# *Down House: An Insight to a Revolution of Evolution*

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English Heritage: Down House

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ENGLISH HERITAGE

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## Abstract

The following report has been prepared for English Heritage to evaluate the success of interactive mechanical exhibits in Charles Darwin's home, Down House. This was done by designing, fabricating and evaluating a mechanical interactive prototype exhibit based on the topic of classification. Results were found and analyzed by interviewing, surveying and observing visitors using the prototype exhibit.

## Executive Summary

In 1859, Charles Robert Darwin introduced his theory of evolution in his most famous of publications *On the Origin of Species*. Since that day he has been the recipient of much scrutiny and debate. Granted most of the science world today has accepted it as a theory, most of the real world still rejects this belief. With contradictory theories still being taught in most religions, it is hard for this theory to gain full acceptance throughout the world. However, there is still one place in the world today where not only are his theories celebrated, but also Charles Darwin as a person. This place is called Down House.

Located 16 miles southeast of London, in the town of Downe, is a house that Darwin called home for the final 40 years of his life. After his famous voyage to the Galapagos Islands on the HMS Beagle, he returned to Great Britain to reside in this lovely estate until his passing on April 19th, 1882. That is where he worked on many major works and solidified his theory of evolution.

Down House is currently a museum where Darwin the father, the husband, the scientist, and the man are all celebrated. Down House is owned and operated by the organization known as English Heritage whose sole existence is to protect and promote England's spectacular historic environment and ensure that its past is researched and understood.

Recently it has been English Heritage's duty to improve the overall experience of Down House for the celebration of Darwin's bicentennial birthday and the 150th anniversary of the publication of *On the Origin of Species*. Down House is also attempting to obtain World Heritage status, and in order to achieve this, necessary improvements to the estate must be completed.

One of the major improvements being made to Down House is located in the 'interactive room'. Currently the theme within the interactive room is rather childish. With bright green painted walls and big and bright colorful interactive exhibits, it tends to turn away the mature crowd. With the intention to appeal to all ages, a

professional exhibit design and creation company has been hired by English Heritage to create quality exhibits that would fit the updated theme. This company is known as MDM Props Limited and is located in Brixton, UK.

In conjunction with MDM Props limited, it is our goal as a team to develop one interactive mechanical prototype exhibit and determine its effectiveness. A methodological approach was established, and several objectives were laid out in order to achieve this goal. The objectives are listed below:

1. To identify basic evolutionary concepts and/or observations made by Darwin that could likely be used as the basis of an interactive exhibit.
2. To design and evaluate an interactive mechanical exhibit that can properly demonstrate these ideas.
3. To build the prototype.
4. To evaluate the prototype and determine effectiveness.

After the objectives were clearly laid out, we then began the process of identifying concepts. A concept was chosen with help from our sponsor as well as a selection method involving decision matrices. The concept we chose was that of classification, or more specifically, taxonomy. Our prototype was to show how certain species within a given family are related. Based on observations, and identifying certain traits, the user was expected to place certain animals into their correct place within the family tree. Upon completing it, a button was pressed to see if the user arranged them correctly or not. Depending on the arrangement, a corresponding reaction occurred within the prototype to inform the user.

The evaluation of the design was an ongoing process from the point of conception. Using the professionals available to us at MDM and English Heritage, we constantly modified our design based on the expertise. Also throughout the entire fabrication process, we consistently had a source of input from various professionals at MDM, which shaped and melded our prototype to what it eventually became. The design process was a collaborative one, involving input from anyone around.

Upon completion of the prototype, we tested the demonstrative properties with actual Down House visitors. By setting up our prototype temporarily we were able to obtain data on the conceptual and functional properties.

An important finding throughout all the data acquisition at Down House, was the fact that most visitors would not test the prototype exhibit unless explicitly asked by us. Many times the "average visitor" of Down House, around 50 years old, would just be in the room to observe rather than interact. This was rather interesting seeing how the room was titled the "Interactive Room".

During our time spent at Down House, a total of 45 visitors stopped and began analyzing our prototype exhibit for some period of time. Of those 45 visitors, only 29 of them, 64%, actually attempted to complete the exhibit. Of the 29 visitors who attempted to complete the prototype exhibit, 22 (76%) completed it successfully. This turns out to be rather successful, seeing how part of the goal outlined by our sponsor was that people should fail and it shouldn't be too easy.

It was also found that the younger visitors seemed to have a better success ratio than the remaining 40+ year olds. Our survey sample consisted of four 13-17 year olds, seven 40-60 year olds, and eleven 61+ year olds. Keeping that in mind, it was observed that the 13-17 year olds had a 100% success ratio and also, on average, completed the exhibit in half the time of the remaining visitors. A reason for this may be that the younger demographic immediately starts interacting, while the elders stood and observed for sometime before actually beginning to interact. The younger kids also had a more competitive drive, attempted to complete it until they did, in fact, complete it successfully.

We also analyzed the effect of changing the instructions from one day of testing to the next. After the first day of testing it was observed that the instruction sheet was too long and wordy. Most of the visitors would not get through the entire instruction sheet, and would begin to start attempting. This was shown to have a great affect on the success ratio of the visitors. This was simply because some of the important information, such as "Hints", were provided at the bottom of the document. So in order to direct this issue, we created a more concise instruction sheet. This proved to help drastically since the success ratio increased from day one being 55% to 89% on day two.

The overall success of the concepts we were trying to convey were measured by the quantitative data provided by the surveys. Three questions were asked and the visitor responded by providing a ranked answer from 1-5. The following structure was used for these questions on the survey:

**1)** How **interesting** is the exhibit?

| **5** | **4** | **3** | **2** | **1** |
|---|---|---|---|---|
| (Very interesting) | | | | (Rather dull) |

**2)** Did you find the exhibit **thought provoking**?

| **5** | **4** | **3** | **2** | **1** |
|---|---|---|---|---|
| (Thought provoking) | | | | (Uninspiring) |

**3)** Did it seem **relevant** to Darwin?

| **5** | **4** | **3** | **2** | **1** |
|---|---|---|---|---|
| (Very relevant) | | | | (irrelevant) |

With regards to these questions, our prototype exhibit scored quite well. With an average score of 4.18, 4.18 and 4.54 for questions 1, 2 and 3 respectively, this proved that our exhibit's concept is worth pursuing into a final version.

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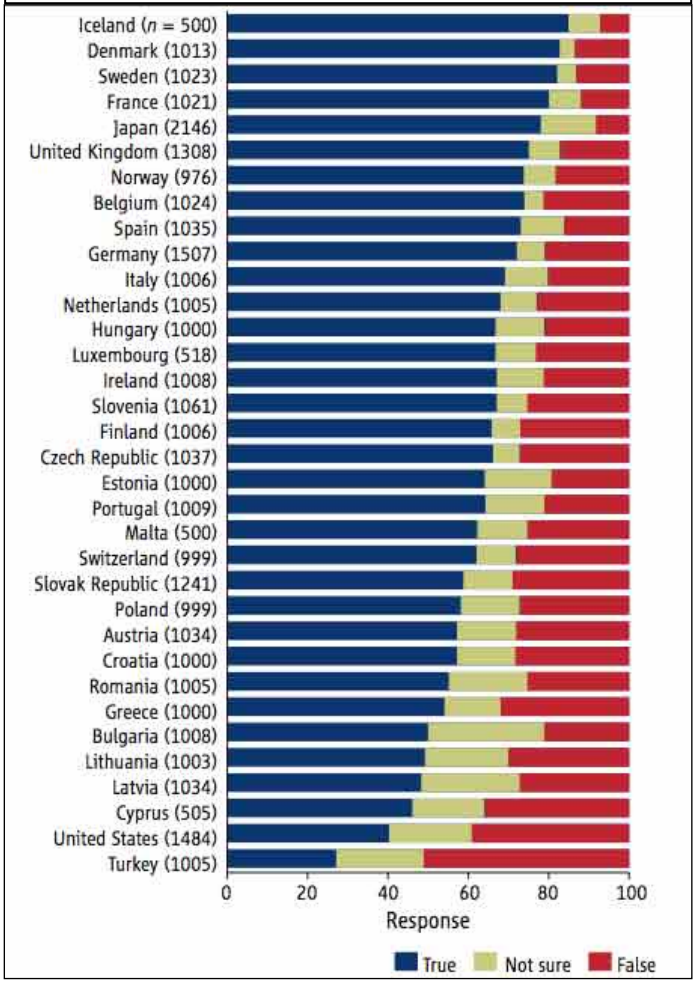
# 1.0 Introduction

Ever since Charles Darwin proposed his theory of evolution in 1859, it has been the source of much debate. Published in his most famous work, *On the Origin of Species*, this theory caused deep controversy, even among established scientists of that time. This theory went against many prominent beliefs. It undermined the religious belief in creation, and also contradicted the current thinking about the age of the earth. The idea that humans were related to a "lesser" species was distasteful to some and considered blasphemy to others.[1] Currently, Darwin's famous theory is still scrutinized among many communities worldwide. Even in some of the most advanced societies of the west this theory is still in question. More specifically in the United States, only 14 percent of adults that evolution was "definitely true", while about a third firmly rejected the idea.[2] Another study conducted placed the United States second to last among 34 countries worldwide in the "public acceptance of evolution", stating that only 40% of adults agree with the statement "Human beings, as we know them, developed from earlier species of animals".[2]

**Figure 1: Acceptance of Evolution**




In Darwin's homeland, the United Kingdom, his theory is much more widely accepted. As you can see according to Figure 1: Acceptance of Evolution, 73% of

the U.K. was in agreement with the idea that human beings developed from earlier species of animals. This is easily understood because the theory of evolution is explicitly taught in the curriculum throughout the entire U.K. Ever since 1988, a national curriculum was introduced throughout all of England and Wales.[3] This curriculum covered the subject content that should be taught in the core subjects: English, mathematics, and science.

Not only does the United Kingdom teach the theory of evolution, but also explains the reasons for controversy that some scientific findings may induce. As stated previously, ever since Darwin proposed this famous theory it has been the source of much debate.

There is a place in the United Kingdom which continues to bring forward Darwin's theory. In fact it is dedicated to Darwin, located in the town of Downe, 16 miles southeast of London is where Darwin called home for the final 40 years of his life. Entitled, Down House, it was here where the revolutionary scientist wrote his most famous of works, *On the Origin of Species*, the book that introduced evolution to the world. Down House is located on a beautiful English countryside surrounded by extravagant gardens. Studying, researching, and observing various plants, these gardens served as a building block for his next endeavor, the science of Ecology.[4]

**Figure 2: Down House**

Currently Down House is a museum, showcasing all of Darwin's contributions to the science world, as well as celebrating him as a person. Since 1996 Down House has been owned and operated by English Heritage, an organization whose sole reason of existence is to protect and promote England's spectacular historic environment and ensure that its past is researched and understood.[5] The museum offers insight to Darwin's personal life, as well as his scientific endeavors and discoveries. On average, Down House attracts approximately 25,000 visitors a year. However, this number has been declining over the past 12 months. In hopes to increase this number,

English Heritage and Down House have interpreted a new plan using various forms of interactive media. This is of extreme importance since 2009 marks the bicentennial of Darwin's birth as well as the 150th anniversary of *On the Origin of Species.* Therefore, an influx of visitors will soon be on the horizon, and a new, innovative experience is desired.

Up to this point, Down House has prepared for 2009 by enhancing various parts of the house itself. The ground floor, the gardens and many other portions of the grounds have been completely remodeled in order to replicate what it looked like during Darwin's day and age. Fortunately, through both Charles Darwin and his descendents, an excellent record was kept for the layout of the ground floor, which enabled them to replicate this as best as possible. The first floor is intended to be a floor where many of his discoveries and journeys will unfold to the visitors. An exhibit designer and fabricator have been appointed by Down House and will be a major part of what is constructed on this floor. Since the museum currently has rather weak interactive exhibits, they plan to entice visitors through a new experience. This new experience would use exhibits that engage the visitor through personal interaction, rather than pure observation. Interactive mechanical exhibits are desired in order to achieve this experience.

The goal of this project is to assist English Heritage by producing an interactive mechanical exhibit prototype for Down House. The initial research is to find ideas and concepts that could be the basis of this exhibit. The design of this mechanical exhibit will be researched, including visitor's understanding of this exhibit and their interpretation of the content. A well designed exhibit will show Darwin's theories and observational experimentation in an effective and thought provoking way. This interactive display will further enhance the experience of Down House by introducing a different way to understanding Darwin's scientific thought.

# 2.0 Background

When we eventually propose the designs for our prototype exhibit, it will be extremely important that we are knowledgeable in the content we choose to use as the basis of our exhibit. To truly understand the scope of this project we must look at Darwin's observations and theories both globally and locally. We must understand the idea of evolution itself and his theories and studies. We must also understand Down House's place in society, as well as its overall objectives. Once we have a good grasp on the topics we choose to use as the basis of our exhibit, we will need to understand the qualities of a good interactive exhibit. The quality of the prototype exhibit we design will be dependent on our knowledge of this subject.

## *2.1 Darwin and His Studies*

Charles Robert Darwin was born on February 12th 1809 in Shrewsbury, Shropshire, England. He and his five other siblings were raised by his father, Robert Darwin, a wealthy society doctor and financier, and his mother, Susannah Darwin (née Wedgewood). In the spring of 1817 Charles began attending Mr. Case's Grammar School in Shrewsbury. Darwin was known for being a rather shy and reserved boy who invented wild stories; however he did like to show off his athletic abilities to other young boys. In July of 1817, Darwin's mother passed away.[6]

**Figure 3: Charles Darwin**

Darwin attended Mr. Case's Grammar School until 1825, at which point he spent his summer as an apprentice doctor, helping his father treat the poor of Shropshire. In the autumn Darwin enrolled at the University of Edinburgh in Scotland. He went there in

hopes to pursue a medical career; however his fear of the sight of blood eventually turned him away from this profession.[7]

Darwin finished up his first year of medical school, and spent the summer hiking the Welsh hills near his home in Shrewsbury. After reading Reverend Gilbert White's, "The Natural History of Selborne", Darwin had a new found appreciation for wildlife. On his hikes, Darwin started making detailed observations of birds and kept a notebook of their habits. Looking back, this may have been a turning point in his life, eventually turning him into one of the most famous scientists of his day.[8]

In the winter of 1828, Darwin attended Christ's College of Cambridge, where he prepared for a career in the clergy. Darwin expressed no interest in his theological studies and eventually became acquainted with the botany professor, Reverend John Henslow, who was destined to become his mentor and have a profound effect on his life. It was Henslow who encouraged Darwin to take an extended sea voyage and explore the world outside England. Darwin took advantage of this opportunity and joined Captain Robert FitzRoy, on the HMS Beagle, for a five year expedition which explored the coastline, flora, and fauna of South America.[9] During the voyages of the HMS Beagle Darwin studied the natural world by examining and collecting plants, birds, insects, fossils, marine life, rocks, and invertebrates and vertebrates.

Upon his return to England he organized his notes and began to read incessantly in all fields of science. In 1838, his ideas were transformed into what eventually became his theory of evolutionary change and the origin of species by a process called natural selection. His ideas were set, however; they were not ready for publication since Darwin intended to keep working in order to produce a larger, more impressive book.[10]

In 1839, Darwin married his cousin Emma Wedgewood. They would spend their time living in the social whirl and professional intensity of London, until 1842. In 1842, now with two children, Darwin was ready for a retreat. He was a countryman at heart and also loved to see the changing seasons and breathe clean air. This lifestyle was easily suited on the English countryside 16 miles southeast of London in

the town of Downe. Down House was the name soon adopted by this home, and would be the final resting place of Charles Robert Darwin.[11]

### 2.1.1 Evolution

Before we crack into the mind of Charles Darwin it is necessary to look at the topic of evolution itself. Life has been evolving on Earth for billions of years. Biological evolution is known as the collective change of populations from one generation to the next. These changes are formed at a genetic level and come from the mutation (alteration) and the recombination of genes. These genetic changes are then passed on through reproduction to the following offspring. These mutations are sometimes traits that are useful to the living organism and may make it more likely to survive, than same organisms that do not have that trait, in a certain environment. As the generations pass, heritable favorable genes become more common in the population. This is known as natural selection [12]

While humans grow and develop we follow a genetic code that is embedded in our DNA or deoxyribonucleic acid. This basic code is a mixture of our parents' genes and is passed on during reproduction. Because all DNA is mixing during reproduction no two individuals have the same genetic code, even siblings vary genetically but their relationship can be seen through physical traits. These physical traits can be extremely different in a species. Inside a species, organisms can become different sizes, colors, shapes and builds but they are all genetically related. A species is defined as a group of organisms that can mate and reproduce offspring who can repeat the process.[13]

Early geneticists believed evolution was due to mutation pressure; however, it is truly focused on the recombination of genes. Genotypes are the product of this recombination or the mixture of genetic material from parents mating. These genetic changes are caused by a mutation in the genes. This is not a simple process; it includes the crossing-over and the reassortment of chromosomes. [14]

Today it is known that organisms inherit traits from their parents. These traits are predisposed by the genes which were passed on by the parent organisms. These genes

are located in sets of genes called genomes and are a part of the genetic makeup of an organism. An organism's genotype is not the only deciding factor in its appearance but it also influences it in combination with its phenotype. The phenotype is described as the physical appearance and behavior due to an organism's interaction with its environment. When combined the phenotype and genotype build a map that describes the organism. The question that is in consideration even today is how much can a phenotype affect the genotype? Charles Darwin answered this question without any knowledge of the genotype. He focused on just the physical aspects that lead to survival. He did not know about genes, and that their mutations that can bring about changes in populations.[15]

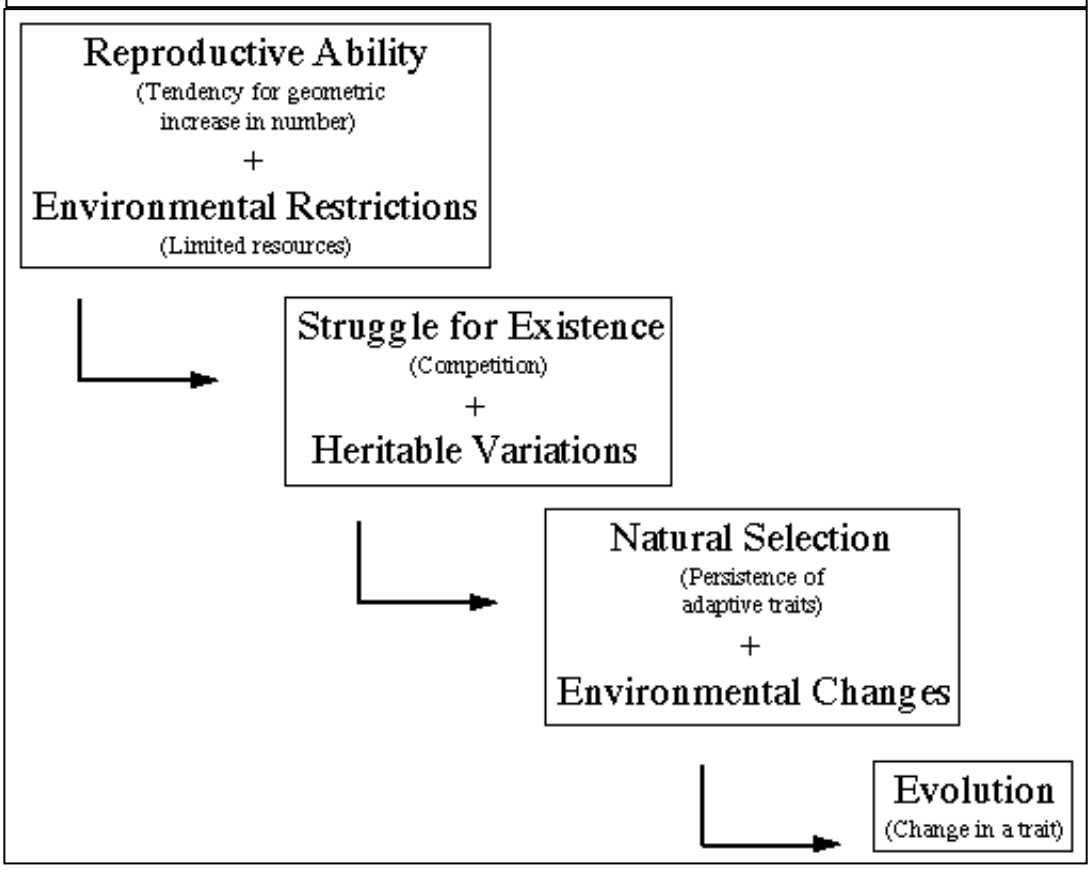
Evolution is considered to be the change over time of a given population. By looking into mutation, variation and inheritable traits, we see the remains of an idea that scientists have been asking for many years. Charles Darwin went on to answer the question of how organisms change, why species come about and some eventually become extinct. He took a question and used all aspects of the world around him to answer it. His theory of evolution by natural selection became one of the most influential scientific theories of his time and even though some still debate it today.

### 2.1.2 Darwin's Theory of Evolution by Natural Selection

Charles Darwin believed that all life originated from a common ancestor. He was a naturalist, who believed that organisms become more complex over time and brought his theory of evolution to the forefront of the scientific world. This theory states that organisms vary and may be born with advantageous traits and that these traits will give them the edge to survive and pass those traits on to their offspring. Darwin knew nothing of genetics and DNA but focused on the physical traits of animals. These advantageous traits will become part of the organisms while the unfavorable traits will become less common over time. Darwin wrote that,

> *New forms produced on large areas, which already have been victorious over many competitors, will be those that will spread more widely, will give rise to most new varieties and species, and will thus play an important part in the changing history of the organic world.*[16]

**Figure 4: The Process of Natural Selection**




Darwin's theory of evolution by natural selection can be seen in Figure 4: The Process of Natural Selection. As populations are growing they are constantly struggling to survive in environments with limited resources. Those organisms that survive the competition reproduce and pass certain heritable variations to their offspring. The offspring will resemble the parent and have similar features to aide them in the struggle for existence. These advantageous inheritable traits will then be more likely to appear in groups of surviving organisms of the species and slowly modify them. Darwin meant that natural selection is a force that keeps organisms with advantageous traits alive in species while they are spreading and changing in the natural world. An example of this is the cats; they have developed many characteristics that are advantageous to their survival. They can outrun and kill prey efficiently due to their physical characteristics. These characteristics have adapted over time while weeding out the ones that were not beneficial.[17]

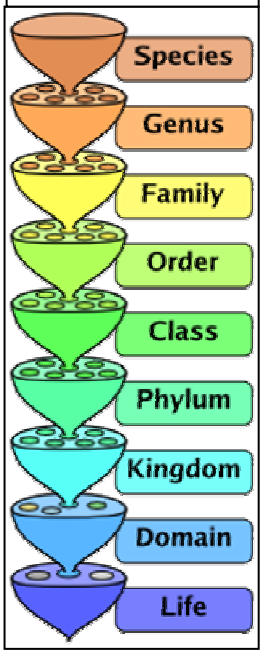
Darwin's theory includes three main reactions of organisms to change in the environment. The first is that they adapt through favored traits, the second is that they

migrate to a more suitable environment and the third is that they go extinct. All three of these reactions are parts of natural selection while forming new species. While some organisms may have moved to a new environment they can return and meet up their original species and might not be able to mate. This means that they are a new species. Darwin did not reinvent the wheel when he wrote *The Origin of Species* but introduced to the world the idea of natural selection as a mechanism of evolution. This theory of evolution showed his observations on species and their relations to each other. He observed their different and similar traits to organize them and solve the origin of all species and how they grew to exist. Darwin classified these species by the number of similar characteristics they contained after adapting and this process is now called taxonomy.

### 2.1.3 Taxonomy and Darwin

Taxonomy can be defined as the classification of organisms into groups based on their origin and genetic relations. Carl Linnaeus (or Carl von Linné), a Swedish botanist, is known as the father of taxonomy because of his work in classification, naming and the ranking of organisms. Taxonomy is the process of identifying and naming species so that they can be put into these systems. Taxonomists name species by their relation from one to another. Carl Linnaeus's system included genera which were split up into orders and these orders were then split up into classes, each of those classes were then divided into kingdoms. Out of his studies came binomial nomenclature or the system of naming species. For example, the kingdom *Animalia* includes the class called *Vertebrata* and inside this class is the order *Primates*. Inside of the order *Primates* is the genus called *Homo* and within that genus is the species *sapiens*. In other words *Homo sapien* means human due to the binomial naming system started by Carl Linnaeus.[18] He attempted to name almost everything in the natural world by splitting them up into three kingdoms; *Rengum animale* (animal kingdom), *Regnum vegetabile* (Plant kingdom), *Regnum lapideum* (mineral

**Figure 5: Eight Major Taxonomic Ranks**



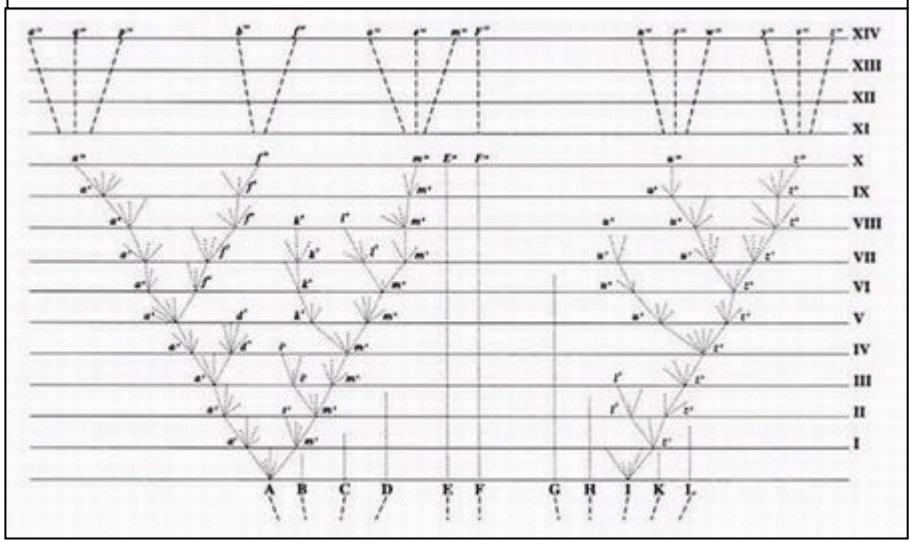
kingdom). Following him, binomial nomenclature became popular in science although it was used before.

Charles Darwin's theory of evolution changed science by giving scientists the ability to see the diversity of life as something dynamic. Darwin stated it as the following:

> *From the first dawn of life, all organic beings are found to resemble each other in descending degrees, so that they can be classed in groups under groups.*[19]

Before Darwin, the relationships between species were seen as a linear progression with human beings at the top and one thing leading right up to the next.

**Figure 6: Tree of Life from *On the Origin of Species***




Darwin introduced his theory through Figure 6: Tree of Life from *On the Origin of Species*, which shows the story of species, creation and change over time in our world. This broke open the field of taxonomy and classification. Taxonomy went from a definite progression to a wide open field of science with many uncharted territories today. It went from a list built during creation to a changing unfinished map that leads to unknown possibilities.[20] Darwin believed that there is more to classification than just resemblance. He believed that classification is a way of showing the connections between organisms due to variation and modifications over time. Darwin used observation as his basic tool for studying taxonomy and believed that,

> *We have no written pedigrees; we have to make out community of descent by resemblances of any kind.*[21]

He used is observations of the world around him as his biggest asset for classifying organisms. Darwin believes that you have to dig deeper in classification than what is just on the surface of organisms. He believed that the organs of reproduction, their product or the seed, their habits and food are just as important as their resemblance with others

### 2.1.4 Darwin Controversies Today

Today Darwin's theory of evolution is still argued in science and religion. It has been fought over and debated for years, in both science and the classroom in the United States and all over the world alike. Since his theory was introduced there have been many changes in science but he is still seen as one of greatest minds of the modern world. Charles Darwin was proposing a theory of evolution to explain the past with the knowledge of those that came before him, as well as what he found in his travels. He could not explain some aspects of the creation of life but he strived to find what answers he could with the tools at his fingertips.

The intelligent design creationist movement has been attacking Charles Darwin's theory of evolution by attempting to keep the teachings of evolution out of public schools. There have been over nine major court decisions in the United States that keep creationism out of public schools since it is promoting a religious belief in a state-sponsored school.[22]

Up until the end of the nineteenth century creationism was being taught in public schools as a part of the curriculum. After World War I, a rising amount of hostility towards evolution grew and the idea teaching of this theory within schools was absurd. William Jennings Bryan was a popular politician, orator, and lawyer at the time who was extremely outspoken against Darwinism and this can be viewed in the famous trial; *Tennessee vs. John Scopes* or the "Monkey Trial" (1925). In Tennessee, the creationists tried to keep evolution out of public schools by the Butler Act (Tennessee Evolution Statutes, 1925). This set off the ACLU (American Civil

Liberties Union) to challenge this outright bid against constitutional rights. John Scopes took up the offer and taught a lesson in school about evolution against the state laws. Clarence Darrow spoke in defense of science and John Scopes. In the end, John Scopes was found guilty for teaching evolution and given a small fine. They tried to bring the trial to the Supreme Court but it did not make it. This is one of the most famous court cases in all the U.S. and brought the science vs. evolution into a nationwide debate.[23]

Since the Scopes Trial and up until today teaching evolution in public schools has been the source of much debate. In Kansas in 2006, the teachings of evolution have been banned by emergency legislation outlawing evolution.

