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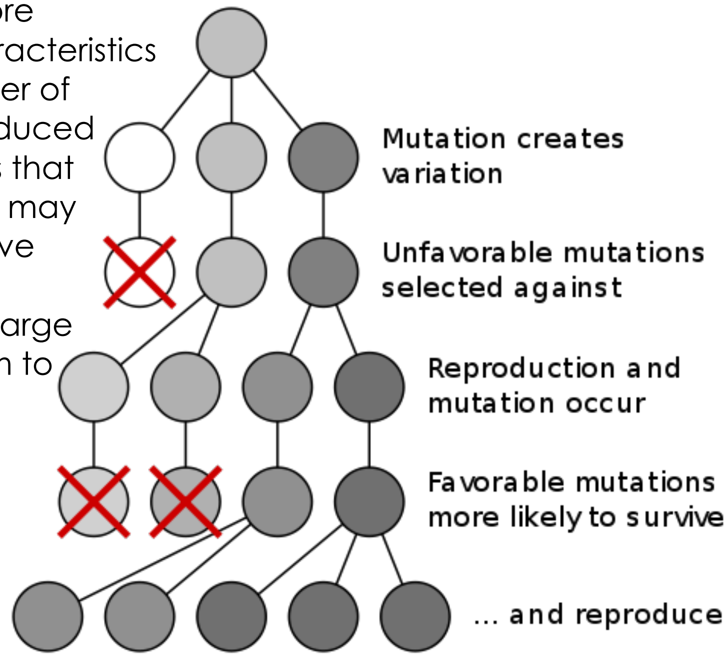
Evidences of Evolution

HASPI Medical Biology Lab 20

Background/Introduction

What Is Evolution?

Evolution is most simply change over time. More specifically, it is a change in the inherited characteristics of a population over generations. At the center of evolution is the need for genetic diversity, produced through sexual reproduction and/or mutations that provide a variety of traits. Some of these traits may make an organism better or less suited to survive and reproduce in a specific environment. For example, polar bears possess traits, such as a large amount of fat and thick coats, that allow them to survive and reproduce in polar environments. On the other hand, a bearded dragon (lizard) possesses traits, such as a lack of hair and specialized cooling mechanisms, that make it suited for a hot and dry desert environment. Bearded dragons would have a very difficult time surviving and reproducing in a polar environment, and would more than likely become extinct.



http://www.macroevolution.net/images/natural-selection-225-212-10.jpg

While Charles Darwin was not the first scientist to consider the evolutionary theory, he was one of the first to formulate a cohesive theory of evolution *through natural selection*. Darwin recorded his observations of a large variety of species he came across in years of traveling, and later wrote a book called "*On the Origin of Species*" that was published in the mid-1800s. At the core of his ideas was the fact that all populations (1) produce more offspring than can survive, (2) have individuals with different rates of survival and reproduction based on traits that vary among individuals, and (3) differences in traits are heritable. As a result, the theory states that the offspring of parents that are better adapted to survive and reproduce are themselves better able to survive and reproduce. If the environment remains stable, the traits that are most successful in that environment become more common over successive generations.


http://www.petersalebooks.com/wp-content/uploads/mass-extinction.jpg

If the environment changes and there are no variations among a population to make some suited for survival, there is a chance that none of the organisms in a species will survive. The disappearance of an entire species is called **extinction.** It is estimated that 96% of all organisms that have lived on the Earth are extinct. Drastic environmental changes, such as a volcanic eruption or meteor impact, have caused mass extinctions at several points in Earth's history. The primary cause of species extinction today is from human impact on the environment.

