The Development, Design, and Evaluation of *Evolved*, an Exhibition on Human Evolution

Undergraduate Research Thesis

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by

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Introduction

Museums, and science centers in particular, present a unique type of learning experience; an experience that holds educational authority and credibility, yet is distinctly focused on being hands-on and enjoyable. It is this spirit of making what can often be esoteric learning into an engaging, more personal experience that not only inspired the creation of *Evolved*, but shaped it's narrative. The exhibition was conceived as an introduction to human evolution through a personal lens relevant to museum visitors. In the exhibition, visitors explore the ways evolution has shaped their own body over the past several million years through interactive components that examine the evolutionary history behind their bodily traits. Through these experiences, they not only see how evolution has shaped the human lineage over time, but also come away with an understanding of it as a science and a force relevant to their own lives. The development of this exhibition has spanned all stages of the exhibition development process, from formulating a narrative and choosing subtopics to explore, to developing hands-on interactives that teach those concepts, to conducting a formative evaluation of exhibition components with museum visitors.

This thesis will provide an overview of the process of creating *Evolved*. The theories and best practices of exhibit design will be explored, as well as the state of evolutionary concepts and content in museums today. A concept narrative of the exhibition will outline its components through activity descriptions and design specifications, sketches and renderings, and label text. It will conclude with a report on the formative evaluation currently being conducted on the exhibition.

Informal Science Education in the Museum

The average American will spend only 5% of their lifetime in a classroom, leaving open an enormous window for learning in other settings. Informal education programs have emerged to fill this gap by providing educational experiences in a range of settings and modalities for people of all ages (Falk and Dierking 2010). Informal education is most often described in contrast with formal education as an everyday, voluntary, and often self-motivated learning experience not necessarily tied to an official educational curriculum, and as a type of learning that is not restricted to the primary years of schooling, but rather occurs throughout a person's life (Stocklmayer and Rennie 2017). Despite the open-ended nature of the experiences it provides, informal learning follows a series of underlying principles and well-developed methodologies. One of the most thoroughly studied and active areas of informal education, and that which will be examined in the paper, is informal science education. Museums, which provide educational opportunities through an experience that is both didactic and leisurely, are one of the most popular centers of informal science education (Falk and Storksdieck 2009). Museums themselves are prominent and largely well-respected social and pedagogical institutions. With attendance approaching a billion visitors a year in the US alone, they reach a large audience of individuals interested in science (Plakitsi 2013). This position has placed them at the forefront of informal science education, both as a center of practice and of study.

Informal science education in the museum represents a unique form of education largely centered on experiential learning and driven by personal interest. There are two primary models of education employed in science museums: the contextual model and the constructivist model. John Falk and Lynn Dierking's Contextual Model of Learning accounts for the influence of museum visitor's sociocultural experiences on their learning within the museum, employing a framework that is deeply cognizant of the ways individuals make meaning. George Hein's constructivist theory, grounded in the idea that learners create meaning through experiences, argues that learners do not truly understand science *content* until they are able to use science as *method* to discover that content for themselves (Plakitski 2013). These models offer frameworks to understand how visitors learn from and make meaning through their museum experiences, and thus have implications for how museums create such experiences. Reflecting many of these ideas, Bell's (2009) "strands of science learning" and have largely set the benchmarks for educational methods and content in science museums. They state that:

> Learners in informal environments:
>
> Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
>
> Strand 2: Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.
>
> Strand 3: Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
>
> Strand 4: Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.
>
> Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools.
>
> Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.

Collectively, these strands describe the role of the museum as an educational institution as not only teaching science content, but as getting visitors to do science. Another key aspect of informal science education in the museum is taking into account and building on visitor's preexisting knowledge. Successful informal learning experiences allow learners to build on their own knowledge or intuitive ideas about topics, as well as encourage them to reflect on what they know and their ways of thinking (Fenichel and Schweingruber 2010).

Though programming and outreach play an important role, the primary way museums educate is through exhibits. An exhibition is a designed environment in which artifacts, media, and/or interactive experiences are arranged and interpreted to teach a specific concept or message. Ultimately, exhibitions are free-choice learning environments, experienced wholly as the visitor chooses (Fenichel and Schweingruber 2010).

The process of creating an exhibition follows a series of steps designed to develop a strong message and meaningful experiences that impart it. In first developing an exhibition, it is important to establish and refine a central thesis, what Beverly Serrell calls “the big idea.” This brief statement serves to dictate the primary idea the exhibition aims to teach and keep the content focused and relevant throughout the design process (2015). Developing objectives for an exhibition requires determining not only the educational objectives – the facts to be taught – but also emotional and behavioral objectives – the attitudes and ways of thinking visitors should ideally come away from the exhibition with. Based on the topic and the learning objectives, a narrative can be developed that weaves the knowledge into a compelling story and a specific design approach can be chosen. In contrast to the artifact-centered approach of many art or natural history museum exhibitions, science museums tend to pursue an interactive approach, focusing on developing a series of activities that teach concepts through the process of doing them. These interactives are tested out and refined, often through the process of evaluation (Parmly Toxey and Cavett McMillan 2009).

Given the breadth of museum visitors and the inherent diversity of their learning styles, exhibitions aim to provide a range of experiences appropriate for different learning abilities and methods. Providing multiple ways in which visitors can learn content within an exhibition has been shown to increase the knowledge gained not only amongst groups of diverse learners but for individuals who have multiple opportunities to learn a particular concept (Fenichel and Schweingruber 2010). To this end, exhibitions often include a range of learning opportunities, from didactic text and structured activities to more open-ended experiences that allow visitors to explore their own ideas on the topic (USS Constitution Museum 2018). Visitors can chose which of these to engage with and therefore have the opportunity to learn in a way that they are comfortable with and confident in. Designing for different learning *abilities* is also important, and universal design approaches are concerned with ensuring that exhibitions are “physically, socially, and cognitively” accessible to all visitors. Such approaches typically present information in multiple and straightforward formats that maximize information clarity and ensure that it is accessible through a range of channels (NISE Network 2010).

In addition to these multiple learning modalities, exhibitions aim to promote engagement not only with content, but also with other learners. The vast majority of museum visitors come to the museum in family groups and often experience exhibitions together. These interactions are an inherent part of many visitors’ museum experiences and have been shown to be powerful tool for increasing learning and engagement. A 1998 research study by PISEC examined the ways in which family interaction in exhibits could be improved, and delineated seven key characteristics of family exhibits: “multi-sided, multi-user, accessible, multi-outcome, multi-modal, readable, and relevant.” They found that by incorporating these characteristics, which largely served to increase the number of family members actively interacting with the exhibit and provide opportunities to learn appropriate for people with different learning styles and of different ages (which describes a multi-generational family group), interaction, and ultimately learning, increased (Borun 1998). Promoting engagement amongst visitors who are not familiar with one another is often more difficult; however, design approaches such as Nina Simon's "me-to-we" philosophy demonstrate how collective participation and collaboration have the power to enhance museum experiences. This approach is not so much about designing exhibits that get unacquainted visitors to work together, though, as it is about designing exhibits that network visitor's individual interactions and improve the more they are contributed to (2010).

The main exhibition technique used in this project is the interactive, and a closer look demonstrates its educational efficacy, as well as reveals what makes *Evolved* a successful interactive experience. An "interactive" or "hands-on" exhibit is one that engages a visitor or group of visitors in an exploratory physical or mental activity involving self-direction and self-motivation with the intention of leading them to an understanding of some object or principle. These types of exhibits have long dominated in science museums, and visitors have come to expect them as part of the science museum experience (Caulton 1998). Successful interactives follow many of the principles already outlined, such as accommodating multiple learning styles and encouraging interaction among visitors. What makes interactives such an effective exhibition method is their power to involve visitors in their own learning. Interactives hold visitors attention by giving them a task, and through that task they engage in the types of cognitive actions that lead to learning such as questioning and explaining (Borun 1998). Considerable evidence supports the idea that the self-discovery promoted by interactives is one of the most powerful ways of learning, particularly in the sciences (Fenichel and Schweingruber 2010).

In constructing these multiple learning modalities, exhibit labels are one of the most important focuses of the design process. Labels play an important role in providing the content underlying the interactives and displays in the exhibition, and research shows that in conjunction with activities they are more effective at transmitting knowledge than the activities alone. (Fenichel and Schweingruber 2010). Writing effective labels can be a somewhat complex process, as they must not only provide information in a way that is accessible to a wide range of visitors, but also be appealing enough so that they are actually utilized as part of the exhibition learning experience. Some important guidelines include writing for a generalist audience with no knowledge of the exhibition topic and writing in a way that is brief and informal, rather than overly didactic. As many label writing guides suggest, the audience does not want "to read a book on the wall." Labels present a great opportunity to contextualize exhibition content and encourage visitor engagement, and successful labels get visitors to examine objects or activities closer, as well as tie them into visitors own lives (Victoria & Albert Museum 2013).

The true test of an exhibition's efficacy will always be the museum visitor, and exhibit designers can look to visitors throughout the design process to determine whether or not exhibition elements are effective and understand the ways by which visitors learn from the experiences they have created. This is done through evaluation. While there are multiple types of exhibit evaluation, this project utilizes formative evaluation. Formative evaluations are conducted during the development of an exhibition using prototypes of concepts or interactives in order to determine how visitors respond to them and what they learn from them. Data is typically collected through informal interviews and observation, and this information is used to further improve the exhibition (Diamond 1999). The power of evaluation in the design process is enormous. While the opportunity to ensure that visitors understand activities and concepts in the way they are presented is clear, the ability to study more nuanced, and often deeply important, aspects of the exhibit's design is what makes evaluation such a useful tool. The ways visitors contextualize exhibition content and make personal meaning out of what they are being taught is one of the most important factors in visitor's museum experiences and educational outcomes, yet is something that is often hard to foresee as a designer. By talking with visitors, however, and examining the ways they learn in and what they take away from an exhibition, these important aspects can be better understood (Downey 2002).

Teaching Evolution

An examination of current exhibitions in evolution – their design approaches, ideologies, and visitors receptions of them – gives a good picture of the current state of evolution education in museums. It also presents several implications that this project has tried to remain cognizant of, as well as grow from.

Teaching evolution in the museum has largely been the purview of natural history institutions, which, for that most part, have taken a very similar approach in their exhibit design. Notable exhibitions such as the David H. Koch Hall of Human Origins at the National Museum of Natural History, the Spitzer Hall of Human Origins at the American Museum of Natural History, or the Penn Museum's *Human Evolution: the First 200 Million Years* highlight many of these similarities. Moving through halls of fossils and dioramas, visitors experience human ancestors and great developments in human biological and cultural history (Smithsonian Institution; American Museum of Natural History; Penn Museum). What underlies these and other similar exhibitions, however, is what Monique Scott describes as a progressive narrative that situates evolution as a largely historical – if not prehistorical – force that brought an uncivilized human ancestry out of Africa and into the modern (European) world (Reiss 2017). In addition to this problematic narrative, these traditional exhibitions also struggle with an often esoteric nature. By presenting evolution through the lens of long-fossilized life and a progression of unpronounceably-named hominids, it becomes inaccessible – something visitors can observe in the museum, but not something the majority of them can understand and experience in their own lives.

Explore Evolution, a traveling exhibition developed by a coalition of Midwestern natural history museums, chose to challenge this prevailing approach and modernize visitor's perceptions of evolution by focusing on the scientific research process and how it allows scientists to study evolution. Visitors engaged in these scientific processes and learned about major discoveries made by current scientists (Diamond and Evans 2007). Breaking the mold even further is the New York Hall of Science's *The Evolution-Health Connection*, an exhibition that explores the role of evolution in modern maladies (New York Hall of Science). As one of the few science museums to have an exhibition on evolution, as well as one of the few evolution exhibitions to contextualize the process in an aspect of visitors own lives, this exhibition not only challenged notions of what evolution is (Weiss, Evans, and Palmquist 2016), but brought evolution into the narrative science museums construct of what is "science."

These exhibitions demonstrate a variety of approaches to teaching evolution, each with their own strengths and weaknesses. Many of these exhibitions have been evaluated and studied, and this research reveals ways in which museum visitors think about evolution and what they learn from different exhibition approaches. Numerous factors have beleaguered evolution education, from the level of scientific understanding it demands, to its seeming irrelevance and imperceptibility in people's own lives, to prevailing religious ideologies (Reiss 2017). However, studies have shown that people are interested in evolution exhibitions, and that many evolution exhibitions do have an impact in teaching evolutionary concepts.

A 2002 front-end study conducted by the Penn Museum in preparation for a traveling exhibition on human evolution aimed to understand potential visitor's knowledge about and feelings towards the topic of human evolution, and provides a good idea of general perceptions towards evolution exhibitions. The study found that while people were aware of the controversies surrounding evolution, they were interested in visiting an exhibition on human evolution. The most notable outcome of the study, though, was that people were almost universally unfamiliar with what evolution is and held a variety of common misconceptions about it. When asked about their interest in a variety of potential exhibition topics, participants largely felt that traditional paleontological or chronological exhibitions were "overdone," and expressed an interest in an exhibition that dealt with modern controversies around evolution and discussed the implications of evolution for the future of humans (Borun 2002).

Studies conducted on traditional natural history museum human evolution exhibitions reveal how these misconceptions can permeate visitor's experiences in evolution exhibitions. Monique Scott, working in the Sackler Educational Laboratory in the Spitzer Hall of Human Origins at AMNH, offers an insider view of human evolution education in the museum. Visitors, Scott says, come to the exhibition with a host of pop culture-derived notions of evolution and human ancestry that deeply influence their perceptions of the exhibition content and, without proper intervention, are easily self-reinforced by the museums dioramas of past human life. However, opportunities for visitors to come into the Sackler Lab and handle fossil replicas as well as ask questions to scientist-educators like Scott have proven to be popular and effective methods of addressing such misconceptions and making evolution a more accessible science (2010).

The contemporizing approaches taken by *Explore Evolution* and *The Evolution-Health Connection* have also been studied, and while they too reflect widespread misconceptions about evolution amongst visitors, their contextual approaches have been shown to be more effective at challenging these notions and educating visitors about evolution. An evaluation of *Exploring Evolution* looked at whether a visit to the exhibition changed visitor's perceptions of evolution, as well as their use of evolutionary thinking and language. Researchers found that in the course of a single visit to the exhibition visitor's views of the impacts of evolution were broadened (the exhibition dealt with evolution in a variety of different organisms) and that they were more likely to endorse and, in a few cases engage in, evolutionary reasoning for why species are the way they are (Spiegel, et. al. 2012). Evaluation of *The Evolution-Health Connection* demonstrated the effectiveness of making things personal in evolution education, finding that visitors had a greater understanding of the role evolution played in their personal health after visiting the exhibition (Weiss, Evans, and Palmquist 2016).

This survey of current work in evolution education in museums presents a series of implications that influenced the approach taken in *Evolved.* The lack of evolution exhibitions in science museums is a troubling phenomenon given the fundamental role of evolution in the biological sciences. The authority of science museums means that they have substantial meaning-making power, and the absence of evolution from the narratives they construct of what is part of "science" by what they do and do not include in the museum offers little support, and in some ways even does a disservice, to evolutionary science. From its outset the *Evolved* project set out to explore ways to fill this gap, seeking to develop an evolution exhibition that would be at home in an interactive science museum. The project also drew from work in science museums, utilizing their highly effective hands-on learning methods to teach evolutionary concepts in an engaging and accessible way. Previous studies showed that exhibitions that contextualized evolution in a personally or contemporarily relevant way lead to deeper visitor engagement, greater learning, and more accurate understandings of the evolutionary process. Based on these findings, *Evolved* set out to teach evolution through the lens of the modern human body, as it presents evolution as an active force that visitors can understand and experience for themselves.

The Project

This project included all stages of the exhibition development process from the initial conception of a topic through the evaluation of exhibition components.

The topic itself, a general introduction to human evolution, was chosen out of a desire to create an evolution exhibition for science museums, rather than their more traditional natural history museum settings. Many natural history museum evolution exhibitions explore the topic chronologically through fossils, and do so in what can often be an esoteric manner. Science museum exhibitions, however, tend to take a very hands-on, generalist approach meant to familiarize their audience with science topics and spark their interest in them. Seeing a lack of evolution exhibitions in science museums that otherwise covered an expansive range of scientific topics, as well as aiming to develop an exhibition that diverged from this traditional approach and embraced the hands-on, interactive nature of science museum exhibitions, a general introduction to evolution through the lens of the modern human body was chosen as the central concept of the exhibition.

Developing the content of the exhibition required the selection of specific topics and the construction of a narrative that wove those topics into a meaningful message. Three major aspects of human evolution were used to shape the storyline of the exhibition: the basic traits shared by all humans, the reasons behind the variation amongst humans, and the impact of the most notable of human traits, the brain. However, the components were constructed non-linearly and interchangeably to ensure that they were understandable and valuable to visitors who did not follow a strict path in experiencing the exhibition. Within these categories, different features of the human body or interaction were chosen that told an interesting evolutionary story or reflected a key principle of evolution.

Each of these chosen features became a component in the exhibition. Research was done on the evolutionary science behind them, and interactives were developed that allowed visitors to learn the principles they demonstrated through an activity or display. Labels were also written that provided instructions and educational content for each component. This process entailed several rounds of ideation, testing, and revision. Devised components were reviewed by exhibit designers and other experts within the field, as well as tested with visitors through a formative evaluation. These reviews lead to revisions and improvements to the components, and helped to shape *Evolved* into a more effective exhibition overall. The final result of this work is the exhibition concept below, which details the structure of the exhibition and its components through text and images.

The Exhibition

Concept

Evolved is designed to explore the topic of human evolution and translate it to visitors of all ages and backgrounds. The goal of the exhibition is to provide an informal learning environment in which visitors can experience and think about how human evolution affects their bodies and lives today. It focuses on different features of the human body and interaction to explore how they have been shaped over millions of years of evolution. By looking at something that they are extremely familiar with, visitors can see how scientific principles that may seem complex or challenging can be witnessed in action on their own bodies and in their own perceptions and interactions as humans.

The exhibition is organized in three major topics: 1) what it means to be human; 2) how humans vary; and 3) how humans think and communicate. Each of these major topics is explored through a series of exhibit components that showcase specific topics within them. The components are interactive, allowing visitors to experience first hand the scientific principles through different activities. There are a range of different types of interactions to account for the diverse learning styles and abilities of museum visitors. Some of the components engage visitors through tactile experiences, while others are visual or auditory in nature. Many of the components can be group experiences that encourage visitors to not only interact with the exhibition, but to engage with one another as they do so. The exhibition is also designed to be a largely non-linear experience. While they work together to teach a common idea and contribute to the larger narrative of the exhibition, the components are independent and can be experienced in any order. This approach accounts for the way visitors often experience science museum exhibitions and ensures that only experiencing a part of the exhibition does not diminish the visitor's learning experience.

Evolved was designed with a target audience of 11-13 year olds in mind, though it is intended to be accessible to and engaging for visitors of all ages and knowledge levels. This age range is a time in which students are integrating the different elements of evolutionary theory they have learned throughout their earlier years into the complete theory of evolution, therefore the exhibition content will not only be relevant to their studies, but they will have a greater understanding of the topic. For those with only some or no familiarity with evolution, though, *Evolved* is still an accessible experience. As mentioned, students learn about essential evolutionary concepts throughout their schooling, and thus are likely familiar with at least some of the basic concepts the exhibition covers. The exhibition also strives to present evolutionary concepts in a non-complex and non-intimidating manner, encouraging exploration and providing information in a way that is accessible to those without any background knowledge in evolution.