> *From now on, the streets, forests, plains, and rivers of Kansas will be safe from the godless practice of evolution, and species will be able to procreate without deviating from God's intended design.*[24]

Bob Bethell, a member of the state House of Representatives said this in conjunction with the new law. The new law did not allow anyone within state borders to willfully adapt to the changing environment conditions, or alter their health by changing their lifespan. Kansas said that any organism that shows evolutionary behavior like natural selection or speciation will be hunted down and investigated. This included everyone from humans to fruit flies. The lawmakers in Kansas believed that evolution had gone too far and the God does not want people to change and pass on traits to their offspring because it's "not natural." These decisions affected the economy in Kansas including plant hybridization, genetic engineering, and animal husbandry. Police raided and made arrests in Kansas.[25] Even though this theory of evolution by natural selection has been and still is the source of much debate, in some places it is actually integrated into the schools curriculum.

### 2.1.5 Teaching Evolution in England

Today in the United Kingdom, the science vs. religion debate has been coming up in schools and curriculum. On October 4th, 2007 the Council of Europe released an edition of the resolution of 1580 that rejects all creationism and intelligent design,

saying that they are not scientific and threaten civil rights when taught as scientific theory.[26] In England, the national curriculum included requirements for teaching evolutionary biology. In the core of science, the requirements for teaching evolution in biology were clearly spelled out.[27]

*It stated that pupils should be taught:*

- *that the fossil record is evidence for evolution*
- *how variation and selection may lead to evolution or extinction*

Another aspect of science, how scientific ideas may change over time and how scientific controversies arise, also is required in the national curriculum. In order to illustrate this correctly, Darwin's theory of evolution is used as a direct example:

*Pupils should be taught:*

- *how scientific controversies can arise from different ways of interpreting empirical evidence (for example, Darwin's theory of evolution)*

Lately the United Kingdom organization called *Truth in Science* has been using this controversy to teach intelligent design in schools. *Truth in Science* has been trying to promote intelligent design as an alternative science of creation. While the government investigated this it was found that one national syllabus for a GCSC science exam included one instance referring to creationist views. This is a national public exam taken at the age of 16 and it stands for General Certificate in Secondary Education in order to measure all state school and most public school students. This test includes most core subjects in order to compare students.[28]

In January 2006 the BBC (British Broadcasting Corporation) focused on creationism and evolution by taking a general public's attitude poll. This poll was done on the science program *Horizon* and asked people to choose on what they believed to be the origin of life. The poll showed that 48% of people believed in evolutionary theory, 22% chose creationism, 17% believed in intelligent design and 13% of people were unsure. The poll done by BBC also asked if they could choose more than one to be

taught in science classes what would they be. The results showed that 69% wanted evolution, 44% wanted creationism and 41% wanted intelligent design.[29]

In conclusion, even though evolution is directly taught within the curriculum, it is still the source of much debate among competing theories. No matter how widely accepted Darwin's theory becomes, competing theories and beliefs will act as a source of controversy. There may be only one place in the world where Darwin's theories and beliefs are constantly honored and revered. This location is where Darwin spent the last 40 years of his life dedicated to his work – Down House.

## *2.2 English Heritage & Down House*

Darwin moved into Down House in 1842, and continued to live there until the passing of his life in 1882. Following his death the members of his family who had been living there moved to Cambridge; however they often visited in the summertime. The house was kept in the family until the turn of the century when it was leased to various tenants. In 1927, Down House was entitled a National Memorial of the United Kingdom. It was not until 1996 that English Heritage purchased Down House, in hopes to protect and promote its historic environment and ensure that its past is researched and understood.

**Figure 7: Down House**

### 2.2.1 English Heritage

English Heritage is officially known as the Historic Buildings and Monuments Commission of England and is sponsored by the Department for Culture, Media and Sport (DCMS). English Heritage's job is to protect and improve the historic sites of England while also enabling public access and interest. Another goal of English Heritage is to increase people's knowledge and understanding of England's past. In 1983, the National Heritage act gave these responsibilities to English Heritage.

English Heritage carries out these tasks with the funding of the government and the income from revenue earned from the historic sites and other services.

They use these funds to reach its goals in many ways. Grants are given out by English Heritage to conserve historic places while also maintaining their registers. English Heritage looks after the historic environments and preserves them while continually researching in order to better educate the public. English Heritage's main areas of expertise are in historical buildings, monuments, areas and archaeological remains. It owns or acts as a liaison for over four hundred sites in England including Stonehenge, and the worlds first iron bridge (The Iron Bridge), and Down House.[30]

### 2.2.2 Darwin at Down House

Few properties can claim to have been as central to the life and work of their owners as Down House.[31] Charles Darwin lived with his family in Down House for a period of forty years during which he produced some of his major works, including the most famous; *On the Origin of Species.* This home is located on the English countryside where he followed his particular method of working: examining and re-examining the minutiae of the natural world day after day.[32] His outlook on the house and location can be summed up by Darwin's own words. Written in a letter soon after moving to Down, Darwin wrote;

> *My life goes on like clockwork and I am fixed on the spot where I shall end it.*[33]

**Figure 8: Gardens at Down House**

Aside from the major works that he published while living at Down House, Darwin also conducted many studies, mainly using the gardens located on his property. After the publication of *On the Origin of Species,* spring and summer rolled around in 1860,

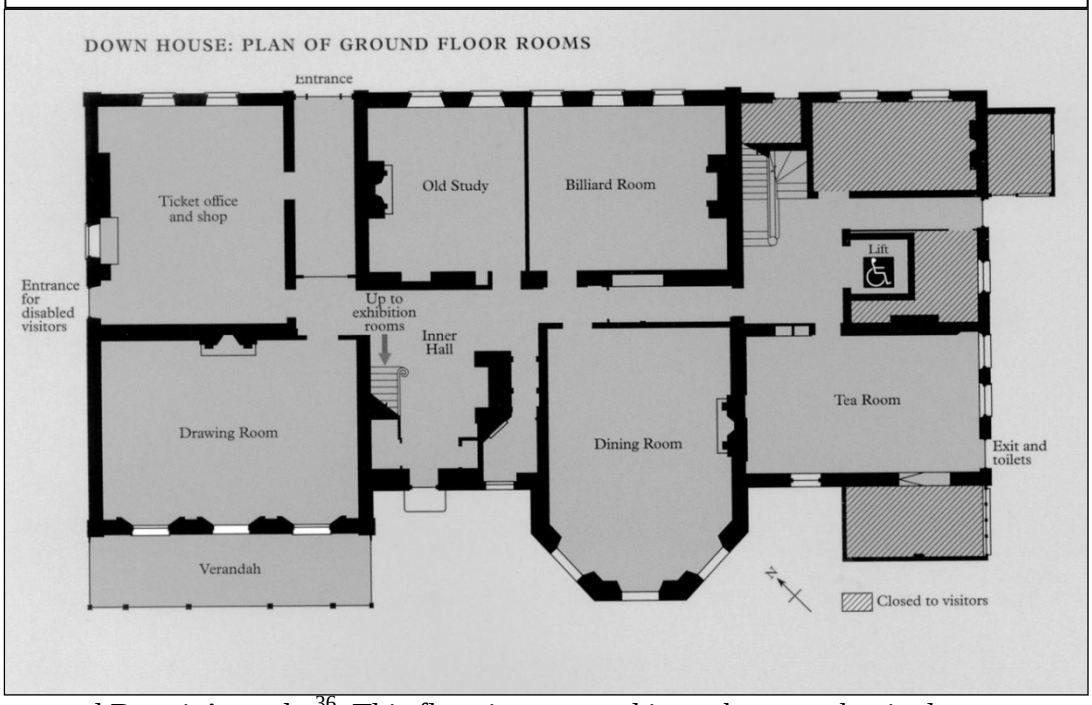
and Darwin wasted little time. He made observations in rapid succession. In May, he discovered a completely new plant-reproductive strategy: heterostyly; in June he deciphered the key to pollination in the exquisite flowers of the orchid, and in July he discovered the existence of insectivorous plants[34]. These revolutionary botanical discoveries launched him into twenty years of research. This research eventually led to six botanical books, all attempting to solidify his theory of evolution by natural selection.

### 2.2.3 Currently at Down House

Since being presented in 1996, Down House averages about 25,000 visitors a year. Visitors are provided with information on Darwin himself, as opposed to his work. The emphasis mainly falls on understanding his life both before and during his stay at Down House. A visitor commonly undergoes a tour of Down House, covering three main parts; the ground floor, the first floor, and the gardens.[35]

Upon entering Down House, visitors would find themselves located on the ground floor. Located on this floor are rooms such as the drawing room, dining room, billiard

**Figure 9: Layout of Ground Floor at Down House**

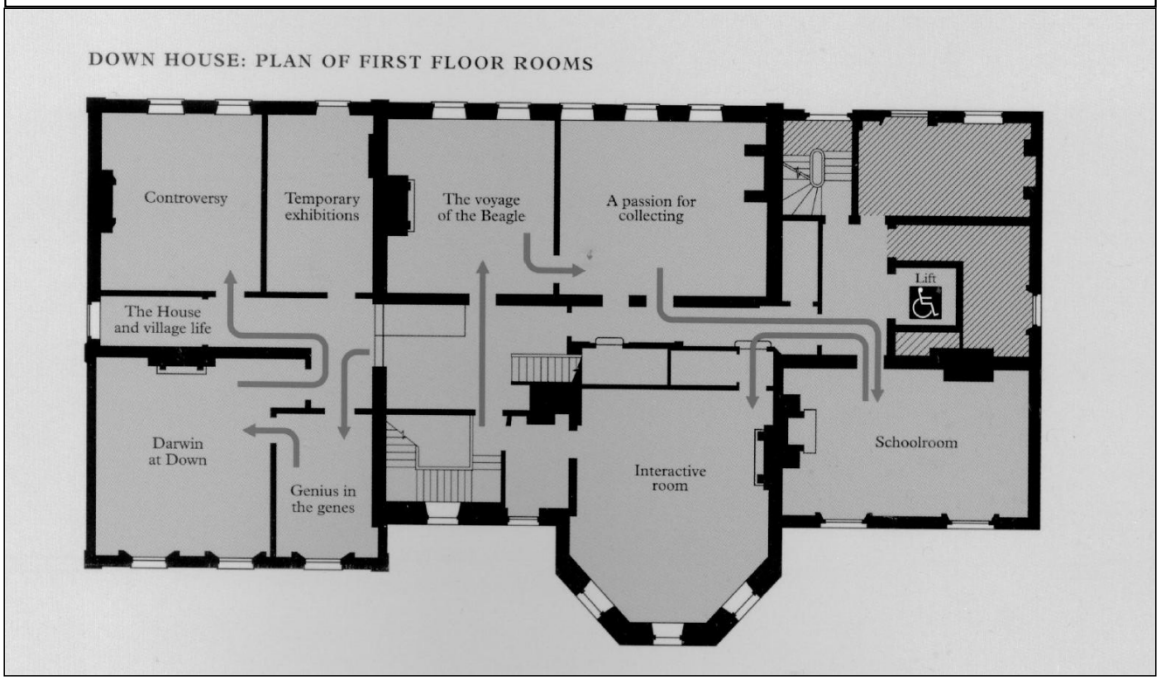



room and Darwin's study.[36] This floor is presented in such a way that it almost

exactly resembles itself from how it was in 1870. Incorporating many original artifacts the rooms are meant to give the impression that Darwin might have just stepped outside for a bit.[37] They were able to duplicate this floor since there were detailed floor plans left behind from when Darwin lived.

As said previously, the current strategy is to focus on Darwin himself and his life before and at Down House. With this in mind, the first floor is treated as a blank exhibition, and each room was designated to a respective theme. Since there wasn't an elaborate floor plan left behind, like there was for the ground floor, it was decided that this floor would be used for display. Museum style displays, interactives and graphics are spread across the eight rooms of this floor. Some of the ideas and content fit well with this floor, and are intended to remain on display. However, most of the existing exhibitions are not fit for reuse. English Heritage and Down House wish to produce more interactive exhibits for this floor in the near future.[38] The new interactive exhibits will be placed in the appropriately named hexagonally shaped

**Figure 10: Layout of First Floor at Down House**




"Interactive Room" as seen in Figure 10: Layout of First Floor at Down House. This is just one of the many improvements being made to Down House in order to enhance the overall experience.

### 2.2.4 Improvements Being Made to Down House

Down House has been undergoing an interpretation plan since December of 2007, the first update since 1997. The interpretation plan was instituted partly because of the approaching bicentennial of Darwin's birthday and the 150th anniversary of production of *The Origin of Species*, which are in 2009. The general aim of the project is to improve the interpretation to better meet the needs of visitors, identified by the visitor research done in 2006. More specifically the aims are to put more of the reserve collection on display, to put greater emphasis on the gardens and their significance, to encourage visitors to spend more time on site, and to better address the theory of evolution.[39] The existing system of headsets with narrated recordings that visitors listen to is now being updated to PDA's that have a visual output as well. The ground floor is having a lot of maintenance work done to it, including a new fireplace for the billiard room, some conservation repairs to the collection on display and new flooring in the hallways. On the first floor one of the rooms will be a detailed reconstruction of Darwin's cabin aboard the HMS Beagle. The first floor also has a room dedicated to *The Origin of Species* where the main idea of the book will be explained, and some original pages of manuscript will be on display. In order to fulfill the need for explanation of the theory of evolution there is a room being reserved for interactive displays of scientific concepts and experiments done in support of Darwin's theory.

Currently the theme within the interactive room is rather childish. With bright green painted walls, as well as colorful and crude interactives, it tends to turn away the mature crowd. With the intention to appeal to all ages, a professional exhibit design and creation company has been hired by English Heritage in order to create quality exhibits that would fit the updated theme.

### 2.2.5 MDM Props Limited

MDM Props Limited is the exhibit design and fabrication company that our team has been partnered with. They were founded in 1993 as a specialist prop and model manufacturer, and has grown since then to one of the best known names in London in

the fields of specialist exhibition, leisure and arts fabrication. Currently, they operate within many different realms of the arts and leisure industries, from building huge exhibitions to making tiny scale models for museums. They work with a wide range of materials, including steel, aluminium, lead, bronze, carbon fibre, fibreglass, various polymers, timber, plastic and laminates. MDM is set up to provide an environment where everyone involved is allowed to explore, invent, and create objects complying to the briefs set up by their clients. Located in Brixton, they have a staff of about 35 people from all over the world, most of them with a degree in the visual arts. However, they do have non college trained individuals who bring many diverse skills to the table as well. See Figure 11: Exhibit Created by MDM Props Limited, for an example of MDM Props work.

**Figure 11: Exhibit Created by MDM Props Limited**


MDM also has a wealth of experience within the realm of interactive exhibits. With more then twenty different clients, including Disney and The National Science Museum, MDM is constantly innovating new ways to incorporate interactivity into their exhibits. They are truly professionals in their field, and it can be seen in the quality of their productions.

## *2.3 Interactive Exhibits*

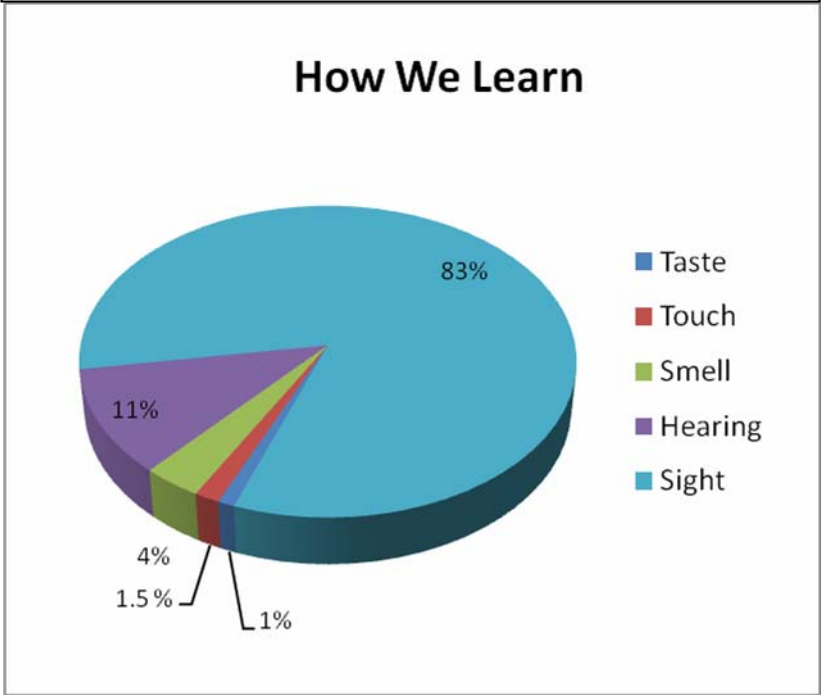
An interactive, or experience based exhibit, is an exhibit that teaches a concept to a museum visitor through interaction and experience.[40] This is opposed to a non interactive, or a factual based exhibit, where a visitor would learn through the written word. For example, an interactive exhibit might involve the turning of a crank to generate power to a light bulb. By doing this the visitor will experience an immediate effect that was caused by their interaction. As for non interactive exhibits, the visitor only needs to designate a small amount of attention, which most likely involves reading and observing. In turn, this leaves the exhibit vulnerable to become over looked and also misinterpreted.

The goal of an interactive exhibit is to let visitors learn through their natural process of experience. This allows visitors to learn while developing skills and gaining a sense of inquiry into the subject explored by the exhibit.[41] Exhibit success is traditionally measured based on the quality and amount of information passed on to the visitor. However, the success of interactive exhibits should be based on the information conveyed to the visitor, as well as their understanding of the concepts being presented.[42]

As well as being interactive, a mechanical approach to exhibits also increases one's ability to interact. A mechanical exhibit, by definition, is a mechanical system. Humans decipher such mechanical systems by making mechanical inferences about the functionality of the system.[43] A mechanical inference can be defined as the mental process that allows us to derive information about how things interact within a given system. Mental representation is the process that was just described, and is an example of mechanical reasoning. Mechanical reasoning is defined as the cognitive process used by the individual when trying to understand the mechanical system being observed.[44]

### 2.3.1 Learning Through Experience

**Figure 12: Learning Through the Senses**




It has been said that explaining science and technology without props can resemble an attempt to tell someone what it is like to swim without ever letting them near water.[45] For example, a child is more likely to learn about electricity by interacting with a hand crank generator powering a light bulb, as opposed to observing a picture of Benjamin Franklin holding a kite. Even if they don't take away as much concrete information, the interest sparked from the experience may later induce further inquiry on the subject matter.[46] Visual and interactive learning are both very important seeing how people learn more from visuals than they do from simply reading or being lectured to.[47] Figure 12: Learning Through the Senses, shows how humans use their senses to absorb information.[48] Figure 13: How Presentation Effects Memory, graphically represents how the presentation of information affects the brains ability to recall such information.[49]

## *2.4 Down House Exhibit*

The most important aspect for this exhibit is how the background information will be applied during the creation process. From the initial conceptual ideas, to the final screw placed in the prototype, it is extremely important that we rely on our background knowledge that we have previously obtained. Since the basis of our

**Figure 13: How Presentation Effects Memory**

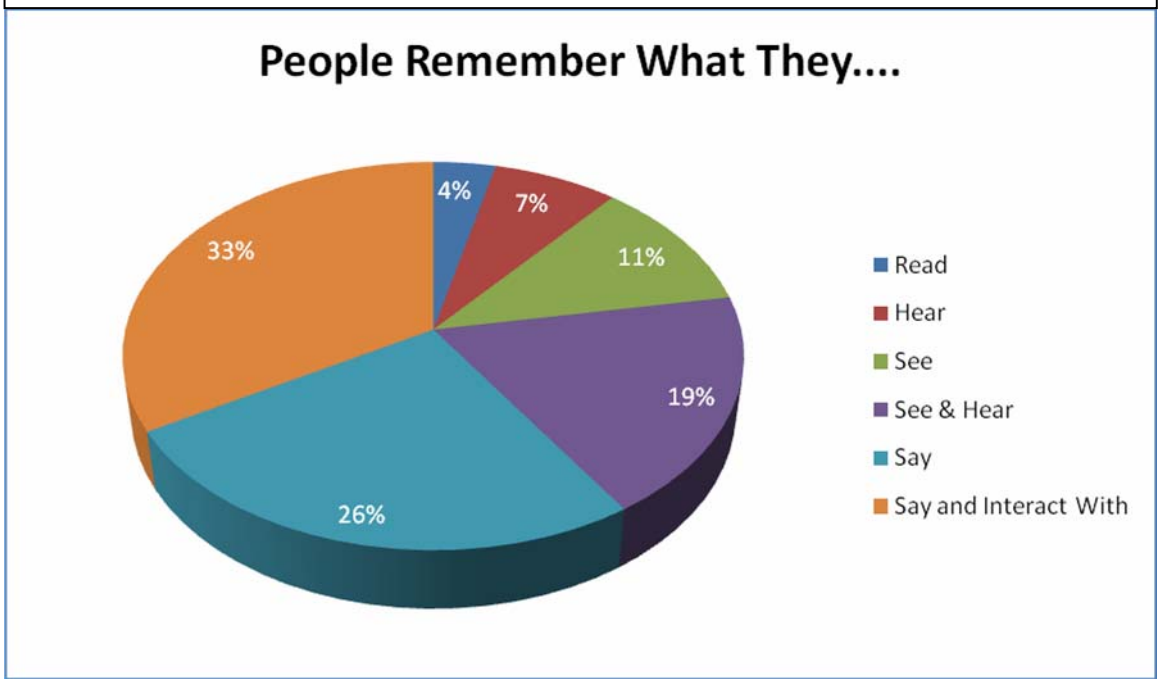



exhibit relies heavily on interactivity, it is extremely important that our concept is easily conveyed in this manner. Of course it is the concept that is the most important aspect of a quality exhibit, however, it can be seen that the concept is only as strong as its means of presentation. People are more likely to retain an experience if there is some sort of interaction involved (See Figure 13: How Presentation Effects Memory).

That being said, it is also essential that our exhibit's content is relevant to that of Darwin's studies and will also fit into Down House with its newly proposed theme.

# 3.0 Methodology

The ultimate goal of this project is to assist English Heritage by developing a simple interactive mechanical exhibit for a portion of Down House. In order to do this objectives have been laid out in order to streamline our process. These objectives can be defined as:

1. To identify basic evolutionary concepts and/or observations made by Darwin that could likely be used as the basis of an interactive exhibit.

2. To design and evaluate an interactive mechanical exhibit that can properly demonstrate these ideas.

3. To build the prototype.

4. To evaluate the prototype and determine effectiveness.

Our study took place at various locations; however most of our time was spent in the London offices of English Heritage. There we developed our initial concepts for potential exhibit ideas, and began the design process. We then carried out the remaining design process at MDM Props Limited, in Brixton, under the supervision of Russell Schofield. This is where we created the final design and built the prototype. A small portion of our time was spent researching various museums such as the Museum of Science (Boston & London) and the Natural History Museum. We visited Down House on multiple occasions to first get an initial idea of the surroundings our exhibit was built for. We eventually returned again to complete field evaluations of our fabricated prototype. **Please see Appendix A for a tentative timetable.**

The project is limited to the seven weeks of preparation at WPI and then the seven weeks in London. The final objective is to improve the overall experience of Down House visitors through interactive exhibits. Our study addresses the issue of presenting extremely strong scientific material to a body of people not necessarily interested in the sciences. We attempted to do this in a specific manner which does not overwhelm the visitor and also provides an interactive experience. We wanted

our visitor to take away an experience to remember, a simple approach to the realm of science in which Charles Darwin studied.

## *3.1 Identifying Concepts*

The first step was to identify possible concepts that could be used as the basis of an interactive mechanical exhibit. Interactive exhibit material was provided by English Heritage which had been previously established prior to our arrival. The intention was to base the exhibit off of Darwin's actual words. In doing so, our liaison (Jenny Cousins) used relevant quotes taken directly from his passages, that she felt could properly be conveyed in an interactive exhibit. **See Appendix B for interactive brief ideas provided by our sponsor.**

### 3.1.1 Deciding On a Concept

We analyzed our options using the interactive brief ideas provided from our sponsor. It was decided that the exhibit would be located in the "interactive room" where the underlying theme is dedicated to explaining the science and methods behind Darwin's theories. Also, wherever possible, each exhibit is inspired by a passage that he wrote. After discussion with MDM Props and our sponsor, it was decided that we would focus our exhibit on the topic of Taxonomy.

### 3.1.2 Narrowing the Concept

After our topic was decided, we then had to narrow it down to a more specific concept. This concept was based off of a quote found in Darwin's *On the Origin of Species:*

> *We have no written pedigrees; we have to make out community of descent by resemblances of any kind.*

A brief for the interactive exhibit was developed by our sponsor, which covers important aspects and deliverables which are to be achieved. Here is where the initial concept for incorporating interactivity into the exhibit was first introduced. The

exhibit was to allow the visitor to assume the role of a classifier by putting animals into the right position on a family tree. Once assembled correctly, then an electric circuit is completed and a reward of some kind is offered. This approach would adequately address our need to involve interactivity within our prototype exhibit. **See Appendix C for the Taxonomy Interactive Brief.**

Once Taxonomy was solidified as the topic of our interactive exhibit, we began to identify possible species on which to base the exhibit off of. When deciding, we took into account many aspects that would create the best possible exhibit for the visitor of Down House. In order to analyze this information quantitatively, we created a decision matrix. The decision matrix aided in determining which of the five potential taxonomy trees would be the best one to base our exhibit off of. We chose the criteria with exhibit presentation and performance in mind. The weight, or significance, of each criterion was set to ensure the criteria that affected the interactions between visitor and exhibit would count the most. **See Appendix D for the Taxonomy Tree Decision Matrix.**

Each potential taxonomy tree was ranked against each criterion individually by discussion and agreement between the members of the group and our sponsor. Based on the results of this decision matrix, it was then decided that our tree would be representing the family of the Felidae (cats). This methodological approach proved to be extremely effective in narrowing our concept of taxonomy into one family of animals, while also taking into consideration many important conceptual criterions.

## *3.2 Designing and Evaluating Our Ideas*

Using our prior knowledge and research we accomplished this task by visiting various museums such as; Down House, Museum of Science (London & Boston) and the Natural History Museum. This was done in order for us to form an opinion on what we felt were both successful and unsuccessful exhibits. We also visited art museums such as the Tate Modern and the National Gallery, simply because some of the best interactive exhibit designers today are artists.[50] We spoke and observed the work of our correspondents at MDM Props Limited. By observing the work of MDM Props Limited we acquainted ourselves with the process of which an interactive exhibit is

created.

The process we used to create started with our first objective, identifying concepts. After we successfully identified our concepts we began to run brainstorming sessions. The idea of this was to get some initial ideas of designs bouncing around, just too simply build off of. We used the taxonomy brief provided by our sponsor to guide us; however it didn't limit our creativity. Using this as a basic idea, we all began to draw up initial sketches individually. After we each drew up several initial sketches, we met with our sponsor and went over them. It was encouraged to depict creative ideas even if they didn't seem practical. Based on her input we streamlined all of our ideas into one, combining and collaborating until we felt we had a solid and practical idea to move forward with.[51] All of the sketches were not based on the content of the exhibit, but rather the structural appearance as well as the mechanisms involved. **Please see Appendix E for the initial designs.**

After the initial structure design was complete, we began to formulate a simplified version of the taxonomic tree obtained previously for Felidae (seen in Appendix D). The original taxonomic tree obtained had a total of thirteen genuses represented. After discussing with our sponsor, it was decided that we would remove a total of four genuses in order to both simplify and strengthen our end product. It was important not to overwhelm the user, and also provide recognizable animals within this tree, such as: the saber tooth cat (*Smilodon*) and the domestic cat (*Felis catus*). At this point, an initial taxonomic tree was constructed and presented to our sponsor. **Please see Appendix F for the initial taxonomic tree.**

During this process, it was extremely important to keep in mind the quote in which our design was being based off of:

> *We have no written pedigrees; we have to make out community of descent by resemblances of any kind. (Darwin, On the Origin of Species)*

It was important that our design portrayed this topic in such a way that it was strictly observational. We wanted the user to be able to deduce conclusions based on the

observation of certain recognizable traits within the images. This provided to be extremely important as we proceeded onto the evaluation of our design.

After we met with our sponsor and advisors, it was suggested that we take an alternate route in displaying our tree. As you can see from the initial taxonomic tree, a timescale was included to inform the user of the time period in which each genus lived. After this discussion it was proven that this information in fact confused the user, and a simpler approach was preferred. It was decided that the desired appearance should be something similar to a common family tree for people. This is simply because nearly everyone would recognize a family tree, and it would be considerably less confusing.

At this point, a second draft of the initial taxonomic tree was created. **Please see Appendix G for the second draft of the initial taxonomic tree.**

Once the second draft was completed we created exhibit instructions to aide the use of our taxonomic tree. We based these instructions on the Taxonomy Interactive Brief and the quote we received from our sponsor along with the aims of our prototype. **Please see Appendix C for the Taxonomy Interactive Brief.** Including in these instructions were hints and tips to guide the user towards the traits of the cats. These instructions were approved by our sponsor before putting into use. **Please see Appendix H for the Prototype Exhibit Instructions I.**

After this second draft was created, we began to test this tree on employees throughout English Heritage. In order to do this, we cut out all the images and fixated five of the nine images in the correct orientation. We informed the user briefly about what was desired, and then let them try to place the images in the correct location within the family tree. After observing each user who struggled with this task, we began to pinpoint the outstanding problem with this tree. The problem lied in the uniformity of the images. Since the images were all obtained from various sources, it was hard for certain traits to stand out in order to make correct inferences. At this point we began to try and find a source that had similar images of each genus being used. Located in the book, *The Big Cats: and their fossil relatives*, by Alan Turner, illustrations for (By Mauricio Anton) all the necessary genuses for our desired tree

were obtained. We used these pictures to reconstruct our tree, and added two pictures under the *Panthera* genus which included the jaguar and the tiger. Using the average shoulder height of each species, they were all scaled to their appropriate size. **Please see Appendix I for the new images that were used.**

After the new images were selected, they were placed into tree accordingly, and another test trial was run on English Heritage employees. We began to see an immediate improvement in the success of the user. We experimented with which images were fixated, in order to see which configurations were more difficult for the user to complete.