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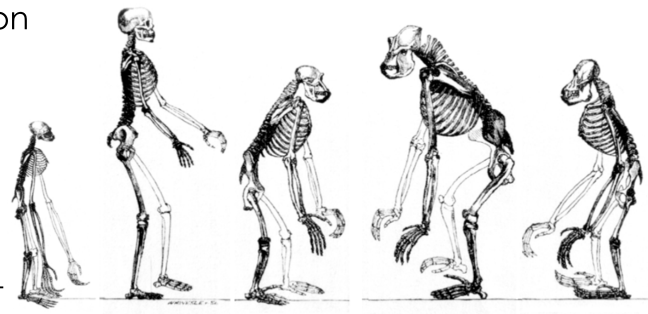
Common Descent

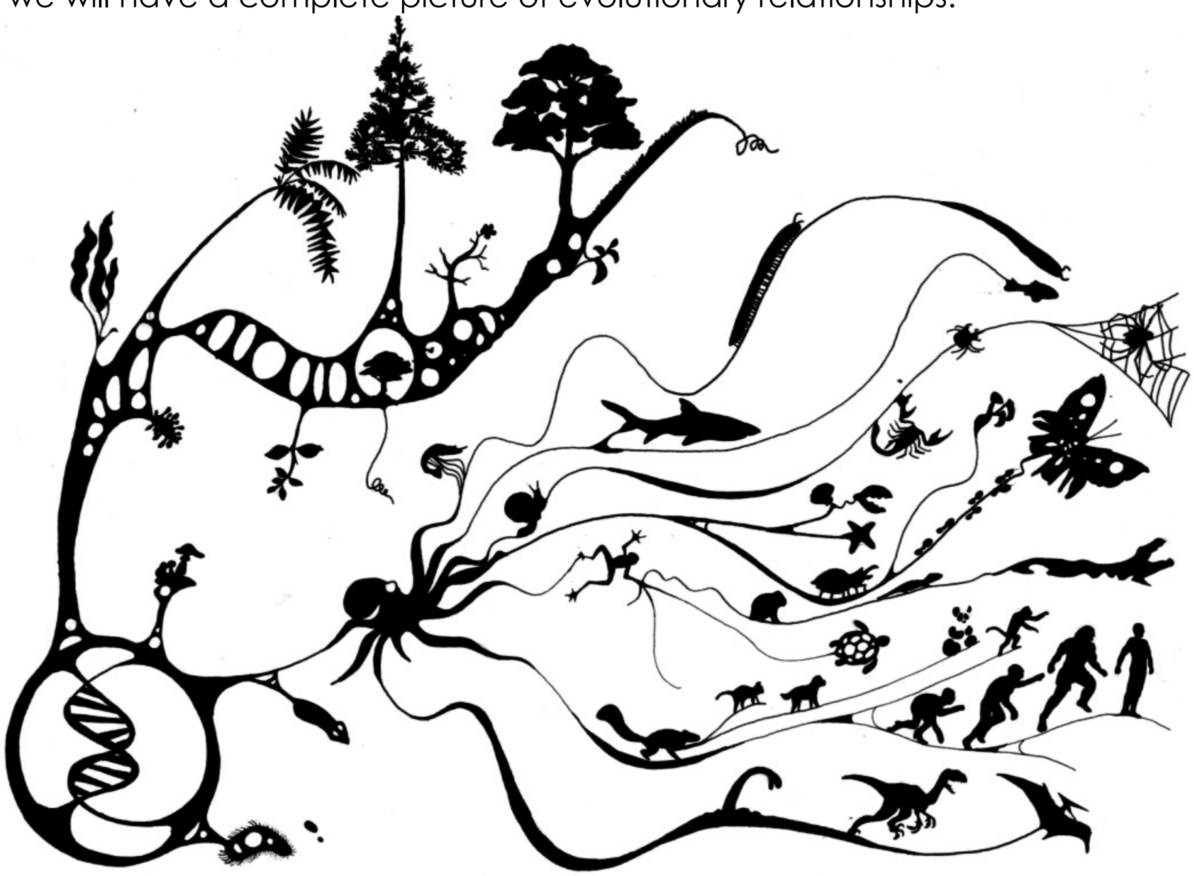
It has been hypothesized that approximately 4 billion years ago, self-replicating molecules formed in an aquatic environment. Less than half a billion years later, the first form of life developed. This first organism is considered the original common ancestor for all living things on Earth. Simple and eventually complex life formed from biochemical reactions. This theory revolves around the concept that all living things have shared molecular traits and use DNA or RNA as genetic information.