Big Idea

The process of evolution shapes how the human body looks and works.

Exhibit Objectives

The goal of this exhibition is to provide an informal learning environment in which visitors can experience how evolution affects their bodies and lives today, and in doing so understand its larger role as a universal biological force. Evolution can often seem to be an esoteric and even controversial topic; however, this exhibition aims to present it in a way that is relevant and accessible to visitors.

The objectives of *Evolved* are centered on an understanding of evolution as a dynamic force and a natural part of participant's lives. The following learning and behavioral objectives outline what the exhibition aims to provide and teach to visitors.

- **Main Objective:** Visitors will understand that evolution is a biological process that has and continues to shape humans
- Visitors will recognize the changes that evolution has made in the human body
- Visitors will recognize the biological or cultural forces that act(ed) to create these changes
- Visitors will understand that human evolution is part of the larger process of evolution that affects every other living organism
- Visitors will understand that evolution continues to shape our species today
- Visitors will feel more familiar and comfortable with the idea of evolution

Reactions	Knowledge	Skills	Attitude	Behavior

Participants will be curious about a topic with which they are likely not very familiar. In some cases participants will be wary of the exhibition due to their perceptions of evolution.	Participants will learn how evolution works and how it has shaped them as humans.	Participants will be able to relate environmental and social forces to the appearance and actions of people.	Participants will be surprised by the complex history of our seemingly simple body parts and actions. They will have a better appreciation for how their environment and their actions shape their bodies.	Participants will think more critically about how their actions in regards to personal health, social engagement, and the environment will shape future generations. School-age participants will have a better foundational knowledge in biology.

Exhibition Components

Due to the large number of individual traits/behaviors explored in Evolved, it made sense to group them in a way that would not only make the exhibition easier for visitors to follow, but that would allow them to better conceptualize how evolution impacts every element of being human. Thus, Evolved is divided into three major groups: Being Human, Human Variation, and Human Thought and Communication. The common thread of the evolutionary process ties these groups together, and they will be interlinked by the inherent interconnectedness of the human body and human interactions that often leads to overlapping evolutionary causations or impacts.

- Thematic Concept A – Being Human

  This group covers the basic traits that all humans share and that define them as the species *Homo sapiens*. These traits are shared by all humans and demonstrate the changes that occurred along the evolutionary lineage to create the modern human form.

  - Component 1 – Hands
  - Component 2 – Stereoscopic Vision

    - Component 3 – Eating
    - Component 4 – Homeostasis
    - Component 6 - Feet
    - Component 6 – Bipedalism
    - Component 7 – Vestigial Structures

- Thematic Concept B – Human Variation

  This group examines the factors that create the variation observed amongst humans from genetic makeup to physical features. Looking at evolution on a more local and even personal scale, these traits show how different environmental and genetic factors result in different adaptions and variations that distinguish people from one another.

    - Component 1 – DNA
    - Component 2 – Body Shape
    - Component 3 – Skin Color

- Thematic Concept C – Human Thought and Communication

  This section looks at perhaps the most notable human feature, our brains, in both a physical and functional sense and explores the evolutionary advantages of having such large brains. These traits illustrate some of the major milestones in the evolution of the human brain and show particularly well how both the environment and culture have shaped the course of human evolution.

    - Component 1 – Brain Size
    - Component 2 – Language
    - Component 3 – Art
    - Component 4 – Tool Use

The exhibition components will now be outlined in chronological order. Each description includes the educational goal of the experience, why the particular experience was created, what the experience entails, the design of the component, a list of the materials required for each component, and sketches and 3D renderings of the component.

Introduction

Experience Goal

Give a brief introduction to the general process of evolution so that visitors will be familiar with it and can apply it to the following components.

Why This Experience?

This experience is necessary to familiarize participants with the basics of the evolutionary process so that they have a framework in which to better contextualize the activities they will do and the things they will see in the rest of the exhibition. The panels are the first thing visitors will see upon entering, and whether they stop to read them in depth or simply glance at them, they will glean some information on the exhibition and evolution.

Visitor Experience

Participants will read text and look at pictures on brief examples of how evolution works in order to become familiar with the basic process of evolution.

Design and Production

A series of panels will form an entryway to the exhibition. As visitors pass by it, text and images will provide an introduction to the exhibition as well as a brief summary of the process of evolution and how it works.

Exhibit Components

- Panels with text and images

Label Text

Evolved: The Story of Us

Evolution tells the story of us – from our basic human traits, to why we are all different, to how we think and communicate.

As you move through Evolved, you'll explore the importance of our different adaptations and see how they came to be as a result of the environmental and cultural changes that occurred throughout human evolutionary history.

Evolution

The process of evolution has driven life on Earth for the past 3.5 billion years. From the tiniest microorganism, to the massive dinosaurs, to the grass below our feet, evolution has shaped the world both around and inside us. (images of evolutionary clock, different types of life)

For all of that it has done, evolution does not actually do that much. It is a process that occurs naturally, from generation to generation, as parents pass on their genes to their children. (image of gene tree)

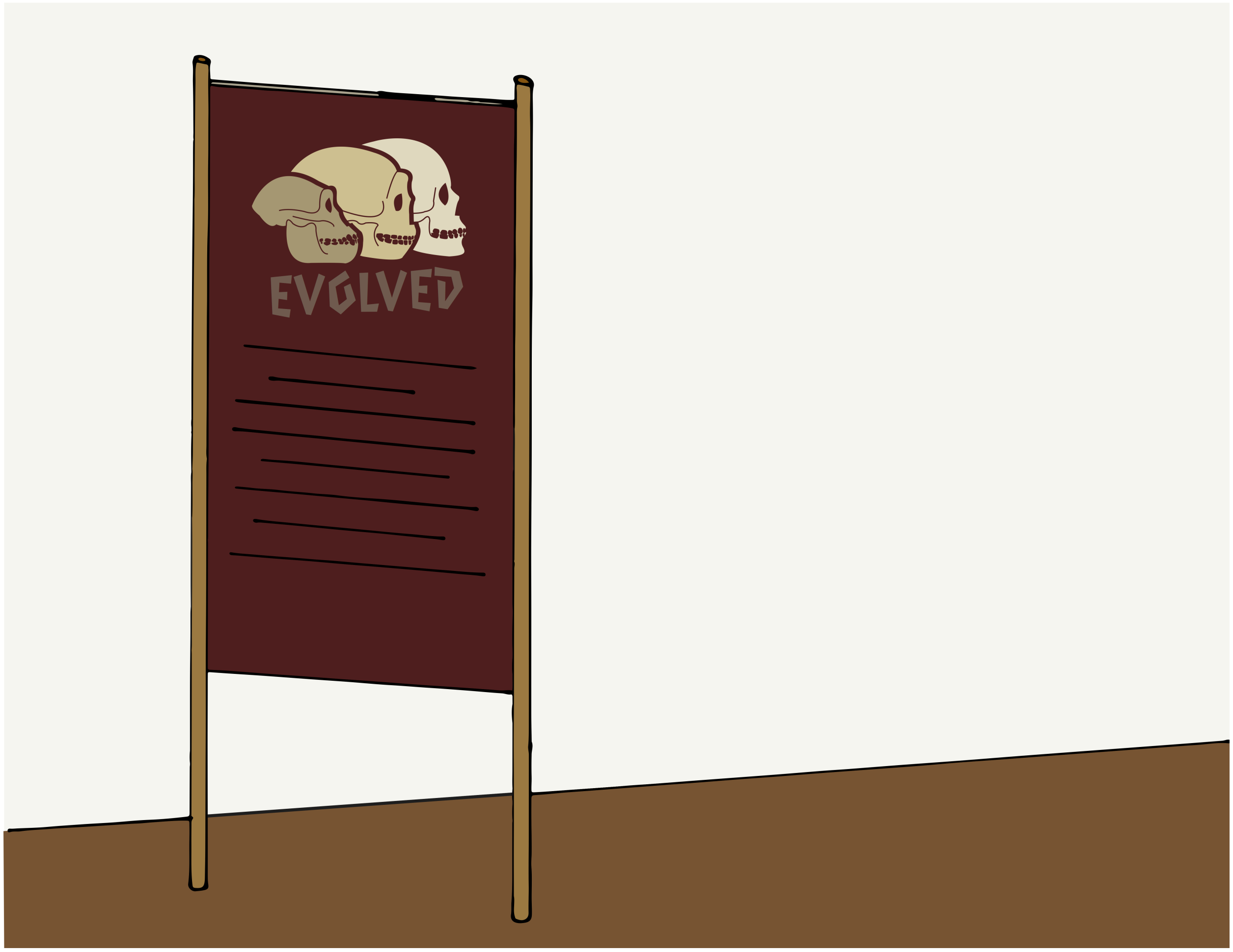
Evolution is all about two things: ***change*** *and* ***time****.*

Organisms have traits that allow them to survive in the environment they call home. As time passes, these environments change. Different environments mean organisms need different traits to survive. Individuals with beneficial traits will survive and reproduce more than others. The next generation will have more of their offspring and more of their beneficial traits. With different traits better suited to the environment, they will have evolved.

The changes from generation to generation may be so small that they go unnoticed. However, over long periods of time – thousands, even millions of years – these changes add up. With enough changes, members of a species can be very different than their ancestors, or may even become and entirely new species.

*For many organisms, evolution is a process that only occurs through genes. Humans, however, have another type of evolution. We experience **biocultural evolution**. Not only do we adapt to our environment through our genes, but also through our culture. Culture is a system of traditions, beliefs, and technologies. Our highly complex culture allows us to adapt to different environments quickly by creating new tools or inventing new technologies. These actions impact our bodies. As you move through the exhibition think about how different traits are affected by biology, culture, or both. (Photos of person wearing coat in the arctic, using a stone tool, sailing in a boat)*

Images


EVOLVED

Being Human

This section covers the basic traits that all humans share and that define us as the species *Homo sapiens*.

Label Text

> *We are* Homo sapiens*, or humans. We make up a single species and share 99.9% of our DNA with one another. In this section you'll explore the defining features of humans that we all share, many of which go back to our earliest evolutionary roots.*

Hands

Experience Goal

> Show that our opposable thumbs are evolutionarily significant because they allow us to better manipulate tools and objects. This in turn allows us to complete tasks as simple as

writing our name, or as important as hunting and butchering food as our ancestors would have done.

Why This Experience?

Opposable thumbs were an important development in primate, and eventually human evolution as they allowed our primate ancestors to get around safely and eventually allowed early humans to make and use tools. This experience allows participants to experience what it would be like if we didn't have our thumbs or the fine motor control they allow us. Through the activity, they will recognize the importance of their thumbs for completing both everyday and essential tasks.

Visitor Experience

Participants will attempt simple tasks without the use of their thumb. A table of various objects is provided for visitors to explore as they don a set of four-fingered gloves, which prevent them from using their thumbs. The tasks include: writing their name, tying a shoe, buttoning a button, picking up a cup, sealing a Ziploc bag, picking up a coin, taking a selfie, cutting with scissors, and sewing.

Design and Production

A table with a tray will hold all of the objects. Participants can gather around with their gloves and try using the different objects.

Exhibit Components

- Text/activity instruction panel
- Activity table with in inset trays that hold the various task items and hooks for the four-fingered gloves
- Four-fingered gloves (4 pairs)

- Slips of paper
- Pencils
- Shoes with laces
- Buttons and button hole fabric pieces
- Plastic cups
- Ziploc bags
- Coins
- Safety scissors
- Plastic needles
- Yarn
- Felt pieces with pre-punched stitching holes

Label Text

Hands

Two thumbs up

Thumb-less gloves

Grab a pair of thumb-less gloves down below and see if you can still do some of the things you do everyday. Try writing your name, tying a shoe, or even taking a selfie. Are you still able to do these things?

Our hands are very useful, and we owe it all to our thumbs. They are opposable – meaning that we can touch our other fingers with them. They are also extra long. Together, these characteristics allow us to grip things more carefully and with extreme *precision. Not only can we grab onto railings and hold boxes, but also thread a needle or write with a pencil. (photo of opposing thumb)*

Millions of years ago, our mammal ancestors lived in the trees, climbing along the branches in search of food. It was important for them to be able to hold on as they moved, and their hands adapted to this demand. Their thumbs got longer and more flexible, allowing them to grasp branches. (photo of Plesiadapiform climbing in trees)

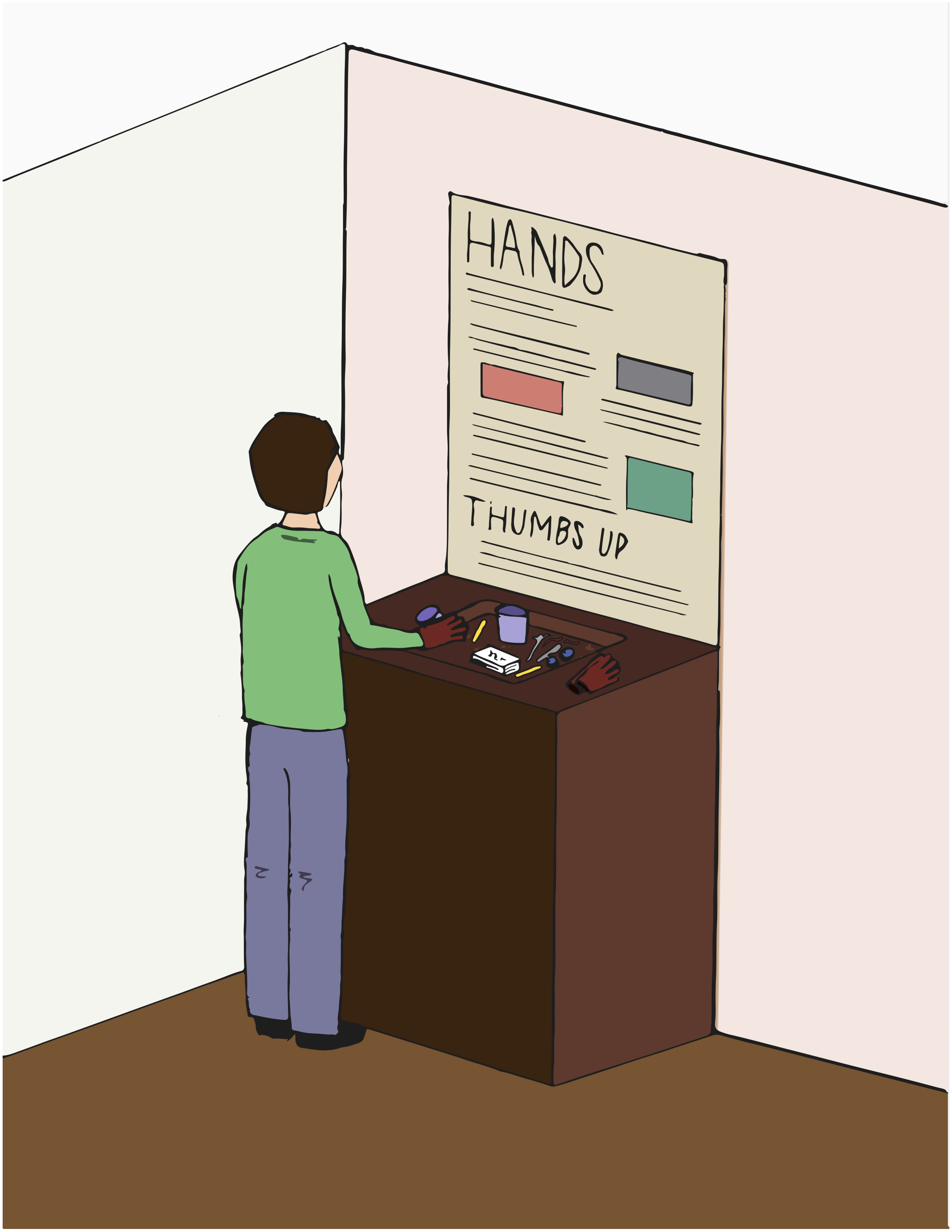
Opposable thumbs also proved to be useful beyond the trees. They allowed our ancestors to hold things carefully and control small movements. With them, they could make finely detailed stone tools for hunting and other survival tasks such as cooking and building shelters. Today we still use them to perform those simple survival tasks, as well as to communicate through writing and even interact with our modern technology. (photo of Australopith using tools; photo of human texting with thumbs)

Misconception: evolution makes every species different

Many traits are shared across different species. These same traits evolve because these organisms face similar environments and lifestyles.

Opposable thumbs are a great example of this. We share this trait with creatures throughout the animal kingdom, from other apes – who also have opposable big toes – to koalas, and even some dinosaur species. All of these animals are adapted to a life in the trees, where opposable thumbs are important. (three photos of ape opposable thumbs around branch, koala opposable thumbs around branch, dinosaur opposable thumbs).

Images


HANDS
THUMBS UP

Stereoscopic Vision

Experience Goal

Show the benefits of stereoscopic vision and to explain how this feature arose in our early arboreal ancestors.

Why This Experience?

Through this activity, participants will see the difficulty of judging distance between objects without stereoscopic vision. They will see how stereoscopic vision would have been important for early arboreal human ancestors moving through the trees, just as it is for the things modern humans do everyday that require them to judge distances both large and small.

Visitor Experience

Participants will take two pointed dowel rods and hold them directly in front of their face. With both eyes open they will touch the ends of the rods together. Then, they will close one eye and attempt to do the same thing, but, because of the loss of depth perception that comes from using only one eye, they will miss and swing one dowel rod in front of the other rather than bring them together.

Design and Production

Two dowel rods will be suspended from the ceiling by cords so that participants can easily grip and move them. The rods should be (dully) pointed to make matching them up difficult. There will be two different length sets for visitors of different heights.