The final design was then created while keeping in mind that certain specifications are desired by English Heritage, Down House, and MDM Props Limited. A design specifications checklist was created to ensure that all topics were touched upon. **Please see Appendix J for the design specifications checklist.**

This methodological approach was deemed appropriate since it involved direct interaction with the user. Using Darwin's quote stated previously, we allowed the visitor to make inferences based *only* on visual observations. This approach focused strongly on the interactive properties that our exhibit would include. By designing and evaluating in this manner, we didn't lose sight of the issue at hand; learning through experience and the use of interactive exhibits.

## *3.3 Building the Prototype*

After we created this true to form final design, we once again ran through the design specification checklist to ensure that we weren't going off track. **See Appendix J for the design specifications checklist.**

After these steps were complete, we began to proceed onto the next step, fabrication of the prototype. In tight collaboration with experts at MDM Props Limited, we fabricated our design's prototype. This process included fabricating what we believed would be the mechanical aspects behind the design. Once we had an idea of the

mechanical process, we then moved onto the actual framework. By removing any unnecessary parts, we simplified the exhibit as much as possible.

This process was much more intricate that we anticipated. Originally we assumed once we had our final design, we would just build from that. However, we were constantly modifying our prototype with the advice and criticism of the professionals around us. This exact process can be understood in greater detail in the data and analysis section of the report.

After a total of nine days spent on fabrication our prototype was created, we were then ready to move onto the evaluation process.

## *3.4 Evaluating the Prototype*

After our interactive exhibit prototype was created, we began to move onto the evaluation process. The evaluation process entailed three main steps: a personal evaluation, followed by a professional evaluation, eventually ending in a visitor evaluation.

In all of the evaluation steps it was analyzed to see if the prototype would hold up to all sorts of abuse. That included testing of all of the mechanical parts involved. We fiddled and tinkered, in a rough manner, to see if it in fact was a durable prototype. The prototype needed to last the test of time, so it was extremely important that the mechanical parts were resilient and could hold up to continuous abuse.

### 3.4.1 Personal Evaluation

Throughout the entire design and creation process of our prototype we constantly evaluated every decision regarding the final outcome of our exhibit. This is simply because evaluation is part of the creative process.[52] Each of us would provide our own opinions at certain checkpoints throughout the project. In most cases, a consensus was reached and therefore a decision was made.

Each one of us analyzed the prototype individually, and wrote down any glaring problems or concerns regarding both the functionality of design. After the problems or flaws were directed, we made the proper adjustments and moved onto the professional evaluation.

### 3.4.2 Professional Evaluation

At this point we have established the functionality of our prototype to be adequate from our personal point of view. At which point it was time to see if it was adequate in a professional's point of view. The professional evaluation included input of our sponsor, as well as any professionals available at MDM Props Limited. The professionals analyzed all aspects that we previously evaluated, however a greater focus on the value and functionality of the prototype were examined. We were constantly given oral advice, where they pointed out any evident problems with our prototype so that we could address them prior to Down House visitor evaluation. Throughout the entire fabrication process, we constantly had various employees throughout MDM Props observing our progress. Whenever possible they never hesitated to add input regarding their personal observations. This is how MDM Props is extremely successful at what they do. By never ruling out anyone's opinion it enables the construction of a better end product.

### 3.4.3 Visitor Evaluation

This was the most important part of the evaluation process, simply because we created this exhibit for the visitors of Down House. After the professional evaluations were complete, and all the necessary modifications were made based on the input from various professionals involved, our prototype was ready for visitor evaluation. Our exhibit went on temporary display, where we obtained important visitor feedback regarding both the demonstrative properties as well as aesthetics of our exhibit. A total of 20-30 people directly interacting provided us with plenty of data to evaluate properly. Like previous evaluations, we attempted to receive information regarding the exhibits functionality, entertainment and educational value, as well as its interactive properties. The data was collected by the use of two different methods: observations and surveys.

Surveys of the visitors were very important in the evaluation of the prototype. The surveys were given to the user immediately after the use of prototype exhibit so that it was fresh in the mind of the user. The survey strived to collect quantitative and qualitative data. Closed questions were used in order to collect exact data, rating each aspect on a scale of 1-5. Open ended questions were used in case our survey did not hit upon a topic that the visitor found to be important. These questions are more time consuming, however the information retrieved is opinionated and of good quality. This brought up issues that may have never been touched upon until this stage in evaluation. It was important that we show no sign of ownership over the prototype, since users may hold back their true feelings about the exhibit.[53] In some instances the visitor wanted to know who created the prototype, in which case we replied by saying unknown employees of English Heritage and it was our job just to evaluate this prototype. **See Appendix K for a Visitor Survey.**

It was also important to conduct observational surveys. This was done by simply watching people interact with our prototype. It was important to see if the visitors could actually operate the exhibit, and if they couldn't, it was noted where they got stuck. Most of the information obtained here was based on the viewer's judgment; therefore all members of the team will observe each user independently.[54] This stage was also very important to evaluate the functionality of our prototype. Here we were able to analyze if our prototype exhibit failed both mechanically and electrically. This information is very important for the future success of the final exhibit. After the data was analyzed, the prototype was removed from temporary display and the data was analyzed.

The evaluation of the prototype was of extreme importance for the overall improvement of Down House's interactive room. By analyzing the data we acquired, while using our methodological approach to evaluation, we were able to obtain essential information regarding our prototypes functionality as well as its conceptual properties. The data from the visitor evaluations is partly qualitative. The analysis of the qualitative data will involve thematic coding. First a number of categories were created, such that all the answers to survey and interview questions fell into at least one of them. Each of these categories had themes associated with them, such as "the

exhibit was about evolution" which would be a category that fell into a code family. A code family being a group of categories, for example the code family that is all the different types of answers to the question "what was the exhibit about?"[55] The frequencies of categories in each code family were listed and then put into a bar chart, which provided for a general overview of the responses too the survey questions. The quantitative data was tabulated and put into a similar bar chart. We also put certain categories in scatter diagrams against certain demographics of the surveyed to find possible trends. The analysis will allow us to draw conclusions to how well the prototype exhibit performed and to what aspects of the exhibit need to be changed to better serve the target audience.

# 4.0 Data & Analysis

Throughout the two week design and fabrication process data was collected and directly incorporated. Throughout the two weeks following that, data was collected by both employees and Down House visitors. By obtaining this data we hoped to understand what makes an effective interactive mechanical exhibit.

Data was obtained for the design on a daily basis from our fellow co-workers who have a plethora of knowledge in all aspects of design and fabrication. We attempted to use the information we received from them by immediately introducing it into our design. Also, every decision we made was overseen by our superiors at both English Heritage and MDM Props Limited. Our final prototype was created using immediate response data that we obtained from our fellow co-workers, as well as the guidance and wisdom of our superiors.

Once fabrication of the prototype was complete we obtained data by using our co-workers as well as actual visitors of Down House. Our prototype was first tested for functionality at MDM Props Limited. Employees tested the functionality by physically interacting with it, as well as using there prior knowledge in attempts to expose a weakness in our design. After the functionality was approved we then moved our prototype to Down House for to test it on visitors. Our first test at Down was on the employees of English Heritage and after their approval the prototype was ready for visitor use. Our next set of data was collected through visitor use. Visitors were interviewed and provided surveys for them to fill out, asking them questions about the interactive and educational properties. Aesthetic properties were neglected since this is the prototype of a future exhibit.

Surveys were conducted alongside interviews in order to obtain the most honest answer from the visitors. Generally, when interviewing people, they may tend to be more kind than necessary, in attempt to avoid making the interviewer upset. So by providing surveys, it gave the visitor a chance to be brutally honest in their opinions

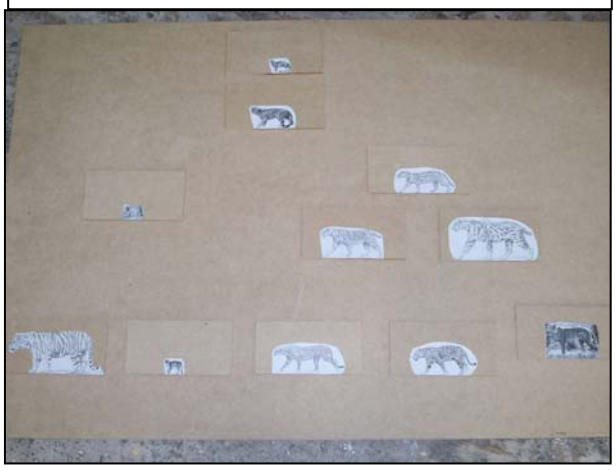
of our prototype. This data allowed us to draw some preliminary conclusions on what makes an effective interactive mechanical exhibit.

## *4.1 Design Data & Analysis*

Once the draft of the design was created, as shown in the methods, data from the professionals at MDM was then collected. Data was gathered by discussing the designs with the people at MDM. By conducting these interviews many different types of data were compiled. This data included size, cost, mechanics, electrical and functional information. Data was also collected on tools, materials and safety from the employees at MDM. Information was also gathered on both electrical and mechanical parts. Data was collected for parts from online data bases and catalogues from the local company RS that MDM uses.

During the stage of evaluating the design the team met with a curator of the Science Museum. She gave advice on many different aspects of mechanical interactive exhibits and how they go about using prototypes. She explained how most prototypes look nothing like the final product, however they bring in a large amount of useful data. She inspected our cat tree and designs and gave us advice on the evaluation techniques used by the Science Museum.

**Figure 14: MDF Prototype main surface during construction**



The first step at MDM was to find information on what exact material would be used for the main body of the prototype. Data was collected by inspecting many different types of materials at MDM and which of those were available for use in our prototype. Wood, plastics and other materials were considered for the base of the prototype, however, MDF (medium density fiberboard) was decided upon because of it being easy to work with and its smooth surface finish.

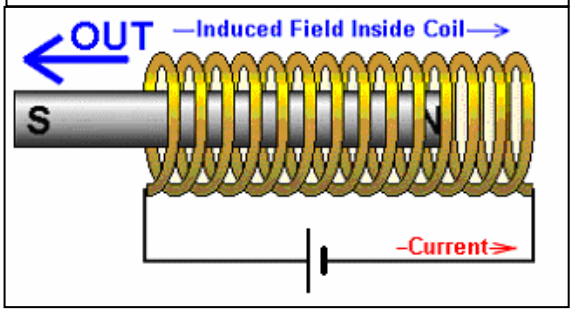
Based on the pieces of MDF found, our design, and the space we were allotted in Down House, we collected data on the possible size of the base of our exhibit. This data was then analyzed and incorporated into our plans. The final size of the main surface of our exhibit (the surface which our tree was to be displayed) was one hundred centimeters by seventy centimeters. This surface had a backboard the same size and then the top board which includes the holes for each piece of the tree. Each cat picture was to be eight centimeters tall and sixteen centimeters wide. This size also included space for possible labels to be included in the final exhibit. This decision of piece size was made by analyzing each cat and its features so that they could be shown and compared easily by the human eye. This was done using our own judgment and the collection of data, while testing the design on employees of MDM. This data was evaluated and then the scale and size was adjusted for the prototype.

After the board was measured and pieces machined the circuit and reset mechanism became the main focus of data collection. To collect data from a working example of a reset mechanism we used and analyzed a child's game called "Time Shock." This game included putting pieces in the right place under a time restraint. At the end of this allotted time the pieces were rejected and the game was reset. This data was noted and collected by taking apart the device and figuring out how it works. The game's reset mechanism was based on a simple coiled spring and gears connected to a launch platform. When turned and pressed down the coils tightened and waited for the timer to end to launch the pieces out of the game. It was decided not to use an actual timer but instead build an electric mechanism which does a similar reset task. By discussing these plans and the data found from "Time Shock" with the professionals at MDM the idea to use solenoids, a type of electric actuator, was approved.

The data that was then located included different types of solenoids and how to build them into a reset mechanism. While looking into other options and weighing out our possibilities, solenoids became the integral part of the circuit and focused the data collection process. The solenoids each had to pop out our pieces one hundred percent of the time. The reset mechanism was significantly important in the design of the prototype because without a reset the exhibit would not allow visitors to have a clean slate to begin with. Many different reset mechanisms were discussed and researched

but for our budget and time table the solenoids **(See Figure 15: Diagram of Solenoid)** became the most practical device we could use.

**Figure 15: Diagram of Solenoid**




Many other electric parts were researched including LED's and or lights as a guidance system to our prototype. After testing, advice and finding more parts it was concluded that this would become too expensive and intricate for our prototype. While analyzing this data we did decide to incorporate one red light as a symbol to let the user know that their choices were incorrect. Instead of spending more money to buy parts, the budget was kept to a minimum by incorporating unused items around the shop. Motors, lights, wires, micro switches and many other materials were torn out of unneeded parts. With these parts located and researched the circuit itself was then designed for our specific application.

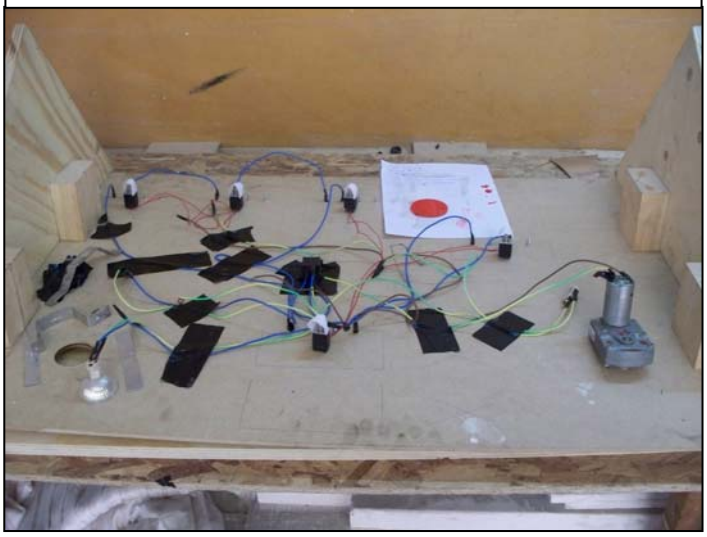
This design was based on the idea that we needed a few different effects when things were put into different places. One main part of design was that all five removable pieces needed to be popped out and reset at the touch of a button when the visitor was done with exhibit. This part was its own circuit but it was hooked up to the same power source as the other. The main circuit was designed with a relay switch which had two separate responses. The correct response or when all of the pieces were put in the correct spot and the test button hit a motor ran which indicated a correct response. When the pieces were in the incorrect spot a false light, similar to a stop light, would light up when the test button pressed **(See Figure 16)**. All of the data on these electrical circuits was found by going through our plans with members of MDM who had much more electrical knowledge than we did. The circuit was analyzed during the entire design process. Spacing, size, power usage, durability and functionality were all incorporated into the

**Figure 16: Test Button with Wrong Light**

constant evaluation. After the circuits were fully analyzed we were given the permission to order parts through MDM.

The order was based on all of the data collected while being at MDM. Through the recommendations of the professionals at MDM and the decisions of our team we ordered five solenoids, a relay switch, two buttons and a transformer. These items were planned to be added to what we could not locate at MDM. We found wires, micro switches, a light and bulb and a working motor. A power adaptor was also available at MDM to supply power to the prototype. These items were all researched and analyzed so that they best fit the prototype's needs. All electrical components needed to run on the same voltage (12V DC) in order to function. Before the final order form was filled out we had one of the directors at MDM inspect it. After his approval the parts were ordered from RS.

**Figure 17: Wiring and Circuit Setup**



Once the parts came in the circuit was built and tested. By attaching one solenoid to the power adaptor it came to our attention that they had to be put at the right distance from the piece for it to have enough power to push the piece. When the rod of the solenoid is first shot out it is weak but the force increases with distance. By testing solenoids we collected data on the distance and how to place them. This data was analyzed and used when the solenoids were mounted.

The reset circuit was created first as it was the simpler of the two circuits to be installed. Machine screws were used to secure the solenoids to the back of the main board of MDF. They were then wired up to the circuit with the "RESET" switch and the power supply, as indicated in **Figure 19: "Reset" Circuit Diagram**, which shows the position of the solenoids in the family tree.

**Figure 19: "Reset" Circuit Diagram**

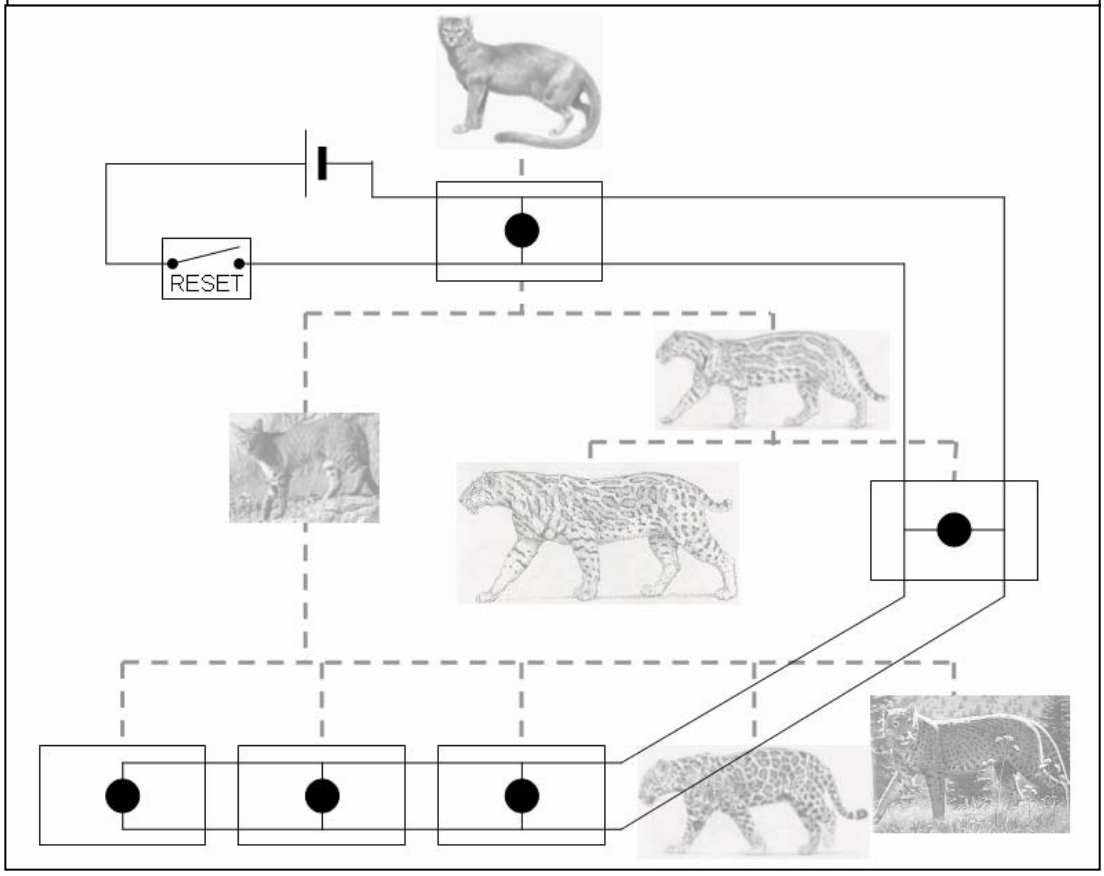



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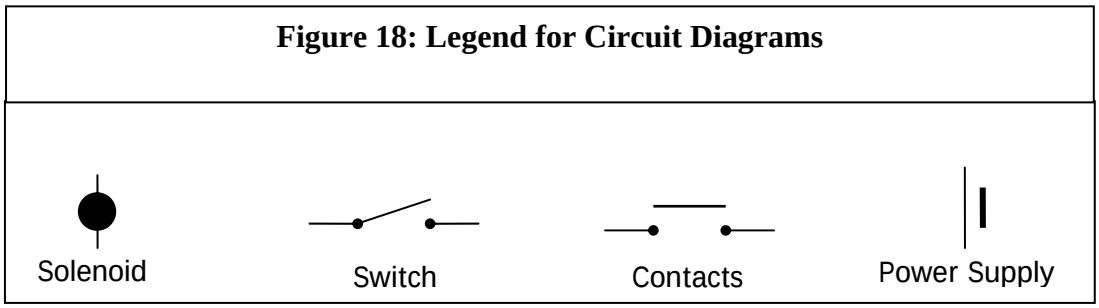
**Figure 18: Legend for Circuit Diagrams**



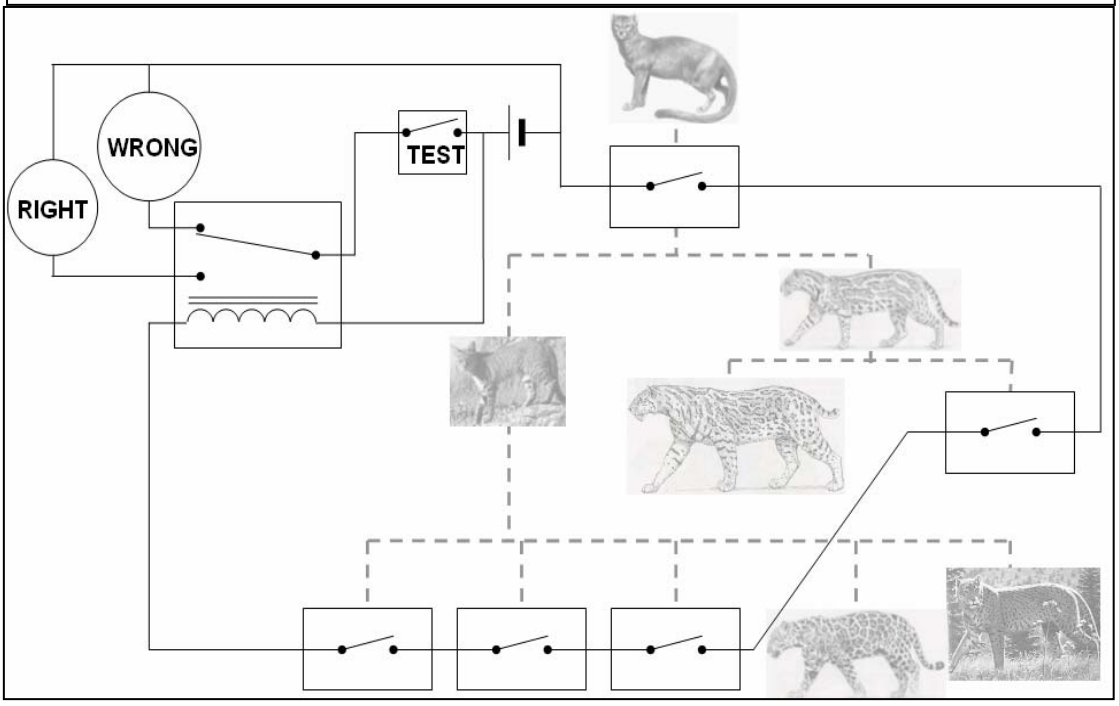

Once this was fully assembled and the solenoids were working the pieces were tested. By building this and collecting data on it, it was discovered that the MDF pieces were too heavy for the solenoids to push them. This prompted a search for another material to be used. By collecting data on this issue and analyzing the problem it was concluded that a much lighter material such as another composite or plastic would be necessary to proceed with the fabrication phase. Plastic sheets were found in MDM and by testing them it was apparent that they would be a much superior fit for our project. New pieces were built in tandem with testing them. These new plastic based

pieces were the same size and shape of the old MDF ones but were much lighter and reset easily with the solenoids.

After the reset circuit was fully attached and running efficiently the “TEST” circuit was created. This circuit contained a salvaged light bulb, motor, a button and multiple connections for each game piece which were all hooked up to an adaptor. This brought up new challenges with connections, hiding them and weight of the pieces. In the prototype there are five different cats that need to be put in five different places. Two of the cats have to be put into exact spots while the other three were interchangeable in three spots. This caused for more data to be collect and analyzed to modify our designs.

Our goal was to have each piece be able to fit in everyplace and get a response, be it wrong or right. The relay switch allowed for this but the next task was to make sure each piece connected to the circuit every time, when in the correct place. Wires, screws and metal plates were tested on the back of our pieces. By collecting data from the knowledge at MDM aluminum tape was used. Each removable piece was then fitted with aluminum tape in order to complete the circuit when placed in the

**Figure 20: Test Circuit Diagram**




correct spot on the family tree. By default the relay switch was set to illuminate the

"wrong" light when pressed, however, when all the pieces were in the correct position, then the "right" motor would spin.

We tried different materials and magnets to hold down the pieces. After trial and error and looking for materials, steel wool became an option. By screwing the steel wool into the board with screws and attaching them to the circuit it made the completion rate much higher but not perfect. By a few more trials with magnets it was discovered that the small (5 ml in diameter) magnets would work. By placing them inside the pieces over the connections they solidified the completion of the circuit. Data was obtained on these earth magnets and due to our lack of enough magnets another order was put out, through the guidance of MDM. As you can see from **Figure 21**, the reverse side of all the pieces to be placed within the family tree looked exactly like this. By creating breaks in the aluminum tape and covering the three possible areas where the breaks could lie with electrical tape, the user could not tell the difference. This allowed us to make it so each piece was unique with respect to the connections on the back. Where each piece fit on the prototype exhibit there were four screws located accordingly in order to make contact with the four magnets/aluminum tape on the back of the piece. Only two of the four screws were connected to the circuit, however, this was undetectable to the user. By creating the breaks in the appropriate area on the aluminum tape, we were able to individualize each piece. Meaning, each piece could only complete the circuit if placed in the correct position on the family tree. However, three of the pieces were interchangeable.

**Figure 21: Reverse Side of Pieces**

While awaiting the arrival of these magnets the board was mounted upon a frame. By collecting data through the testing of our solenoids and the pieces an appropriate angle was found. Triangular plywood supports and two by four blocks were added

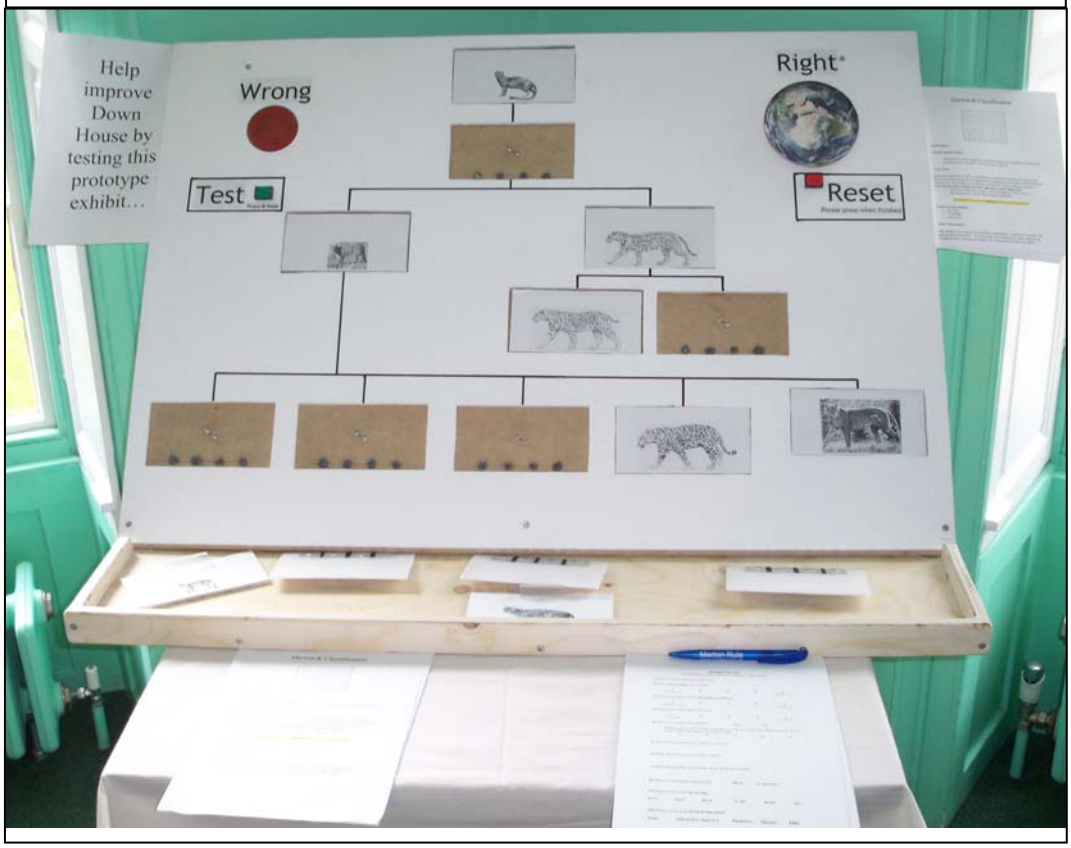
for strength and rigidity.  A trough like extension was then added to the bottom at a fitting length due to repeated testing of the pieces popping out and sliding down the exhibit.  All of these were attached together using screws while the face of the board, with the cut outs, was being painted.  From here the rest of the face was attached once the primer and paint was set.

## *4.2 Obtaining Prototype Data*

Throughout the entire fabrication process data was obtained in the form of informal interviews. MDM employees were constantly dropping by and giving us tips on how to emphasize certain desired aspects. After every significant step in the fabrication process, we presented the exhibit to our supervisors, and obtained there response as data. We used their responses to eliminate unnecessary features in order to optimize our end result. By eliminating undesirable features it enabled us to streamline our prototype for simplicity.

After the fabrication was completed we then conducted interviews and surveys. Data was obtained from the professionals around us using both interviews and surveys. Throughout the entire fabrication process, our co-workers were encouraged to test the exhibit explicitly in hopes to expose any weak areas that we may have overlooked. Surveys were filled out by some employees; however informal interviews were most helpful for adding any final touches prior to any further testing. By using their input,

**Figure 22: Prototype Exhibit at Down House**



we were able to make any last minute changes before the next evaluation stage at Down House.