http://upload.wikimedia.org/wikipedia/commons/4/49/Ape_skeletons.png

Organisms evolve and change at the genetic level, which eventually leads to them branching off into new species. As a result, we assume that the more traits that are similar, or homologous, between two species, the higher the likelihood that they shared a more recent common ancestor. For example, humans and primates are believed to have a close common ancestor due to their many anatomical similarities and molecular similarities. In fact, humans and chimpanzees have less than a 2% difference in DNA sequences.

Organisms are classified in groups based on common descent and are often represented within the evolutionary "tree of life." The tree of life shows the evolution and development of species over time from a common ancestor. The study of evolutionary relationships between species is complex and changing. New discoveries in molecular biology have led to some rearranging of organisms and branches of the tree, and there is still a lot to be discovered before we will have a complete picture of evolutionary relationships.



http://www.fromquarkstoquasars.com/wp-content/uploads/2013/11/evolution.jpeg

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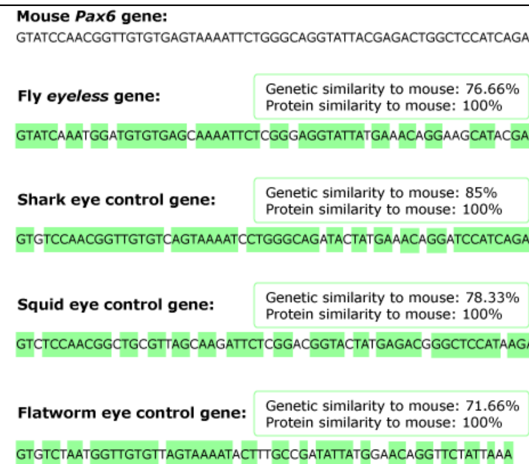
Evidences of Evolution

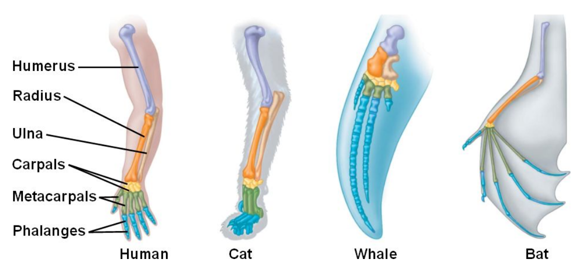
If we strip down evolution to its most basic principle, it is simply that life has existed for a very long period of time, and it has changed during that time. Formulating hypotheses and theories about how life has changed involves using the evidence that has been left behind, and/or through observations of how life can change today. Multiple lines of evidence have been used to reconstruct this story. The following concepts summarize a few examples that provide evidence for evolution.

<table>
<tr><th colspan="2">Table 1. Evidences for Evolution</th></tr>
<tr><th>Evidence</th><th>Example</th></tr>
<tr><td>The Fossil Record
The fossil record provides a glimpse of organisms that have populated the Earth, and provide us with a part of the picture of Earth's history. Of the millions of different species that have lived on the Earth, very few were actually preserved in the fossil record. It is estimated that less than 1% of all species that have ever lived are even known. As a result, the "picture" is incomplete because of missing pieces, but it still shows that organisms have changed over time.</td><td>