Exhibit Components

- Text/activity instruction panel
- Pointed dowel rods (4)
- Adult eye height suspension cords (2)
- Child eye height suspension cords (2)

Label Text

Stereoscopic Vision

In the eye of the beholder

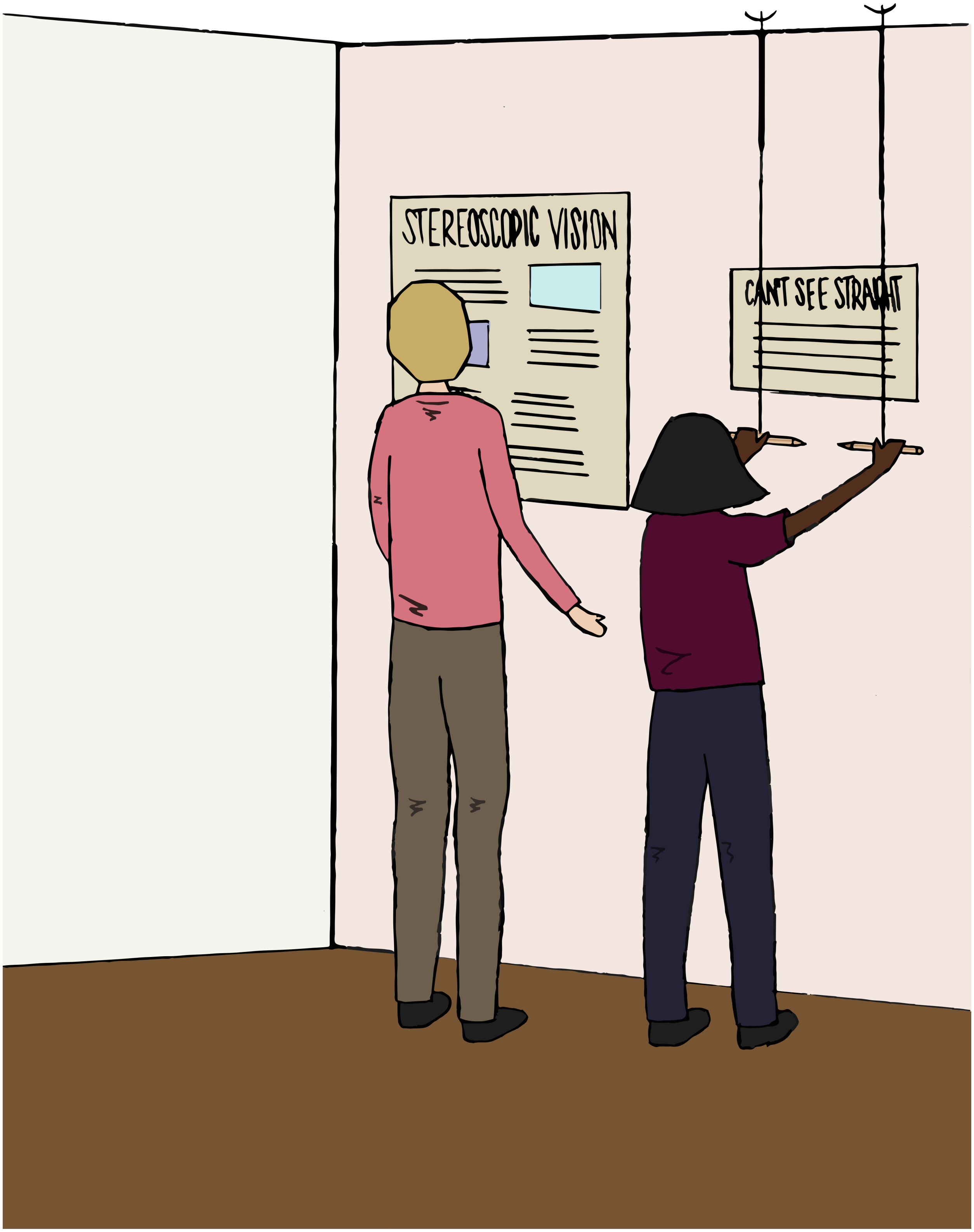
Can't See Straight

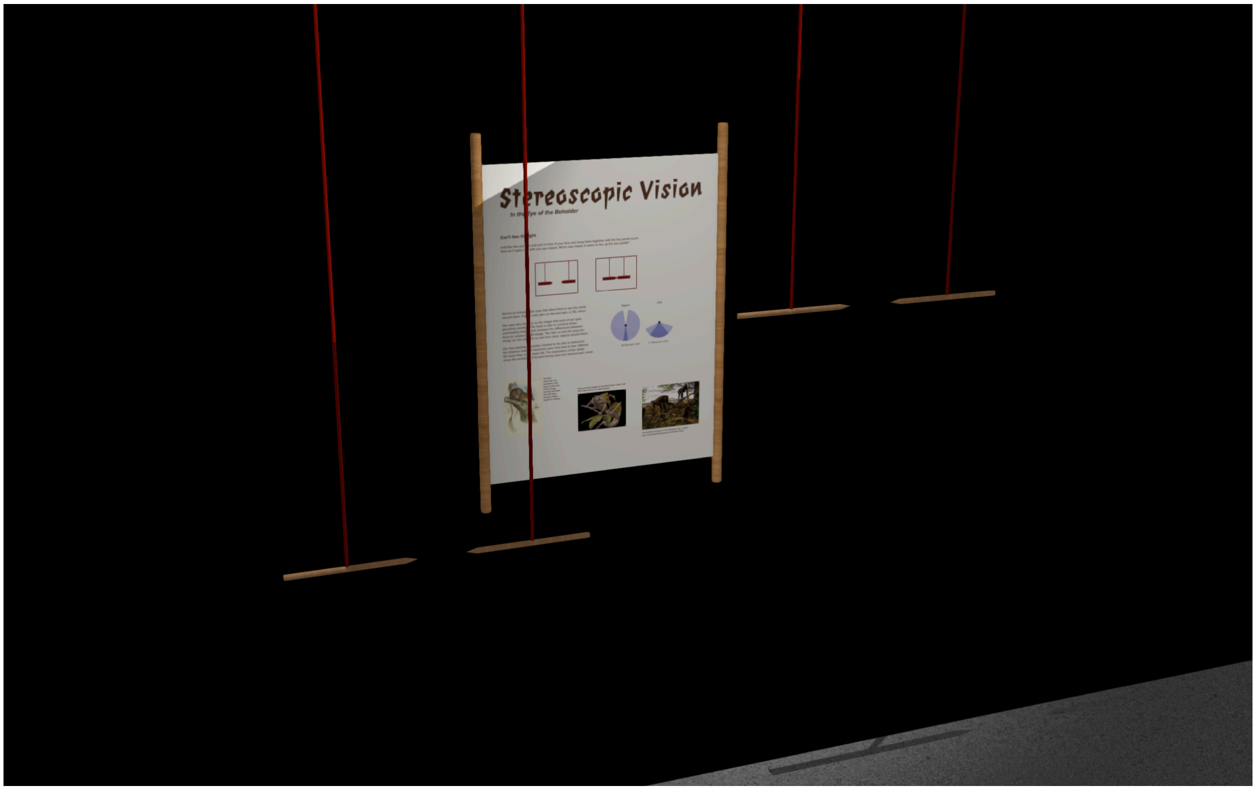
Hold the two pointed rods just in front of your face and bring them together until the two points touch.

Now try it again, but with one eye closed. Which way makes it easier to line up the two points? (photos of rods apart and rods together)

Almost all animals have eyes that allow them to see the world around them. Human eyes give us stereoscopic, or 3D, vision. (photo to compare 2D and 3D vision)
Our eyes face forward, so the image that each of our eyes perceives overlaps. The brain is able to combine these overlapping images and compare the differences between them to construct a 3D image. This tells us how far away the things we see are from us and from other objects around them. (image of overlapping vision fields in human vs. non-overlapping in horse)
Our tree-dwelling ancestors needed to be able to determine the distance between branches were from tree to tree. Without 3D vision they could easily fall. The importance of this ability drove the evolution of forward facing eyes and stereoscopic vision. (image of plesiadapiform and Miocene ape)

Images


STEREOSCOPIC VISION
CAN'T SEE STRAIGHT



Eating

Experience Goal

Demonstrate how cultural adaptations such as cooking and processing food have shaped the biological structure of the human teeth and jaw.

Why This Experience?

This experience allows participants to see how different cultural adaptations alter the foods the body must be able to process. By testing the different amounts of force needed to process the foods, they can see how the pressures for a strong chewing apparatus lessened over the course of human evolution, impacting the physiological structure of their mouths.

Visitor Experience

Participants will press down on three different "tooth" buttons, which will push into "unprocessed corn," "ground corn," and "cooked cornmeal" respectively. The less processed the corn, the harder it will be to push down the tooth.

Design and Production

Three oversized molar-shaped tooth buttons will rest over openings in a stand. Through a glass window in the stand visitors will be able to see images of the different types of processed corn so that they can identify each type. The button will push into plastic or foam with the appropriate tension for the food it represents.

Exhibit Components

- Text/activity instruction panel
- Activity stand
- Buttons and insets (3)
- Plastic "corn kernels"
- Plastic chip "ground corn"
- Foam "corn mush"

Label Text

Eating

Chew on this

Thousands of years ago, the average human hunter-gatherer spent around 8 hours a day chewing. Today we spend about 30 minutes.

This change is the result of food processing. Our early ancestors ate food raw. They needed large, strong jaws and teeth to break down tough plants and meat so that they *could digest them. Gradually though, new inventions such as stone tools and cooking fires arose, allowing our ancestors to break down food before eating it. Today, without the pressures of chewing tough foods, our jaws are considerably smaller than those of our ancestors. (images of mortar and pestle, cooking fire, hunter-gatherer jaw vs. modern human jaw)*

Our teeth are a different story. They haven't changed, and now with smaller jaws dental problems have become very common. From wisdom teeth to overbites, many modern dental issues are a result of our teeth adapting to dietary pressures at a slower rate than our jaws. (image of malocclusion, wisdom teeth)

Whack-a-tooth

Press down on the teeth to see what it takes to chew the different foods.

Corn

Most food is naturally very hard to eat. Like the corn kernels below, unprocessed foods take a lot of effort to chew. Before cooking or tools, our ancestors ate these types of tough foods. A diet like this requires large, powerful jaws and teeth. (image of corn and hominin eating)

Ground Corn

With the invention of stone tools around 3 million years ago, human ancestors began processing food. By breaking food down with tools before they ate it, eating became much easier. Jaws no longer needed to be large and powerful enough to do the work tools were doing. (image of ground up corn and hominin eating)

Cornmeal

Eventually human ancestors learned how to harness the power of fire to cook food. Cooking allowed them to break down food even further, making it softer and even easier to chew. Today we cook almost all of the food we eat. Our jaws are no longer doing the food processing work taken over by our tools and cooking, and thus have become smaller. (image of cooked cornmeal and human eating)

Images


TEETH

Homeostasis

Experience Goal

Explain how different temperature regulation mechanisms evolved and how they provide an evolutionary advantage.

Why This Experience?

This experience shares some of the ways the human body has evolved to maintain homeostasis, or balance. By moving the board out of balance, participants can learn about what happens when the body gets out of balance from an extreme temperature in either direction. This tangible balance activity helps to convey what the process of maintaining homeostasis is all about.

Visitor Experience

Participants will tip the balance board in the middle of the display, revealing on one side information about adaptations for keeping cool such as sweating, and on the other side information about adaptations for staying warm such as shivering.

Design and Production

The display board will have two empty cutout windows into which the text to be read and a symbol indicating weather it is a hot or cold adaptation will slide when the board is pushed down in the opposite direction of the text.

Exhibit Components

- Main text panel
- Balance board
- Moving text panel (attached to the balance board for movement)

Label Text

Homeostasis

Striking a balance

Homeostasis is a state of balance. All living things maintain homeostasis through a variety of natural processes that help the body respond to extremes it faces.

Tip the wheel to see how our bodies have adapted to respond to heat and cold.

Beat the Heat

Heat can lead to heatstroke and permanently damage organs. Because of this, it is important for us to be able to cool ourselves down. (photo of person sweating, diagram of sweating cycle)

Animals cool off in all sorts of ways. Dogs pant, elephants and rhinos have lost the hair that once covered their Ice Age ancestors, and many desert animals are active only during the cooler nighttime. Our bodies cool off by sweating. (photos of panting dog, wooly mammoth and elephant, nocturnal desert animal)

While it may seem like we got the stinky end of the deal, sweating is very effective. Our early ancestors lived on the savannahs of Africa – a hot area with very few places to stay out of the sun. It was important for them to be able to stay cool, especially when they were running long distances in search of food. In order to do so they lost the body hair they once had and developed more sweat glands. (photo of the savannah)

There's a Chill in the Air

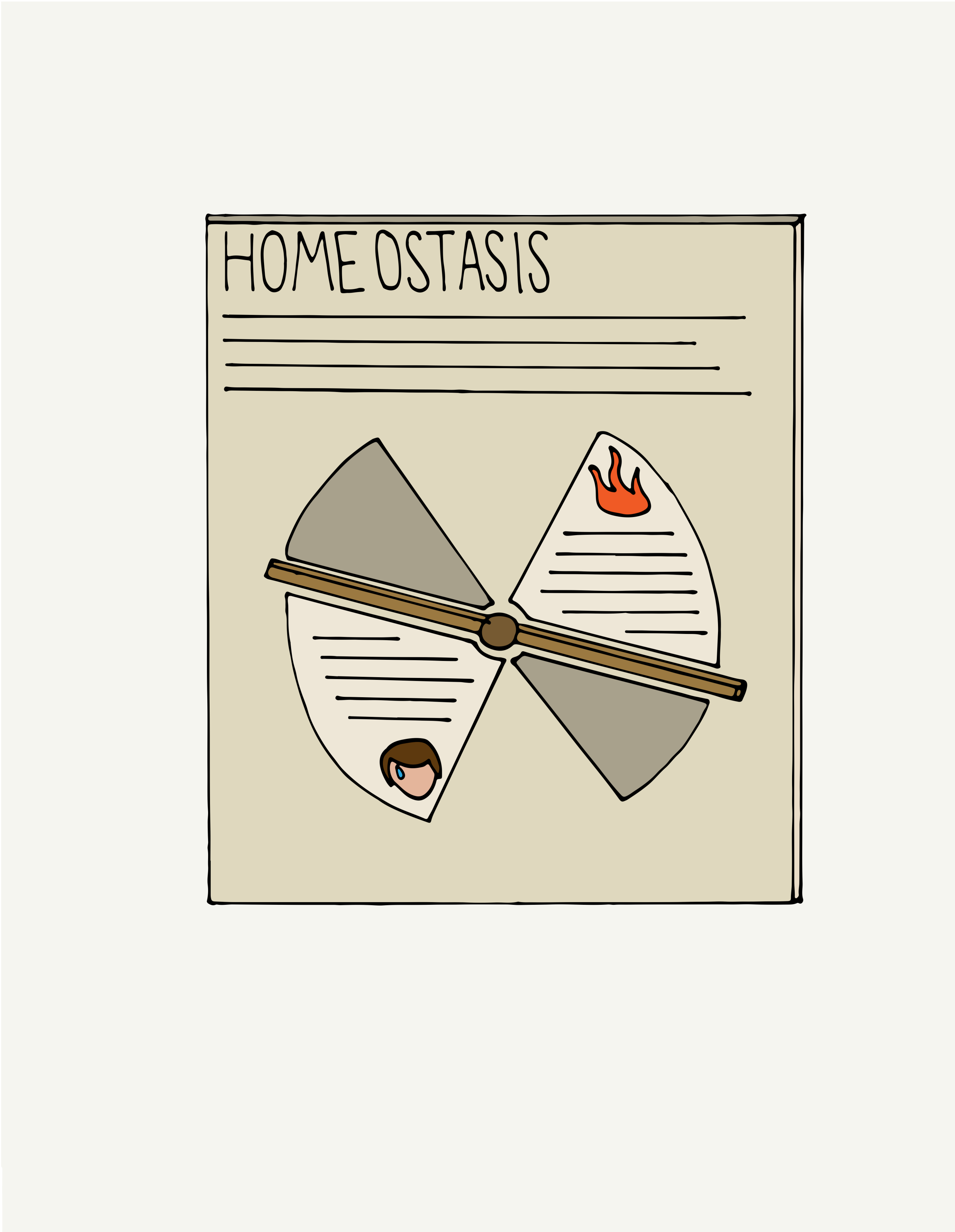
Cold can lead to frostbite and extreme strain on the heart and lungs. Through different processes our bodies help us to stay warm in the cold. (photo of person in the cold, diagram of shivering cycle)

Many animals that live in cold environments have adapted to staying warm through heavy fur coats or thick, fatty skin. We humans have neither of those things, so our bodies must stay warm in a different way. (photos of polar bear and seal)

One way we keep warm is by shivering, a trait we inherited from our mammal ancestors. As early humans began to spread around the globe, they encountered new environments. Some of these, like Europe, Northern Asia, and the Arctic, were very different than the

> *hot savannahs they once came from – they were cold. Biological mechanisms such as shivering became important in helping people to stay warm in these climates. (photo of people in arctic)*

Images


HOME OSTASIS

Feet

Experience Goal

Highlight human bipedalism and demonstrate the differences between feet adapted to bipedalism and feet adapted to quadrupedalism. This component is related to the bipedalism component and serves as a good introduction to the topic of bipedalism.

Why This Experience?

This experience allows participants to compare their foot shape and number of feet with those of other animals. They are able to see how their feet compare to those of other animals who use them in different or similar ways, as well as think about how the way animals use their feet leads to different foot morphologies. By placing the component on the floor, participants are constantly focused on how they are walking and using their own feet.

Visitor Experience

Participants will walk around on a projected surface of different animal footprints. The footprints will represent both quadrupedal and bipedal animals of all sizes to allow for a wide comparison. As participants walk across the surface the will leave a projection of their own human footprint, which they will be able to see and compare with the other footprints around them. These footprints will fade as they walk away, leaving room for other participants.

Design and Production

A projector will project the images onto the floor, and sensor will be used to track where participants step in order to project their human footprints as they move. The label will also be on the floor so visitors can easily read more about what they are seeing as they look around at the feet.

Exhibit Components

- Text/activity instruction panel
- Projector
- Projection
- Tracking sensors

Label Text

Feet

Step two it

As you walk around, compare your footprints to those of the other animals. What similarities do you notice? What differences?

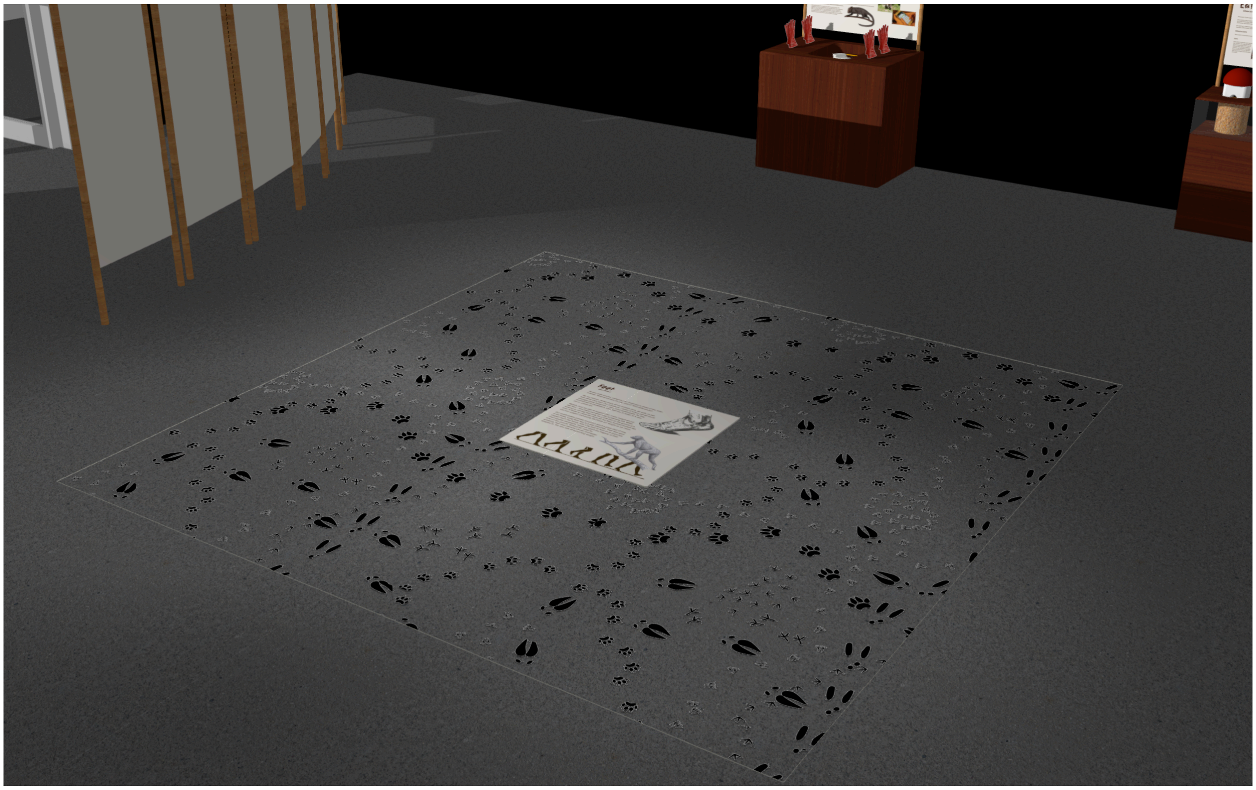
We are bipeds. Unlike many of the animals here, we walk on two feet rather than four. Our ancestors – some of whom can be found amongst these footprints – were once quadrupeds. As they transitioned to bipedalism, their feet had to adapt to a new set of pressures.