Once that is completed the prototype was then taken to Down House, where visitors used the prototype exhibit. Observational data was obtained by watching the user and examining when they went wrong, if at all. Other important observational data was obtained such as; time to complete, sex, age, and if they reset the prototype. Also, surveys were provided to examine the effectiveness of certain aspects we wished to fulfill. To subsidize the surveys, informal interviews with visitors were conducted if the visitor seemed responsive to it. Most visitors, in the interest of time, didn't want to speak with us after completing the survey. However, on a few occasions the visitor did speak with us and let us know what they felt was both effective and ineffective.

## *4.3 Analyzing Prototype Data*

During the fabrication process we obtained data from the constant input of our co-workers, and were able to tweak our prototype accordingly. This data was analyzed by taking the consensus of all the professionals available to us.

After the fabrication was completed, the analysis took a more formal approach. Still using the professionals available to us, we analyzed the surveys quantitatively in order to identify weak aspects of our prototype. We also conducted informal interviews with employees of English Heritage and a team of scientists, where we used their opinions and advice, in order to modify our prototype accordingly.

### 4.3.1 Analysis of Quantitative data

**See Appendix L for the quantitative data**

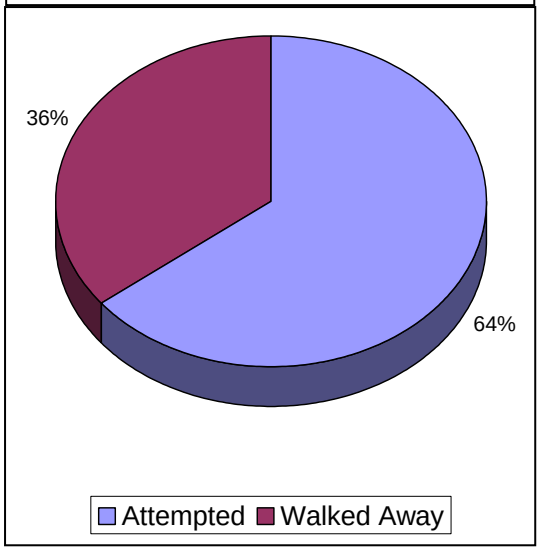
After that analysis, we then moved our prototype exhibit to Down House where it was on display temporarily for data acquisition purposes. Here is where we obtained the most crucial and beneficial information regarding the effectiveness of our prototype. Data was collected over a period of two days by the use of surveys along with the corresponding observational data. As you can see according to **Table 1**, a total of 45 Down House visitors passed by our prototype and observed it for at least 10 seconds.

**Table 1: Summary of Results**

| Category | | Total | Day 1 (6/13/08) | Day 2 (6/18/08) |
|---|---|---|---|---|
| Visitor Information | Number of Visitors | 45 | 18 | 27 |
| | Male Visitors | 22 | 10 | 12 |
| | Female Visitors | 23 | 8 | 15 |
| Progress | Attempted to Complete | 29 | 11 | 18 |
| | Walked Away | 16 | 7 | 9 |
| Outcome | Successfully Completed | 22 | 6 | 16 |
| | Did Not Finish | 7 | 5 | 2 |
| **Surveys Completed** | | **22** | **9** | **13** |

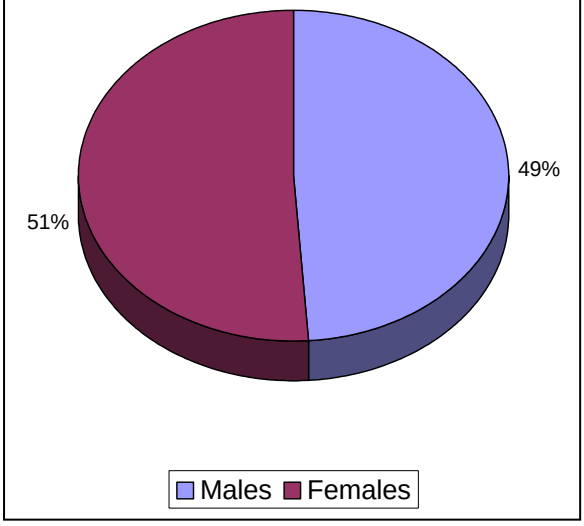
Out of the 45 people, a total of 29 visitors actually attempted to complete the prototype exhibit, while the remaining 16 walked away. **(See Figure 23)**

**Figure 23: Percentage of People Who Attempted/Walked Away**



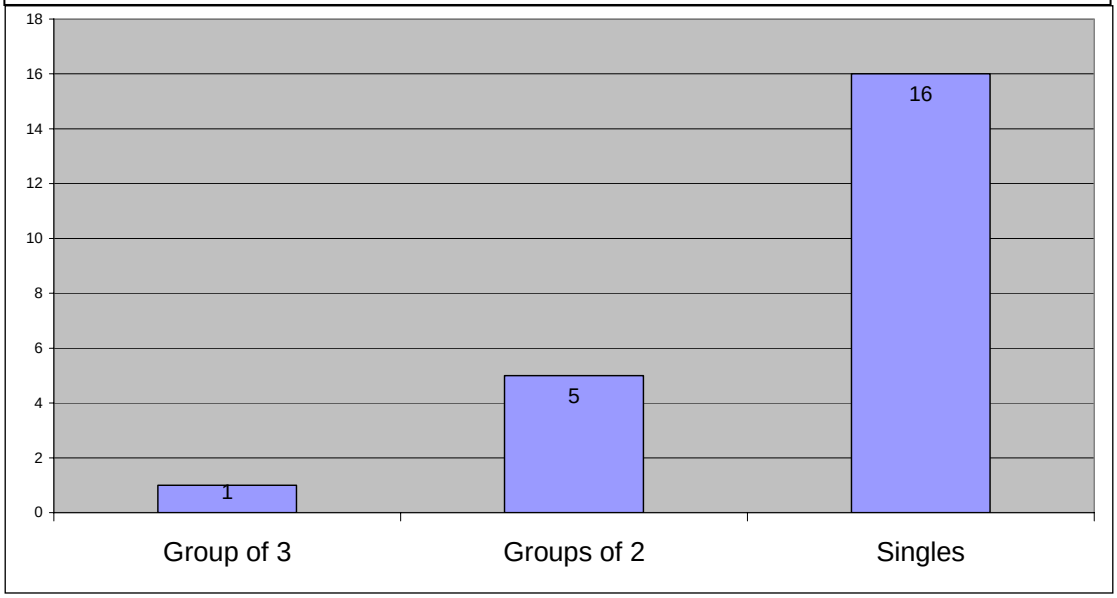

A total of 22 males and 23 females were observed **(See Figure 24)**

**Figure 24: Gender**



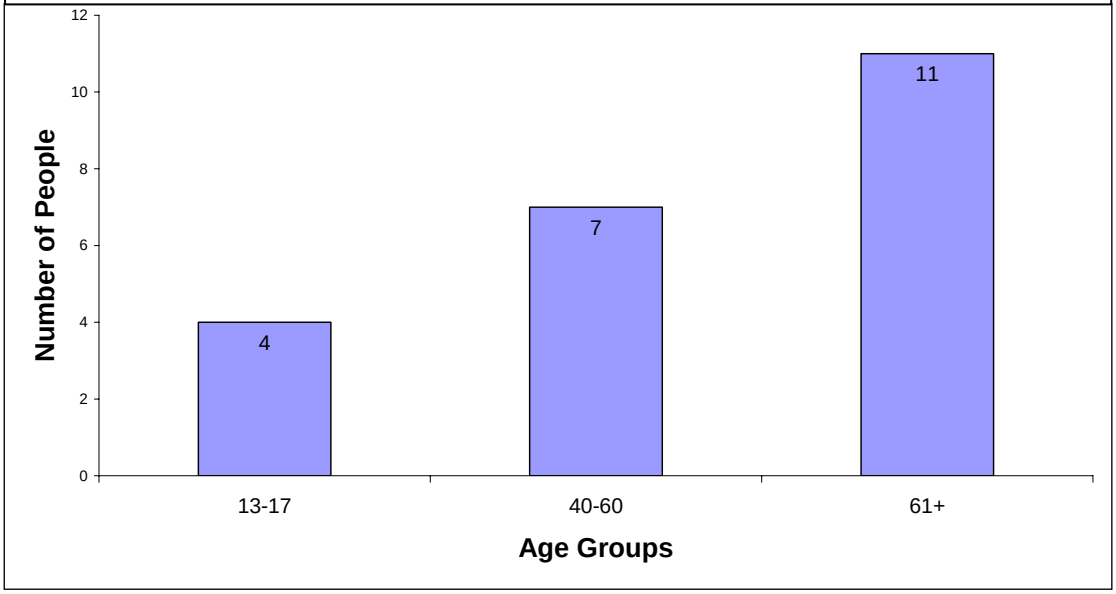
Two (2) people actually began to attempt the exhibit on their own, while we had to ask the remaining people if they were willing to attempt it. 22 surveys were filled out by 29 visitors, including, 1 group of 3, 5 groups of 2, and 16 single visitors **(See Figure 25)**. Over the 2 days of testing it took the users, on average, 166 seconds to complete the prototype exhibit.

**Figure 25: 22 Surveys Completed By...**



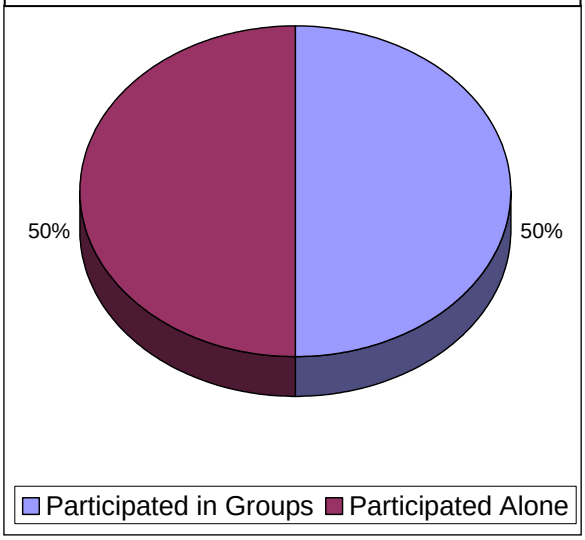

Among the 22 surveys filled out 3 different age groups were represented, 13-17 year olds, 40-60 year olds, and 61+ years old. **(See Figure 26)**

**Figure 26: Age Groups**



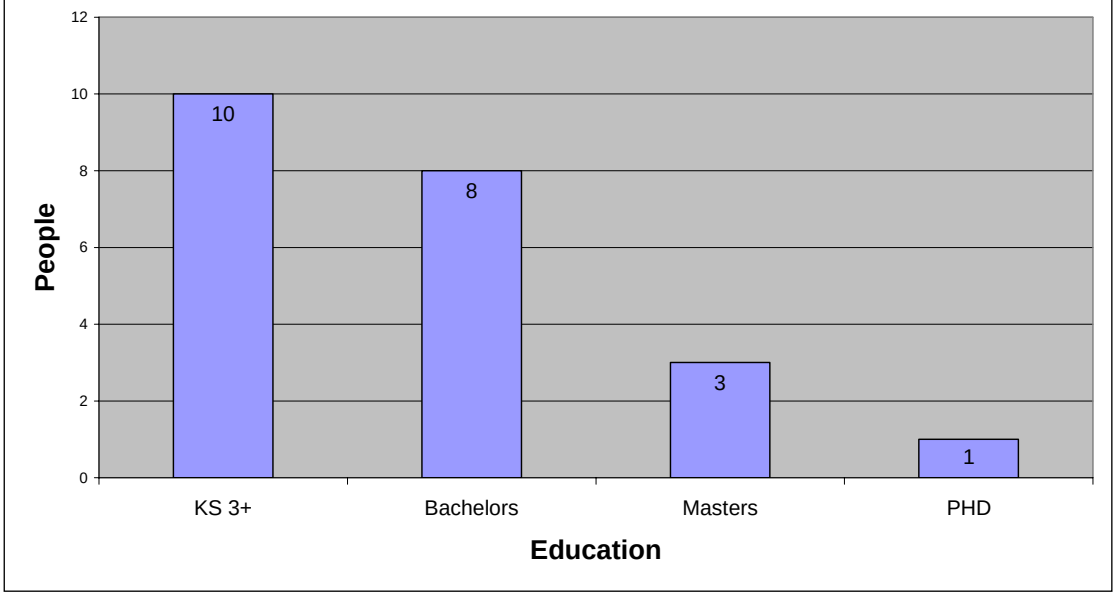
Of the 22 surveys received, it was noted that 11 people attempted the prototype alone, while the other 11 worked in a groups of 2 or more. **(See Figure 27)**

**Figure 27: Group vs. Solo Participation**



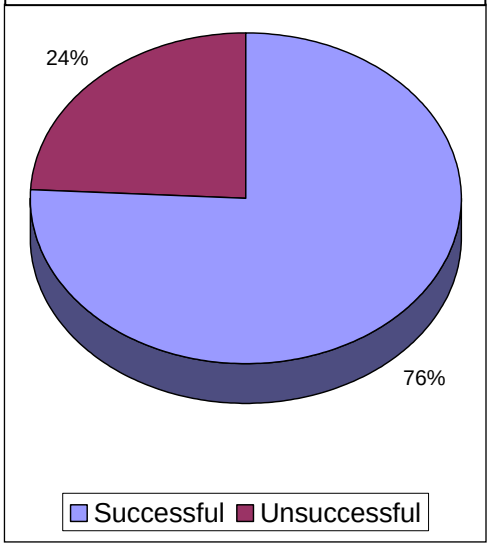

It was also observed that the visitors had various levels of education from KS 3+ to PHD's. **(See Figure 28)**

**Figure 28: Level of Education**



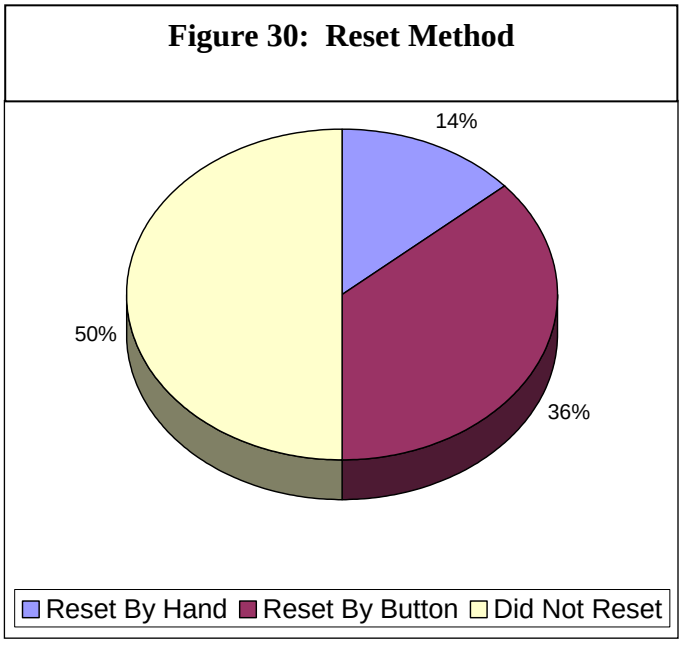
Of all the visitors over the 2 day span of testing, it was seen that 22 out of the 29 people successfully completed the prototype exhibit, measuring to a 76% completion rate. **(See Figure 29)**

**Figure 29: Completion Percentage**




Upon a successful completion, the users' method to reset the prototype exhibit was noted. Whether they actually used the reset button as informed through the instructions, reset it by hand, or did not reset it at all, all possibilities were observed and noted. **(See Figure 30)**

**Figure 30: Reset Method**



The survey also examined how many attempts it took the visitor before they successfully completed the exhibit. Attempts were defined by the visitors' use of the "Test" button, where he/she would press this button to see if their arrangement was correct. How many times they rearranged and pressed the "Test" button determined their number of attempts. **(See Figure 31 & Figure 32)**

**Figure 31: Number of Attempts Before a Successful Completion**

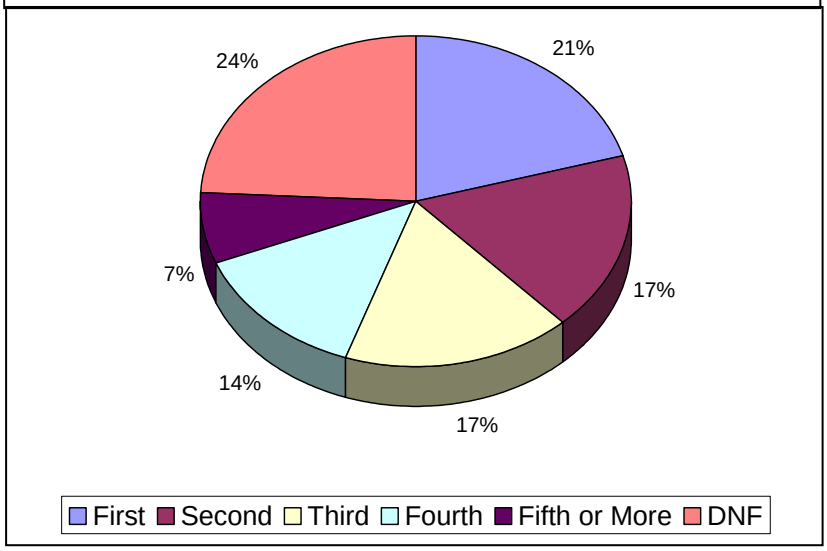
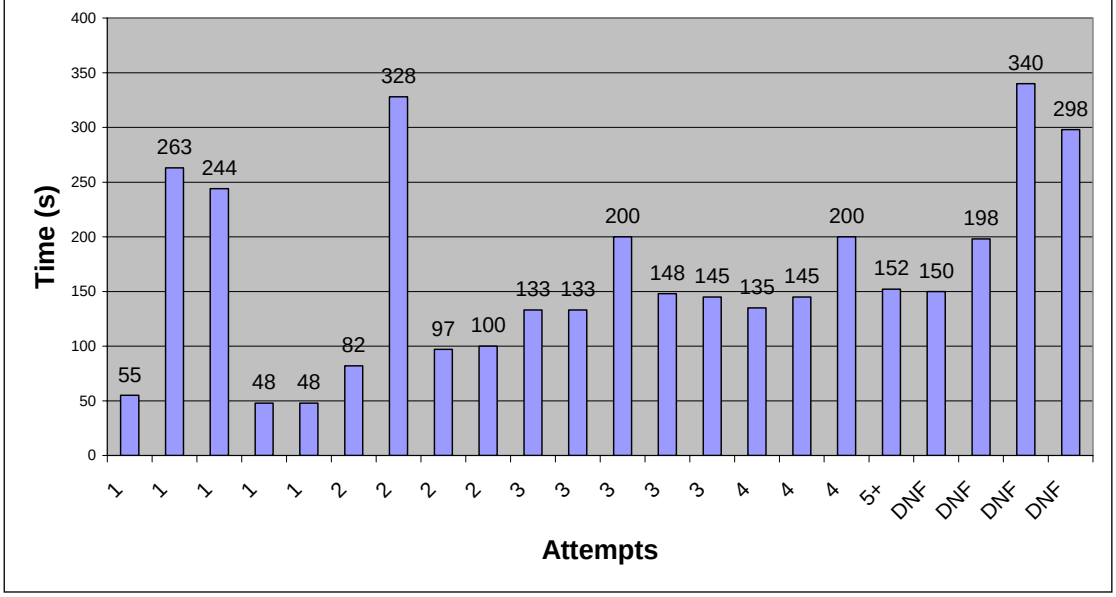
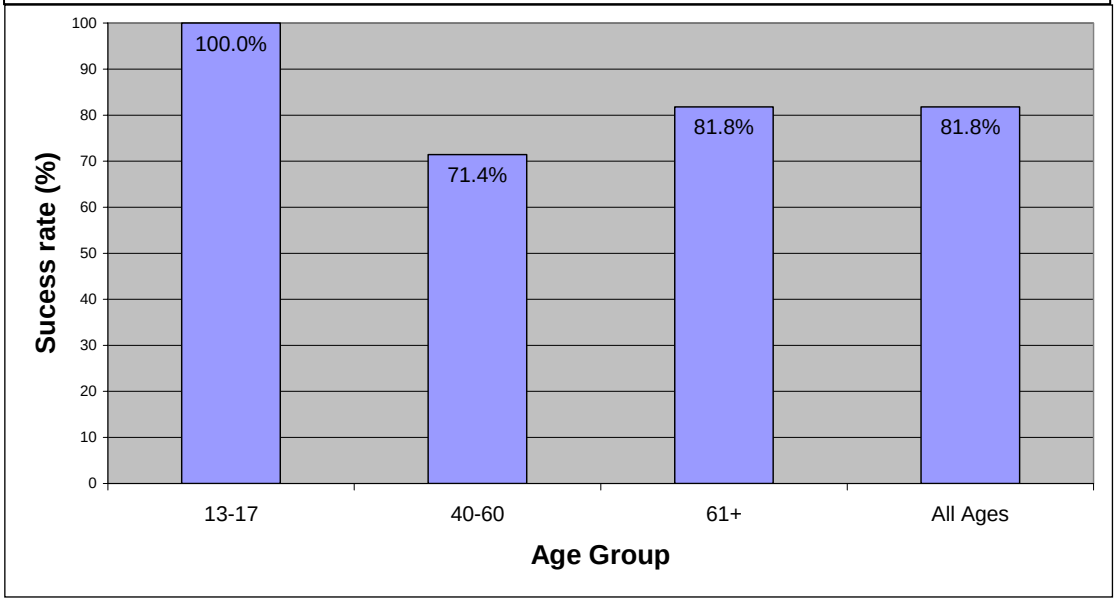



**Figure 32: Time vs. Attempts**



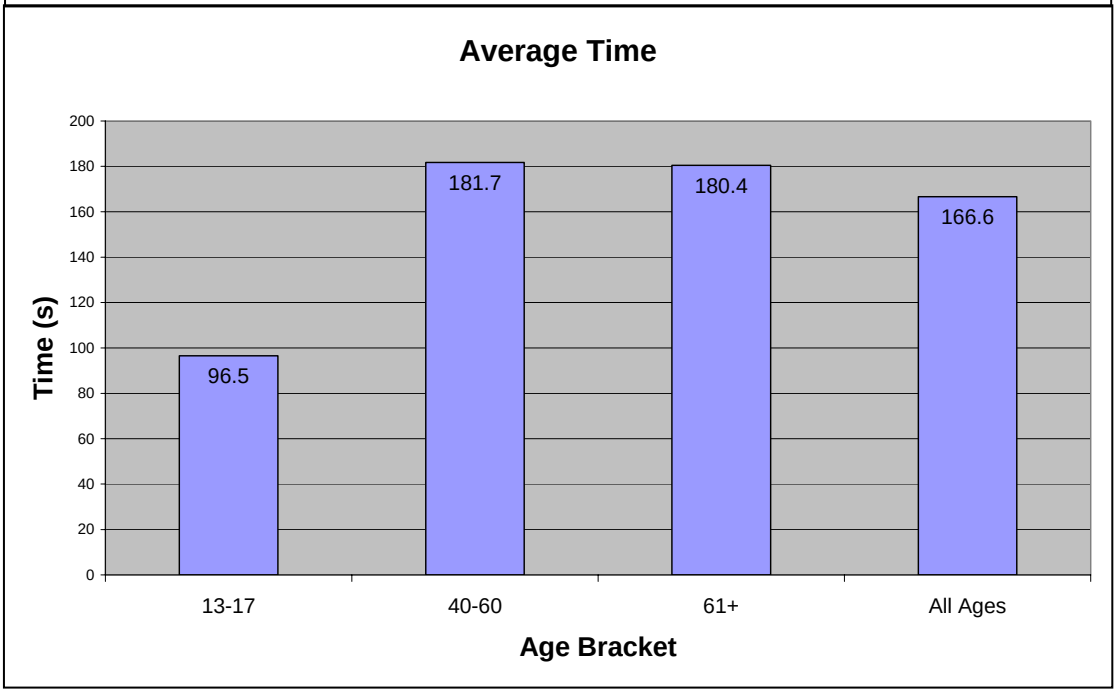
We were able to examine any trends that may be apparent within certain age groups, by analyzing each age group individually. It was observed that the 13-17 year olds seemed to be the most successful with a 100% success rate

**Figure 33: Age vs. Success Rate**



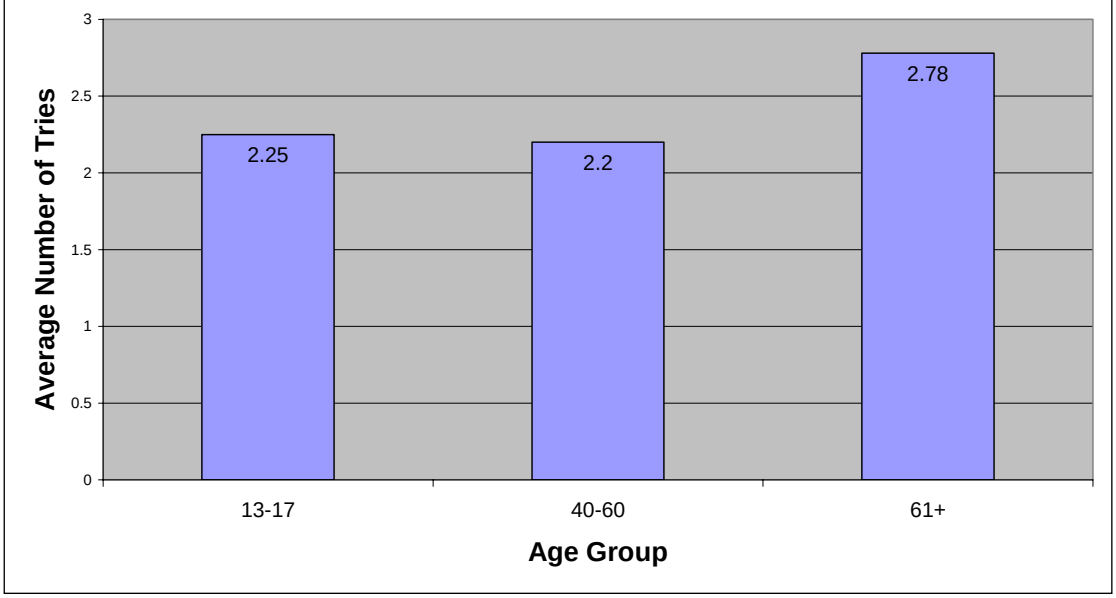

The 13-17 year olds also managed to complete the task, on average, in nearly half the time of both the 40-60 and the 61+ age groups. **(See Figure 34)**

**Figure 34: Average Time**



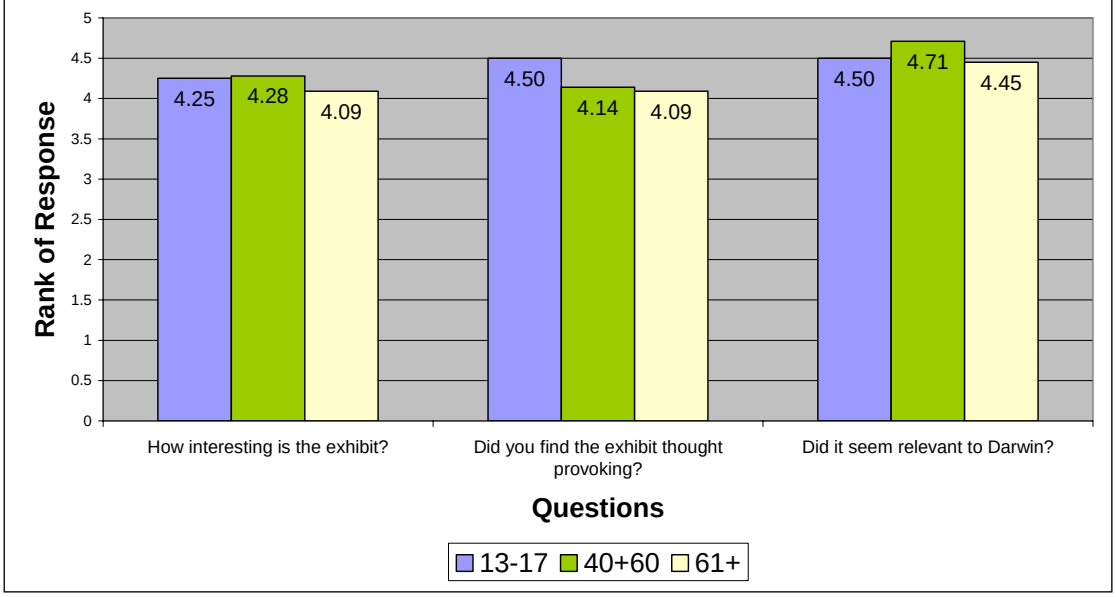
It was also observed that, on average, the 61+ age bracket took more attempts before getting the correct arrangement. **(See Figure 35)**

**Figure 35: Age vs. Average Number of Tries**




The three main concepts that were extremely important to the success of our exhibit were explicitly ranked by each visitor who completed the survey. **(See Figure 36)**

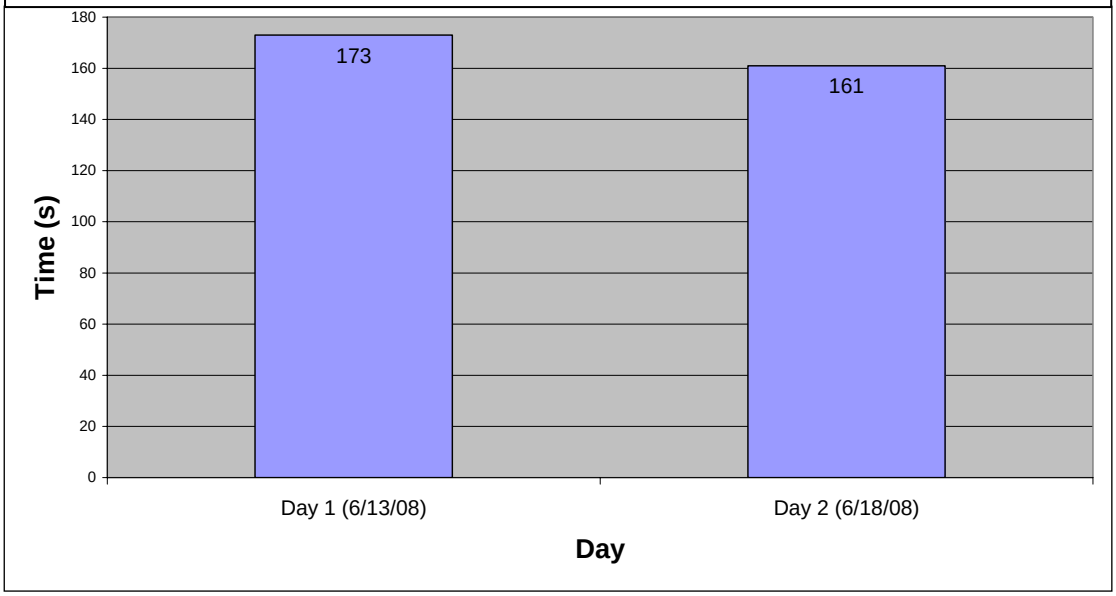
**Figure 36: Age vs. Response.**



It can be seen from Figure 36 that there is only slight variation across the different age groups in their ranking of the quantitative questions on the survey. After the first day of testing, and observing the visitors' of Down House reaction to our prototype exhibit, it was necessary to make slight modifications to our instructions. At that current time our instructions were rather long and wordy. In the interest of saving the visitor time, and not overwhelming them with text, we decided to simplify our instruction sheet. The second day of testing was done with the new instruction sheet, see **Appendix M**, and comparisons were made with the data in order to evaluate any positive or negative effects caused by this change.

