

K-T (Cretaceous-Tertiary) Rock

A chunk of rock, which records the asteroid impact with Earth 65 million years ago, provides a touchstone for discussion of evidence for the extinction of dinosaurs. Again, a flipbook contains extra content for extreme label readers. Surprisingly, some visitors go the distance.

An end and a beginning

These rock layers preserve evidence of a catastrophic event.

The layers in this rock are like chapters in a book. Each one tells a bit of Earth's history. Geologists have long recognized the dark coal layer as the beginning of a new major era—the Tertiary Period. Below, dinosaur fossils are common. Above, mammal fossils become abundant and diverse. But closer inspection of sedimentary layers like these from Wyoming revealed a surprise.

The lower layer of dark gray mudstone formed along the mud banks of a lazy river. Using a microscope, scientists found 79 kinds of fossilized pollen from lush flowering plants, conifers, and ferns preserved in this rock layer.

Arrow

65 million years and older/65 millones de años o más
Latest Cretaceous Period/Periodo Cretácico tardío

Photomicrograph courtesy of D. J. Nichols, U.S. Geological Survey

The thin gray claystone contains 1,000 times more iridium than the other layers. This element is rare on Earth, but common in asteroids.

This layer also holds crystals of quartz, riddled with fractures running in different directions. This type of unusual “shocked” quartz only forms from high velocity impacts. An impact crater, also of this age, lies buried on Mexico's Yucatan Peninsula.

Arrow

65 million years old/65 millones de años
End Cretaceous Period/Fin del periodo Cretácico

Photomicrograph courtesy of D. J. Nichols, U.S. Geological Survey

A bed of coal, formed from plants in a swamp, makes up the upper black layer. Here, fern spores dominate the fossil record. Hardy plants that grow from wind-borne spores, ferns are often first to recolonize areas devastated by fire or volcanic eruptions.

Arrow

65 million years old and younger/65 millones de años o menos
Earliest Tertiary Period/Inicio del periodo Terciario

Photomicrograph courtesy of D. J. Nichols, U.S. Geological Survey

Sedimentary rocks of this age in other parts of the world contain similar patterns—the presence of iridium followed by a sudden drop in plant diversity and a predominance of ferns.

Hypothesis: An asteroid, perhaps six miles wide, slammed into Earth 65 million years ago. Many ecosystems collapsed and ferns took over on land, for a time. After the

impact, life endured, but it would never be the same again.

Sedimentary rock
Roca sedimentaria
65 million years old
Cretaceous-Tertiary (K-T) boundary
Sussex, Wyoming

Compare Plants Present and Past

Photographs of modern plant “specimens” look similar to fossil plants and create a beautiful and compelling display.

Leaves offer abundant clues

Modern plant adaptations hold the key to understanding past climates and habitats.

Compare these Eocene plant fossils with their modern relatives. The leaf shapes of modern plants, temperature tolerance, and habitat preference provide clues to Eocene climate and plant communities.

(flip book p.1)

Palms require winters without freezing.

(2)

Water escapes from plants' leaves. Bananas and sycamores, with their broad leaves, only grow where there is plenty of water.

(3)

Smooth-edged leaves, like those of magnolias, are more likely to grow in wet climates.

Ragged-edged leaves are more common in dry climates.

(4)

Mangrove trees grow at the fringe where land meets sea.

(5)

Water lily and horse tail grow in shallow fresh water where their roots can anchor.

(base)

Based on these fossils, we conclude that during the Eocene, our region had a warm, wet climate. These plants flourished here in various lush, coastal habitats.

Look at the variety of habitats in the scene around you: coastal wetlands, mangrove lagoons, freshwater ponds, upland rainforests. Each features different plants, adapted to specific soil and water conditions.

Moving Jaws

Visitors discover the distinguishing features of modern meat-eater and plant-eater skulls, then compare them with features on a fossil skull. They also make the interactive skulls “talk” to entertain their friends and family.

What’s for dinner?

Teeth and jaws determine the menu.

Examine skull features of this deer—a plant eater.

The lower front teeth pinch against the toothless upper jaw to crop leaves, berries, and seeds.

Packed close together, the cheek teeth with ridges form one continuous grinding surface. In life, the jaw moves up, down, and side-to-side.

The jaw joint lies above the tooth row, so all grinding teeth make contact at the same time. (Humans have this feature too.)

Examine the skull features of this cat—a meat eater.

Pointed canines pierce and puncture to make the kill. Chisel-like incisors strip flesh from carcasses.

Blade-like rear cheek teeth work in pairs, top and bottom, shearing against each other to cut through flesh.

The jaw joint lies level with the tooth row, so teeth come together from back to front, slicing like scissors.

Close the jaws slowly and notice how the teeth come together.

Fish from Our Pliocene Bay

Visitors love the strange sculptural quality of these fish fossils and the connection to fishing and diving off our coast.

A feast of familiar fish

Dive into our region’s Pliocene bay and find lots of fish much like today.

From big to small, from shallow water to deep, Pliocene fish were very diverse. As both predators and prey, fish played a central role in the bay community.

Paleontologists have identified well over 60 fish species from fossil backbones, skull parts, and teeth. Many of these fish still live here today.

Why have the fish changed so little since the Pliocene, while the birds and mammals have changed so much? Based on fossil and genetic evidence we know that fish evolve more slowly. So, the fish community has remained more stable.