Bipeds must be able to support their entire weight on just two feet – and that's just when they're standing still. While walking or running they only have one foot on the ground at a time. In order to meet this demand, we have evolved arched feet that can support and evenly distribute our weight as we move. (diagram of feet walking)

Our quadrupedal primate ancestors spent a great deal of time in the trees, using their feet to grasp branches. Their feet were shaped much like hands, with long toes to hold on to branches. Their bipedal decedents, however, spent the majority of their time on the ground. Without the need for grasping, their toes became shorter and better adapted to the new task of supporting weight. (image of Ardipithicus ramidus foot vs. human foot)

Images


FEET



Bipedalism

Experience Goal

Describe the suite of features that modern humans possess that make it possible for us to be bipedal. Show these features help make us more efficient bipeds, as well as how they, and bipedalism in general, impact other areas of our biology and lives.

Why This Experience?

Bipedalism is one of the key features of humans, and this module demonstrates the breath and depth of the changes that occurred to make bipedalism possible. A variety of activities allow participants to explore these features through comparisons with our ancestors or other species and interactive challenges. The Formen Magnum activity allows participants to examine the placement of the formen magnum as an indicator of bipedalism just as anthropologists do. By comparing at the placement of the spine in quadrupeds and hominin ancestors to its placement in humans they can see how the position of the spine changed in the bipedal transition. The Arthritis activity demonstrates one of the flaws of bipedalism by challenging participants to hold up the amount of weight that the average human pelvis and lower limbs must support 24/7 for several decades. The difficulty of this will show people just how much stress bipedalism places on the lower half of the body and lead them to think about how this pressure results in conditions such as arthritis. The Spine activity, attempting to bend over while standing against the wall, helps to demonstrate what a center of gravity is and why it is so important for balance. This leads into a discussion of how the spine became reoriented during the bipedal transition to place the center of gravity more efficiently. In Childbirth, participants explore another of the flaws of bipedalism, the obstetric dilemma, wherein the pelvis must be as narrow as possible for efficient walking, but wide enough for a baby's head to pass through. By attempting to pass the infant skull through the different pelvises, participants will see how evolution has lead to a compromise between these two necessary traits in the actual human pelvis. The Legs activity demonstrates how our knees have adapted to bipedalism by helping to center our center of gravity. By attempting to walk with a box between their knees, thereby bending their knees outward instead of inward, participants will see how difficult bipedalism is without this trait.

Visitor Experience:

This component will consist of six different activities, each exploring a different aspect of bipedal adaptation:

- Foramen Magnum: Participants will place "spine" rods in different "skulls" to see how the positions of the foramen magnum are different in bipeds and quadrupeds.

- Arthritis: Participants will attempt to lift a heavy weight to see how much weight is balanced on their legs and how, over time, this leads to the development of arthritis.
- Spine: Participants will stand against the panel and attempt to bend over and touch their toes to demonstrate the principle of the center of gravity, which has lead to the reshaping of our spines.
- Childbirth: Participants will attempt to pass an infant skull through three different pelvises, each optimized for different demands to demonstrate how the shape of our pelvis is compromise between the demands of childbirth and the demands of walking on two legs.
- Legs: Participants will attempt to walk with a box between their knees to force their knees to bend outward.

Design and Production

Each activity in this component will be on one side of a 6-sided stand. Participants can move around the stand in any order.

- Bipedalism/Introduction: A short text and images
- Foramen Magnum: Three skull models, human, hominin ancestor, and chimpanzee, will be mounted to the panel. A bin secured to the panel will hold the "spine" rods, which can be taken out to do the activity. The foramen magnum holes in the skulls will allow the spine rods to be placed into them.
- Arthritis: A vertical track will hold a 50 lbs. block weight that visitors can attempt to lift with handles on the sides of it.
- Spine: An outline of where guests should stand in order to do the activity will be posted on the panel.

- Childbirth: Three pelvises will be mounted on the panel in order from optimal bipedal to optimal birth. The infant skulls will be attached to extending cords that allow them to rest against the panel but be pulled out to use for the activity.
- Legs: A bin mounted to the panel will hold several lightweight boxes that visitors can take out and use to do the activity.

Exhibit Components

- Text/activity instruction panels
- "Skull" spheres: human (hole on bottom), hominin ancestor (hole at angle between back and bottom), chimpanzee (hole in back)
- "Spine" rods (3)
- "Spine" rods bin
- Weight block (50 lbs.) with handles
- Track for weight to lift on
- Pelvis models: optimal bipedal pelvis, optimal childbirth pelvis, standard human pelvis
- Infant skull model (3)
- Infant skull model suspension cord (3)
- Boxes
- Boxes bin

Label Text

Bipedalism

Humans are bipeds, meaning we walk on two legs. Our ancestors, however, were quadrupeds – they walked on four legs. Over the course of human evolution many *changes occurred that allow us to go from four to two-legged walking. These changes have had in impact on the way our bodies look and work. (photos of quadrupedal primate ancestor and modern human biped walking)*

Why Bipedalism?

There is no clear, single reason why humans first became bipedal. There are a range of theories, and it is likely that they all played a part in driving the human lineage toward bipedalism.

Once bipedalism began, though, its advantages were clear. Walking on two legs (and having free hands) allowed our early ancestors to:

(images of different bipedalism hypotheses – standardized look)

1) *Carry objects like food back to homes and families*
2) *More efficiently travel long distances*
3) *See better over the tall savannah grasses*
4) *More efficiently control body temperature*
5) *Make and use tools*
6) *Use weapons to hunt bigger and better prey*

As you move around this display you will explore some of these changes and the impacts they have had.

Spine

Stand with your back flat against this wall. Now, bend over and try and touch your toes. Can you do it? (image of someone doing activity)

Our spine is uniquely curved to help us maintain our center of gravity as we walk on two feet. (diagram of human center of gravity) This is important because it keeps us from loosing our balance and falling over, like you probably did when you tried to touch your toes while standing against the wall.

The curve in our lower spine keeps our torso from leaning forward. The curve in our upper spine keeps our head in line with our torso. By centering the upper half of our body over our hips and feet, the spine saves us the energy of having to balance ourselves with every step we take. (model of curved human spine)

The spines of quadrupeds like our ancestors do not have this lower curve. Though beneficial for balancing their weight between four legs, when it comes to walking on two legs it puts their center of gravity too far forward and makes balancing difficult. (model of a quadruped spine)

Childbirth

Try and pass the fetus's skull through each of the pelvises. Which one is easiest? Which is the hardest?

In childbirth, a baby's head must pass through the opening in its mother's pelvis. This means that the human pelvis must be wide enough for our big-brained babies. However, walking on two legs works much better with a narrower pelvis.

This dilemma resulted in an evolutionary compromise: our pelvis is as narrow as it can be for efficient walking, while being just wide enough for a baby's head to pass through.

The journey from the womb to the world is by no means easy. Mothers must endure considerable pain as their pelvis is stretched to accommodate their infant's large head, and obstetricians and other childbirth specialists must carefully navigate babies through the narrow birth canal. Even with today's modern medicine, childbirth can be difficult and dangerous for both mothers and babies. (childbirth photo)

Misconception: evolution produces perfect organisms

Evolution cannot create ideal traits, it can only shape what organisms already possess. It also must make compromises between the demands of different parts of the body, like in the case of childbirth. Because of this, even successful organisms that are well adapted to their environment can have limitations to their abilities or flaws that can be harmful to them.

Foramen Magnum

The foramen magnum is the large opening at the base of the skull. The spinal cord passes through it to transmit brain messages to and from the rest of the body. (picture diagram of foramen magnum).

To see what the foramen magnum can tell us about locomotion, try placing the spine rods in place on the different skulls. How is the monkey's spine placed differently than the humans?

Because our ancestors were quadrupeds, their foramen magnum was located at the back of their head, much like a monkey's. This allowed their head to naturally face forward when they walked on four legs.

However, this position was less effective as human ancestors shifted to bipedalism. It meant the muscles in the neck had to work extra hard to keep the head facing forward. Gradually, the strain of this feature on our ancestors resulted in the foramen magnum shifting underneath the skull. This allowed the face to naturally look forward much more comfortably and efficiently. (images of quadruped spine/skull position and biped spine/skull position)

The position of the foramen magnum underneath the skull is also tied to increasing brain size. Its move provided more room in the skull for the brain to expand, especially in the parts that deal with language, problem solving, and social behavior. (image of brain)

Arthritis

Lift the weight and see what it's like to be your leg bones. The average person's upper half weighs about 50 pounds – pretty heavy for just a few bones.

In order to move efficiently on two legs and maintain our balance, our weight is centered over our hips and feet. While this is necessary for walking, it places a great deal of pressure on our hip and knee joints.

Joints are plates of a smooth, rubbery tissue called cartilage that form at the places where bones meet. They cushion the pressure placed on bones by movement. Throughout a person's lifetime these cartilage layers wear down through use, leaving the bones to *rub against each other. This painful condition is known as arthritis. (image of joints and cartilage)*

Modern procedures like knee and hip replacements offer the chance to restore the use of these deteriorated joints. These are some of the most common medical procedures in the US today. As people live longer and wear down their joints more and more, they are likely to increase even further. (knee and hip replacement rates graph)

Staying healthy

Arthritis is the result of pressure wearing down on joints over time. The more pressure that is placed on the joints, the more rapidly arthritis will develop and the worse it will be. Because of this, rates of arthritis are higher in people who are overweight or extremely active. (photos of eating fast food and football player)

Keeping your joints healthy is all about having a balanced lifestyle. Some of the best ways to prevent arthritis are maintaining a healthy weight and engaging in regular, moderate physical activity. This helps to keep joints active, but not overly stressed. (photo of older people exercising)

Legs

Place one of the boxes between your knees and try to walk. Can you do it?

Quadrupeds, like our primate ancestors and modern chimpanzees, have straight legs. This works out just fine as they walk because they always have at least two feet on the ground providing a base of support. However, when they try to walk on two legs, it is *very difficult. Much like trying to walk with the box between your knees, their gait is wobbly and slow. (images of human vs. chimp bones and walking)*

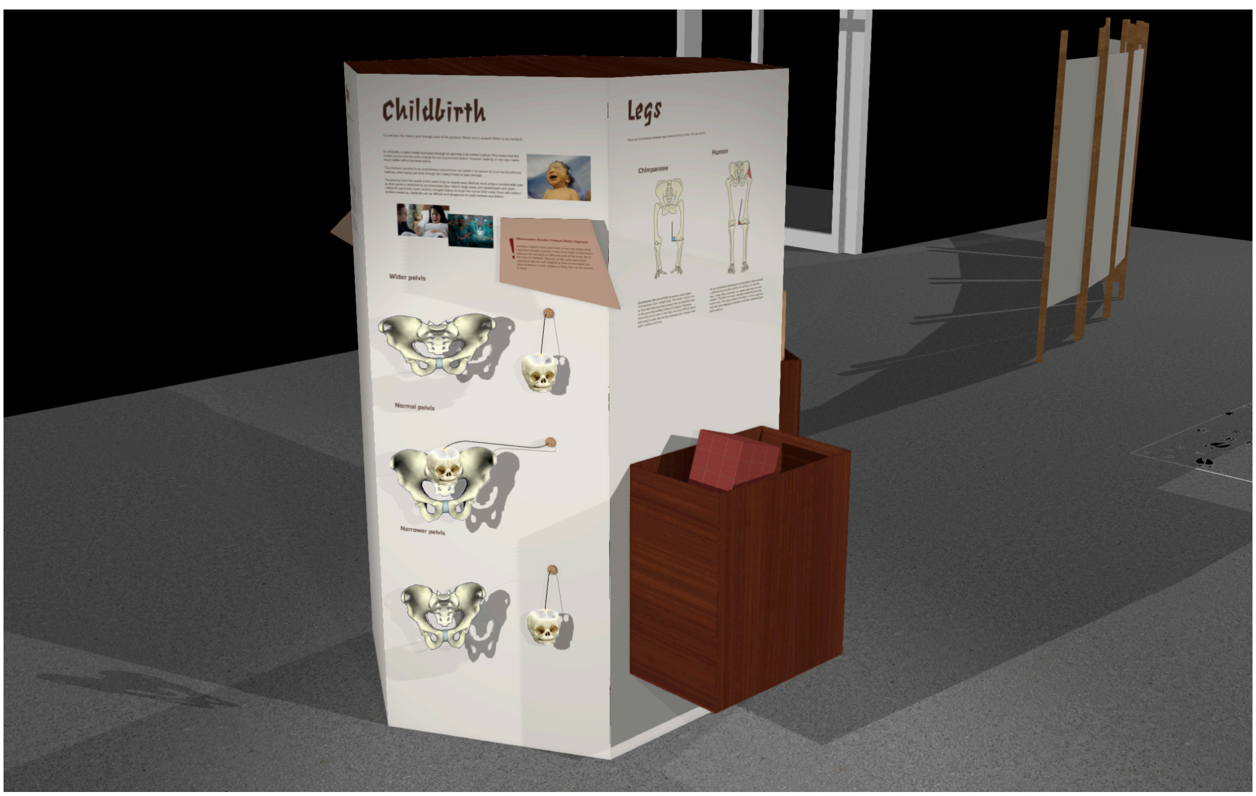
As our ancestors transitioned to bipedalism, they evolved a different leg structure better for walking on only two legs. Unlike other primates, our upper leg bones are not straight. The form an angle, bending inward from the hip to the knee. This angle keeps the body's center of gravity over the feet, helping to maintain a smooth, balanced gait while walking. (images of bicondylar angle, walking stride)

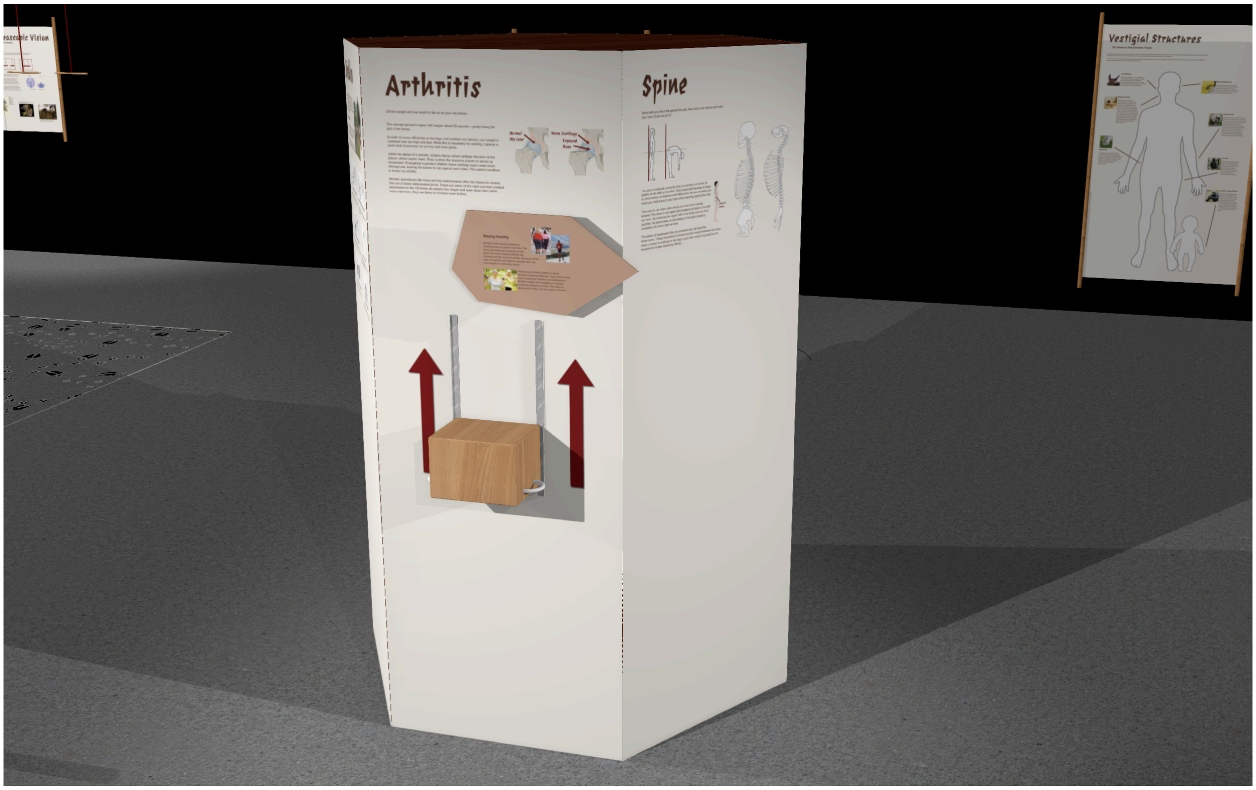
Images


FORAMEN MAGNUM
BIPEDALISM
ARTHRITIS


SPINE
CHILDBIRTH
LEGS


Foramen Magnum
Bipedalism
The Human Brain


Childbirth
Legs
Wider pelvis
Normal pelvis
Narrower pelvis
Chimpanzee
Human



Vestigial Structures

Experience Goal

Show that while evolution can lead to many beneficial adaptations, it can also lead to useless features.

Why This Experience?

This experience explains to visitors what vestigial structures are and gives examples of them with in their own body, showing what they physically look like and where they are within the body. Through the selection of structures, the diversity of vestigial structures in terms of part of the body, function, and impact is demonstrated.

Visitor Experience

Participants will observe a display of the vestigial structures of the human body showing models of the structures and will read explanations of their evolutionary origins and why they are no longer functional.

Design and Production

Models of the different vestigial structures will be secured to the silhouette backdrop.

Exhibit Components

- Text panel with silhouette of the human body in the center
- Model mounts
- Tailbone model
- Ear muscle model
- Eye model
- Appendix model
- Arrector pili model
- Teeth model
- Infant hand model

Label Text

Vestigial Structures

The features that evolution forgot

Vestigial structures are body parts or behaviors that do not have a functional purpose, but are left over from our evolutionary ancestors. When these traits first evolved they were useful, but over time changes in the environment and other adaptations made them unnecessary.

In most cases, natural selection weeds out features that do not help organisms to survive. However, vestigial structures do not have any strong negative effects, so there is no pressure for them to be completely removed.

Coccyx

Most people probably know this bone as the tailbone. It is the remnant of the bones that supported a tail in our evolutionary ancestors. Because we do not have a tail, it is small and it mainly serves as a place for different muscles to attach.

Ear Muscles

We have muscles in our ears that our mammalian ancestors used to turn their ears, allowing them to hear better. However, we are able to turn our heads more than they could, making ear muscles unnecessary for focusing hearing. (picture of monkey with turned ears)

Plica Semilunaris

The plica semilunaris is the small tissue flap in the inner corner of the eye. It is the remnant of a "third eyelid" that mammals, reptiles, birds, and sharks use to protect their eye while still being able to see. (picture of plica semilunaris)

Appendix

The appendix is an organ located where the small and large intestines connect. In herbivores it helps to digest cellulose-rich plants, but we have fewer plants in our diet so we don't rely on it as much. Many people have their appendix removed without consequence.