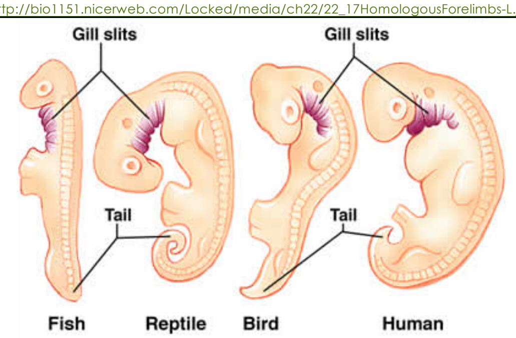
http://www.freedomsphoenix.com/Uploads/Graphics/338/08/338-0808203248-human-evol.jpg</td></tr>
<tr><td>Molecular Similarities
An individual organism's physical traits, or phenotype, result from its genetic traits, or genotype, and are influenced by the environment. Variation in these traits occurs at the genetic level and can result from mutations, sexual reproduction, or even migration to populations with different traits. By comparing the genes or DNA, RNA, amino acid sequence, and even cellular structure, we can infer evolutionary relationships. If two organisms have molecular structures that are similar, it makes sense that they are closely related. On the other hand, if two organisms have molecular structures that are very different, we assume they separated from each other evolutionarily a much longer time ago.</td><td>



http://evolution.berkeley.edu/evolibrary/images/interviews/visionaries_dna3.gif</td></tr>
<tr><td>Anatomical Homologies
The theory of evolution predicts that organisms that are closely related will display similarities, or homologies. In fact, early evolutionary relationship theories were solely based upon observations of similarities between organisms. The focus has shifted more to molecular similarities, such as DNA, because the genotype leads to the phenotype; organisms that are anatomically similar are often genetically similar.</td><td>



http://bio1151.nicerweb.com/Locked/media/ch22/22_17HomologousForelimbs-L.jpg</td></tr>
<tr><td>Embryology
An embryo is an organism in its early stages of development. The stages of embryo development across many species can be compared to determine relationships. For example, nearly all vertebrates have similar stages of embryo development, and are difficult to discern until much later in their growth. As can be seen in the image, all vertebrate embryos start life with a tail and gill slits.</td><td>



http://dtc.pima.edu/blc/182/lesson1/1step3/1step3images/embryoes2116.jpg</td></tr>
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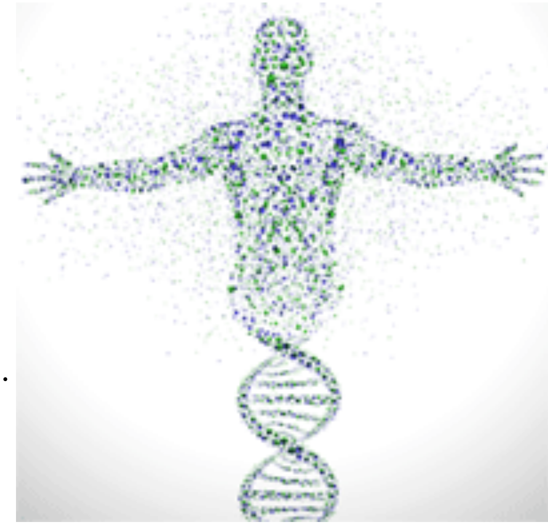
Evolution's Impact on Medicine


http://www.biomedcentral.com/sites/2999/series/EvolMed.png

An understanding of how evolution has impacted us in the past can further our understanding of its impact on modern human populations. Evolutionary biology can contribute important information to studies of the genome, physiology, and even environmental interactions. We are now capable of genetically engineering organisms with specific traits by manipulating DNA. Using this technique, humans no longer have to wait for mutations to randomly occur for genetic variation. We are able to provide genetic variation and beneficial (or detrimental) genetic traits to organisms. Scientists are already able to genetically modify organisms to produce enzymes and antibodies needed for medical treatments. For example, specialized bacteria and yeast species have been genetically engineered to produce human insulin that is provided for diabetes treatments. In addition, an understanding of the mutations that have occurred during an organism's evolution can reveal specific mutations that cause genetic disorders. While not yet a reality, the hope is that someday this information can be used to remove or reverse detrimental mutations and eradicate genetic disorders.