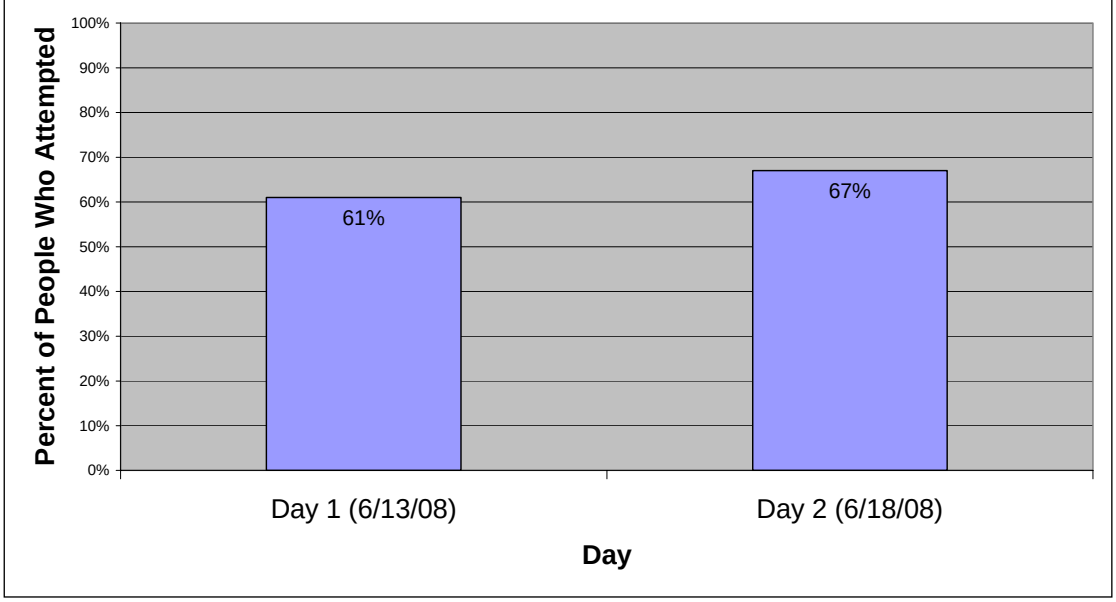
On average it took the second day users about 10 seconds less than the first day users to complete the prototype exhibit. **(See Figure 37)**

**Figure 37: Day vs. Average Time**



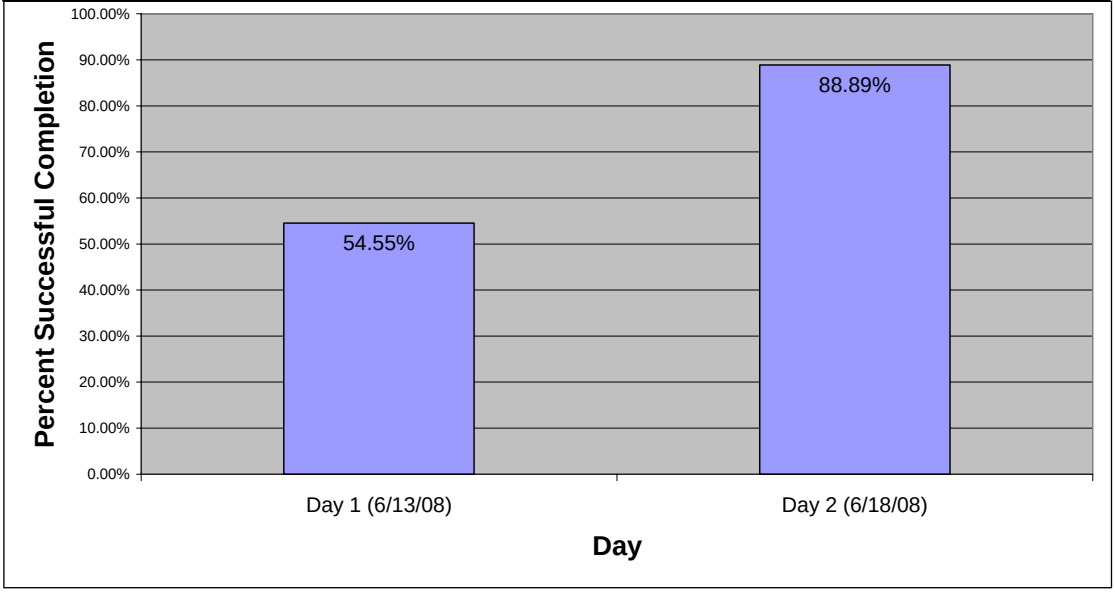
There was also an 8% increase in people's willingness to attempt the exhibit from day 1 to day 2. On the second day there were a total of 27 visitors who showed interest and 18 of those visitors went on to actually attempt the prototype exhibit. **(See Figure 38)**

**Figure 38: Day vs. Percent of People Who Attempted**



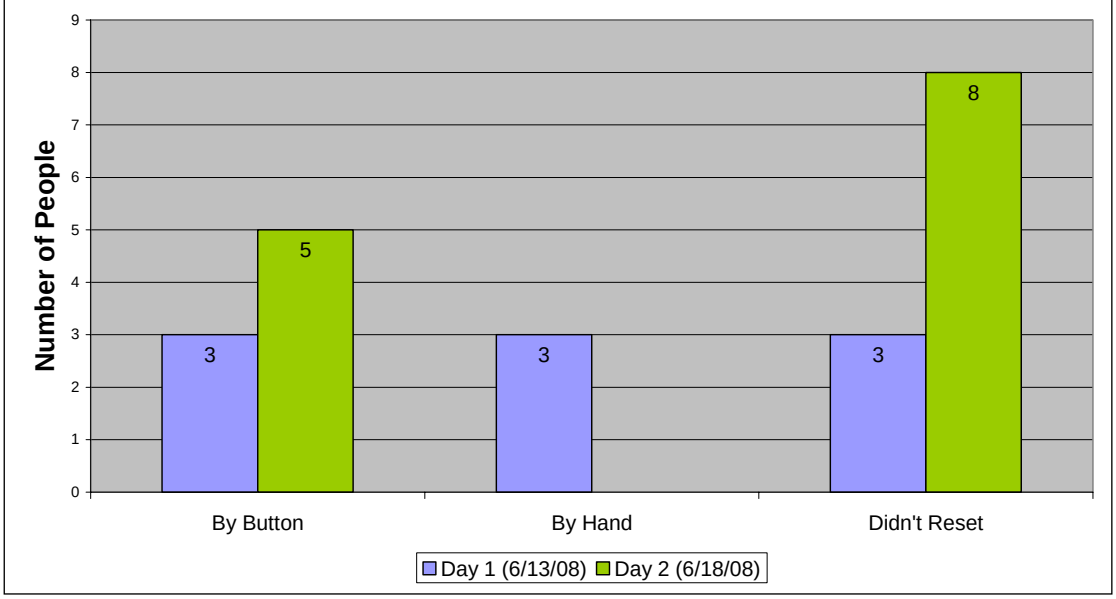

There was also a 34% increase in people's ability to complete the exhibit from day 1 to day 2. On the second day there were a total of 18 visitors who attempted, and of those 18, 16 visitors went on to successfully complete the prototype exhibit. **(See Figure 39)**

**Figure 39: Completion Percentage**



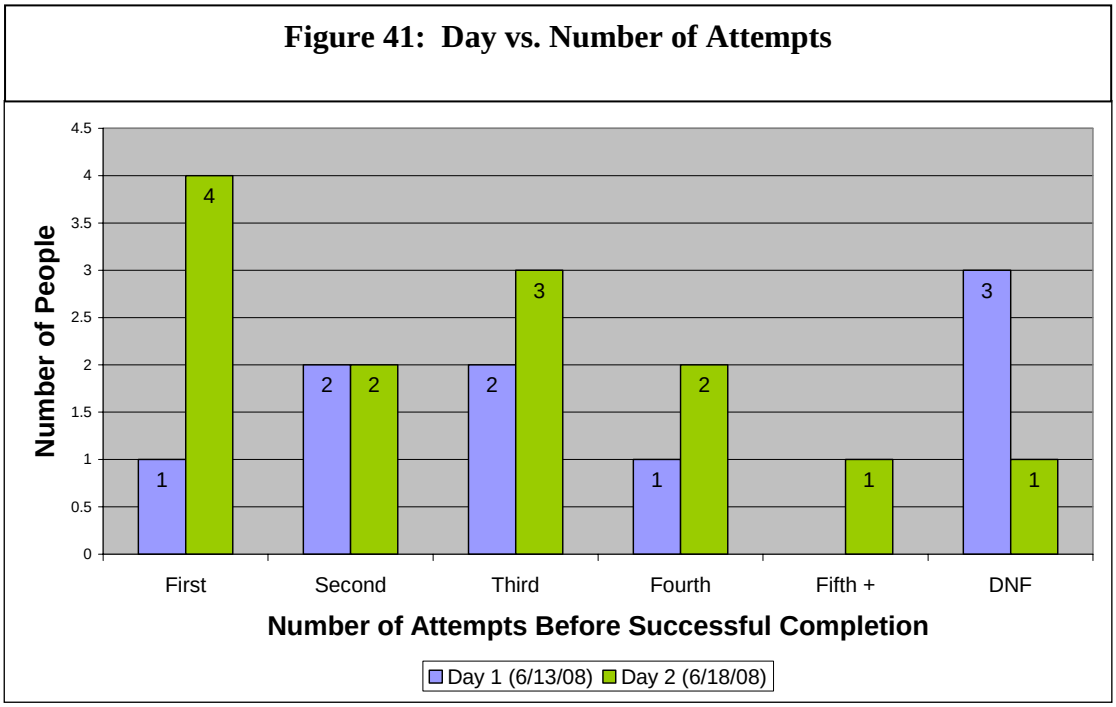
It was observed that on the second day, more visitors used the reset button; however more people forgot to reset as well. **(See Figure 40)**

**Figure 40: Reset Methods**



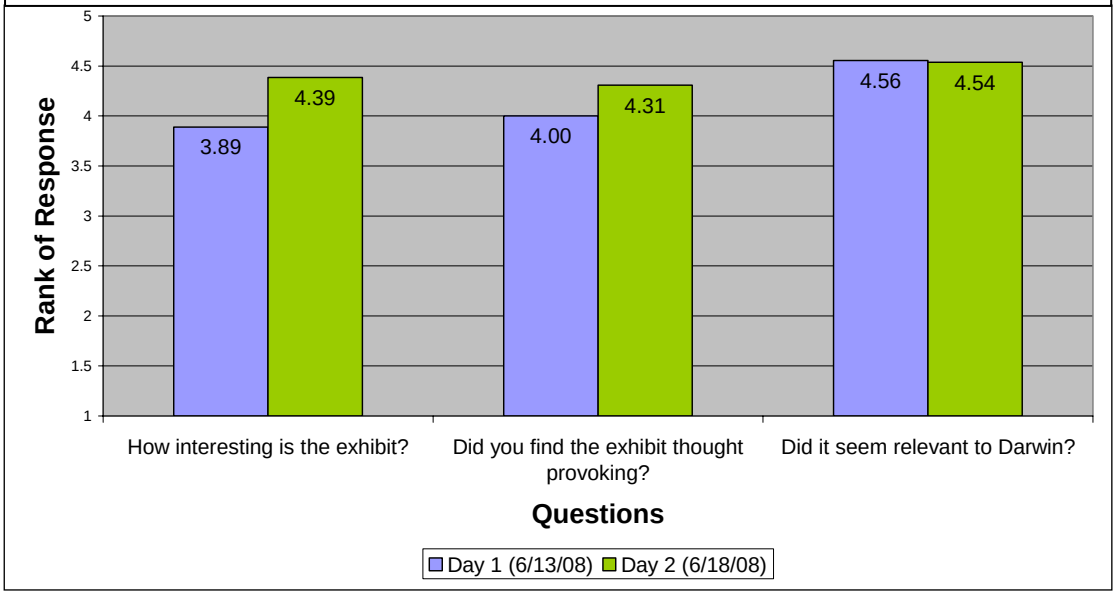

The new set of instructions also may have increased the rate at which the visitor solved the prototype exhibit. In other words, on average, it took the visitor fewer attempts to successfully complete the prototype exhibit. **(See Figure 41)**

**Figure 41: Day vs. Number of Attempts**



It may also be shown from the new set of instructions, that the overall opinion of certain aspects were improved. More specifically, how visitors ranked their interest in the exhibit increased 12% from day 1. **(See Figure 42)**

**Figure 42: Day vs. Response**



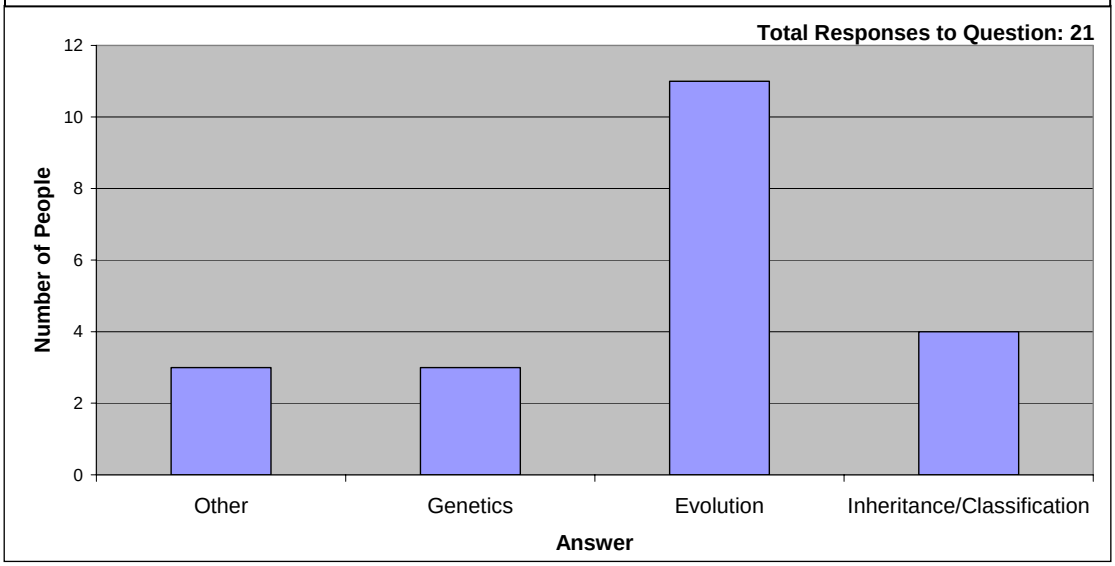

## 4.3.2 Analyzing Qualitative data

See **Appendix N** for table of qualitative data collected from surveys

The analysis done on the qualitative data is not based on a large enough sample. Therefore it may be fairly statistically inaccurate. The sample is not large enough to analyze any differences between day one and day two, or any differences between age groups or between levels of education.

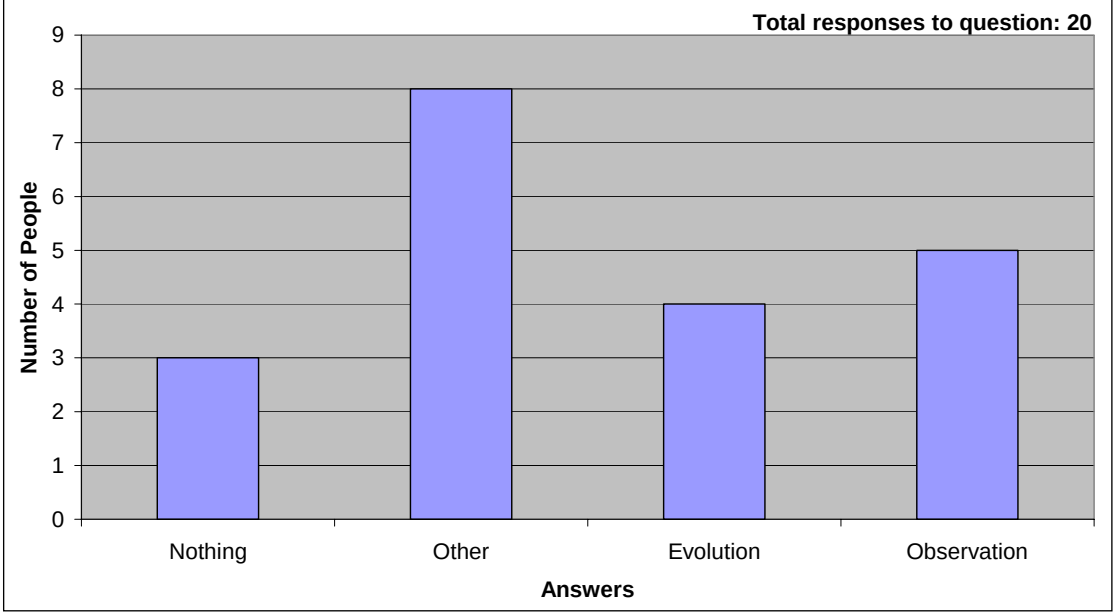
In order to better represent the general outcome of the questions on the survey, the most common answers given to each question were generalized and then counted. The following graphs are a product of this procedure.

**Figure 43: What did you think this exhibit was about?**



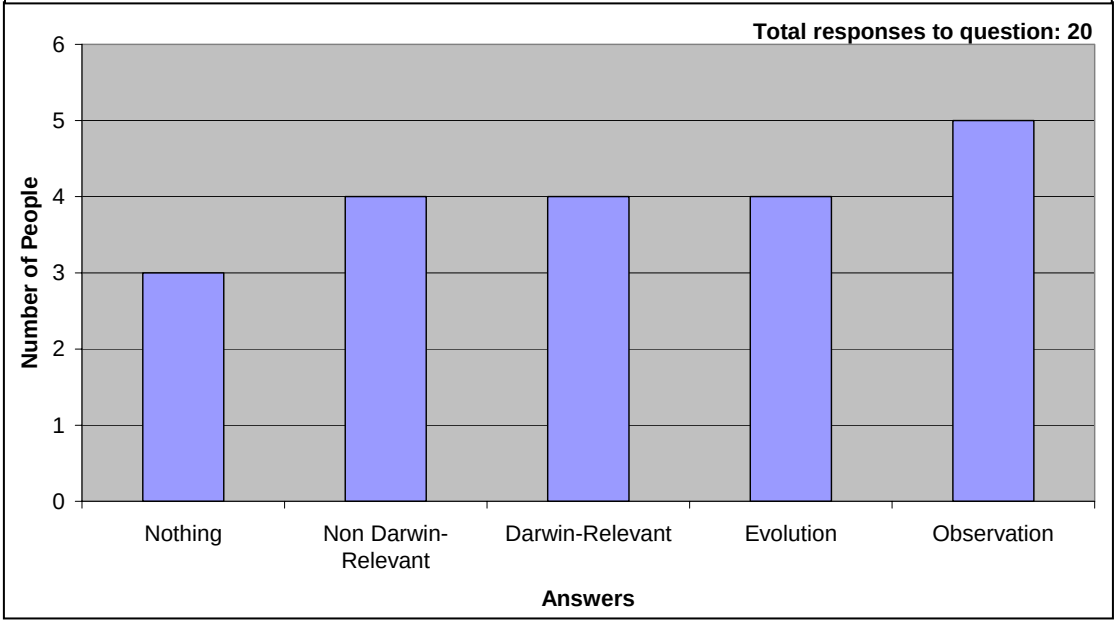

Considering the title of the exhibit was *Darwin & Classification* and that we mention in the exhibit instructions that there were no genetics in Darwin's day. "Genetics" is the least desirable answer; "Evolution" is a satisfactory answer as that is an overhanging theme, and "Inheritance/Classification" are the main biological topics of the exhibit. Roughly 20% of the visitors understood exactly what the exhibit was about. 70% had at least a reasonable understanding of what it was about.

**Figure 44: What did you learn from the exhibit?**



The chart suggests that at least 40% of the visitors who responded learnt something very relevant to the exhibit, with “Nothing” being our least desirable answer and “Other” being a mixture of answers that were close to and far from the exhibit topic. “Evolution” is a more than satisfactory answer for this question as it is in the interests of Down House for visitors to learn more about evolution. “Observation” is something the visitors must do in order to complete the exhibit; hence if they learned more about it, or knew how to do it, they must have been more successful at understanding the exhibit.

**Figure 45: What did you learn from the exhibit? -- Expanded Chart.**




The data in the previous chart can be categorized differently so as to answer the question of how many visitors learnt anything relevant from the exhibit.

With 13 of the 20 visitors’ answers falling in three relevant categories, this chart shows that roughly 65% of the visitors were taught something by the exhibit.

# 5.0 Conclusions and Discussions

This project was aimed at fabricating a fully functional prototype exhibit and analyzing the effectiveness of its interactive and conceptual properties. The final exhibit will be created based on the prototype, using the analysis to enhance it wherever possible. The prototype was tested by various professionals associated with this project, as well as actual Down House visitors. The visitors of Down House provided information by the use of surveys, interviews, and observation. When investigating the prototype, we were specifically interested in the prototype's interactive and conceptual properties. It was important that the concept was interesting, educational, and portrayed in a thought provoking way.

## *5.1 Conclusions*

Throughout the whole design and fabrication process, it was extremely important that our allotted time frame was kept in mind. Every decision was made while taking that into consideration. Granted there may have been more efficient ways of achieving certain mechanical aspects desired, however, it may have took us three more days to achieve this. In which case, that alternative was neglected, and the simpler approach was chosen.

### 5.1.1 General Conclusions

After receiving and analyzing the data, many things became more apparent. For example, it was noted that approximately 40% of the visitors who entered the interactive room left without interacting with the exhibit. They simply walked throughout the room, observed things from a distance, and then departed. This suggests that either the room as a whole is unappealing to them, or the visitors are generally uninterested in interactive exhibits. Another conclusion that we reached throughout the two days of testing was; if we didn't ask the visitor explicitly to attempt our exhibit, they would just ignore it. Even in some instances, the visitor

would read the instructions and examine the entire prototype for nearly two minutes, then walk away. At which point, we would ask them if they would like to help Down House by testing this prototype exhibit. Even after that, only approximately 60% of the people attempted the prototype exhibit. The most solid conclusion that can be observed from this is that the atmosphere of the room is directed towards the wrong audience. Currently, as previously stated, the room's theme is directed towards children, and if they wish to involve all Down House visitors in the interactive room, this theme needs to change drastically.

After the visitors began to engage themselves into the task of completing our prototype exhibit, 76% of them finished it successfully. This is a fairly good percentage, seeing how our sponsor desired a certain level of difficulty to be achieved. According to the brief provided by our sponsor, the exhibit should not be made too easy and it should be possible to make a few mistakes. Of the 29 people who attempted our exhibit, as previously stated 76% of them completed it. Of that 76% (22 people), 21% of them completed the prototype exhibit successfully on the first try. Even though 24% of the visitors did not finish the prototype exhibit, nearly the same percentage got it on the first try. So this either means one of two things; that the visitors just got lucky, or there is something that gave them an extra advantage. Even after 5+ attempts, 24% of the users still couldn't successfully complete the prototype exhibit. Granted, some people have a natural ability to identify and place animals in the correct place within a family tree, but all the information was available to help guide the visitor through this prototype exhibit. So that suggests that the visitors who got it on the first try may have read the instructions more carefully, specifically taking notice to the hints provided.

On average, it took 166 seconds (2 minutes and 46 seconds) for the visitor to complete the prototype exhibit. This too also met the criteria outlined in the brief provided by our sponsor. It was desired that the interaction time would fall somewhere between 1 and 3 minutes. The time represented here started when they first began observing the exhibit, and ended once they completed it or gave up. So this time is not just representative of interaction time, but observing time as well. That being said, the time of 166 seconds may be close to the upper limit of the desired

time provided by our sponsor, however, it takes into account more than just the time of interaction.

The visitors that were surveyed had varying levels of education. While most visitors were only educated up to KS 3+, there were also visitors with Bachelors and Master degrees, as well as one person with a PHD. No correlations could be drawn from the differences in education levels. Figure 28 illustrates the exact distribution breakdown of the visitors' levels of education. The only failures in completing the prototype exhibit occurred to visitors with Bachelor degrees or lower. While the 4 visitors that had Master degrees and higher recorded no failures, and completed the prototype exhibit successfully.

Another important aspect of the prototype exhibit that was analyzed was the method each visitor used to reset it. The instructions provided the visitor with information on how and when the visitor should reset the prototype. It specifically said to reset the prototype by pressing the reset button after completing the exhibit. It was noted that only 50% of the surveyed population reset the prototype exhibit. Only 36% of the visitors reset it properly with the reset button, while the other 14% removed the pieces by hand. This just goes to show how much of the instructions were actually read and absorbed.

One good conclusion that was obtained from the surveys was that the concepts our exhibit was focusing on were displayed and well understood. Out of the three quantitative questions that were asked, none of them received an average rank of anything lower than 4.18 out of 5. This proves that our prototype exhibit was successful within these three categories; is it interesting, thought provoking, and relevant to Darwin? Since these three categories were extremely important to the success of our prototype exhibit, these results are great for the future of this prototype exhibit.

Although the exhibit ranked very well in terms of how interesting, thought provoking and relevant to Darwin it was, the qualitative data (sections 4.3.2) shows that only 20% of the visitors that responded understood exactly what the exhibit was about. This number should be increased by altering certain features of the exhibit while

preserving the features that kept the visitors interested. When visitors were asked what they learnt from the exhibit at least 40% learnt some the central topics or skills involved in the exhibit. 70% of the visitors learnt something at least reasonably related to Darwin. This shows that the exhibit is fairly good at demonstrating evolutionary topics and with slight improvements it could prove excellent at showing visitors concepts that cannot be learnt easily from other exhibits, currently at Down House.

Other correlations involving the success of the visitors were analyzed while observing the data. We analyzed whether or not the age of the visitor affected the outcome of the result. Also the results from the first day and second day of testing were analyzed to see how the change in instructions affected the outcome.

### 5.1.2 Age vs. Outcome

As previously stated, the average rank for each of the quantitative questions asked on the survey was nothing lower than 4.18. There was a slight variance in the ranking with respect to the different age brackets; however, they are too minimal to be of any significance. Between the sample size and the minimal variance in the ranking of each quantitative question, it is impossible to say that the differences are statistically significant. Therefore, it is inferred that the exhibit was successful across all ages surveyed, for these particular concepts.

The age vs. the outcome of the results from each visitor were analyzed to see if the exhibit was lacking for any one particular age bracket. Considering that the number of 13-17, 40-60, and 61+ year olds were 4, 7, and 11 respectively, it is hard to say that any conclusion drawn here is statistically significant. This is just because the sample size for each age bracket is rather small. However, putting this aside and analyzing the data that we did obtained, it was found that 13-17 year olds had the best success rate at 100%. While the 40-60 and 61+ year olds had success rates of 71.4% and 81.8% respectively. This shows us that the 13-17 year olds are more persistent, attempting to complete the exhibit, and not willing to give up. Younger people are generally more competitive and will continue to attempt the exhibit until they have assembled it correctly. The 61+ year olds have a better success rate than the 40-60

year olds as well. This may be because the 61+ year olds are generally more patient, and are willing to stick around until they figure it out.

Another interesting finding that arose was that the 13-17 year olds, on average, finished the prototype exhibit in nearly half the time of the other age brackets. With an average completion time being 96.5 seconds it is significantly lower than 181.7 seconds for the 40-60 year olds, and 180.4 of the 61+ year olds. This shows how the younger kids just immediately started interacting. Putting pieces in, seeing what fits where, etc. By trial and error they were able to complete the exhibit, on average, much faster than the other ages represented. While the 40+ year old visitors were generally more timid with interaction, it took them longer to arrange the pieces correctly. On average, it took approximately 2.25 attempts before a successful completion for all visitors under the age of 60. While the visitors older than 61 years took, on average, 2.75 attempts to successfully complete the prototype exhibit. Once again, this difference is not statistically significant since the sample size is not large enough to make these deductions.

Not only was the differences analyzed for different ages, but also for the two separate days of testing. This is elaborated more in the following section.

### 5.1.3 Day vs. Outcome

All the data was obtained over a 2 day period of testing. The first day of testing took place on Friday June 13$^{th}$ 2008, and the second day was on Wednesday June 18$^{th}$ 2008. A different instruction sheet was used on the second day, and the success of the exhibit was measured accordingly.