Arrector Pili

Arrector pili are the small muscles at the base of all the hairs on our body. They are responsible for goosebumps and making our hair stand up. In the past, this helped our mammal ancestors to keep warm by raising their hair to increase the thickness of their fur coat. But this reflex also happens when we are scared. This was also beneficial for our hairier ancestors because it helped them appear larger to scare away threats. (picture of a cat with its hair raised)

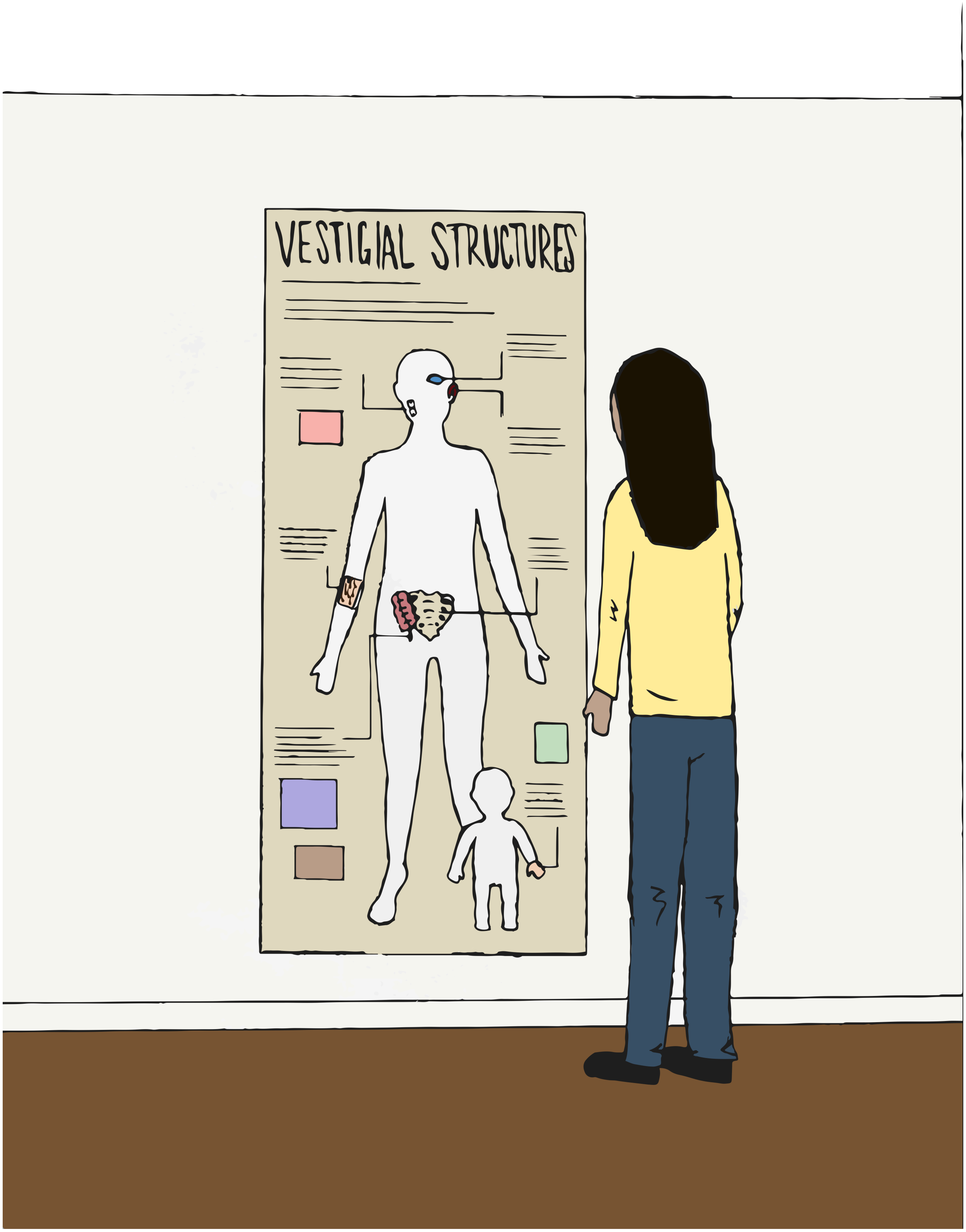
Wisdom Teeth

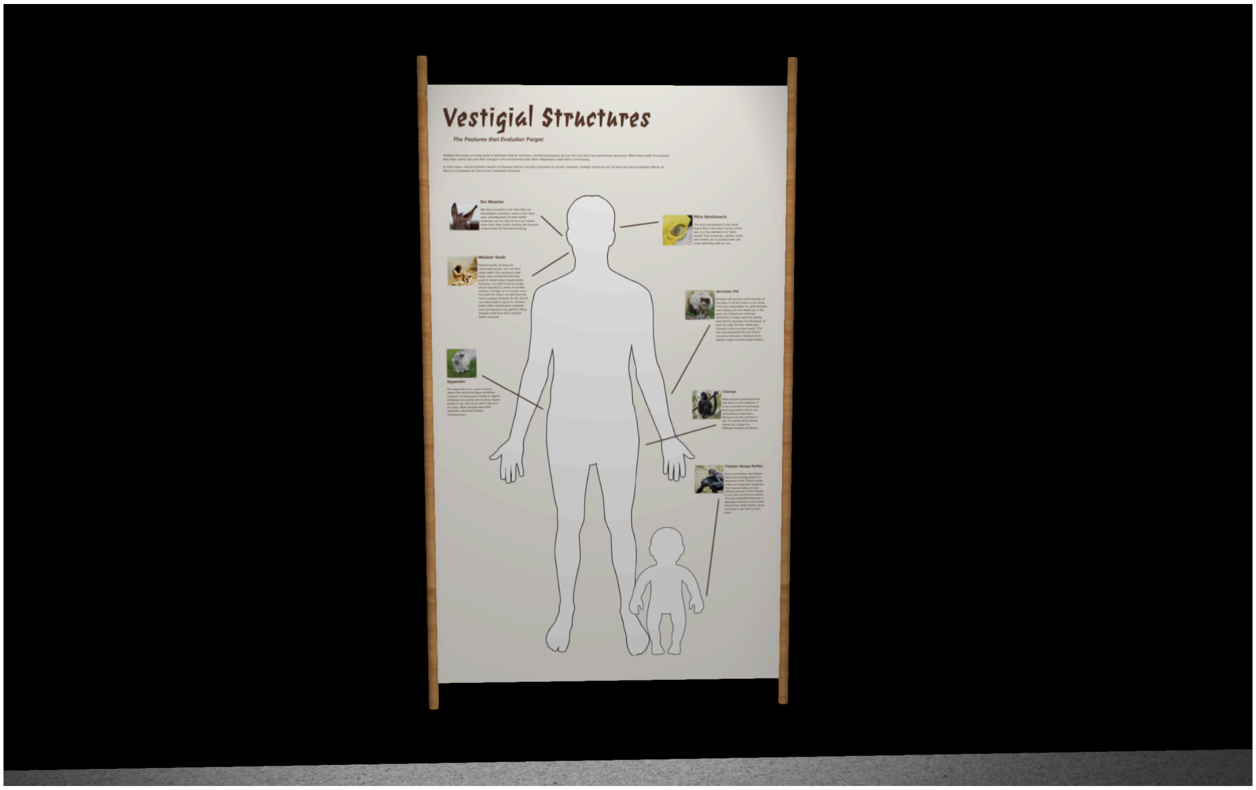
Wisdom teeth, as they are commonly known, are our third molar teeth. Our ancestors had larger jaws and teeth that they used to break down tough plants. However, our diet is not as tough, which has led to a trend of smaller mouths. Though we no longer have the room for them, we still have the same number of teeth. As the last of our adult teeth to grow in, wisdom teeth often cannot grow correctly and can become very painful. Many people must have their wisdom teeth removed.

Palmer Grasp Reflex

Every wondered why babies have such strong grips? It is because of the Palmer grasp reflex, an automatic response that causes babies to grip objects placed in their hands. In our hair-covered ancestors this was important because it allowed mothers to have their hands free while infants clung securely to the hair on their back. (chimpanzee baby on mother's back)

Images


VESTIGIAL STRUCTURES



Human Variation

This section examines the factors that create the variation observed amongst humans from our genetic makeup to our physical features.

Label Text

> *It is easy to see that not all humans look the same, so what makes us different? That's where that 0.01% of DNA we don't share comes in. In this area you'll explore how and why we are so diverse.*

DNA

Experience Goal

> Explain the underlying genetic system that unites us all, as well as the ways in which just a few small changes to our DNA separate us from our ancestors and create so much variation among us.

Why This Experience?

This experience demonstrates not only the importance of DNA as the basic material on which evolution acts to shape our physiological appearance, but also how changes in DNA arise through mutation. As participants translate DNA just as the cell does and naturally make errors of their own, they will see how mutations occur in DNA through mistakes in the translation process. Additionally, this module can act as a transition between the previous thematic grouping and its own by examining the system through which human genes are shared and altered, leading to not just the similarities seen in the previous section, but the differences that will be seen next.

Visitor Experience

Above a digital screen will be a line of DNA code and on the digital screen will be successive lines of that code translated by previous participants. The participant doing the activity will read the bottom line of code and translate it using the base pair buttons. Their translation will appear at the bottom of the screen, and when they have completed it they will compare it with the line of code from which they translated, as well as the original. Any mistakes they made will count as a mutation, and they can see how frequent mutations were not only in their single translation, but also over the time since the original line was translated.

Design and Production

The digital screen will have a simple display of successive lines of DNA code. Pressing the buttons for each base pair letter will select them and send them to the screen, where they will make up a new line of code. Once a line of code is full the activity is complete and a window announcing the number of mutations from the previous line and since the beginning will pop up for the participant to see.

Exhibit Components

- Text/activity instruction panel
- Digital screen
- Mantle for buttons
- Buttons (4)
- Electrical
- DNA transcription computer program
- Computer

Label Text

DNA

Coding life

DNA is the genetic material found in every cell in your body. It's like a reference manual, telling your cells what to do and how to make you. DNA is made of long strings of molecules similar to letters in the alphabet. Their order spells out instructions for the cells to follow. Cells read these instructions by translating the molecules. (images of DNA and of base pairs)

Be the Cell

Use the buttons to translate the line of DNA code at the bottom of the screen.

There are four types of molecules in DNA: Adenine, Thiamine, Guanine, and Cytosine. The are translated by converting:

Adenine (A) ➔ *Thiamine (T)*

Thiamine (T) ➔ *Adenine (A)*

Guanine (G) ➔ *Cytosine (C)*

Cytosine (C) ➔ *Guanine (G)*

When you're done, compare your translation with the line at the top. This was the original DNA code that started this morning. See how it's changed throughout the day.

Translating the pattern correctly is how cells normally function. They translate bases to make copy after copy of our genetic material, passing on the same information.

If DNA were always replicated in this way, though, evolution would never occur. Every organism would remain exactly the same, and the only life on Earth would be single cell organisms floating in the ocean. (image of first life)

What really happens is that sometimes cells mess up. These mistakes are called mutations, and they can affect the way our body works or looks. They vary from the addition of an extra chromosome, causing Down Syndrome, to the appearance of a new eye color. Many have no effect at all. When a mutation is beneficial, it helps an organism survive and have more offspring, and it will be passed down through generations. (photos of different mutations)

From person to person, DNA varies. Different people have different mutations and different genes they receive from their ancestors. These unique genes comprise less than

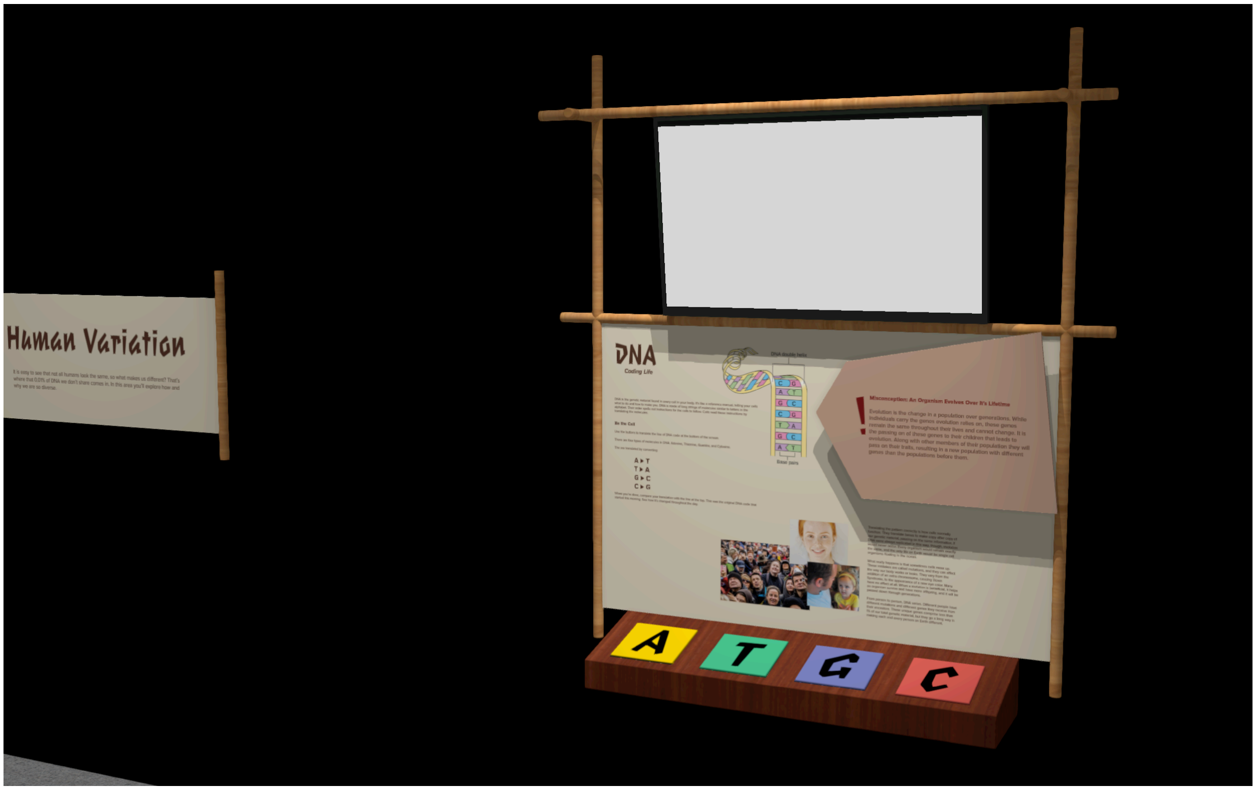
1% of our total genetic material, but they go a long way in making each and every person on Earth different. (photo of group of people)

Misconception: an organism evolves over its lifetime

Evolution is the change in a population over generations. While individuals carry the genes evolution relies on, these genes remain the same throughout their lives and cannot change. It is the passing on of these genes to their children that leads to evolution. Along with other members of their population they will pass on their traits, resulting in a new population with different genes than the populations before them.

Images


DNA
AGCAATTTCGGATCCAGT
TCGTTAAAGCGTAGCACA
AGCAATTTCGCTTCGTGT
TCGTATTTGCG
T
G
C



Body Shape

Experience Goal

Show how different environmental factors can affect the body shapes of humans in different climates, demonstrating Allen's and Bergmann's rules.

Why This Experience?

This activity visually demonstrates Allen's and Bergmann's rules, which state that body size and shape are a factor of climate and reliant on surface area to volume ratios that help to maintain normal body temperature and function within that climate. By first looking at familiar animals and comparing their body shapes between the different climates they call home, visitors are familiarized with this idea. They can then look at how it relates to humans by pulling out the screen to see the similar body shapes of humans native to such climates.

Visitor Experience

Participants will match animals to the climates they originate, either desert or tundra, by placing magnets of the animals on climate backdrops. A list of climate demands will help them to decide which animals would belong in which environment. They will compare the body shapes and sizes of the animals in the different climates and consider how humans in those environments might look based on the trends they see. When they are done they can pull out a screen that reveals the correct matches, as well as human body size trends for those climates. Text on the screen will explain the reasons for these trends.

Design and Production

The animal magnets will be cutouts of common desert or tundra animals that demonstrate the typical adaptations of their climates. The magnetic backdrops will be photographs of desert and tundra scenes. The screen will pull out over the tray when visitors are ready for the answer and retract back when not in use.

Exhibit Components

- Text/activity instruction panel
- Tundra magnetic backdrop
- Desert magnetic backdrop
- Mantle with tray to hold animal magnets
- Animal magnets (12; 6 desert animals, 6 arctic animals)
- Retractable screen

Label Text

Body Shape

All shapes and sizes

Climate Matchup

Sort the animals below into the habitats they are known to come from.

Observe the differences in the body shapes of the animals between the two habitats. What trends do you see? When you think you've got the right answer pull the screen out to check – and to find out how these trends relate to humans.

Desert

These trends can be seen in humans too. People who come from hot, tropical climates like the deserts of sub-Saharan Africa tend to be taller and leaner. (image of Maasai people)

Tundra

People from Artic regions and other cold climates tend to be shorter and stockier. (image of Inuit people)

Differences in body size are a result of the need to maintain a stable body temperature. In hot climates, people need to be able to cool off. By being thin and taller their body has more surface area to cool off with. In cold climates, on the other hand, people need to be able to stay warm. These climates have driven the evolution of stockier bodies with less surface area to prevent heat loss and keep people insulated from the cold.

Why don't people's bodies always follow these trends?

There are many factors that affect body size and can lead people to deviate from these trends.

Diet and nutrition are an extremely important part of our adult body size. Excessive eating can lead to larger body size. Poor nutrition, especially in young children, can lead to low body weight and decreased height. (photo of food)

Genes are also an important factor. Your ability to loose or gain weight is affected by a complex mix of bodily functions involving hormones, metabolism, digestive processes, and more. These are controlled by genes, and different genes can make a person more or less susceptible to weight gain or loss. Genes also control height, and short or tall statures are passed down through families. (photo of family)

Images


CLIMATE ADAPTATIONS

Skin Color

Experience Goal

Demonstrate that skin color is the result of environmental factors that place different melanin-level requirements on individuals in different geographic locations.

Why This Experience?

This activity demonstrates how melanin works to block UV rays by blocking light in differing amounts based on the darkness of the lens, a scale that corresponds with the lightness and darkness of skin colors. Visitors will see how darker lenses block out greater amounts of light, just as dark skin does in sunnier climates, and how lighter lenses allow more light to pass through, as light skin does in less sunny climates.

Visitor Experience

Participants will move differently shaded dials in front of a lamp to see the differences in the amount of light that passes through onto a screen. This will demonstrate how melanin pigment in the skin works to block sunlight and show why people with warm-climate ancestry have darker skin than those whose ancestor's evolved in colder climates with less sunlight.

Design and Production

The component elements will be arranged in a row, with the screen on one end, the lamp on the other, and the dials lined up from lightest to darkest in between. The dials will be pulled down into the beam of light by rotating on a pole. The lenses will block the light to varying degrees, making it appear brighter or dimmer on the screen.

Exhibit Components

- Text/activity instruction panel
- Screen
- Lamp
- Rod
- Round lens dials with rotating mechanism and handles (4)
- Glass lenses (4; black, dark grey, light grey, clear)

Label Text

Skin Color

Nature's sunscreen

Sun Lenses

Pull down each of the dials to see how they affect the amount of light that passes from the lamp to the screen.