Review Questions – *answer questions on a separate sheet of paper*

1. What is evolution?
2. Why is genetic diversity so important to evolution?
3. What were the three major core ideas that Charles Darwin contributed to evolution?
4. What is extinction and why does it occur?
5. What is common descent? Why is it important to the theory of evolution?
6. Explain how the fossil record can be used as an evidence of evolution. Provide one example.
7. Explain how molecular similarities can be used as an evidence of evolution. Provide one example.
8. Explain how anatomical homologies can be used as an evidence of evolution. Provide one example.
9. Explain how embryology can be used as an evidence of evolution. Provide one example.
10. How can evolution impact human health and medicine?

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Purpose

Evolution is an important aspect of biology, and it is important to understand how and why this theory developed. In this activity you will visit five stations that provide evidence for the evolutionary theory, and discover how these evidences can be related to humans, health, and how they may contribute to medical research.

Materials

Station 1

"Ancient Tuberculosis Found in 500,000-Year-Old Fossil" article

"Making Sense of Homo floresiensis: Small-Bodied Humans, Dwarfism, or Disease?" article

"Modern Cancer Type Found in Neanderthal Remains" article

Station 2

Human DNA Sequence

Fish DNA Sequence

Mouse DNA Sequence

Chimpanzee DNA Sequence

Station 3

Digestive tract sheet

Scratch paper

Scissors

Tape/glue

Station 4

Human Insulin Amino Acid Sequence

Dog Insulin Amino Acid Sequence

Sheep Insulin Amino Acid Sequence

Mouse Insulin Amino Acid Sequence

Ape Insulin Amino Acid Sequence

Horse Insulin Amino Acid Sequence

Station 5

Embryo images and animal/stage labels

Procedure/Directions

	Task	Response
1	Find a partner.	a. Who is your partner?
2	This is a station lab. There are 5 stations placed throughout the room.	b. Why is an understanding of the evidences of evolution important to human health and medicine?
3	Choose a station and follow the instructions at each station. Each station should take approximately 10-15 minutes to complete.	
4	Answer the questions for each station using the lab answer sheet.	

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Connections & Applications

Your instructor may assign or allow you to choose any of the following activities. As per NGSS/CCSS, these extensions allow students to explore outside activities recommended by the standards.

1. **ANALYZING THE FOSSIL RECORD:** Go to the following website for an interactive timeline of human evolution:

   http://www.pbs.org/wgbh/evolution/humans/humankind/index.html

   The timeline provides a summary of human fossils that have been discovered and what has been inferred about human evolution through each discovery. Move through the timeline (by moving the cursor over the small, blue left and right arrows) and answer the questions below for the following hominid species. To learn about a specific hominid species, click on the name in the timeline.

   - *Orrorin tugenensis*
   - *Australopithecus afarensis*
   - *Australopithecus africanus*
   - *Homo habilis*
   - *Homo erectus*
   - *Homo heidelbergensis*
   - *Homo neanderthalensis*
   - *Homo sapiens*

   The Questions

   a. How old is the species?
   b. When and where was it discovered?
   c. What similarities did this species have to modern humans?
   d. What part of the skeleton was fossilized (skull, femur, etc.)? *Click on the "SEE DETAILS" on each image for a closer look.*

2. **EVIDENCES OF EVOLUTION:** In this activity you had the opportunity to learn about some broad evidences for evolution. There are many more specific examples that provide evidence for evolution. For example, the anatomical similarities between zebras, donkeys, and horses provide evidence for a common ancestor of these species. Research and summarize a minimum of three specific examples of evolution evidences, and present them in a poster or newsletter. For each example include:
   a. *At least one image that supports the example*
   b. *2-3 paragraph explanation of the example*
   c. *Description of how the example supports evolution*
   d. *References for the example (cite all of your sources!)*