It was noticed that the average time decreased by approximately 10 seconds from day one to day 2. Once again this difference cannot be considered to be significant, seeing how the sample size of day 1 was just a total of 6 surveys, and day 2 had 16 surveys. However, there is a difference, and that difference must be acknowledged. Also there was a 6% increase in the percentage of people who attempted to complete the exhibit. This may have to do with the new set of instructions; however the

increase is too small to give credit solely to the new instruction sheet. It could just be random chance, or it could be because of our efforts as a team to recruit people to attempt the prototype exhibit.

The one thing that may be a considerable statistical difference is the increase of completion percentage for day 2. A completion percentage of 54.55% was observed on day 1, and jumped to 88.89% for day 2. This is a significant difference, however, the sample size for day 1 is still approximately half the size of day 2. This suggests that the simpler approach for the instructions helped the visitors more so than the extended version. The smaller set of instructions allowed to visitor to refer back to them many times throughout the completion of the prototype exhibit. Being able to quickly find the hints allowed to visitor to make inferences quicker. This is opposed to a longer instruction set where the hints were harder to find, and in some cases may have been completely ignored.

No correlations from day to day were found with regards to the reset mechanism. With the new instruction sheet more people did use the reset mechanism properly, but more people also didn't reset it at all. With a previous ratio of 6:3, reset to not reset, and one of 5:8 for day 2, it can be assumed that the new structure to the instruction sheet was insignificant.

A significant increase of the total number of people completing the prototype exhibit successfully on the first attempt was noticed from day 1 to day 2. On day 1 only 11% of the visitors who attempted to complete it did it on the first attempt. While on day 2 31% of the visitors completed the prototype exhibit on the first attempt. It was also observed that 33% of the visitors on day 1 did not finish the exhibit and gave up. While on day 2 only 8% of the visitors gave up. This suggests that the new set of instructions was beneficial in the efficiency of completing the prototype exhibit.

With regards to the quantitative questions asked:

1. How interesting was the exhibit?
2. Do you find the exhibit thought provoking?
3. Did it seem relevant to Darwin?

No significant differences were observed. An increase of 10% was observed for how interesting the exhibit was to visitors, however, the sample size is too small for the differences to be statistically significant. The only thing that can be observed as statistically significant is that our exhibit was generally well liked according to the responses to the quantitative questions. Once again, disregarding the instruction change, in general our exhibit still received quality responses across all ages, education levels, and days.

### 5.1.4 Observations

Throughout the two days of testing it was important to observe the visitors entering the interactive room in order to subsidize our survey data. While testing the prototype exhibit at Down House we observed the visitors, our exhibit and the interactive room itself. We recorded our observations while taking turns monitoring the prototype exhibit in the interactive room. We noticed that almost every visitor examined the prototype, if not for a few seconds, when they visited the interactive room. Some visitors examined the exhibit for over a minute without touching it. It seemed as though they were trying to solve the puzzle hands off or were trying to understand what was going on entirely. After these people looked at the exhibit most of them just chose to walk away. However, at this time we intervened by politely asking them to try the prototype exhibit. Visitors either said no and moved on or yes and interacted. It came to our knowledge that the average Down House visitor was very accustomed to just perusing through the Down House reading and looking at everything.

We needed to give people a small inspiration to try our exhibit. The prototype exhibit was set up in the interactive room which is thought of as the room for school children to play in. For example; one middle aged female visitor of the Down House walked into the room and stated that, “this is the schoolroom, it is for children” and walked out without even examining any of the exhibits. A few aspects of the current interactive room turned away visitors from using the exhibits. The green paint and brightly colored DNA exhibit are rather childish and gave off this kind of ambiance. The Pangaea interactive or “air hockey” table exhibit also gives the room a child-like

feel. Aspects like this were most likely reasons that turned people away from the interactive room, including our exhibit.

By inspiring visitors to interact with our exhibit we collected most of the data. We recorded and observed functional issues like the instructions. Our first days of testing the instructions were extremely wordy, long and in small print. **Please see Appendix H for the Prototype Exhibit Instructions I.** It was observed that people want a simple and quick explanation when looking at a truly interactive exhibit. They want to glance over the exhibit in its entirety and know what is going on without reading a document like set of instructions. After using the original instructions on the first day it was decided, on the research done by Ben Gammon at the Science Museum and our own observations, to condense and simplify a second set of instructions. The new set of instructions was formatted with larger and bolder font, much more concise wording and in landscape format. **Please see Appendix M for the Prototype Exhibit Instructions II.** These instructions were added and implemented on the second day and final day of testing.

Many other aspects of the visitors' interactions with the prototype exhibit were recorded during observations. Visitors would attempt to put one piece in at a time and then repeatedly press the test button to get a piecewise confirmation of their actions. This was not how the exhibit was fabricated to function. Each piece needed to be in any place to complete the circuit. It was decided that the second set of Instructions needed to be modified to clear up this instance. We then adjusted our instructions on the second day to say put ALL the pieces in and then test the exhibit. We also color coordinated the test and reset buttons with the instructions to lower the chance of confusion or misunderstanding. We observed that the more basic the instructions the more likely it is for people to understand and interact with the exhibit. This was also very true to those visitors under time constraints; by having shorter and more concise instructions it left them more time to interact with the prototype exhibit.

People do not like to read instructions. Those who followed and fully examined the words on the instructions and exhibit had a much higher ratio of completing the task. These observations brought us to the attention of how important labeling is. Some visitors could not figure out that the light with WRONG above it in bold meant that

they were incorrect. The same thing happened with reward mechanism. People would get it correct and see the world spinning but not understand that the word RIGHT in bold above it meant that they had completed the interactive.

During testing it was observed that visitors would not fill out the surveys on their own will. While monitoring the exhibit we would have to ask people after their interaction to complete our survey. Some would do it willingly and others would say no and move on. These reactions were expected because filling out the survey took effort and time.

## *5.2 The Design Process & Mechanical Interactive Exhibits*

While we went into the process with as much knowledge as we could find about the design and creation of interactive exhibits much more was discovered from actually creating it ourselves. While designing our prototype we realized that the one of the most important aspect of an exhibit is the facts, data or theory itself that you are trying to show. The idea behind the exhibit or what you are teaching has to be concrete and flawless or else there mechanical aspects are not worth producing. Even after all of our research and preparation we did not put our exhibit into the Down House until scientist from English Heritage inspected it. After the exhibit was put into test at Down House we were still contacting a cat specialist to further solidify the accuracy of our tree.

While designing our exhibit our team discovered many aspects to the process that we did not foresee. We had no idea of what MDM was actually like and had to adjust to their style of fabrication. MDM studio is based around art and creativeness and not blue prints and CNC machines. We changed our design and fabrication style slightly to adjust to their methods. MDM does not always have set or exact blue prints but builds off of ideas and trial and error. While we had designs and plans they changed and were modified as we were collecting data and analyzing it as we proceeded. We learned that you never truly know what is going to happen or what to expect until you try it, correct it and do it again. We kept to our methods as tightly as possible while adjusting to a different process then planned.

We learned about voltage and the difference between outlets in the United States and England during the design phase. Electronic parts had to be chosen to make sure they worked in the same range as to not overheat and catch fire to the MDF board. We learned about materials and there weight and that physically having the specifications or an example was key to designing an exhibit. We learned that having and ordering the right parts can either keep you moving or slow up creation. It came to our attention that finding the right tools for the right job was a key factor to getting the exact results we wanted. Data collection and analysis also was different than we expected.

Our team thought to just build off our designs and then analyzed it after would be efficient, but by going through and inspecting each small part the exhibit evolved much more effectively. We had employees from MDM watching and testing our ideas the whole time and these people brought us a wealth of knowledge we lacked. We learned by talking to people of all different jobs and backgrounds in MDM of their perspectives and what they knew about the materials and tools we were using. This informal way of analyzing our prototype helped round it to fit what we needed. We discovered the importance of much more experienced and well rounded minds in the area of fabrication.

We learned and touched up on our skills with machines in the shop. Our team was briefed on many of the tools and figured others out on our own. Our skills with the ban saw, circular chop saw, router and drill press were all improved upon. We learned about the difference of cutting plastics, woods and composites. The most important aspect we discovered about fabrication was the accuracy of measurements.

Working at MDM we learned how to find the right tools and the best fit parts. We had to figure out which employee to ask for mechanical, materials and electrical advice. After enough searching our team became familiar with the set up and location when items like nuts and bolts needed to be exchanged or modified.

When we were first given the task of creating interactive exhibits we entertained the idea of creating multiple prototypes and possibly each of us working on our own

individual prototypes. This was changed during the first stages of our project because we wanted to combine our expertise to create one successful, accurate and functional prototype. During the fabrication process it was realized that using all of our unique skills and ideas in tandem the prototype evolved. This method was taken from studying IDEO and their creation process. Also, by dividing tasks and playing to each individual's strengths the prototype exhibit was created in the time frame needed. If individual prototype interactive exhibits were created then our project would most definitely not have been completed on schedule.

## *5.3 Recommendations and Improvements*

After the entire process of design, fabrication, and analysis were completed, we were able to look back and observe this process holistically. We learned various things from our mistakes throughout the entire process, as well as from our successes. Most of our decisions were made while keeping in mind our time restriction. Seeing how we only had seven weeks from the point of conception to complete a prototype exhibit, a lot of decisions were made in the interest of time. However, even though these decisions were made in the interest of time, they still needed to perform the task at hand correctly. With an increased time frame for the project to be completed we may have made different decisions for the certain aspects of our prototype.

For example, for the electrical aspects of our prototype, we may not have used actual electrical connections for the pieces that went into the family tree. Instead we could have used RFID (radio frequency identification) tags, seeing how they are much more robust, and there are no exposed connections. With low frequency RFID tags in the pieces and readers beneath the spots where they are to be placed, the prototype would not need connections, steel wool and aluminum tape to function. Each reader reads the specific radio frequency corresponding to the correct piece, and recognizes it accordingly. This has many benefits superseding direct electrical connections; however is more costly and technical and did not fit into the needs of our prototype exhibit. RFID tags in a final exhibit would be extremely effective and efficient for connections and accuracy. They would ideally work every attempt and not depend on the placement versus connections.

Ideally it is preferred to have the final interactive exhibit on classification by as intuitive as possible, but instructions are necessary. During testing it was observed that people would not focus as much on the instructions placed outside of the exhibit but just on the mechanisms themselves. For a final exhibit we recommend that the instructions be directly incorporated into the display either above or in between the placement of the cats. For the reasons of our prototype this was not necessary to do but should be implemented when the final is created. The final prototype needs to have the topic and content labeled as clearly as possible to attract people and help them to understand what is happening. Designing the labels will not only include the size of the print but also they need to be in high contrast and lighted correctly. They need to be read easily with glasses and placed lower down, at a slant for easy viewing with bifocals for the visitors who need them.[56]

Also involved with instructions to the exhibit could be an audio guide or video to build upon the experience of the classification interactive. The video guide could be looped or have a start mechanism and teach the visitor how Darwin classified species through observations. This video would lead into the exhibit by guiding them with the methods that Darwin used. This audio guide could read the instructions and hints or be the quote of Charles Darwin displayed in the instructions.

Along with changing the instructions many of the parts should be much different than our prototype. The cats especially should be displayed on larger pictures for those easier viewing. The pictures themselves need to be protected with either a coat of glass, plastic or other transparent protective material. During testing our pieces pictures were vulnerable to pealing off because they were attached directly to the surface of the plastic. Also with the pieces they should be three dimensional with a grip or protrusion for people to move them with. We attached pieces of transparent plastic to simulate what these final parts should exist as. Expanding our view from the cat pieces themselves the entire exhibit should look much different than our prototype.

While the final exhibit should use a similar design and possibly mechanisms it should fit the remodeled ambiance of the room. The room needs to be changed to fit the

Down House visitors and the ambiance of the rest of the house and exhibits. This is all in the plans being set by English Heritage and MDM but was especially apparent to us while testing our prototype exhibit. By changing aspects like the color of the room and connecting each exhibit into a type of learning story line will further the likely hood of visitors interacting without encouragement.

Another possibility for increasing the accessibility of the upcoming remodelled interactive room would be a map of its exhibits. The visitors will want to know where each exhibit is located. Along with a map people, especially the elderly will want more seating. By adding more seats in the interactive rooms as a queue for exhibits they will have more places to wait to use them. Also by placing seats and or benches or stools at the exhibits it will be easier for those who do not want to stand for an extended period of time.

As for our design and the prototype exhibit we recommend a slightly modified family tree. The current tree has a few issues which were brought to our attention after recently reviewing it with a cat specialist.[57] She has modified our tree by removing one cat and advising us to reshape the modern cats and add a couple. One issue is that the visitors might walk away thinking that the big cats of today have descended from the domestic cat. Therefore the domestic cat should be removed and all modern cats coming from the *Pseudaelurus.* Her modifications can be seen in **APPENDIX O**.

During observations we noticed another issues with the cats chosen in our prototype exhibit that could have influence on the final. The color and designs of the fur should be the similar, or the same on all the cats. If the furs are all different it may confuse visitors who try to use colors and designs to match the cats. If the colors and designs are the same for cats that are related, it will be simple for visitors to match up cats.

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# APPENDIX A: Timetable

| Week 1 | | | | |
|---|---|---|---|---|
| **Date** | | **Location** | **Details** | **Main Objectives** |
| Monday | 12/5/2008 | EH | Introduction to EH - Develop Timetable | • To initiate ourselves with our employers.<br>• Prepare initial sketches.<br>• Prepare for presentation.<br>• Identify our exhibit idea. |
| Tuesday | 13/5/2008 | EH | Taxonomy Sketches/Presentation preparation | |
| Wednesday | 14/5/2008 | DH | Introduction to DH - Tour of DH | |
| Thursday | 15/5/2008 | MDM | Introduction to MDM - Presentation 14:00 PM | |
| Friday | 16/5/2008 | EH | Develop and Choose Exhibit Idea | |

| Week 2 | | | | |
|---|---|---|---|---|
| **Date** | | **Location** | **Details** | **Main Objectives** |
| Monday | 19/5/2008 | EH or MDM | Initial Sketches/Methodology | • To finalize the design of both exhibits.<br>• Continually revise our methodology. |
| Tuesday | 20/5/2008 | EH or MDM | Initial Sketches/Methodology | |
| Wednesday | 21/5/2008 | EH or MDM | Initial Sketches/Methodology | |
| Thursday | 22/5/2008 | EH or MDM | Finalize Design/Methodology | |
| Friday | 23/5/2008 | Holiday | Holiday | |

| Week 3 | | | | |
|---|---|---|---|---|
| **Date** | | **Location** | **Details** | **Main Objectives** |
| Monday | 26/5/2008 | Holiday | Holiday | • To finalize the design of our prototype.<br>• To go to London Museum of Science and learn there evaluation techniques.<br>• Finalize our methods for evaluation.<br>• Evaluate the design. |
| Tuesday | 27/5/2008 | EH & LM of S | Finalize Design/Evaluation Techniques | |
| Wednesday | 28/5/2008 | LM of S | Evaluation Techniques | |
| Thursday | 29/5/2008 | EH | Finalize Methods for evaluation | |
| Friday | 30/5/2008 | MDM & EH | Evaluation of Design | |

| Week 4 | | | | |
|---|---|---|---|---|
| **Date** | | **Location** | **Details** | **Main Objectives** |
| Monday | 2/6/2008 | MDM & EH | Evaluation of Design/Fabrication of prototype | • To finalize the evaluation process of the design.<br>• To begin the fabrication process. |
| Tuesday | 3/6/2008 | MDM | Fabrication of prototypes | |
| Wednesday | 4/6/2008 | MDM | Fabrication of prototypes | |
| Thursday | 5/6/2008 | MDM | Fabrication of prototypes | |
| Friday | 6/6/2008 | MDM | Fabrication of prototypes | |

| Week 5 | | | | |
|---|---|---|---|---|
| **Date** | | **Location** | **Details** | **Main Objectives** |
| Monday | 9/6/2008 | MDM | Fabrication of prototypes | • To complete the fabrication process.<br>• Begin the evaluation process of our prototype. |
| Tuesday | 10/6/2008 | MDM | Fabrication of prototypes | |
| Wednesday | 11/6/2008 | MDM | Fabrication of prototypes | |
| Thursday | 12/6/2008 | MDM | Complete prototype/Evaluation | |
| Friday | 13/6/2008 | Unknown | Employee evaluation | |

| Week 6 | | | | |
|---|---|---|---|---|
| **Date** | | **Location** | **Details** | **Main Objectives** |
| Monday | 16/6/2008 | DH | Evaluation of Exhibits | • To continue the evaluation process.<br>• Analyze the evaluation. |
| Tuesday | 17/6/2008 | DH | Evaluation of Exhibits | |
| Wednesday | 18/6/2008 | DH | Evaluation of Exhibits | |
| Thursday | 19/6/2008 | EH | Analysis of Evaluation | |
| Friday | 20/6/2008 | EH | Analysis of Evaluation | |

| Week 7 | | | | |
|---|---|---|---|---|
| **Date** | | **Location** | **Details** | **Main Objectives** |
| Monday | 23/6/2008 | EH | Final Compilation of Report | • To finalize our report and provide suggestions for possible revisions and recommendations on the final exhibit prototype. |
| Tuesday | 24/6/2008 | EH | Final Compilation of Report | |
| Wednesday | 25/6/2008 | EH | Final Compilation of Report | |
| Thursday | 26/6/2008 | EH | Final Compilation of Report | |
| Friday | 27/6/2008 | EH | Final Compilation of Report | |

# APPENDIX B: Interactive Brief Ideas

1. ‘We have no written pedigrees; we have to make out community of descent by resemblances of any kind.’ (p.337)
   Put the animals into the right position on a family tree. If they are assembled correctly, then a circuit is completed and a reward of some kind is offered.
   What the visitor should get out of it:

   - They should be able to make visual deductions as to what belongs where. They get to play the role of the classifier. They get to understand that pre-DNA classification was a matter for the senses. Could be linked with a short film explaining how new species are classified when they are discovered.

2. ‘Embryology rises greatly in interest, when we thus look at the embryo as a picture, more or less obscured, of the common parent-form of each great class of animals.’ (p.357)
   ‘Embryos are so similar as to not be able to tell them apart – like the story of the Ugly Duckling!’ (p.348)

   - The interactive should be based on trying to match the baby with the adult it will become. It shouldn’t be too easy – the point is that the embryonic state reveals the common ancestor. Could use horses, zebra, antelopes? Or the cat family?

3. ‘The ruins of a house burnt by fire do not tell their tale more plainly, than do the mountains of Scotland and Wales, with their scored flanks, polished surfaces, and perched boulders, of the icy streams with which their valleys were lately filled.’ (p.290)

   - Could we create an interactive or installation – possibly a transparent model annotated with text that tells the story of a mountain to show how Darwin read the landscape – e.g. ‘Here is where the iceberg sat on me.’ The story is revealed when a light is switched on.

4. The Power of Selection
   ‘Why, if man can by patience select variations most useful to himself, should Nature fail in selecting variations useful, under changing conditions of life, to her living products? What limit can be put to this power…?’ (p.372)

   - Push button voting interactive. Visitors have to pick the pigeon or flower, etc. which most attracts them. Interactive should keep a voting tally. The purpose is to explain nature’s invention by looking at the hand of the breeder. In this case the decision is being made by attractiveness, but it might as easily be for speed or for meat, etc. Supported by a diorama of pigeons and pigeon fanciers film?

5. '…the relation of organism to organism… the most important of all relations.' (p.277)

    - Fruit machine design-an-animal: fruit machine gives you the combination of predator, environment and diet. You have to invent your animal – draw or describe and leave it for other visitors (like the Wellcome exhibition)

6. '…natural selection can act only by taking advantage of slight successive variations; she can never take a leap, but must advance by the shortest and slowest steps.' (p.154)

    - Mutascope showing evolution of animal into a new animal – fish into reptile? Bear into whale? Wellcome Trust animation?

7. '…I look at the natural geological record, as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page, only here and there a few lines.' (p.246)

    - Like Edwin Morgan's *Archives* poem. Graphic installation?

8. 'The crust of the earth is a vast museum; but the natural collections have been made only at intervals of time immensely remote.' (p.137)

    - Installation?

9. 'a knife which has to cut all sorts of things may be almost any shape; whilst a tool for some particular objects had better be of some particular shape.' (p.119)

    - Interactive?

10. Sexual selection 'a struggle between males for the possession of the females… Generally, the most vigorous males, those which are best fitted for their places in nature, will leave most progeny. But in many cases, victory will depend not on general vigour, but on having special weapons confined to the male sex.' (p.68)
    - Should be illustrated by extraneous male characteristics in animals – stags horns, peacocks, cocks' spurs, etc.

# APPENDIX C: Taxonomy Exhibit Brief

INTERACTIVE EXHIBIT SPECIFICATIONS:

## 1. TAXONOMY

*SCOPE OF WORK*

The scope of work is for the creative design, development and prototyping of hardware for the Taxonomy exhibit.

*SUBJECT MATTER*

'We have no written pedigrees; we have to make out community of descent by resemblances of any kind.' (p.337, *On the Origin of Species*)

Using this quotation as the basis for the exhibit, your brief is to design an interactive where visitors get to play the role of the classifier. They have to put animals into the right position on a family tree. If they are assembled correctly, then an electric circuit is completed and a reward of some kind is offered (to be determined by the design of the exhibit).

The interactive could be linked to a short film explaining how new species are classified when they are discovered, perhaps based on interviews with scientists from the Natural History Museum.

*WHAT DOES IT COMMUNICATE?*

The Taxonomy exhibit should illustrate that, pre-DNA, classification was a matter for the senses rather than a precise art. Things are looked at and deductions are made from what is outwardly apparent.

*TARGET AUDIENCE*

The target audiences are:
Non-specialist adults, either on their own or in groups
Children in family groups receiving adult help

*THEMES*

The exhibition is structured by the themes or messages we wish to communicate at Down.

Key theme for the room: Level 1
Darwin's theories were developed through routine and observation.

Specific theme for the exhibit: Level 2
Rather than using specialist equipment, Darwin employed what was at his disposal in

his experimentation at Down and improvised methods as necessary – his most important tool was observation.

*LEVEL OF DIFFICULTY*

It should not be too difficult as it requires observation skills rather than knowledge, but it should not be made too easy either. It should be possible to make a few mistakes (e.g. the pieces should fit in more than one hole).

*EXHIBIT CONTENT*

This exhibit sits in a room with several exhibits dedicated to explaining the science and methodology behind Darwin's theory. Where possible, each is inspired by a passage that he wrote.
The guiding principle for the room's design is C.19th-century science and technology. Where possible, the interactives are to be lo-tech mechanical rather than computer-based exhibits. Where possible they should employ technology Darwin himself would have been familiar with, in keeping with the tradition of amateur science and experimentation. However, the room should look reasonably modern so that the exhibits look relevant to the modern-day visitor.

*EXHIBIT USAGE*

It is envisaged that it will be used by 1 person alone or a 1-3 in a group.
It is envisaged that the average duration for interaction will be 1-3 minutes.

*LEARNING OUTCOMES*

Exhibits will foster interaction in many different ways, but should generally be based on the inquiry approach to science education, which allows for experimentation, questioning, reflection, open ended play and testing.

Cognitive
They should understand that the similarities between creatures are genealogical – they are due to inheritance or, in other words, that creatures share a common blueprint.

Developing skills
It should test visitors' skills of observation and hypothesising.
They should be able to make visual deductions as to what belongs where.

Social
The exhibit should be sufficiently challenging that some people are prompted to discuss the activity with others.

*DESIGN GUIDELINES*

Size of space – this is one of several exhibits and it should not dominate the gallery space. A table top-sized space should be sufficient.
The design needs to be robust.
The exhibit must follow good accessible design principles, with clear print and large

pieces.
The exhibit should be made from solid, sustainable materials.
The exhibit should look simple to understand – i.e. visitors should be able to understand intuitively and immediately that the pieces need to be sorted into the correct spaces.

*TEXT*

Labels should be a minimum of 22pt in GillSans Standard.
Text should be kept to a minimum and agreed with EH. For the purposes of developing the exhibit, the following instruction text should be used:
'We have no written pedigrees; we have to make out community of descent by resemblances of any kind.' *On the Origin of Species*
Before the discovery of DNA, classification of animals and plants into species was done by looking closely at an organism and comparing it with others. Darwin showed that species were related to one another because they shared common ancestors. Can you put these animals into their correct families?
There will also need to be a supporting graphic which gives more information. It will say something like:

Taxonomy, the science and process of naming living organisms, is a field that is constantly changing as our knowledge of the world improves.

Carl Linnaeus invented a system which is still in use today, albeit in a much modified form. He based his scheme on structural similarities between organisms and classified them into species and varieties.

Darwin's theory of evolution showed that the similarities between organisms were due to their common descent. In short, organisms can be grouped into families because they are related to one another.

[Picture caption: Linnaeus's most important innovation was to establish the principle of giving each organism a unique scientific name with two parts in Latin. The first part expresses the genus, the second part the species. For example homo = genus and sapiens = species.]

*M&E*

The exhibit is likely to require lighting (supplied by the exhibition designer).
The exhibit will require power.

*CREATIVE RESPONSE*

The creative response from the designer should consider the following:
What will the exhibit look like?
How will visitors operate / interact with the exhibit?
How will they know what to do?
How will visitors work together?
How will the exhibit foster a sense of collaboration?
What challenge will this exhibit provide for visitors?
What opportunities will the exhibit provide to extend the visitors experience beyond their initial interaction?
What will happen if visitors join half way through, or leave before the end?
How will the exhibit allow for non-participant spectators to be able to see what is happening?
How will success be measured?
How will visitors receive feedback (audio / visual / touch?)
How will the exhibit cater for visitors with special needs?

*CONTENT RESEARCH*

You need to determine which group(s) of animals will make the best examples for the interactive.
You will also need to source images, following agreement with EH as to which animals you wish to use and why.