Just as the darker lenses prevent more light from passing through, our skin can have different levels of pigment that allow different levels of sunlight to get through. This pigmentation comes from melanin, a molecule in skin. The more melanin a person's skin has, the darker it is.

Sunlight contains UV radiation, which can be extremely damaging to our cells. People in climates near the equator are exposed to the highest levels of sunlight, and melanin acts as a natural sunscreen for them. For our early ancestors, evolving in this climate lead to the adaptation of darker, melanin-rich skin. (photo of people with dark skin)

As our ancestors left Africa, they encountered new climates to the north. In these places the sunlight was not as strong, lessening the danger of UV radiation. However, sunlight is important for getting essential nutrients like Vitamin D, which helps to grow strong bones. In order to allow enough sunlight to pass through for them to get the nutrients they needed, people in these climates evolved lighter skin with less melanin. (photo of people with light skin) (images of UV radiation gradient map and skin color gradient map)

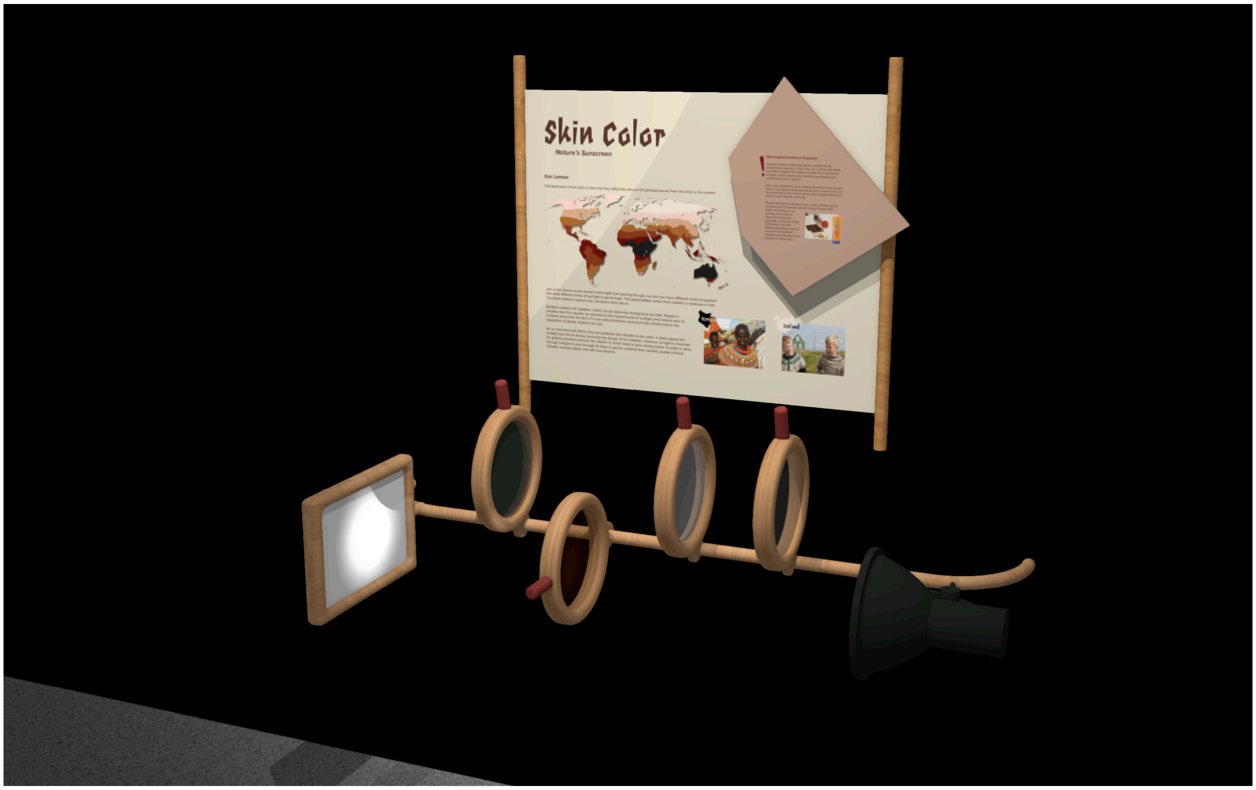
Misconception: evolution is progressive

Evolution leads to organisms that are adapted to the environment they live in. Over time, they will become better and better adapted. Sometimes, though, that environment changes. If that happens, that evolutionary progress can suddenly become a setback.

Skin color adaptations were certainly beneficial when people lived in the same climates their whole lives. However, they are less beneficial in the modern world, where people travel and move to new climates every day.

People with light skin living in warm, sunny climates are at increased risk of sunburn and skin cancer. People with darker skin living in cold climates are at risk for Vitamin D deficiency, especially during the winter. Fortunately, we have cultural adaptations such as sunscreen and vitamin supplements that allow us to account for these risks. (photos of sunscreen and vitamins)

Images



The Human Brain

This section looks at perhaps the most notable human feature, our brains, in both a physical and functional sense and explores the evolutionary advantages of having such large brains.

Label Text

> *If there's one thing that sets humans apart it's our large brains. Through this area you'll explore the abilities our large brains give us, from language to complex technical and creative thought.*

Brain Size

Experience Goal

> Explain how the humans have the most complex and relatively large brains of any animal without our brains actually being the largest, as well as how having a complex brain allows us to think, behave, and communicate the way we do.

Why This Experience?

This experience demonstrates how the development of ridges across the surface of the brain allows for greater surface area without an equal increasing in volume. As visitors pull out the spheres they will see how this expansion works. It also shows through comparison with other animals just how large the human brain truly is for its seemingly small size.

Visitor Experience

Participants will observe and compare the brain size of a rat, a cat, a chimpanzee, a human, and an elephant through models of their brains. They will then pull on handles of expanding models of the brains of each of the animals to stretch them out to their full surface area. Through this, they will be able to compare them with both their original size and the expansion rates of the other animals' brains.

Design and Production

The brain models will be displayed above the expanding brains for comparison. The expanding brains will consist of an expandable rubber wrapping around a Hoberman sphere. By pulling on the handle, the Hoberman sphere will expand, stretching the rubber covering. The sphere will rest at the size of the animal's brain and be able to be stretched out to the total surface area of it's brain.

Exhibit Components

- Text/activity instruction panel
- Brain model platforms (5)
- Rat brain model
- Cat brain model

- Chimpanzee brain model
- Human brain model
- Elephant brain model
- Expanding rat brain with handle
- Expanding cat brain with handle
- Expanding chimpanzee brain with handle
- Expanding human brain with handle
- Expanding elephant brain with handle

Label Text

Brain Size

It's all in your head

Brain Balloons

Pull the handles on the each of the brain balloons to see just how big each brain really is.

When it comes to brain size, it's all about folding. Over the past 2 million years our brains have tripled in size. It would have been impossible to grow this big with a smooth brain surface; our skull just cannot get that big! But, by folding over, our brains pack all of that surface area into a smaller space. (photo of brain)

More brain space equals more brain power. Highly intelligent animals like dolphins and chimpanzees make the most of this folding system, but humans top the charts. At 30 square feet, our brains have the largest surface area of any organism. We also have the largest brains for our body size. (photos of dolphin and chimp)

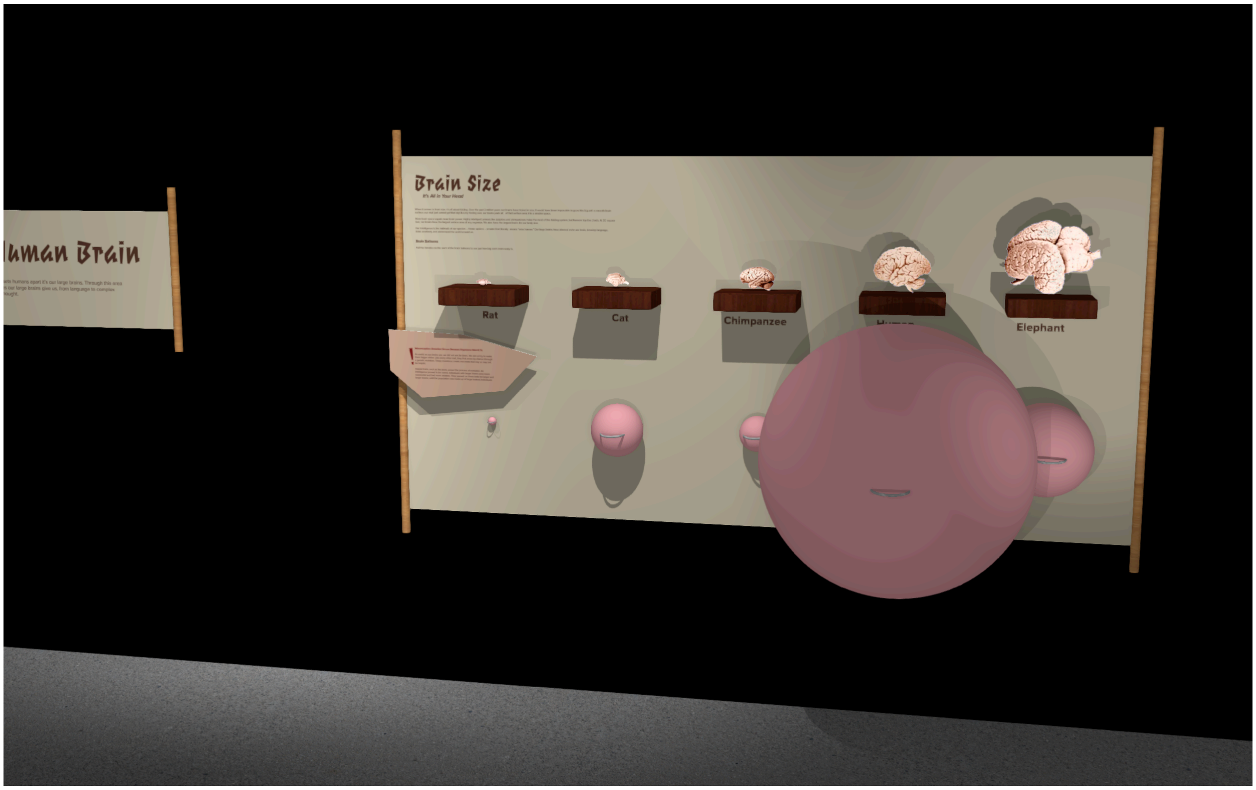
Our intelligence is the hallmark of our species – Homo sapiens – a name that literally means "wise human." Our large brains have allowed us to use tools, develop language, think creatively, and understand the world around us.

Misconception: evolution occurs because organisms want it to

As useful as our brains are, we did not ask for them. We did not try to make them bigger either. Like every other trait, they first arose by chance through a genetic mutation. These mutations create new traits that may or may not be helpful.

Helpful traits, such as the brain, power the process of evolution. As intelligence proved to be useful, individuals with larger brains were more successful and had more children. They passed on these traits for larger and larger brains, until the population was made up of large-brained individuals.

Images



Language

Experience Goal

Demonstrate that language is important for social creatures such as humans because it allows us to communicate more quickly and accurately when we are working together, as well as reveal some of the communicative pre-cursors to complex language.

Why This Experience?

This experience demonstrates the importance of complex language to human communication in society. By attempting to communicate through only gesture and simple sounds, participants see just how difficult it is to communicate something as simple as a block design without the use of words. The methods of communicating they will likely resort too, including gesture and different tonal sounds, will show some of the ways human ancestors communicated without a full language system. These early communication methods conferred an evolutionary advantage and lead to the development of the brain capacity for increasingly complex language.

Visitor Experience

Participants will need partner for this activity. One participant, the builder, will construct a design out of blocks as the other participant, the communicator, will give them instructions on what to do without the use of words. The activity station itself will be divided into two sides; on one side the communicator will look through a selection of block designs and secretly choose one. They will use gestures and/or noises to explain what to do without using any actual words. On the other side, the builder will attempt to construct the design based on what the communicator is instructing them to do.

Design and Production

The table will be divided into two opposite sides. On the communicator side a book will be set up with templates for block towers. The pages will be made of a durable, solid material such as wood or plastic and can be flipped through, providing several different building options. On the listener side, a tray will hold a variety of blocks and there will be an area to build on. Each side will have different instruction panels, but the same text on the evolutionary background and implications of the topic. There will be a stool on each end for seating while the activity is completed.

Exhibit Components

- Text panels (2)
- Instruction panels (2)

- Table with an inset tray for the blocks on one side and a design book on the other side, divided by a short wall to prevent seeing the workspace on the other side of the table
- Design book with a series of block designs
- 2 stools
- Assorted wooden blocks

Label Text

Language

Talk it out

Speechless

****Listener side***

Grab a partner and put your communication skills to the test.

As the listener, it is your job to interpret the instructions your partner will give you. Use the blocks to create the pattern they describe.

When you have completed the pattern, compare your creation to the diagram and see how good you and your partner were at communicating.

While all animals communicate, humans have developed the most complex method of communication of any species on Earth. That method is language. (photo of meerkats signaling, bees dancing, and humans talking)

Like modern humans, our early ancestors were social and lived together in groups. In order to work together they needed to be able to share things with each other. They did *this through non-verbal communication, such as the gestures or noises you probably used to communicate with your partner.*

Over time, these sounds and motions grew more complex and standardized. Words were created and put together into sentences. This vocabulary and system of arranging words grew until it comprised a language. Our early ancestors used language to work together on hunts and teach each other how to make tools.

Language is one of our most beneficial adaptations, as it allows us to communicate with one another in ways other animals cannot. It gives us the ability to coordinate with other people, share technology, and discuss thoughts and ideas. These abilities were essential for our ancestors to spread across the globe, and remain essential in our modern world today. (photo of people talking)

Communicator side

Grab a partner and put your communication skills to the test.

As the communicator, you must tell to your partner how to use their blocks to create one of the patterns from the diagrams below. You can't use any words – only gestures or noises.

When your partner has finished creating their pattern, compare it to the diagram and see how good your communication skills were.

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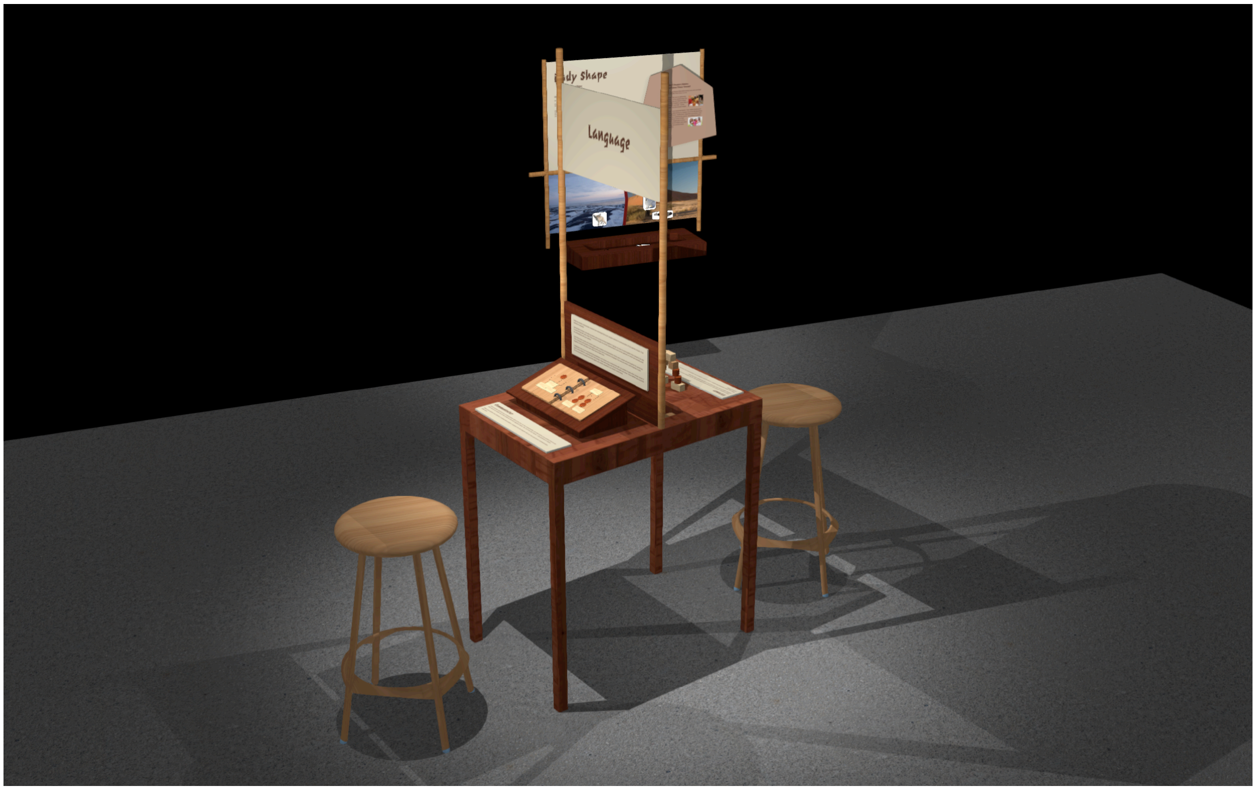
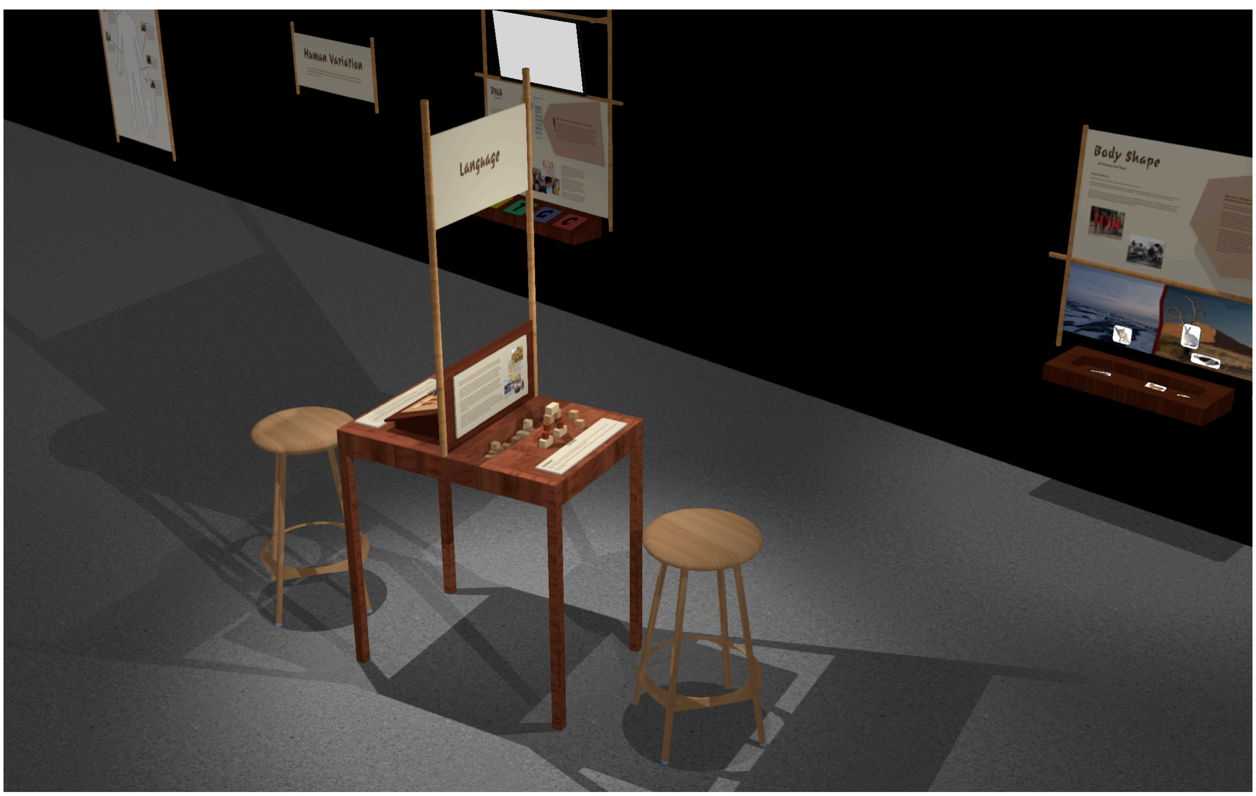




Art

Experience Goal

Demonstrate how art is one of the unique features of humanity that sets us apart from other organisms and explain how it relates to higher thought.

