

## Population genetics of Colorado Yeti



Due to the recent discovery of *homo yetis* or 'The Yeti', in Colorado, USA the question was asked, - How does the yeti fit into the primate phylogenetic tree? Blood samples from 6 humans, 7 gorillas and 7 yetis were collected and isozyme analyses were performed on the following loci- PGM, MDH-1, MDH-2, LAP, SKDH, PGI, EST-1, EST-2 and IDH. Behavior of the isozymes was typical of that observed for diploid organisms and as such were interpreted in this manner. The Yeti phenotypically appears to be a combination of gorillas and humans, it has an 'S' shaped spine, and walks upright, - similar to humans. The Yeti is fully covered in black hair and has a robust skeleton and skull, - similar to gorillas. Gorillas were chosen for this analysis due to very close similarities between the skulls, and also because the Yeti displays remarkable behavioral similarities to the gorilla. Like the gorilla the yeti are territorial and live together in groups, each group contains one dominant male which can be distinguished from other males in the group by its size and the growth of silver hair on its back.

### Results-

The 9 putative loci were resolved reliably and scored as follows: PGM, MDH-1, MDH-2, LAP, SKDH, PGI, EST-1, EST-2, IDH. Allele frequencies and estimates of genetic variability for the species level and the entire data set are presented in the table below.

Allele frequencies of Human, Gorilla and Yeti species and the entire data set. N is the number of individuals per locus.

	Humans Species level	Gorilla Species level	Yeti Species level	Entire data set
N	6	6	7	19
Locus				
Allele				
PGM				
1	0.6667	0.2500	0.4286	0.4474
2	0.3333	0.5833	0.2857	0.3947
3	0.0000	0.1667	0.2857	0.1579

MDH-1					
1	1.0000	1.0000	1.0000	1.0000	1.0000
MDH-2					
1	0.5000	0.4167	0.5714	0.5000	0.5000
2	0.5000	0.3333	0.2857	0.3684	0.3684
3	0.0000	0.2500	0.1429	0.1316	0.1316
LAP					
1	0.5000	0.5000	0.2857	0.4211	0.4211
2	0.5000	0.5000	0.7143	0.5789	0.5789
SKDH					
1	0.3333	0.4167	0.2143	0.3158	0.3158
2	0.3333	0.4167	0.2857	0.3421	0.3421
3	0.3333	0.1667	0.5000	0.3421	0.3421
PGI					
1	0.4167	0.0000	0.0000	0.1316	0.1316
2	0.5833	0.0000	0.0000	0.1842	0.1842
3	0.0000	0.6667	0.0000	0.2105	0.2105
4	0.0000	0.3333	0.0000	0.1053	0.1053
5	0.0000	0.0000	0.5000	0.1842	0.1842
6	0.0000	0.0000	0.5000	0.1842	0.1842
EST-1					
1	1.0000	1.0000	1.0000	1.0000	1.0000
EST-2					
1	1.0000	0.3333	0.0000	0.4211	0.4211
2	0.0000	0.6667	1.0000	0.5789	0.5789
IDH					
1	1.0000	1.0000	0.9286	0.9737	0.9737
2	0.0000	0.0000	0.0714	0.0263	0.0263

Descriptive statistics for the human species.-

Locus PGM-

For this locus the human species expresses 2 alleles a third allele present is both gorillas and yetis is not expressed. The allele frequency for allele 1 is twice as high for that of allele 2. No human is heterozygotic for this locus. This is a polymorphic locus.

Locus MDH-1

Only 1 allele is present on this locus resulting in an allele frequency of 1.000 and a heterozygosity value of 0.0000. This is a monomorphic locus.

Locus MDH-2

Two alleles are expressed in humans for this locus, a third allele present in both gorillas and yetis is not expressed. The expression of these alleles is equal and the heterozygosity value for this allele is 0.5000. This is a polymorphic locus.

#### Locus LAP

Humans have an equal expression of the two alleles on this locus, with a heterozygosity value of 0.5000. This is a polymorphic locus.