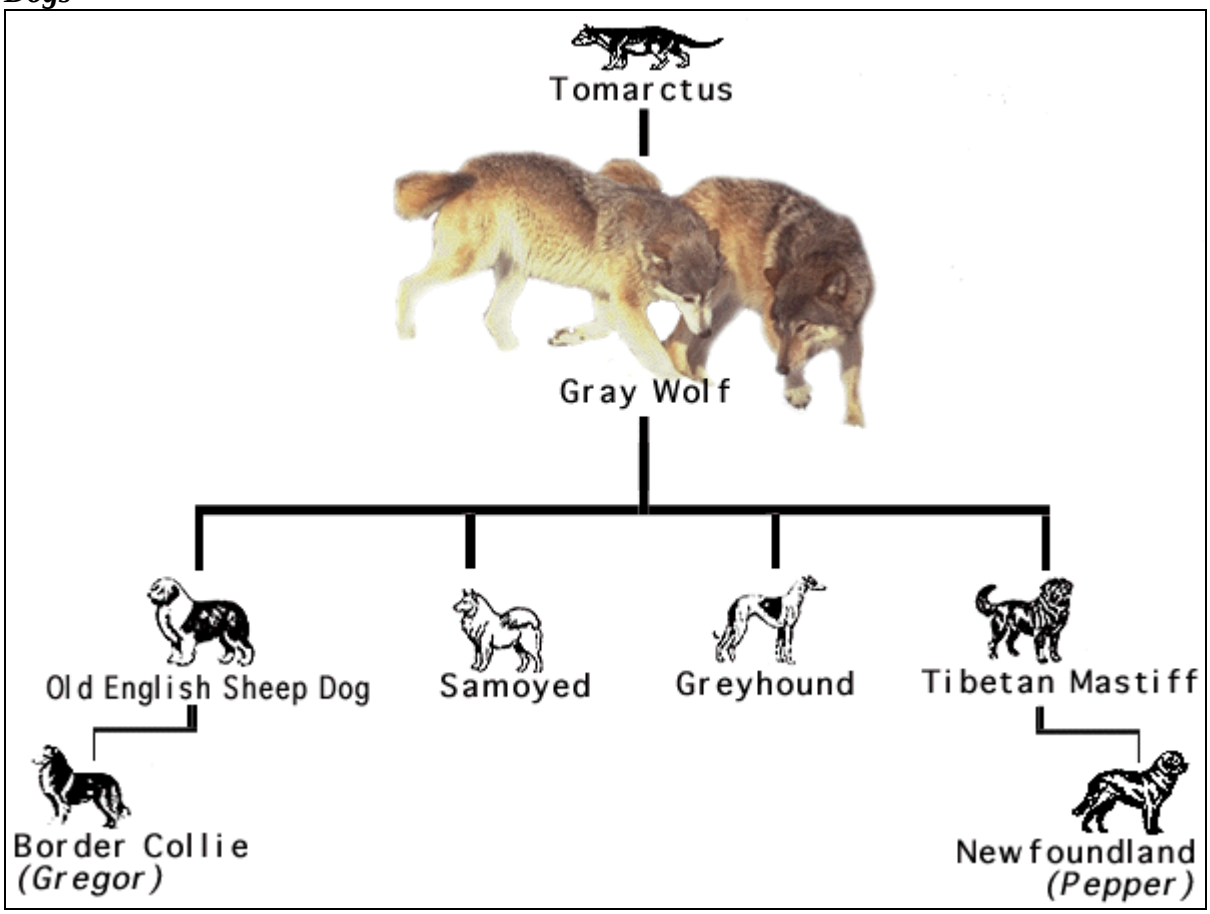
# APPENDIX D: Taxonomy Tree Decision Matrix

The five potential taxonomy trees are ranked from one to 1 to 5. Using each number Below the Decision Matrix are the taxonomy trees and pictures that are to be considered. Only rank is decided upon. Score is calculated as: Score = Rank * Weight

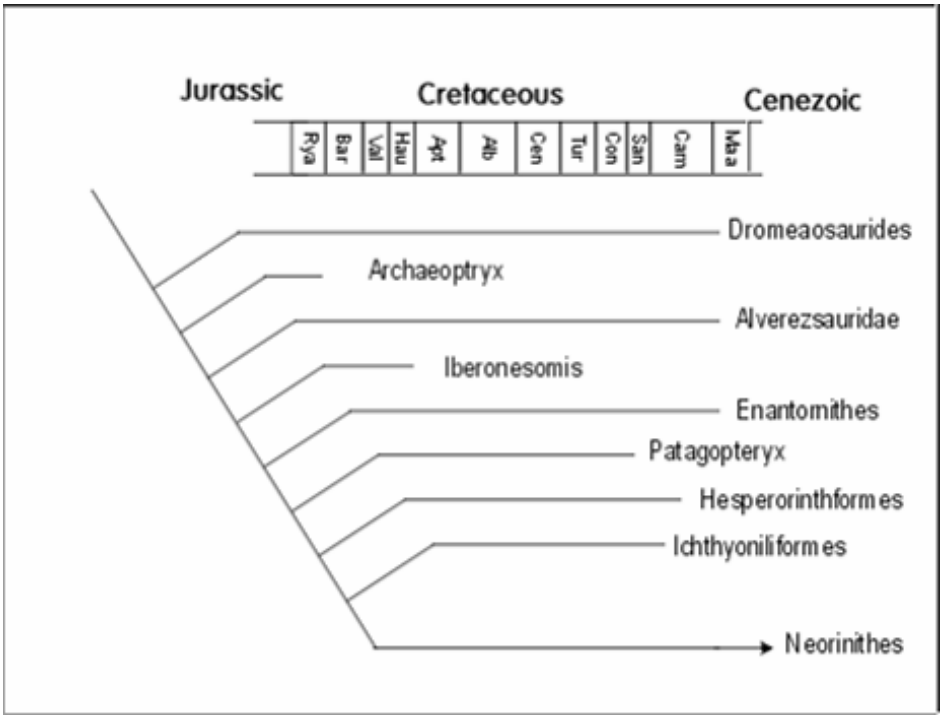
| Criteria | Weight | Taxonomy Tree | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cats | | Dogs | | Birds | | Insects | | Horses | |
| | | Rank | Score | Rank | Score | Rank | Score | Rank | Score | Rank | Score |
| **Completeness of tree** | 2 | 5 | 10 | 1 | 2 | 2 | 4 | 3 | 6 | 4 | 8 |
| **Can visitor relate to animal?** | 4 | 4 | 16 | 5 | 20 | 2 | 8 | 1 | 4 | 3 | 12 |
| **Are traits easily identifiable?** | 3 | 5 | 15 | 3 | 9 | 2 | 6 | 1 | 3 | 4 | 12 |
| **Quality of pictures** | 3 | 5 | 15 | 4 | 12 | 1 | 3 | 3 | 9 | 2 | 6 |
| **Is the tree simple enough?** | 3 | 3 | 9 | 4 | 12 | 2 | 6 | 5 | 15 | 1 | 3 |
| *Totals* | | | 65 | | 55 | | 27 | | 37 | | 41 |

****Please See Below Reference Material**

***Dogs***


Tomarctus
Gray Wolf
Old English Sheep Dog
Samoyed
Greyhound
Tibetan Mastiff
Border Collie
(Gregor)
Newfoundland
(Pepper)

***Birds***

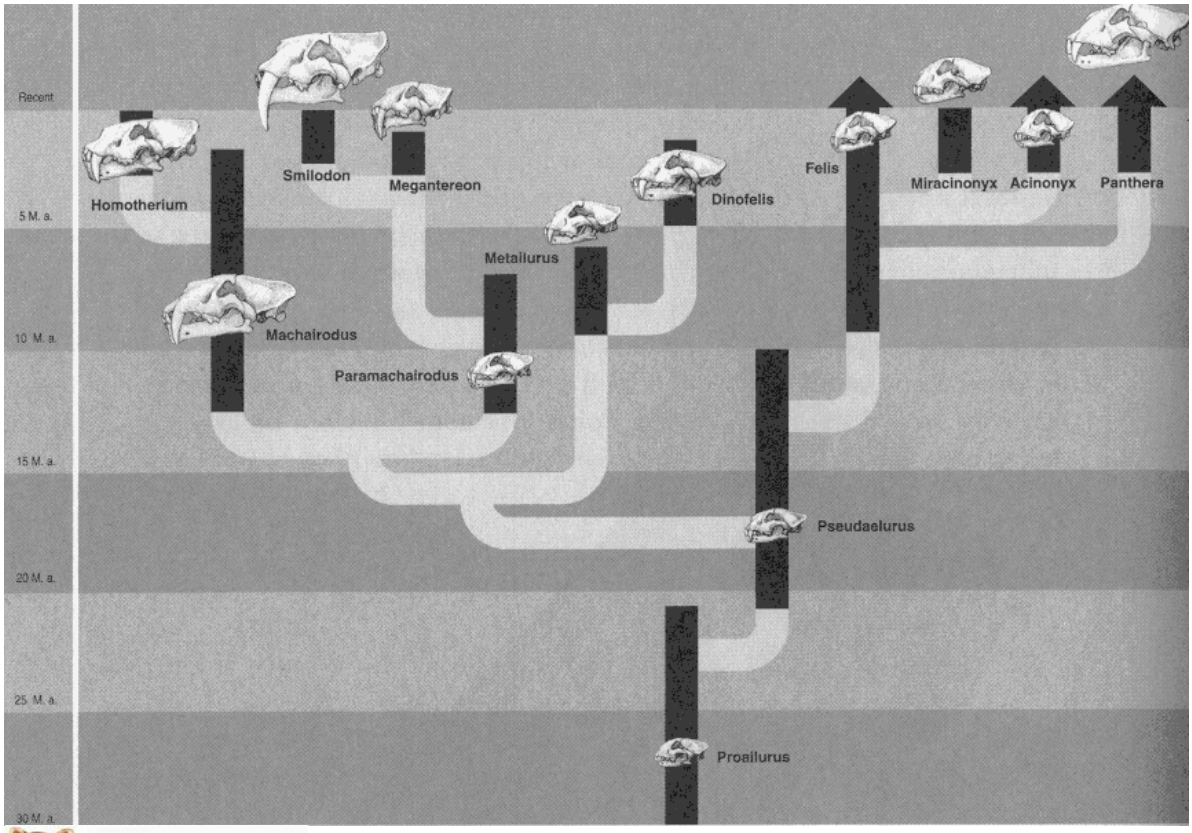



Patagopteryx

Dromeaosaurides

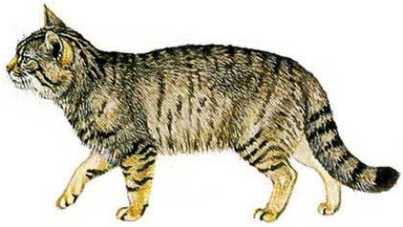
Neorinithes(Modern Birds)

***Cats***

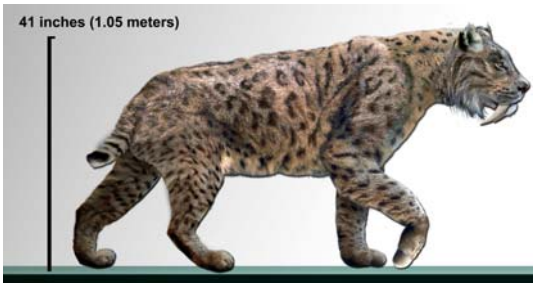



Proailurus

Pseudaelurus



Felis (Domestic Cat)



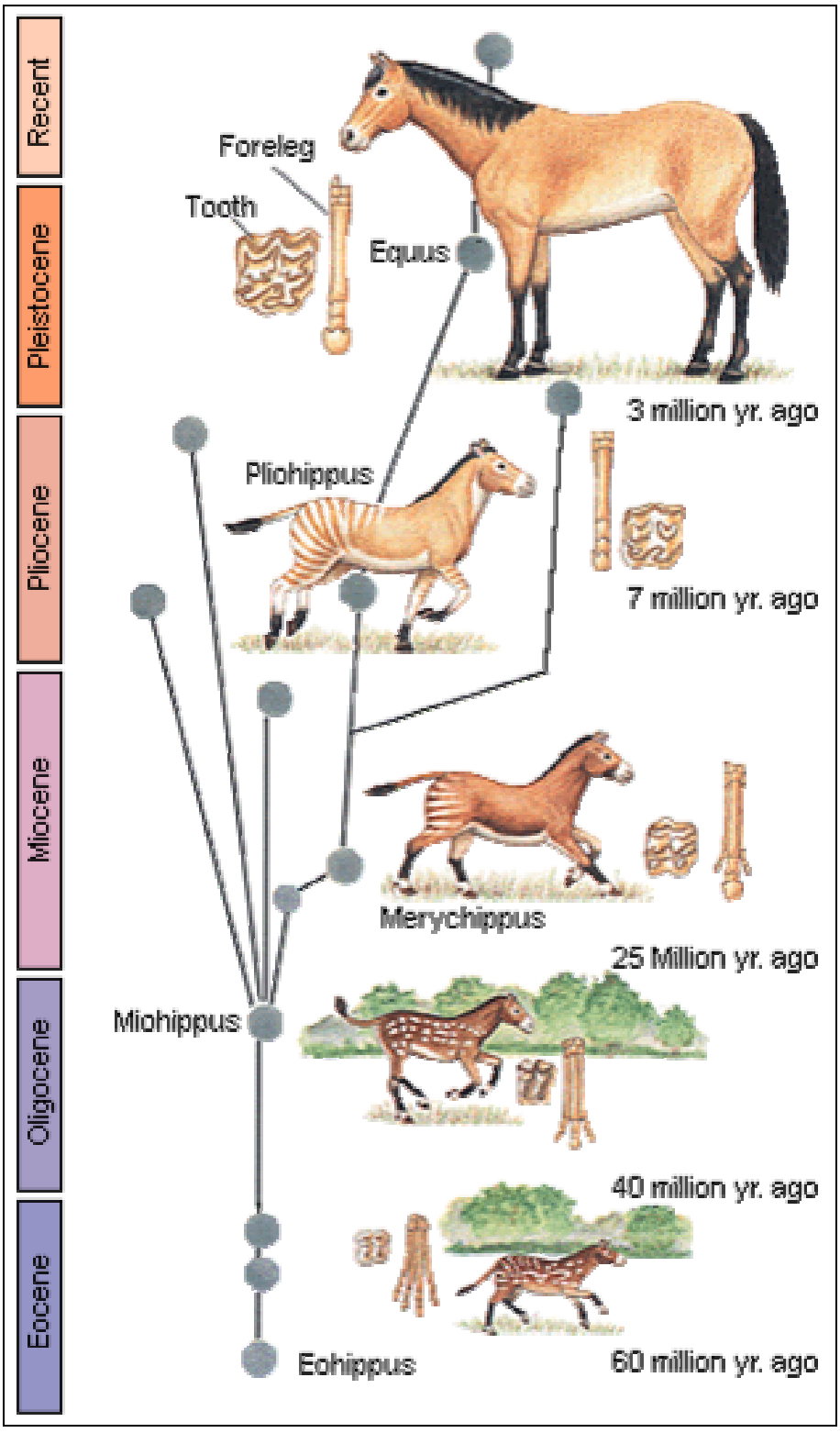

Smilodon (Sabre-toothed Cat)

Acinonyx (Cheetah)

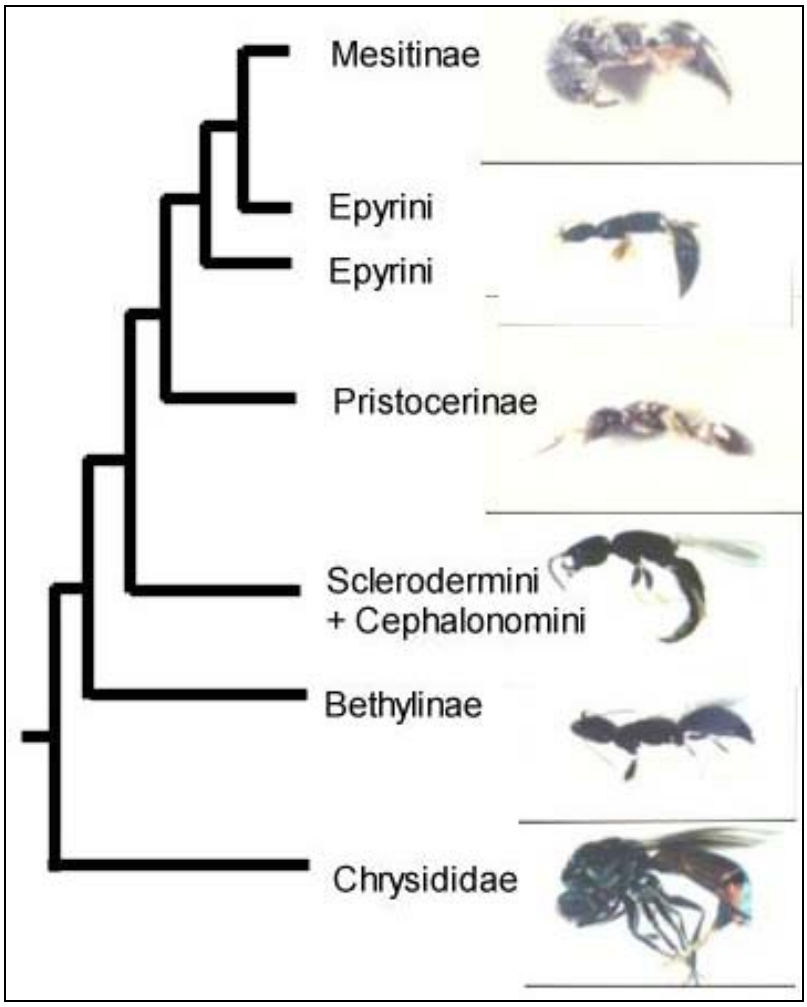
Panthera *tigirs* (Tiger)

Panthera *leo* (Lion)

***Horses***


Recent
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
Foreleg
Tooth
Equus
3 million yr. ago
Pliohippus
7 million yr. ago
Merychippus
25 Million yr. ago
Miohippus
40 million yr. ago
Eohippus
60 million yr. ago

***Insects***




Dogs tree from:
http://darwin.nmsu.edu/~molbio/dog/Dogie3a.html

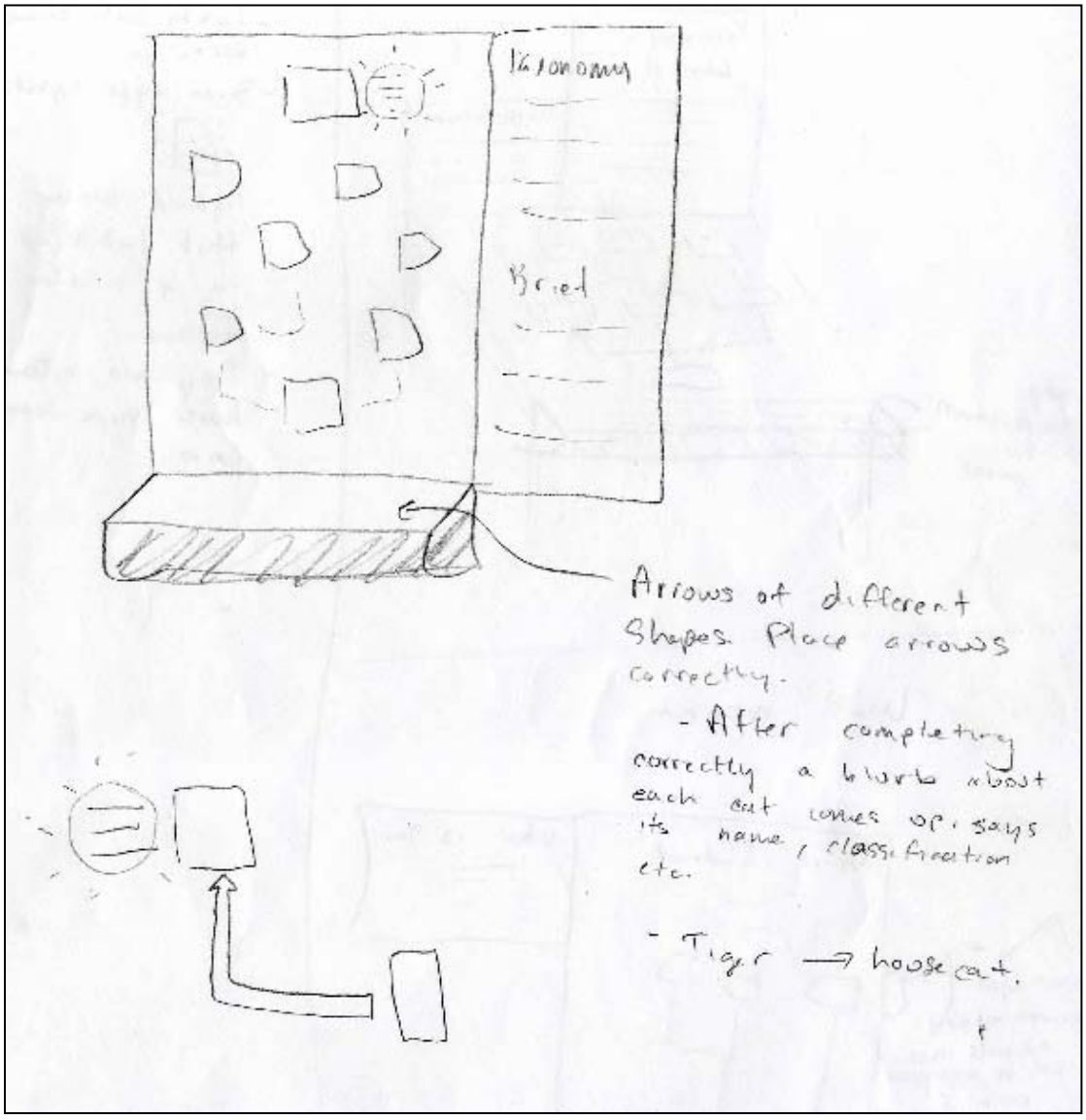
Birds tree from:
http://www.geologyrocks.co.uk/tutorials/origin_and_early_evolution_birds

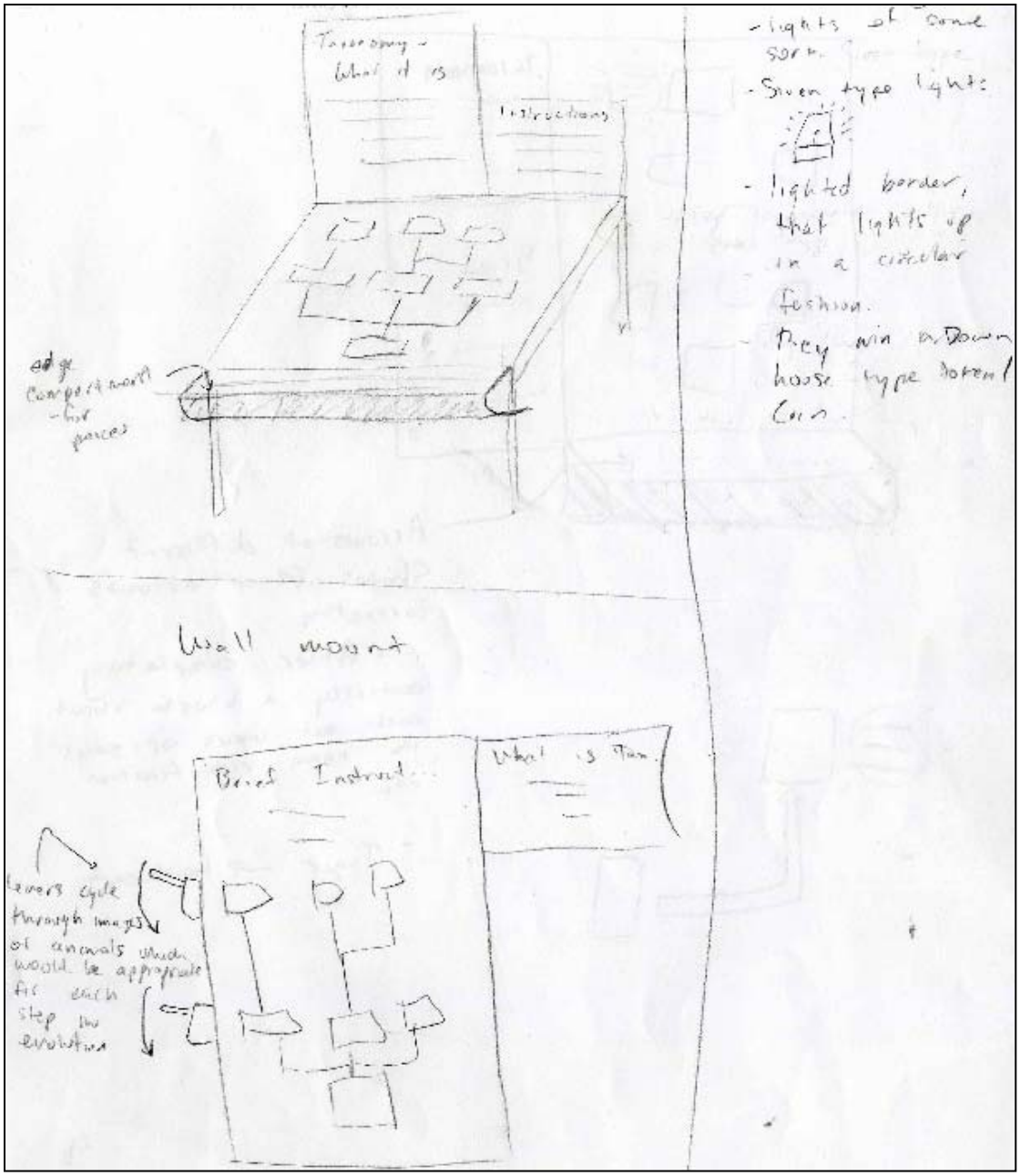
Cats tree from:
http://www.mun.ca/biology/scarr/Felid_evolution.htm

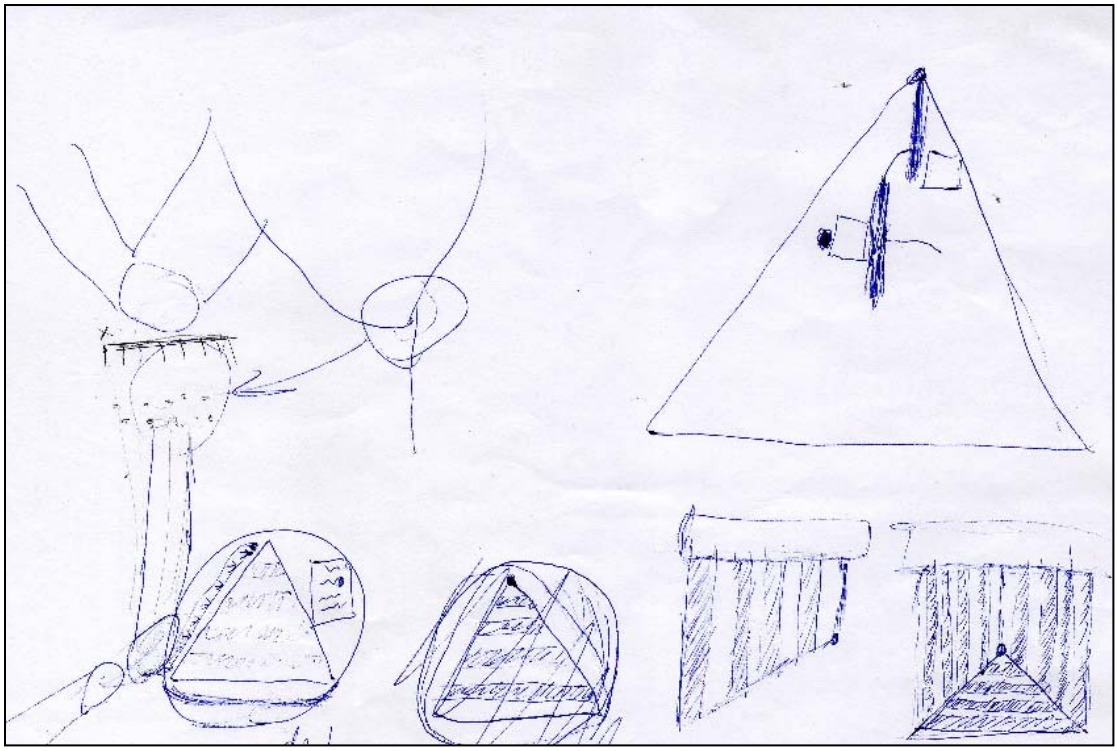
Horses tree from:
http://members.aol.com/darwinpage/horses.htm

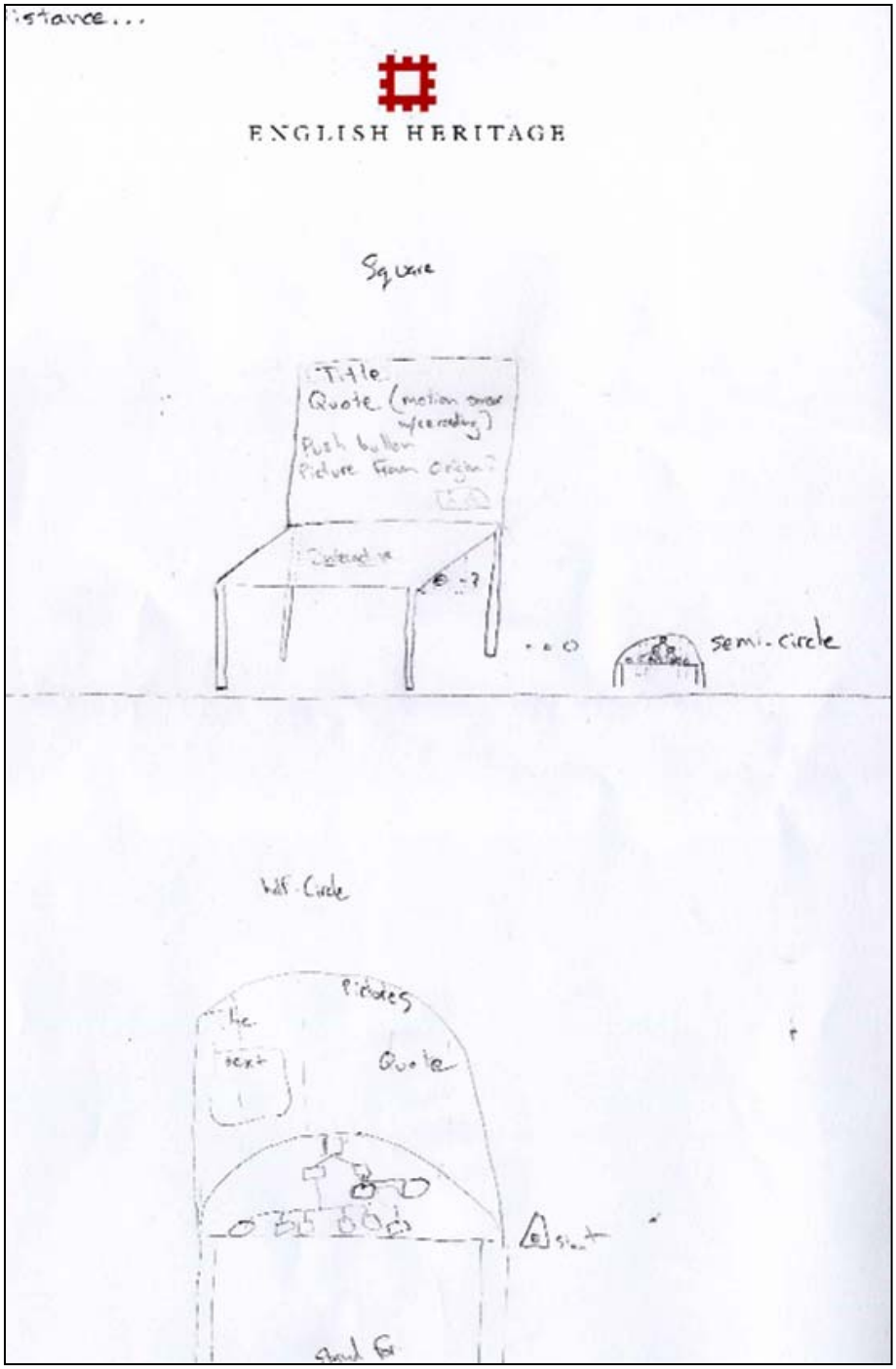
Insects tree from:
http://www.york.ac.uk/depts/biol/staff/pjm/peter1.htm