Why This Experience?

This experience explores the power and meaning of art for humanity. Participants will be encouraged to think about what cave art represents and why it was created. Through this question they will think about the many different reasons humans create art, and, through their own observation of art, think about the ways in which humans appreciate art. The label will provide context on the history of art creation and its significance for human brain development.

Visitor Experience

Participants will watch a moving projection of cave art overhead and be encouraged to think about a common question asked about cave art – what was its purpose?

Design and Production

A large white screen will cover the ceiling or a portion of it and moving cave art images will be projected onto it. Seating underneath will allow guests to spend a longer time looking at it. The projection will be a key element in the lighting design of the exhibition space.

Exhibit Components

- Text panel
- Seating area
- Screen
- Projector

- Cave art projection

Label Text

Art

Let's get creative

The images above were painted on the walls of Lascaux Cave 17,000 years ago by prehistoric humans. Cave paintings were among the earliest works of art. Our prehistoric ancestors also engraved shells, carved figurines from ivory and stone, and made musical instruments out of bone. (images of abstract carvings, the Löwenmensch figurine, bone flute)

As you watch the images move across the screen, try and put yourself in the shoes of the people who first created them. Imagine standing in a cave, observing these massive animals come to life along the stone walls by the flickering light of a fire.

There have been many ideas about why these paintings were created. They may have been used for teaching, as pictures could go a long way in explaining ideas. But they also appealed to something new – an appreciation of the images for more than practical use. By connecting viewers with memories or emotions, art made people think in deeper and more complex ways.

Images

Tool Use

Experience Goal

Show how our ability to use tools is an evolutionary advantage because it helps us to solve problems and obtain things more efficiently, as well as demonstrate how tools have changed over time.

Why This Experience?

This experience demonstrates the importance of tool use to humans by exploring how tools have changed, diversified, and become more complex over time. Through these three activities, participants will see the breadth of tools that have been and are used by humans, illustrating the broad definition of a "tool." Additionally, they will recognize how tools offer an advantage to the user, demonstrating the evolutionary advantage the ability to use tools has given humans.

Visitor Experience

Through three tasks, participants will see how tools have helped humans to complete ever more complex tasks throughout history. In the first task, participants will attempt to retrieve a higher number of magnetic termites from the termite mound, first with their hand and second with the magnetic “stick” tool. The termites will cling to the magnetic “stick” as real termites do to real sticks, demonstrating how tools make this task of collecting food easier. In the second task, participants will attempt to push a heavy box first by itself, and then with wheels. It will roll easier with the wheels, showing the effectiveness of the wheel as a tool. In the third task, visitors will be given a complex equation and the choice of a chalkboard and chalk or a calculator to do it with. The calculator will make the task much quicker and likely more accurate, showing the importance of computers as tools in the modern world.

Design and Production

The termite mounds will consist of a conical stand stylized to look like the outside of a termite mound with a cavity in the middle and an opening at the top. The inside will be magnetically lined so that the magnetic termites will stick to it. The termites can be removed with the hand or with the magnetic stick by reaching into the opening. The boxes will be identical, though one will have a set of wheels. They will be able to be pushed along a short track. The calculator and chalkboard will be secured to the stand, and chalk will be provided to write on the chalkboard.

Exhibit Components

- Text/activity instruction panel
- Activity station

- Termite mounds (2)
- Magnetic termites
- Magnetic “stick”
- Box with handle
- Box with wheels and handle
- Tracks for boxes to move on (2)
- Calculator
- Chalkboard
- Chalk

Label Text

Tool Use

Changing tools for changing times

Tools make our lives easier. They can be anything from the stone tools of our ancient ancestors, to hammers and wrenches, to the latest milestone in tool invention – the computer.

As our ancestor’s brains grew more advanced, they began to come up with design ideas for useful tools and figure out how to create them. The tools they made were a huge advantage and helped them become better at hunting and gathering food. These tool designs were shared through teaching and cultural exchange, and they rapidly spread among our ancestors.

Today we develop tools in similar ways, but on a much larger scale. Modern tools allow us to reshape our environment, fight diseases, and grow more food than ever before.

The First Tools

Termites are an important source of food for chimpanzees, and early ancestors might have enjoyed a termite treat now and then too.

Using your hand, reach into the termite mound and see how many you can pick up. Try it again, but this time use the stick. Which one worked better?

The search for food drove the invention of the very first simple tools – tools that chimpanzees use even today. (image of chimp using a stick to get termites)

These tools, in addition to stone tools like the hand-axe, made our ancestors better at hunting and gathering food. Primitive tools like these were so simple, yet so useful, that they remained the height of technology for more than 2 million years. (photo of stone tools)

New Tasks, New Tools

From the blocks used to build the pyramids, to today's semi trucks, people have been moving heavy things throughout history.

Try pushing the crates. Which one is easier to move?

Around 6,000 years ago, humans began to gather together in the earliest civilizations. They lived alongside more people than ever before and faced new challenges with their new way of life. They needed to build structures and transport goods for trade.

In one of the earliest human civilizations, Mesopotamia, the wheel first became popular. While the first wheels were used to make pottery, people later discovered they could use *them to move things. They attached wheels to carts, were able to move heavy objects and travel great distances easier than ever before. (world map with Mesopotamia)*

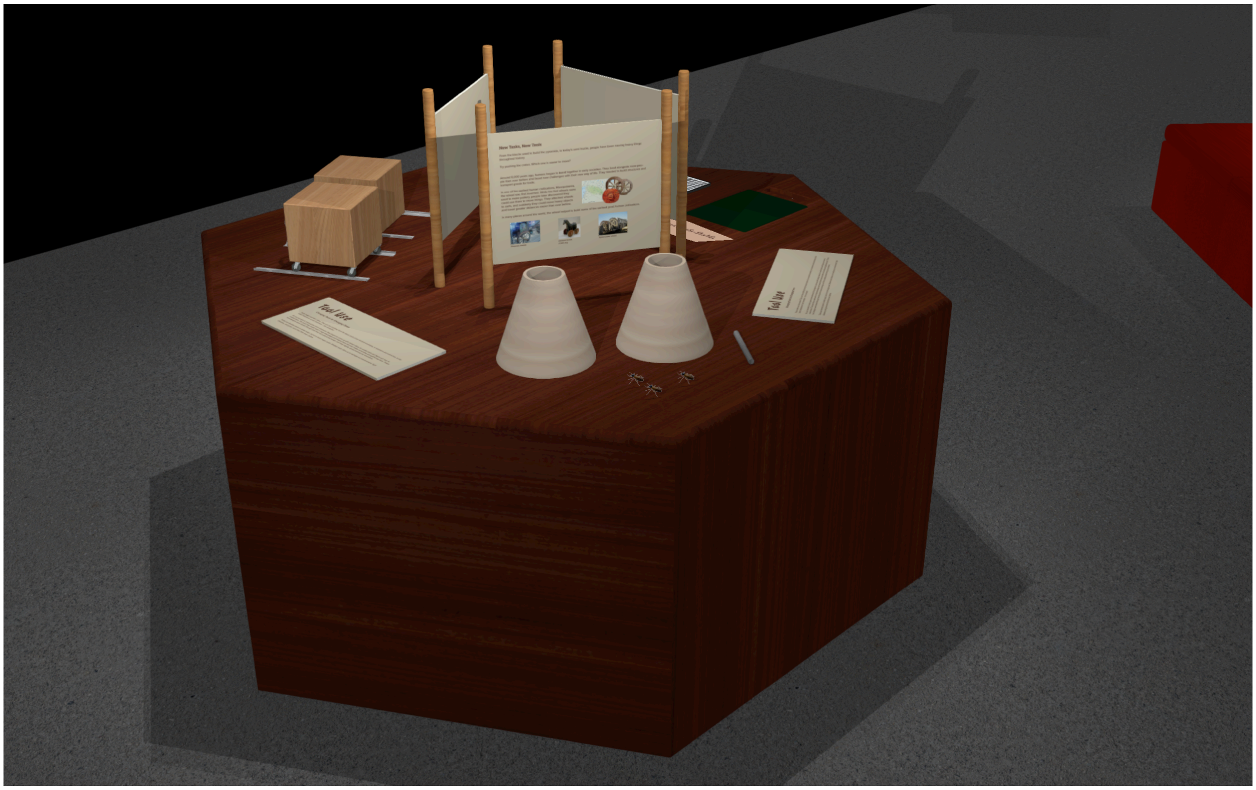
The Tools of Today

As human ability and knowledge grew, we sought to understand the world around us in more advanced ways. Early civilizations mapped the stars and developed advanced number systems. Great scientists like Isaac Newton and Albert Einstein discovered the physical laws of the universe. As our study and understanding of the world grew more complex, we needed more complex tools.

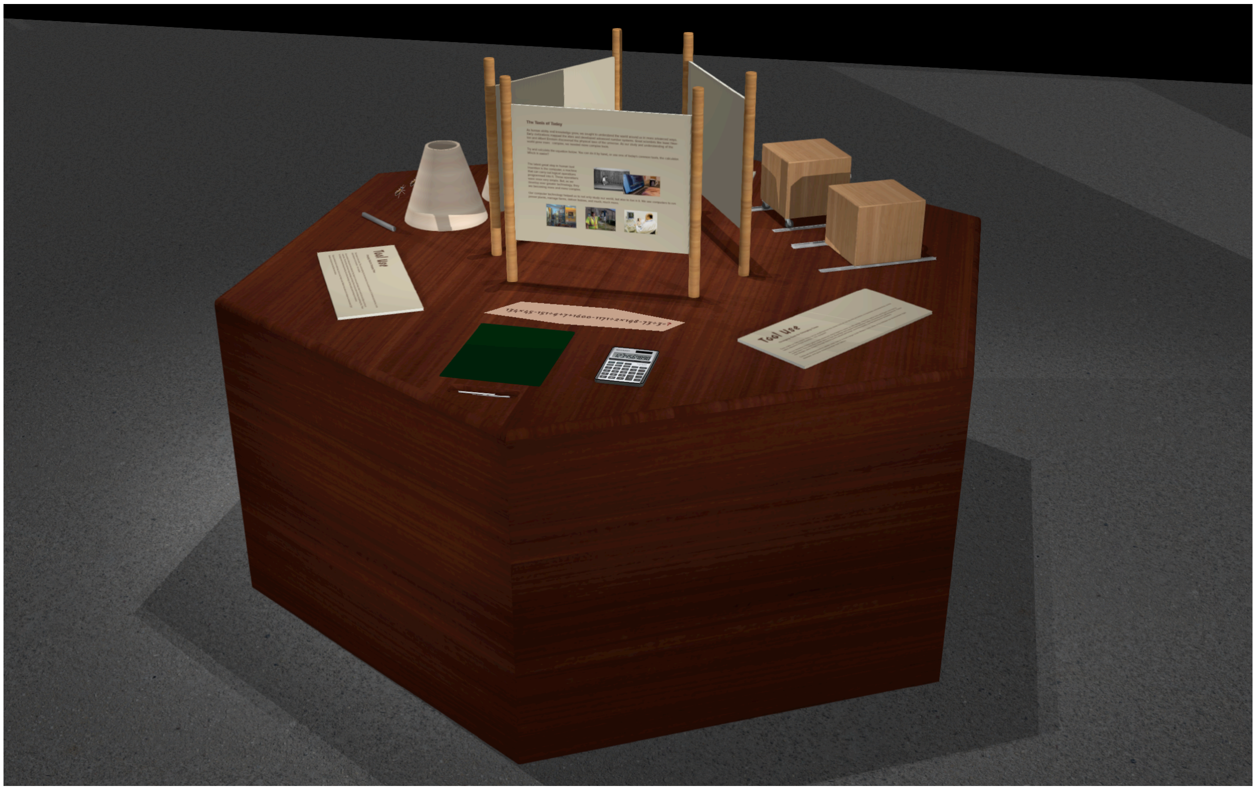
Try and calculate the equation above. You can do it by hand, or use one of today's common tools, the calculator. Which is easier?

The latest great step in human tool invention has been the computer, a machine that can carry out logical operations programmed into it. These operations were once very simple. But, as we develop better technology they are becoming more and more complex. Our computer technology helps us to not only study our world, but also to live in it. We use computers to run power plants, manage farms, deliver babies, and much, much more.

Images


Tool Use


Tool Use



Conclusion: The Story Continues

Experience Goal

End the exhibition by demonstrating how the process of evolution is ongoing and explore some of the ways in which it continues to shape the human species.

Why This Experience?

This component wraps up the exhibition by conveying the important message that evolution is an ongoing process and that it is not limited to the features they have just explored in the exhibition. This idea was chosen as a conclusion not only to emphasize how fundamental it is to evolution as a concept, but also to give visitors with something to continue to think about when they leave the exhibition. Presenting visitors with images that represent the factors influencing current human evolution gives them an indication of what they are, and the flaps offer a quick, simple way to get more in depth information on how they work.

Visitor Experience

Participants will lift up different flaps to see how factors in the world today such as food, diseases, globalization, and more continue to shape how the human lineage evolves.

Design and Production

The component will consist of a text panel and four round flaps with the words food, disease, globalization, and a question mark on them. On the reverse side of the flaps will be an image that represents the evolutionary factor and text explaining its impact.

Exhibit Components

- Text panel
- Flaps (4)
- Rings for flaps (4)

Label Text

The Story Continues

Evolution is an ongoing process that continues to impact humankind through our modern environment.

Though you may not even notice it, everyday you are part of the story of evolution. Your ability to live in your environment, eat enough food, and stay healthy shapes future generations of humans as you pass along to your children the genes and ideas that equipped you to do so.

Lift up the panels to learn some of the ways evolution is at work today.

Food

(picture of a person eating modern food)

Our modern diet is changing the structure of our mouths. Jaws grow in response to the amount of chewing they need to do, and by processing and cooking our food we make it soft and very easy to chew. This dietary shift has lead to a trend of smaller, thinner jaws than humans of the past had. This shift has also had an impact on our teeth. Teeth don't grow differently based on diet like jaws do. Because they have not gotten smaller in size or number as fast as our jaws, they have become crowded in our mouths.

Disease

(picture of a person getting a vaccination)

Have you gotten sick recently? If so, then you were part of what is known as an evolutionary arms race. Bacteria and viruses have adaptations that help them to infect humans. But we also have adaptations to prevent them from doing so, such as skin and white blood cells, as well as medicines and vaccines.

Over time bacteria and viruses overcome these defenses by evolving their own adaptations. We, in turn, adapt new ways to fight them, and the race goes on and on.

Misconception: evolution is really slow

Evolution usually takes a very long time to occur. But not always…

Evolution occurs over many generations. For many larger organisms, like us, these generations can last for many decades. They quickly add up, and it can take anywhere from a thousands to millions years for noticeable evolutionary change to occur.

For microorganisms like bacteria and viruses though, this process occurs much more quickly. They can reproduce in a matter of hours, so their generations are much shorter. A virus may be changed by natural selection in as quickly as a few months or years. The evolutionary arms race between humans and disease-causing microorganisms highlights this, as every year medical professionals struggle to stay ahead of new strains of the flu.

Globalization

(picture of immigrant family)

Our world is more interconnected than ever before. People move from one end of the Earth to the other every day. Not only do they bring with them their cultural experiences and plans for a new life, but also their genes.

As we continue to move to non-native climates, as well as travel from climate to climate, our bodies are no longer shaped by the same local pressures that drove much of our past evolution. Instead, our global lifestyle is leading to adaptations that allow us live in a wide range of climates.

What do you think?

(picture of a large mass of people)

What factors do you think might be impacting human evolution?

Images

Formative Evaluation

A formative evaluation of *Evolved* was carried out based on the following study design.

Objectives

The purpose of the research study was to understand museum visitors' reactions to and learning outcomes from *Evolved*, and to utilize that information to inform and further improve the design of the exhibition.

This evaluation aimed to:

- Determine how and if visitors interact with the exhibition activities and concepts
- Determine if visitors enjoy learning about human evolution as an informal learning experience
- Determine what visitors gain from the exhibition, whether in terms of formal learning objectives or less strictly defined outlooks or perceptions.

Methodology

The evaluation was conducted at COSI through the Center for Research and Evaluation. It included the completion of an activity (outlined further below) and a brief verbal questionnaire conducted with participants after completing the activity, as well as the taking of observational notes on participant demographics and interaction by the evaluator after each trial. The experience testing station consisted of an activity table and an informational sign to attract participants, and both the activity and questionnaire phases were conducted at the station.

The questionnaire gathered demographic information including the number of participants in a trial, the ages of the participants, and their relationship to one another. This information was collected to determine whether the activity is effective for different ages and group makeups. The post-activity participant questionnaire consisted of 6-7 open-ended questions meant to assess participants' enjoyment of and ability to complete the activity, as well as whether the learning objectives of the exhibit come across as intended. After completing the activity and questionnaire, the evaluator answered a series of nine questions reflecting on the experience. They recorded the logistics of the demo, if and how participants completed the activity, and the level of engagement groups of participants had with one another.