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3. **AMINO ACID COMPARISON:** The following figure is actual data from a scientific research project that compared the amino acid sequence of the GBGT1 gene across seven different species. The GBGT1 gene codes for a protein that acts as an enzyme, called **globoside alpha-1,3-N-acetylgalactosaminyltransferase 1**. There are 347 amino acids in this protein, and each letter in the sequence below represents a specific amino acid. In order to fit the entire sequence on one page, only the first 90 amino acids are compared in the first row, then the next 90 in the next row, and so on.
    a. *Use an internet search to determine the common name of the 7 species that were compared.*
    b. *Carefully read through the amino acid sequence. Circle every amino acid that is different from the H. sapiens amino acid sequence.*
    c. *Create a table that summarizes the number of amino acid differences between each species and H. sapiens.*
    d. *Determine and include the percent similarity and percent difference of each species in the table.*
    e. *List the species in order from most closely related to H. sapiens, to least related.*

Species	***Amino Acid (AA) Sequence***	***# of AA***
M. musculus	MTRPRLAQGLAFFLLGGTGLWVLWKFIKDWLLVSYIPYYLPCPEFFNMKLPFRKEKPLQPVTQLQYPQPKLLEHGPTELLTLTPWLAPIV	90
C. porcellus	MSRRRLVLSLGLIVLASTGLWALWVYIENWLPVSHVPYYLPCPEIFNMKLQYKGEKPLPPVTQAQYPQPRLTQHRPTELLTLTPWLAPIV	90
E. caballus	MRRHRLAIGLGVCLLVGTVLCTLWVYVEDWLPVSYVPYYLPCPEIFNMKLQYKGEKLFQPVAQSRYPQPKLLEQRPTELLTLTPWLAPIV	90
C. familiaris	MRCRRLALGLGFSLLSGIALWSLWIYMETWLPFSYVPYYLPCPEIFNMKLQYKGEKPFQPVTRSPHPQPKLLEQRPTELLTLTPWLAPIV	90
H. sapiens	MHRRRLALGLGFCLLAGTSLSVLWVYLENWLPVSYVPYYLPCPEIFNMKLHYKREKPLQPVVWSQYPQPKLLEHRPTQLLTLTPWLAPIV	90
P. troglodytes	MHRRRLALGLGFCLLAGTSLSVLWVYLENWLPVSHVPYYLPCPEIFNMKLHYKREKPLQPMVWSQYPQPKLLEHRPTQLLTLTPWLAPIV	90
G. gorilla	MHRRRLALGLGFCLLAGTSLSVLWVYLENWLPVSYVPYYLPCPEIFNMKLHYKREKPLQPVVWSQYPQPKLLEHRPTQLLTLTPWLAPIV	90
M. musculus	SEGTFDPELLKSMYQPLNLTIGVTVFAVGKYTCFIQRFLESAEEFFMRGYQVHYYLFTHDPTAVPRVPLGPGRLLSIIPIQGYSRWEEIS	180
C. porcellus	SEGTFDPELLQHIYQPLNLSIGVTVFAVGKYTRFVQHFLESAEEFFMRGFQVHYYVFTHNPAAIPRVLLGPRRLLDIIPIHGYTHWEEIS	180
E. caballus	SEGTFNAELLQHIYQPLNLTIGLTVFAVGKYTHFVQHFLESAELFFMHGYRVCYYVFTDDPTAIPQVPLGPGRRLGIIPIQRHSRWEEIS	180