# APPENDIX E: Initial Designs

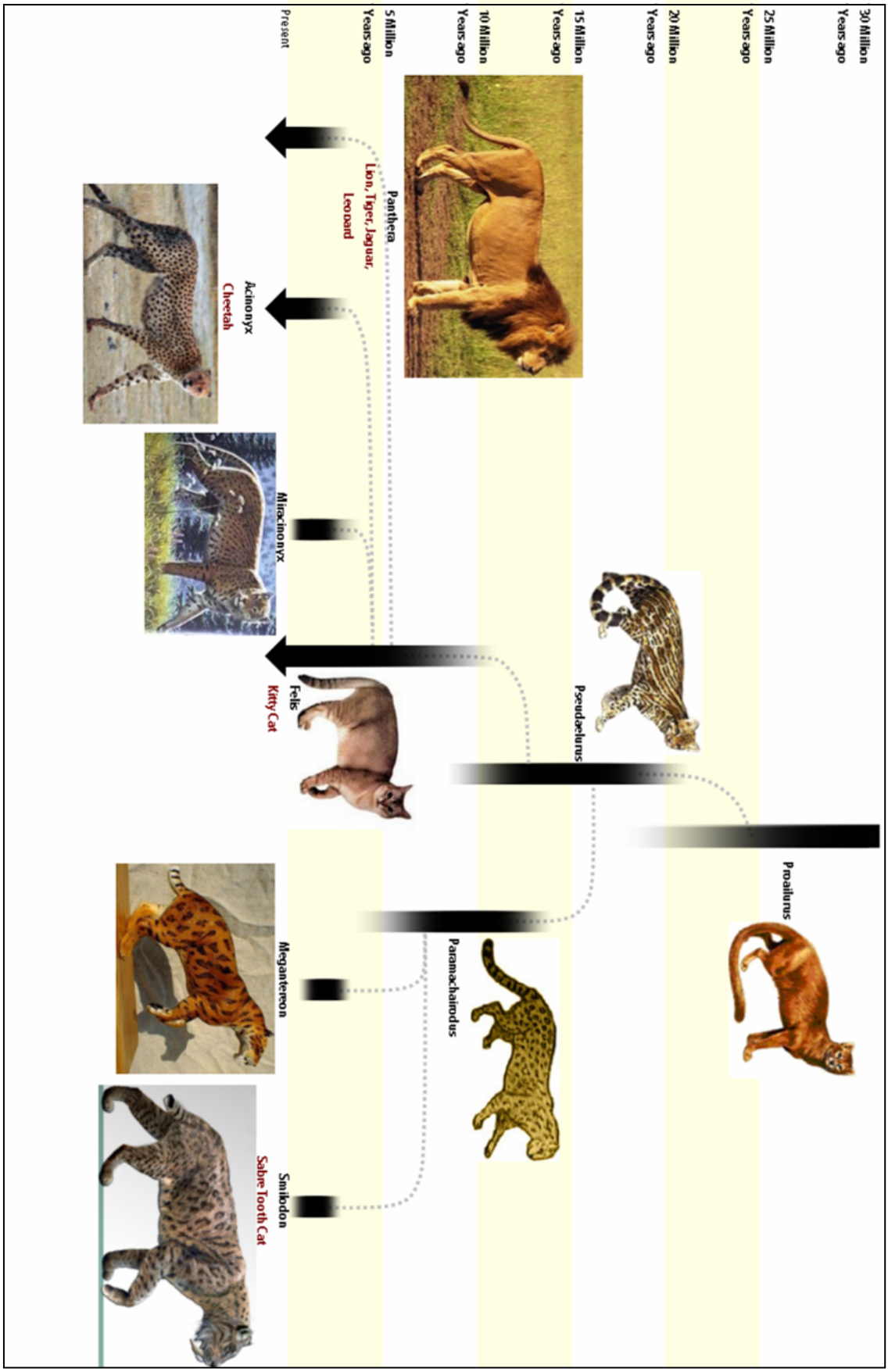



Taxonomy -
What it is
Instructions
edge
Compartment
for
pieces
- lights of some
sort.
- Seven type lights:
- lighted border,
that lights up
in a circular
fashion.
- They win or Down
house type potential
Coin.
Wall mount
Brief Instruct...
What is Tax...
Levers cycle
through images
of animals which
would be appropriate
for each
step in
evolution

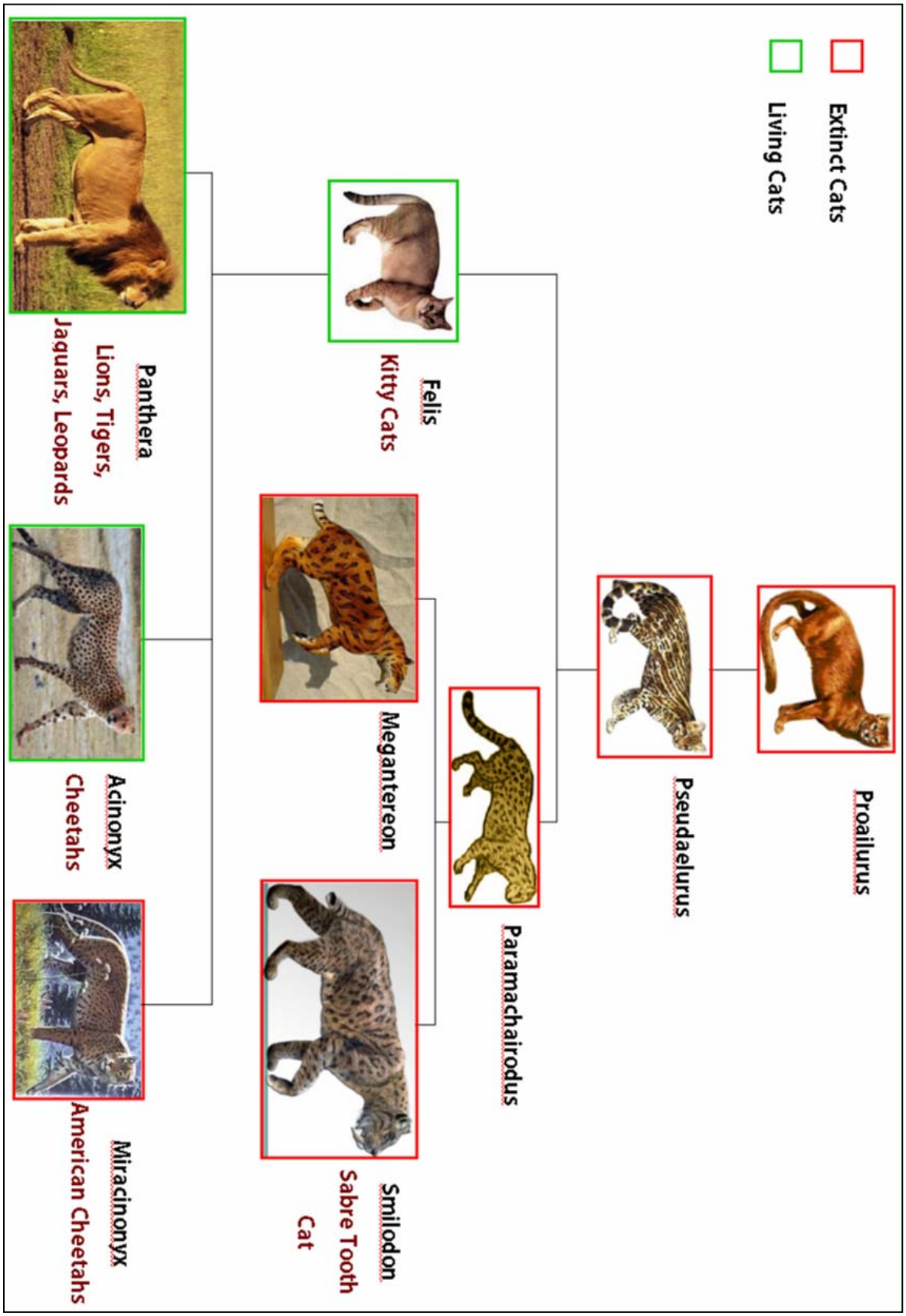



ENGLISH HERITAGE
Square
Title
Quote (motion over
Push button
Picture from
semi-circle
Half-Circle
Pictures
Quote

# APPENDIX F: Initial Taxonomic Tree

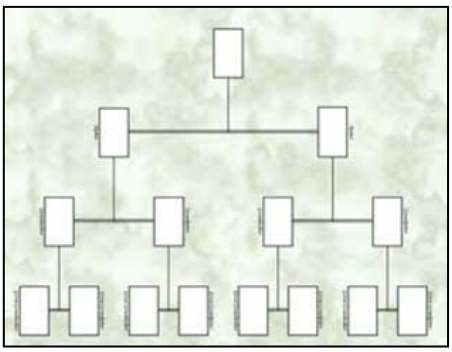


# APPENDIX G: Second Draft of Initial Taxonomic Tree



## APPENDIX H: Prototype Exhibit Instructions I

# Darwin & Classification



**Instructions:**

**Charles Darwin Quote:**

> "We have no written pedigrees; we have to make out community of descent by resemblances of any kind." *On the Origin of Species*

**Your Task:**

Before the discovery of DNA, classification of animals and plants into species was done by looking closely at an organism and comparing it with others. Darwin showed that species were related to one another because they shared common ancestors.
**Can you put these animals into the right place in the family tree?**

- When you think you're right, press and **hold** the "Test" button.
- Please press the "Reset" button when completed.

************************HINTS*************************

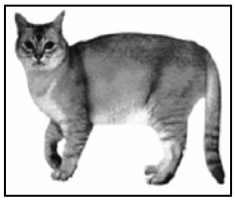
**Examine and compare:**

- Ear shape
- Tail length
- Tooth size

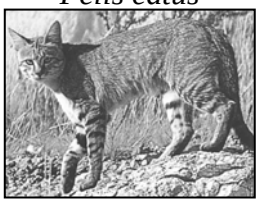
**Other Information:**

This exhibit is an example of taxonomic classification. Taxonomy is literally "the science of classification". It is the science of classifying all living organisms by arranging them in groups according to the relationship of each to the others.

# APPENDIX I: New Images Used For Tree

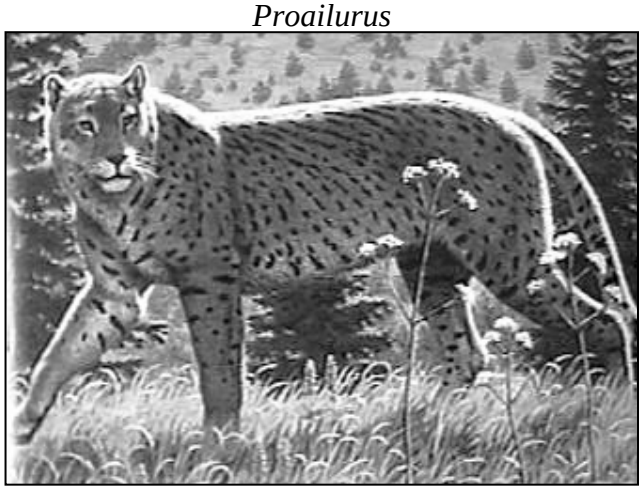


*Felis catus*

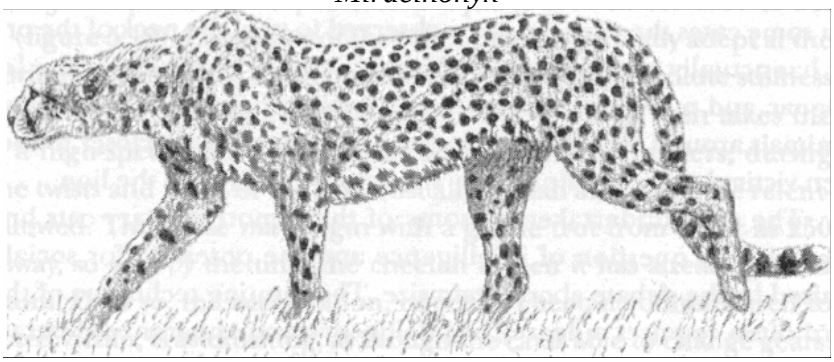


*Felis*

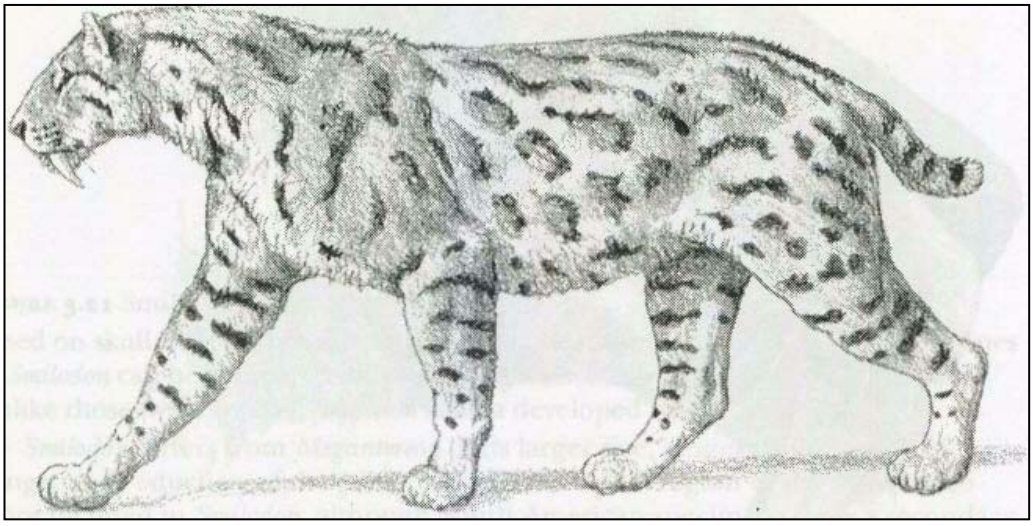
*Proailurus*



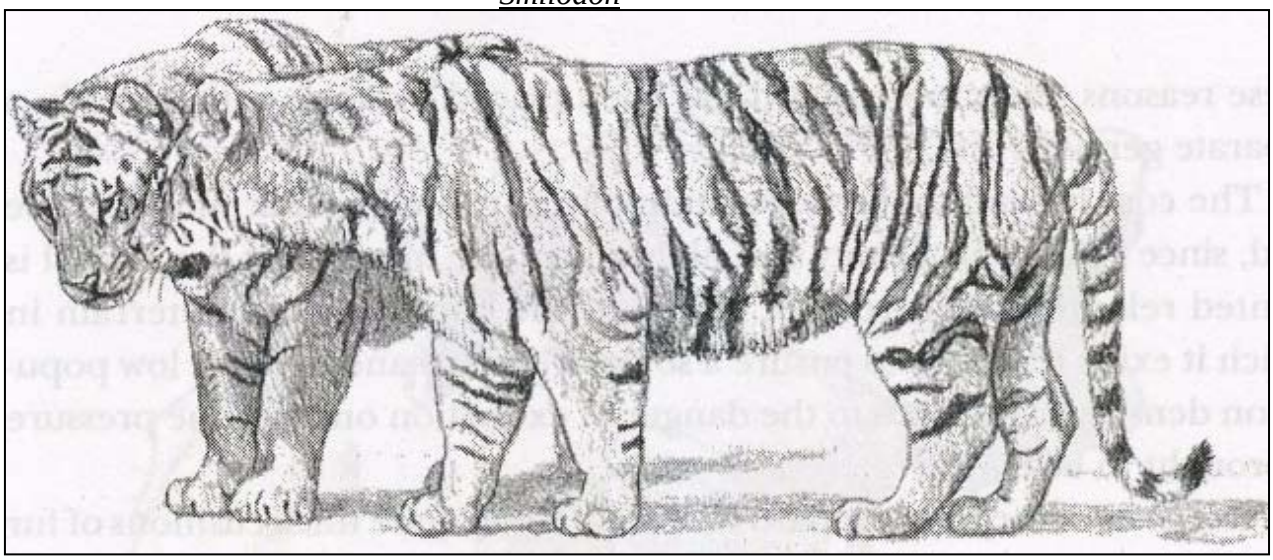
*Miracinonyx*



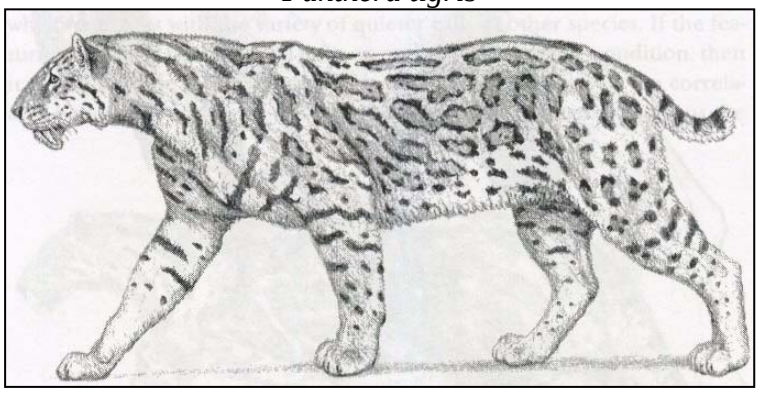
*Acinonyx*



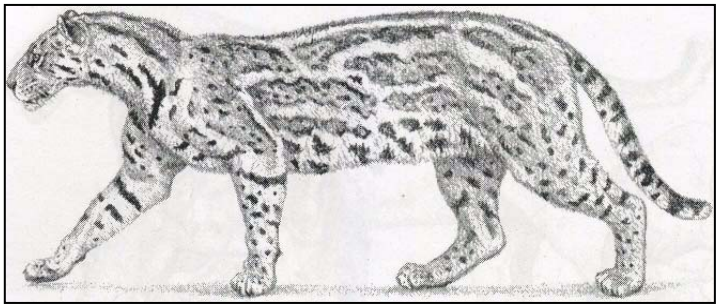
*Smilodon*



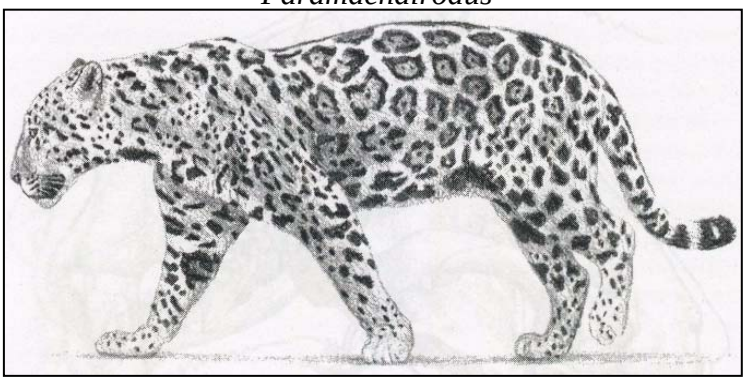
*Panthera tigris*



*Megantereon*



*Paramachairodus*



*Panthera onca*

# APPENDIX J: Design Specifications Checklist

| | |
|---|---|
| | **Aesthetic** |
| | Attractive to visitors |
| | Must fit with surroundings in the house |
| | Appropriate for audience |
| | Must suit theme of the exhibit |
| | **Functionality** |
| | Instructions must be clear and interesting |
| | Must be interactive enough to be engaging to visitors |
| | The importance of the exhibit must be apparent |
| | Should link to Darwin literature |
| | Must be on topic |
| | Must carry the key theme of the room: “Darwin’s theories were developed through routine and observation” |
| | Must carry specific exhibit theme |
| | Simple to use |
| | Must not be too difficult or easy |
| | **Fabrication** |
| | Must cost less than £1000 |
| | Build time must be no longer than four days |
| | Must be made of materials available at MDM Props, or parts that can be ordered |
| | Table top size |
| | Must be light enough to move by hand |
| | **Exhibit reliability** |
| | Scratch resistant surfaces |
| | Parts that can be picked up must be droppable |
| | Easy to maintain |
| | Useable by handicapped people |
| | Nothing should be easily breakable |

# APPENDIX K: Visitor Survey

*Circle one from each question below.*

**1)** How **interesting** is the exhibit?

| **5** | **4** | **3** | **2** | **1** |
|---|---|---|---|---|
| (Very interesting) | | | | (Rather dull) |

**2)** Did you find the exhibit **thought provoking**?

| **5** | **4** | **3** | **2** | **1** |
|---|---|---|---|---|
| (Thought provoking) | | | | (Uninspiring) |

**3)** Did it seem **relevant** to Darwin?

| **5** | **4** | **3** | **2** | **1** |
|---|---|---|---|---|
| (Very relevant) | | | | (irrelevant) |

**4)** Did you complete the exhibit? **Yes** **No**

If **Yes,** approx how many times did you have to press the **test** button & move some of the cats before you got it right

**0** **1** **2** **3** **4+**

**5)** What do you think the exhibit was about?

**6)** What did you learn from the exhibit?

**7)** What did you like and dislike most about the exhibit?

**8)** Did you participate (circle one)… **Alone** **2+ persons**

**8)** Please circle your **age group**,

**0-12** **13-17** **18-26** **27-39** **40-60** **61+**

**9)** Please circle your **level of education**.

None School (key stage 3+) Bachelors Masters PHD

# APPENDIX L: Quantitative Data

| Visitor # | Sex | Time | Reset? | Interesting | Thought Provoking | Relevant | Completed | Test # | # of People | Age Group | Education |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F | 133 | by hand | 4 | 5 | 5 | Y | 2 | 2+ | 61+ | KS 3+ |
| 2 | M | 133 | by hand | 4 | 3 | 3 | Y | 2 | 2+ | 61+ | Masters |
| 3 | M | 135 | N | 5 | 5 | 5 | Y | 3 | 1 | 40-60 | Bachelors |
| 4 | F | 150 | N | 5 | 5 | 5 | N | N/A | 1 | 40-60 | Bachelors |
| 5,6 | MF | 106 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 7 | M | 82 | Y | 5 | 5 | 5 | Y | 1 | 2+ | 40-60 | PHD |
| 8 | M | 198 | N | 2 | 2 | 4 | N | N/A | 1 | 40-60 | Bachelors |
| 9 | F | 328 | Y | 4 | 4 | 5 | Y | 1 | 1 | 61+ | Bachelors |
| 10,11,12 | MF F | 340 | Y | 3 | 4 | 5 | N | N/A | 2+ | 61+ | KS 3+ |
| 13 | M | 55 | by hand | 3 | 3 | 4 | Y | 0 | 1 | 61+ | Bachelors |
| 14 | M | 69 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 15 | F | 60 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 16 | M | 17 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 17 | F | 85 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 18 | M | 15 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 19 | M | 263 | N | 4 | 4 | 5 | Y | 0 | 2+ | 40-60 | Masters |
| 20 | M | 200 | N | 4 | 3 | 4 | Y | 2 | 1 | 40-60 | Bachelors |
| 21 | M | 30 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 22 | F | 148 | Y | 4 | 4 | 5 | Y | 2 | 1 | 61+ | KS 3+ |
| 23,24 | MF | 152 | N | 5 | 4 | 5 | Y | 4+ | 2+ | 61+ | KS 3+ |
| 25 | M | 244 | N | 5 | 5 | 5 | Y | 0 | 1 | 40-60 | Masters |
| 26,27,28 | F | 48 | Y | 4 | 4 | 5 | Y | 0 | 2+ | 13-17 | KS 3+ |
|  | FF | 48 | Y | 4 | 5 | 4 | Y | 0 | 2+ | 13-17 | KS 3+ |
| 29,30 | M | 145 | N | 4 | 5 | 4 | Y | 3 | 2+ | 13-17 | KS 3+ |
|  | M | 145 | N | 5 | 4 | 5 | Y | 2 | 2+ | 13-17 | KS 3+ |
| 31 | M | 15 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 32 | F | 80 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 33,34 | MF | 298 | N | 4 | 4 | 4 | N | N/A | 1 | 61+ | Bachelors |
| 35,36 | FF | 200 | N | 5 | 5 | 5 | Y | 3 | 1 | 61+ | KS 3+ |
| 37 | F | 28 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 38,39 | MF | 77 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 40 | M | 25 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 41 | F | 20 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 42 | M | 27 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 43,44 | FF | 97 | Y | 4 | 4 | 4 | Y | 1 | 2+ | 61+ | Bachelors |
| 45 | F | 100 | Y | 5 | 5 | 4 | Y | 1 | 1 | 61+ | KS 3+ |

# *Darwin on*
# *Classification*

"We have no written pedigrees; we have to make out community of descent by resemblances of any kind."

**Put the pieces in the correct place in the family tree.** (Use golden clue)
**Press TEST to see if you're right**
**Press RESET when you're done**

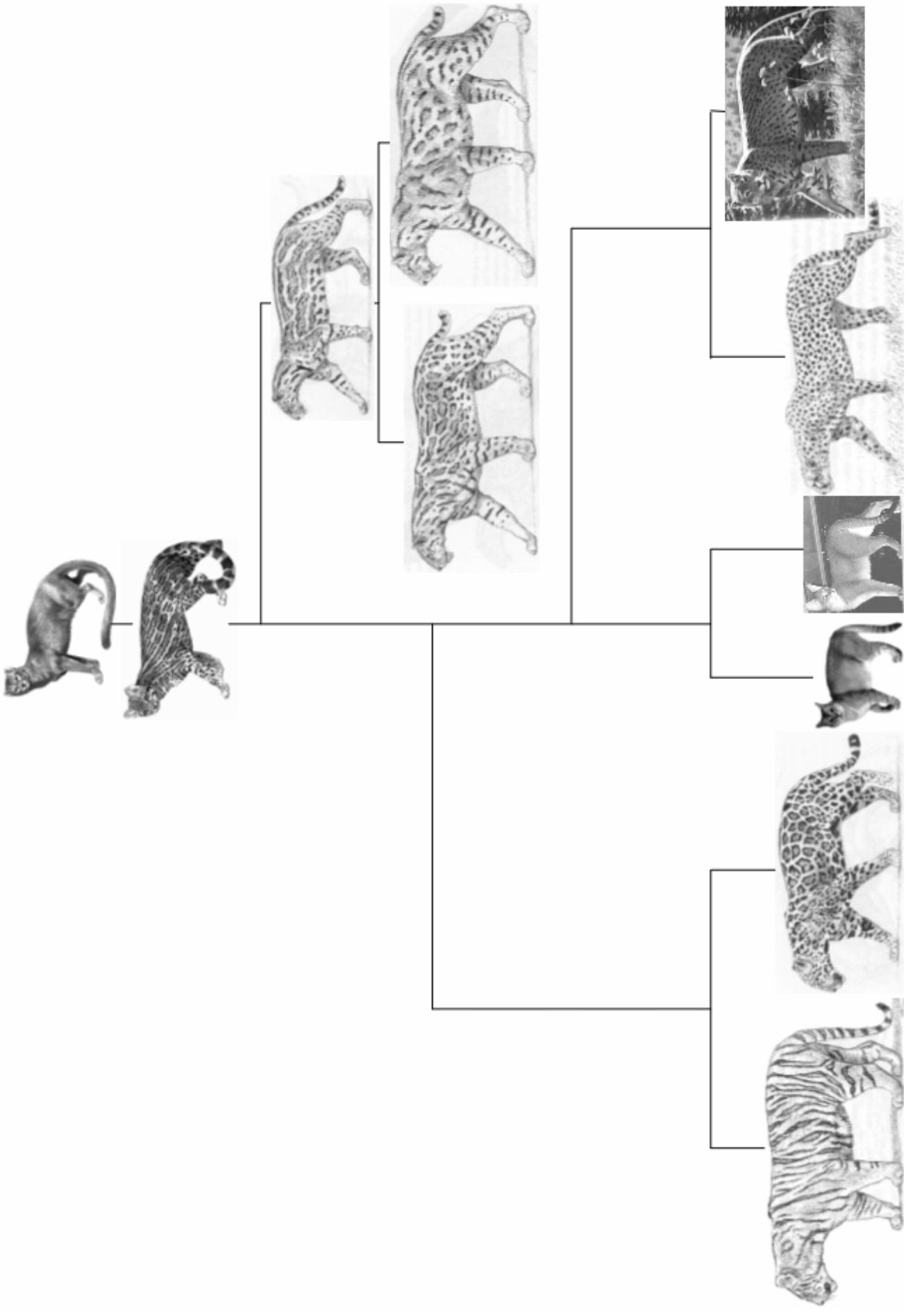
It's easy to think like Darwin. There were **no** genetics in his day…
He had to observe traits.

**Look at cat traits like:**
- **Ears**
- **Tails**
- **Teeth**

# APPENDIX N: Qualitative Data

| Visitor No. | What did you think the exhibit was about? | What did you learn from the exhibit? | Likes? | Dislikes? |
|---|---|---|---|---|
| 1 | evolution | to look closely at ears, teeth, tail | that you could test yourself | not in color |
| 2 | evolution | that animals evolve | N/A | this survey |
| 3 | genetic selection | all is not what it seems | N/A | N/A |
| 4 | evolution | to observe small changes better | N/A | N/A |
| 5 | N/A | N/A | N/A | N/A |
| 6 | N/A | N/A | N/A | N/A |
| 7 | heredity | about inheritence of characteristics | though provoking | N/A |
| 8 | evolution | nothing | | too difficult |
| 9 | genetics/classifcation | deversity of species | N/A | N/A |
| 10,11,12 | development of the species | to look more carefully | | frustrating |
| 13 | how species develop to form multiple species | not a lot | | color |
| 14 | N/A | N/A | N/A | N/A |
| 15 | N/A | N/A | N/A | N/A |
| 16 | N/A | N/A | N/A | N/A |
| 17 | N/A | N/A | N/A | N/A |
| 18 | N/A | N/A | N/A | N/A |
| [redacted] | | | | |
| 19 | what is significant in the classifcation | it is not obvious what is relevant | | |
| 20 | inheritance | to observe closely | | |
| 21 | N/A | N/A | N/A | N/A |
| 22 | evolution | close observation | none | none |
| 23,24 | evolution | how much work darwin undertook | how well laid out | none |
| 25 | none | none | none | none |
| 26,27,28 | evolution | how cats evolved | th world going round when your right | lack of color |
| | evolution | how cats evolved | interactivity | none |
| | evolution | saber tooth tiger does no longer exist | none | small scale |
| 29,30 | evolution | about the evolution of life | multiple choice with images | none |
| 31 | N/A | N/A | N/A | N/A |
| 32 | N/A | N/A | N/A | N/A |
| 33,34 | evolution | not as straight forward as it looks | none | Instructions were not clear enough. Examples tended to make one think in terms of chronology rather than changes in features. |
| 35,36 | inheritance of characteristics | food for thought | none | level of difficulty |
| 37 | N/A | N/A | N/A | N/A |
| 38,39 | N/A | N/A | N/A | N/A |
| 40 | N/A | N/A | N/A | N/A |
| 41 | N/A | N/A | N/A | N/A |
| 42 | N/A | N/A | N/A | N/A |
| 43,44 | genetically transmitted characteristics | none | doing something | none |
| 45 | matching species | to read instrcutions first | none | challenging |

# APPENDIX O: Cat Specialists Recommendations



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