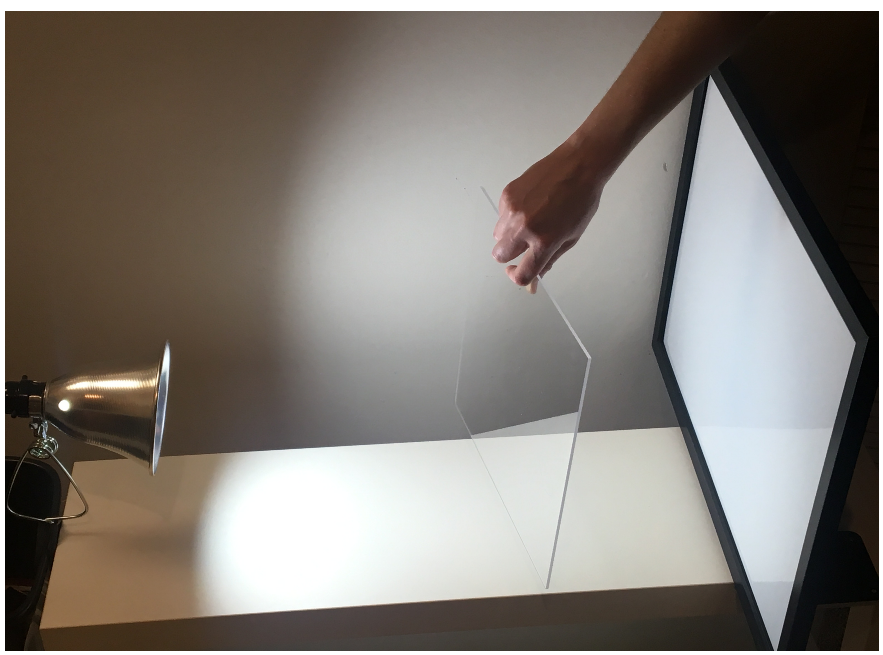
Test Activities

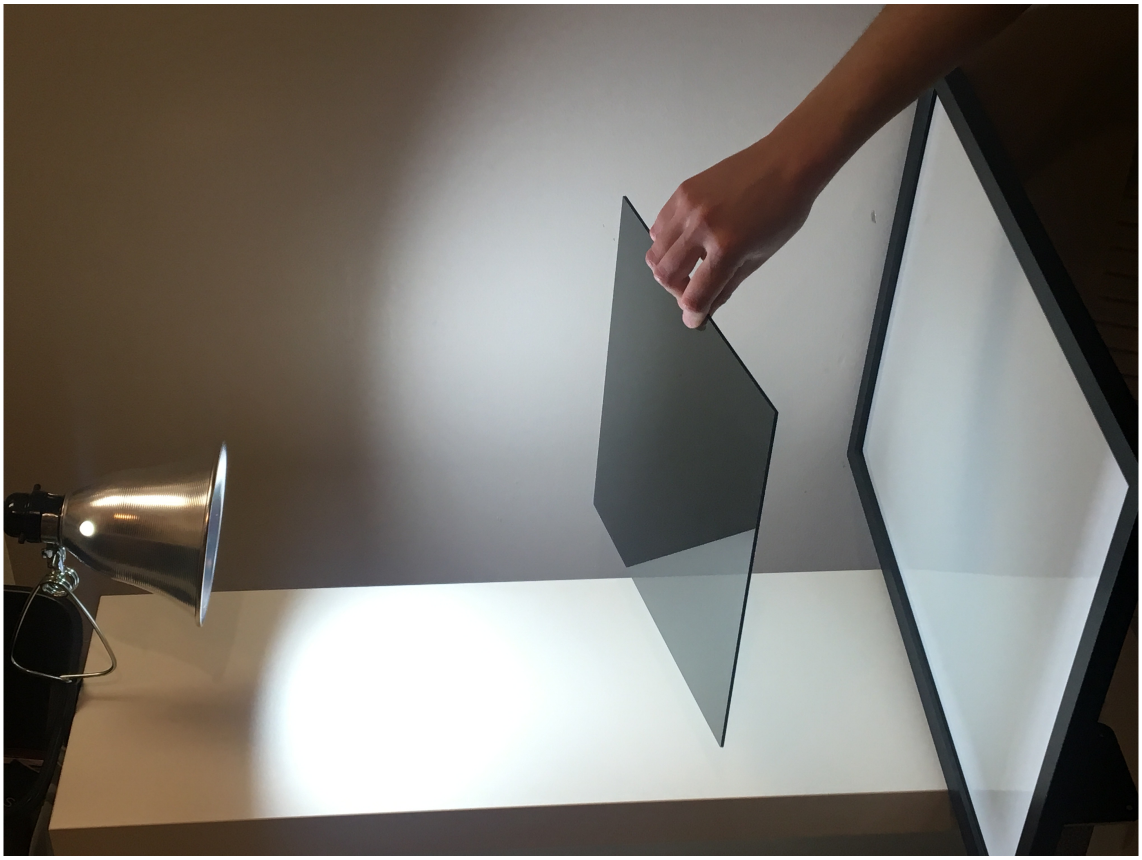
Locomotion – Childbirth Component

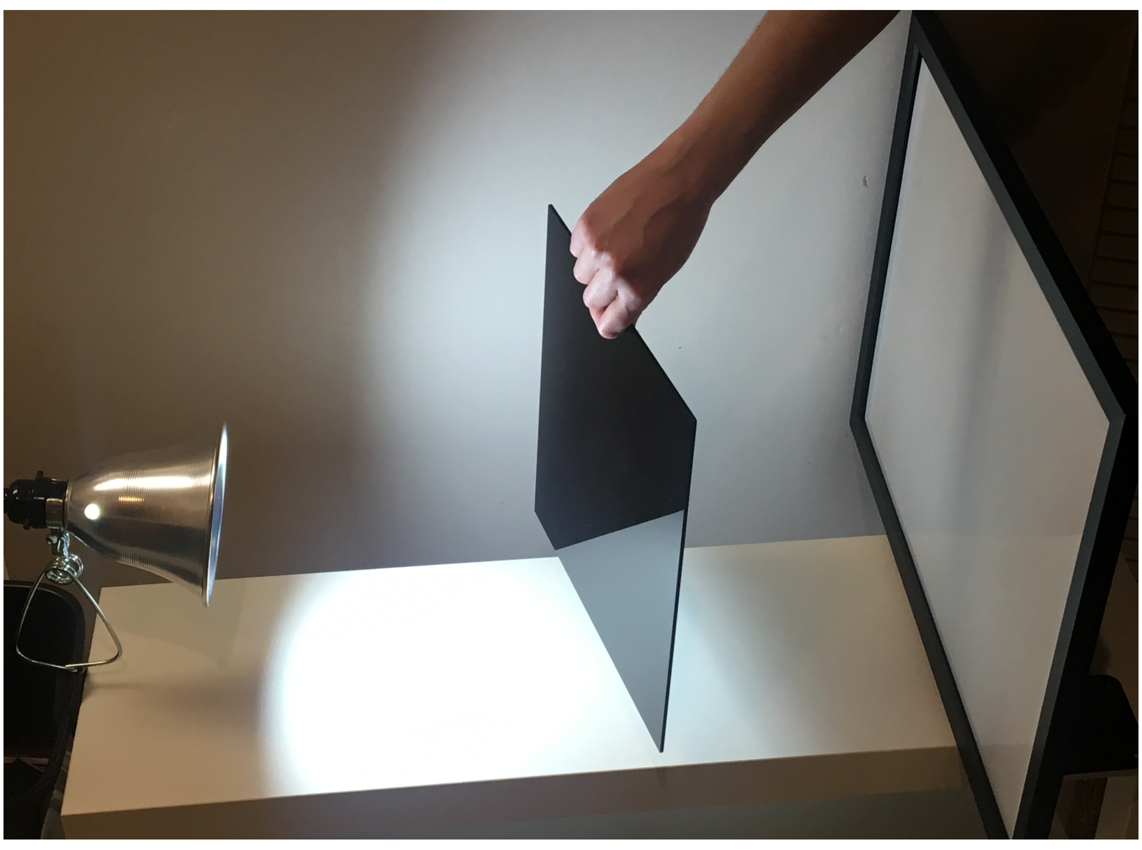
Participants were given an introduction to bipedalism and how it can have both benefits and drawbacks. They then did an activity similar to the "Childbirth" component on the obstetrical dilemma. A female pelvis (wide, optimal for childbirth) and male pelvis (narrow, optimal for bipedalism) were set out, and they attempted to pass an infant skull through each one to illustrate the principle. After completing the activity they answered the questionnaire.

Skin Color Component

Participants were told that the exhibit was about skin color and melanin was explained. They then did an activity that replicated the “Skin Color” component. A lamp was set up at one end of a table and a white screen on another. They picked up tinted pieces of plexiglass and saw how they blocked out the light in different levels. The evaluator then asked them, based on what they observed, why people have different skin colors. They also went on to further explain the principle. After completing this activity participants answered the questionnaire.

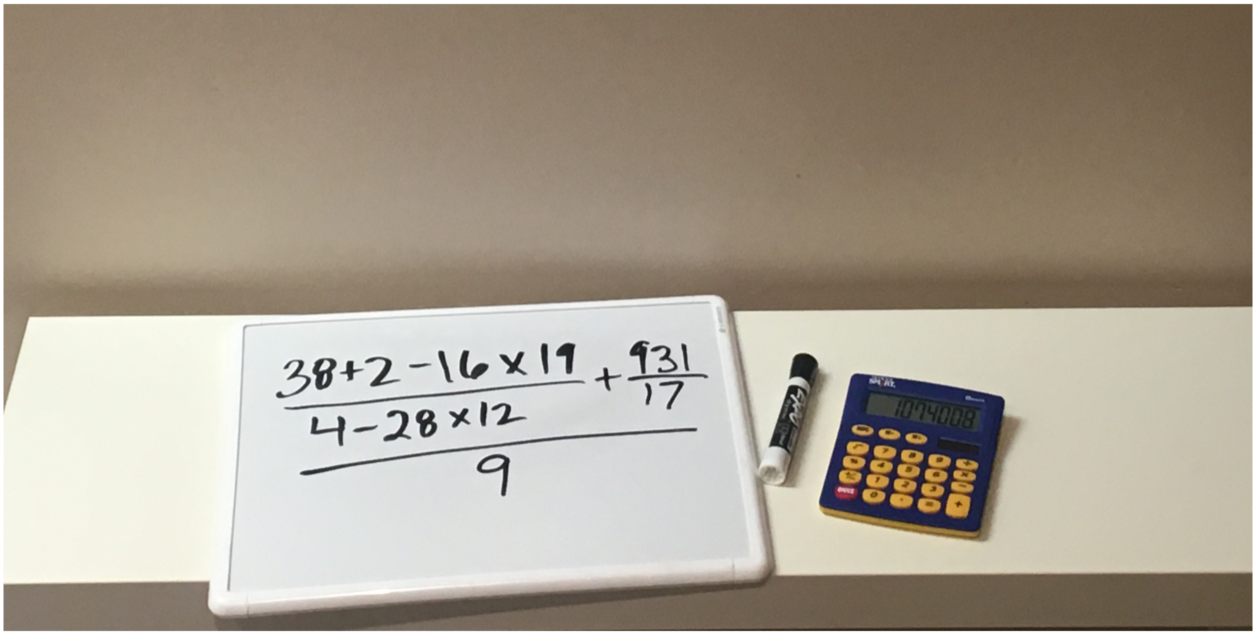






Tool Use Component

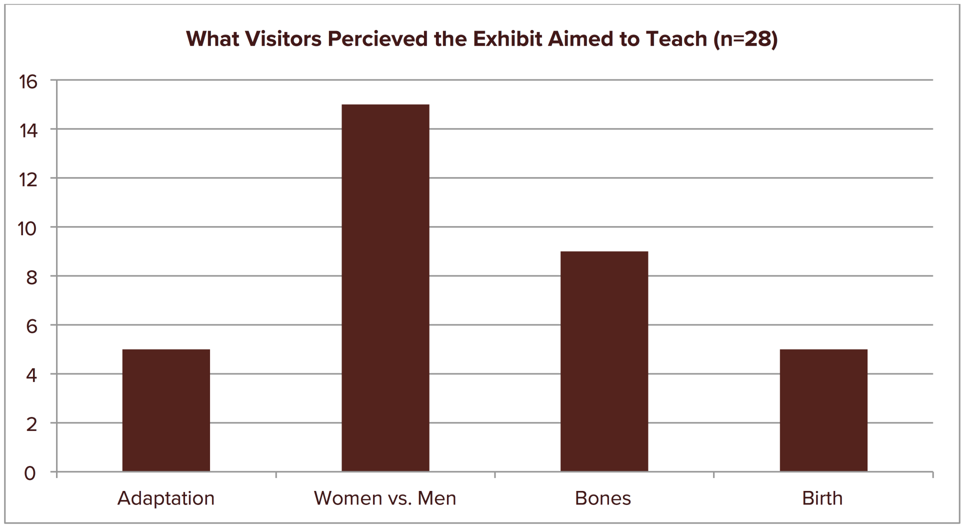
Participants were told that the three activities (the termite mound, the boxes, and the calculator) were a group of activities that made up an exhibit. They then had the chance to interact with all of them. For the termite mound they compared using their hands and the magnetic stick to catch magnetic termites, for the boxes they pushed the one with wheels and the one without, and for the calculator they found the solution to the equation by hand or with the calculator. They were then asked what each of the items (the stick, the wheels, and the calculator) all had in common – the answer: they were all tools! The evaluator then explained the adaptive benefits of tools. After completing this activity they answered the questionnaire.



Results

This evaluation was successful in shedding light on where these components were effective and on what shortcomings they have that could be addressed in future work. Overall, they showed that the components were logistically very effective, but could be improved by making the evolutionary connections more inherent in the interactives for those who do not engage as deeply with the written (or, as in the evaluation, spoken) content. For all of the tested components, the designs of the interactives were practical and intuitive enough for visitors to complete as intended. In terms of meeting learning objectives, participants demonstrated a basic understanding of the concept underlying the component; however, more complex evolutionary principles did not come across as readily.

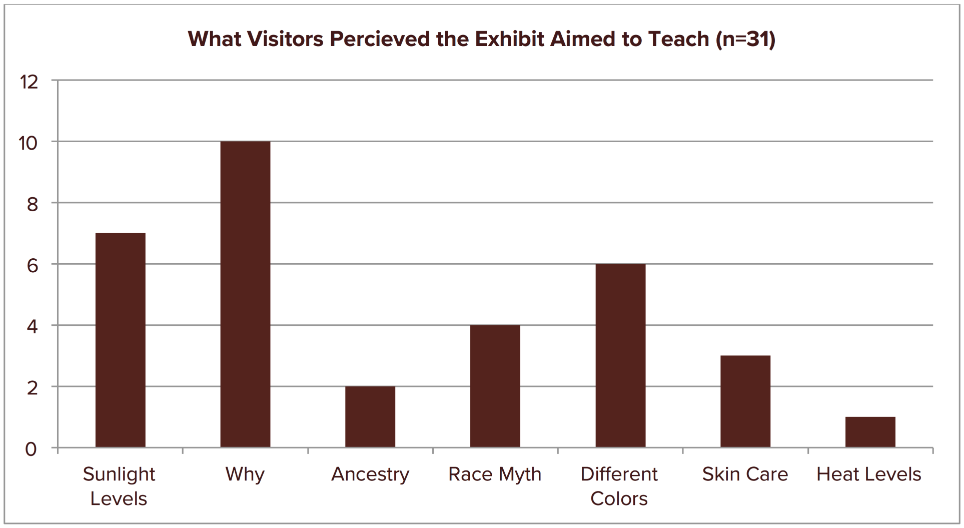
The “bipedalism – childbirth” component was conducted in a similar fashion to the designed exhibition; however availability of materials necessitated a focus more on the comparison of male and female pelvises rather than strictly the demands of walking and giving birth. Participants tended to focus on this comparison, rather than the adaptive significance as was intended. This may have been a result of the different formulation of the activity though, and some participants did suggest that adaptation was a component of what the exhibit was teaching. One of the major goals of the bipedalism component was to highlight aspects that certain visitor demographics could particularly connect with, such as arthritis for elderly visitors or, in this case, childbirth for mothers. The participants that showed the highest levels of engagement with the exhibit and asked the most follow up questions were mothers, which encouragingly demonstrated its effectiveness in this regard. A small number of participants were uncomfortable with the birthing aspect of the exhibit and chose to leave the evaluation. This may have been a result of the more birth-focused framing of the evaluation activity and could be mitigated by the more bipedalism-focused framing of the actual component.



Response Key:

- **Adaptation –** how our bodies adapt to different functions
- **Women vs. Men –** the difference between men’s and women’s bodies
- **Bones –** what bones are, their function and morphology
- **Birth –** how birth works

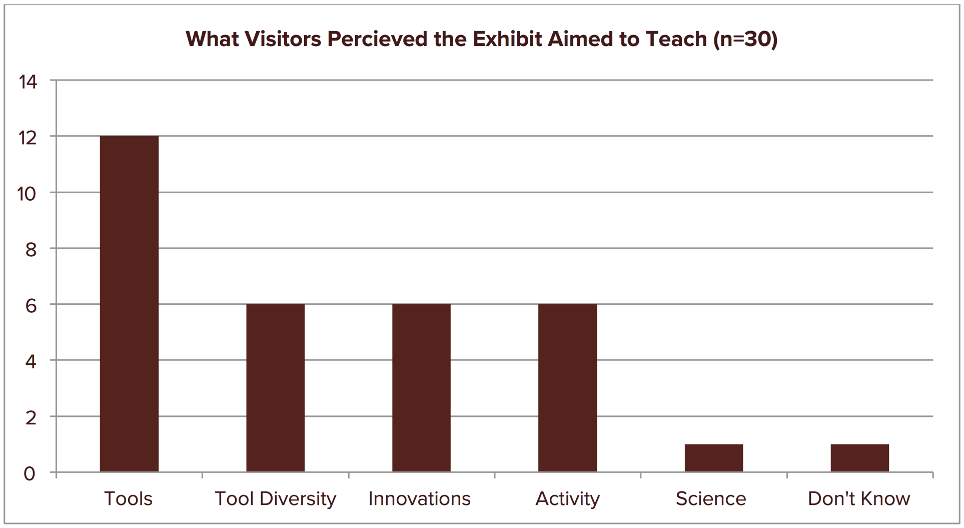
Evaluation of the “skin color” component demonstrated that it was both an effective interactive and teaching mechanism. In the majority of trials participants were able to accurately identify the purpose of melanin after using the interactive. Some showed further engagement as well, using the skin color map to compare their own skin and identify their ancestry. Overall, participants perceived the component to be about why skin colors are different, with quite a few explaining the process itself in their answer. Ties to ancestry and the myth of race were also important educational aims, and while they were not as often mentioned, several participants did see them as an important part of the component.



Response Key:

- **Sunlight Levels** – skin color is a result of variable levels of melanin associated with sunlight levels
- **Why** – why people have different skin colors (not specifically about sunlight levels)
- **Ancestry** – variable skin colors are a result of people living in different climates for long periods of time
- **Race Myth** – skin color is a result of climate and does not mean people with different skin colors are inherently different from one another
- **Different Colors** – skin comes in different colors
- **Skin Care** – protecting the skin from harmful UV rays is important
- **Heat Levels** – skin color is a result of variable levels of melanin associated with temperature

"Tool use" proved to be engaging in surprising ways. Of the three interactives, the termite mound was the favorite among participants, and many turned the calculator activity into an exciting math challenge by competing with one another to write out faster than calculate the answer. This was encouraging as it showed participants working together and learning within their group, which is an important method for promoting engagement and learning. In about half of the trials participants were able to correctly identify the objects as tools, though many others mentioned similar concepts such as "inventions" or "technology." The learning goals came across fairly successfully, and though the most commonly perceived lesson was more general than intended, many participants recognized the main ideas of what tools are and how they represent innovations and changes over time.



Response Key:

- **Tools –** tools are objects used to solve problems
- **Tool Diversity –** tools can be different things, used for different purposes, or used by different animals
- **Innovations –** how technology has changed over time
- **Activity –** an aspect of one of the activities within the exhibit (i.e. math, wheels, termites)
- **Science –** general, this is science
- **Don't Know –** not sure what they learned

Conclusion

The aim of *Evolved* was to create an exhibition that taught human evolution in the context of the modern human body, an experience intended to make the often esoteric science of evolution more personally relevant to museum visitors. The process of developing the exhibition utilized research and methods from across the discipline of museum studies to craft a compelling exhibition narrative and engaging interactives, as well as conduct a formative evaluation that allowed for a better understanding of visitors real experiences with the exhibition and offered practical directions for further improvement.

It is hoped that this paper not only contributes to the body of museum studies literature, but inspires further research on, as well as development and creation of, evolution exhibitions. As a foundational theory of the biological sciences – otherwise well represented in the museum – it is an important idea that must be better incorporated in the narratives museums construct.

Whether approaching evolution in the context of humans or animals, through chronological or other alternative narratives, museums and museum practitioners are facing a meaningful opportunity to explore and improve on the ways they present evolution in their institutions. Through considered design and dedicated research, evolution exhibitions can find their place as part of the museum experience.

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