#### Locus SKDH-

3 alleles are present on this locus and the humans sampled show an equal allele frequency for each of these alleles. No heterozygotes were observed, however the heterozygosity value is 0.6667. This is a polymorphic locus, with the different forms being homozygotes for the 3 different alleles.

#### Locus PGI-

Only 2 alleles are present on this locus in humans. Over the entire data set six alleles are present on this locus, however each species expresses 2 different alleles for this locus. The allele frequency for allele 1 was 0.4167 and for allele 2 was 0.5833. Only heterozygotes were observed for this locus with a heterozygosity value of 0.4861. This is a polymorphic locus.

#### Locus EST-1-

Only 1 allele is present on this locus resulting in an allele frequency of 1.000 and a heterozygosity value of 0.0000. This is a monomorphic locus.

#### Locus EST-2-

Only 1 allele is expressed in humans on this locus with an allele frequency of 1.0000. This is a monomorphic locus.

#### Locus IDH-

Only 1 allele was expressed in humans on this locus with an allele frequency of 1.0000. This is a monomorphic locus.

#### Descriptive statistics for the Gorilla species-

##### Locus PGM-

The gorilla species had three alleles present on this locus. They were expressed with the following allele frequencies, 1- 0.2500, 2- 0.5833, 3- 0.1667. Gorillas had a heterozygosity value for this locus of 0.5694; twice as many heterozygotes were observed for allele 3 than for alleles 1 and 2. This is a polymorphic locus.

##### Locus MDH-1-

Only 1 allele is present on this locus resulting in an allele frequency of 1.000 and a heterozygosity value of 0.0000. This is a monomorphic locus with the only form being homozygous for the only allele present on this locus.

#### Locus MDH-2-

The gorilla species had three alleles present on this locus. They were expressed with the following allele frequencies, 1- 0.4167, 2- 0.3333, 0.2500. The heterozygote frequency was, allele 1- 0.5000, allele 2- 0.3333, allele 3- 0.1667. This is a polymorphic locus.

#### Locus LAP-

Gorillas have an equal expression of the two alleles on this locus, with a heterozygosity value of 0.5000. This is a polymorphic locus.

#### Locus SKDH-

Alleles 1 and 2 for this locus show an equal expression with an allele frequency of 0.4167, allele 3 has an allele frequency of 0.1667. Allele 1 and 2 also have equal heterozygote frequencies, allele 3 has a heterozygote frequency of 0.0000. This is a polymorphic locus.

#### Locus PGI-

Gorillas only have 2 alleles on this locus, they are alleles 3 and 4. Allele 3 has an allele frequency double that of allele 4. The heterozygote frequencies however are equal. This is a polymorphic locus.

#### Locus EST-1-

Only 1 allele is present on this locus resulting in an allele frequency of 1.000 and a heterozygosity value of 0.0000. This is a monomorphic locus.

#### Locus EST-2-

Gorillas have 2 alleles on this locus, the allele frequency of allele 2 is double that of allele 1. The heterozygote frequencies however are equal. This is a polymorphic locus.

#### Locus IDH-

Gorillas only have 1 allele on this locus, allele 1. This is a monomorphic locus.

#### Descriptive statistics for the yeti species.-

##### Locus PGM-

Yetis have 3 alleles on this locus, alleles 2 and 3 have an equal allele frequency of 0.2857, allele 1 has a frequency of 0.4286. The heterozygote frequency is 0.2857 for all three alleles. This is a polymorphic locus.

##### Locus MDH-1-

Only 1 allele is present on this locus resulting in an allele frequency of 1.000 and a heterozygosity value of 0.0000. This is a monomorphic locus.

##### Locus MDH-2-

Yetis have 3 alleles on this locus, allele 2 has an allele frequency twice that of allele 3 and allele 1 has an allele frequency twice that of allele 2. The heterozygote frequency is 0.2857 for all 3 alleles. This is a polymorphic locus.