C. familiaris	SEGTFNPELLQHIYQPLNLTIGLTVFAVGKYTRFVQHFLESAEQFFMQGYQVYYYIFTNDPAAIPRVPLGPGRLLSIIPIQRHSRWEEIS	180
H. sapiens	SEGTFNPELLQHIYQPLNLTIGVTVFAVGKYTHFIQSFLESAEEFFMRGYRVHYYIFTDNPAAVPGVPLGPHRLLSSIPIQGHSHWEETS	180
P. troglodytes	SEGTFNPELLQHIYQPLNLTIGVTVFAVGKYTHFIQSFLESAEEFFMRGYRVHYYIFTDNPAAIPGIPLGPHRLLSSIPIQGHSHWEETS	180
G. gorilla	SEGTFNPELLQHIYQPLNLTTGVTVFAVGKYTHFIQSFLESAEEFFMRGYRVHYYIFTDNPAAVPGVPLGPHRLLSSIPIQGHSHWEETS	180
M. musculus	MRRMETINKHIAKRAHKEVDYLFCVDVDMVFRNPWGPETLGDLVAAIHPGYFAVPRRKFPYERRQVSSAFVADNEGDFYYGGALFGGRVA	270
C. porcellus	MRRMEAISRHIAKKAHQEVDYLFCLDVDMVFHNPWGPETLGDLVAAIHPGYFTVSRRQFPYERRQISTAFVAENEGDFYYGGAVFGGRVA	270
E. caballus	TRRMEIISQHIAKRAHREVDYLFCVDVDMVFRNPWGPETLGDLVAAIHPGYYAVPRQQFPYERRHVSTAFVADGEGDFYYGGAVFGGRVA	270
C. familiaris	TRRMETISRHIAQRAHREVDYLFCVDVDMVFRNPWGPETLGDLVAAIHPGYYAVPRQQFPYERRHISTAFVAENEGDFYYGGAVFGGRVA	270
H. sapiens	MRRMETISQHIAKRAHREVDYLFCLDVDMVFRNPWGPETLGDLVAAIHPSYYAVPRQQFPYERRRVSTAFVADSEGDFYYGGAVFGGQVA	270
P. troglodytes	MRRMETISQHIAKRAHREVDYLFCLDVDMVFRNPWGPETLGDLVAAIHPSYYAVSRQQFPYERRRVSTAFVADSEGDFYYGGAVFGGQVA	270
G. gorilla	MRRMETISQHIAKRAHQEVDYLFCLDVDMVFRNPWGPETLGDLVAAIHPSYYAVPRQQFPYERRRVSTAFVADSEGDFYYGGAVFGGQVA	270
M. musculus	RVYEFTRACHMAILADKANSIMAAWQEESHLNRHFIWHKPSKVLSPEYLWDERKPRPRSLKMIRFSSVKKNANWLRT	347
C. porcellus	NVYEFTRGCHMAILADKANGIMAAWQEESHLNRRLITHKPSKVLSPEYLWDDRKPVPSSLKLIRFSTLLKDTNWLRS	347
E. caballus	NVYEFTRGCHMAILADKANGIMAAWQEESHLNRRFISHKPSKVLSPEYLWDDRKRQPPSLKLIRFSTLDKDTSWLRS	347
C. familiaris	KVYEFTTGCHMAILADKANGIMAAWQEESHLNRRFISHKPSKVLSPEYLWDDRKPQPPSLKLIRFSTLDKATSWLRS	347
H. sapiens	RVYEFTRGCHMAILADKANGIMAAWREESHLNRHFISNKPSKVLSPEYLWDDRKPQPPSLKLIRFSTLDKDISCLRS	347
P. troglodytes	RVYEFTRGCHMAILADKANGIMAAWREESHLNCHFISNKPSKVLSPKYLWDDRKPQPPSLKLIRFSTLDKDISCLRS	347
G. gorilla	RVYEFTRGCHMTILADKANGIMAAWREESHLNRRFISNKPSKVLSPEYLWDDRKPQPPSLKLIRFSTLDKDISCLRS	347

Reference: Yamamoto, M., Cid, E., & Yamamoto, F. 2012. Figure 2: Amino acid sequence comparison of the GBGT1 genes between the Forssman-positive and negative species. Molecular genetic basis of the human Forssman glycolipid antigen negativity. Scientific Reports, 2:975.

Resources & References

- PBS. 2001. Evolution: A Journey Into Where We're From and Where We're Going. WGBH Educational Foundation, Clear Blue Sky Productions, Inc., www.pbs.org/wgbh/evolution/.

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