#### Locus LAP-

Contains 2 alleles, allele 1 has an allele frequency of 0.2857, allele 2 has an allele frequency of 0.7143. The heterozygote frequency is 0.2857 for both alleles. This is a polymorphic locus.

#### Locus SKDH-

Yetis express three alleles for this locus, with frequencies of, allele 1- 0.2143, allele 2- 0.2857 and allele 3- 0.5000. Allele 1 expressed 1 heterozygote with a heterozygote frequency of 0.1429, allele 2 expressed 2 heterozygotes with a heterozygotic frequency of 0.2857, allele 3 expressed 3 heterozygotes with an allele frequency of 0.4286. The overall heterozygosity value was 0.6224. This is a polymorphic locus.

#### Locus PGI-

Only alleles 5 and 6 are expressed in yetis for this locus. The expression of these alleles is equal and the heterozygosity value for this allele is 0.5000. This is a polymorphic locus.

#### Locus EST-1-

Only 1 allele is present on this locus resulting in an allele frequency of 1.000 and a heterozygosity value of 0.0000. This is a monomorphic locus.

#### Locus EST-2-

Only 1 allele is present on this locus resulting in an allele frequency of 1.000 and a heterozygosity value of 0.0000. This is a monomorphic locus.

#### Locus IDH-

Two alleles were expressed on this locus, allele 1 had an allele frequency of 0.9286 and allele 2 had a frequency of 0.0714. The frequency of heterozygotes for each allele was 0.1429. This is a polymorphic locus.

#### Descriptive statistics for the entire data set-

#### Locus PGM-

3 alleles are shown over the entire data set, with allele frequencies of 0.4474, 0.3947 and 0.1579. The heterozygote frequencies for these alleles are- 0.1579, 0.1579 and 0.2105.\

#### Locus MDH-1-

Only 1 allele was expressed by this locus with all individuals of each species homozygous for this allele.

#### Locus MDH-2-

This locus expressed 3 alleles over the 3 different species. Allele 1 had an allele frequency of 0.5000, allele 2 had a frequency of 0.3684 and allele 3 had a frequency of 0.1316. The heterozygote frequency for these alleles was 0.3684 for allele 1, 0.3158 for allele 2 and 0.1579 for allele 3.

#### Locus Lap-

Two alleles were expressed for this locus over the three different species, with allele frequencies of 0.4211 and 0.5789. The heterozygote frequency for both of these alleles was 0.3158.

#### Locus SKDH-

Three alleles were expressed at this locus for the three different species. Allele 1 had an allele frequency of 0.3158 and alleles 2 and 3 had a frequency of 0.3421. The heterozygote frequency was 0.1053 for allele 1 and 0.1579 for alleles 2 and 3.

#### Locus PGI-

This locus showed the most variation between the species as it expressed 6 different alleles, each species only expressing two of these.

#### Locus EST-1-

This locus showed the least variation with the same, single allele expressed in all three species.

#### EST-2-

This locus showed little variation between the species as only 2 alleles were expressed with allele frequencies of 0.4211 and 0.5789. These alleles displayed the same heterozygote frequency of 0.1053.

#### Locus IDH-

This locus showed no variation between humans and gorillas with only 1 allele being expressed in each. Over the entire data set this locus had allele frequencies of 0.9737 and 0.0263. Both of these alleles had heterozygote frequencies of 0.0526.

The data was then analyzed by a chi-squared test to determine which loci from each population were in Hardy-Weinberg equilibrium. The results from this test and whether the locus is in Hardy-Weinberg equilibrium is presented below.

#### Tests for Hardy-Weinberg equilibrium-

##### Humans-

Locus	DF	Chi-square	P	In HW Equilibrium	Heterozygotes
PGM	1	6.0000	0.0143	No	Deficient
MDH-1	-	-	-	-	-
MDH-2	1	0.6667	0.4142	Yes	-
LAP	1	0.6667	0.4142	Yes	-
SKDH	3	12.000	0.0074	No	Deficient

PGI	1	0.0049	0.9442	Yes	-
EST-1	-	-	-	-	-
EST-2	-	-	-	-	-
IDH	-	-	-	-	-

Gorilla-

Locus	DF	Chi- square	P	In HW Equilibrium	Heterozygotes
PGM	3	3.9320	0.2689	Yes	-
MDH-1	-	-	-	-	-
MDH-2	3	2.3267	0.5074	Yes	-
LAP	1	0.6667	0.4142	Yes	-
SKDH	3	8.1600	0.0428	No	Deficient
PGI	1	0.3750	0.5403	Yes	-
EST-1	-	-	-	-	-
EST-2	1	0.3750	0.5403	Yes	-
IDH	-	-	-	-	-

Yeti-

Locus	DF	Chi- square	P	In HW Equilibrium	Heterozygotes
PGM	3	1.6528	0.6475	Yes	-
MDH-1	-	-	-	-	-
MDH-2	3	1.7500	0.6259	Yes	-
LAP	1	0.6300	0.4274	Yes	-
SKDH	3	2.8135	0.4213	Yes	-
PGI	1	0.1429	0.7055	Yes	-
EST-1	-	-	-	-	-
EST-2	-	-	-	-	-
IDH	1	0.0414	0.8387	Yes	-

This test showed that all of the Yeti's loci are in Hardy Weinberg equilibrium. This suggests that the population of Yetis sampled for this analysis is static and that the allele and genotypic frequencies will remain constant from generation to generation. This means that the population is not evolving. This could be due to the fact that the yeti has existed for so long in isolation with no human contact whatsoever. Without human contact and living within an environment which has also remained unchanged for millions of years the Yeti has become genetically very stable. However this means that the yeti population is very fragile to change as it has not experienced any for so long. Any changes in the yetis environment could have drastic effects on the Yeti population. The SKDH locus in both humans and gorillas showed deviations from the Hardy- Weinberg equilibrium, both expressing deficient heterozygotes for this locus. The only other deviation from the Hardy- Weinberg equilibrium was on the PGM loci in humans, this locus also expressed deficient heterozygotes. These deviations from the Hardy- Weinberg

equilibrium could be due to, - Non- Random mating, mutation, or due to the small sample size taken.

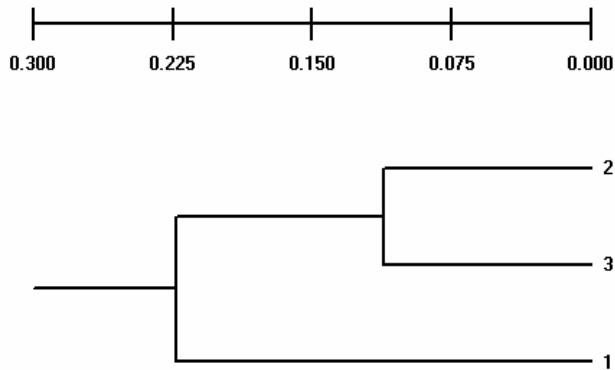
The isozyme data was also analyzed for genetic distance, giving the following results.-

	Genetic Distance	Identity
Human's vs Gorilla	0.1694	0.8442
Human's vs Yeti	0.2764	0.7585
Gorilla vs Yeti	0.1115	0.8945

The values used in this table are the unbiased values.  
UPGMA Cluster using Nei's (1978) unbiased distance

Node Distance Includes Populations

- 1 0.1115 2 3
- 2 0.2229 1 2 3



From this dendrogram and the genetic distance values it can be seen that humans are more genetically distinct from gorillas and yetis. Yetis and gorillas diverged from a common primate ancestor which had diverged from the human lineage at a node distance of 0.2229. Yetis and gorillas are the most genetically similar species.

From the analysis of the isozyme data over the nine loci it can be concluded that *homo yetis* or the Yeti is more closely related to Gorillas than humans. The descriptive statistics showed that Yetis had a unique allele on locus IDH and variations in allele frequencies for the two alleles on locus LAP. Humans, gorillas and Yeti shared 3 monomorphic loci. The Hardy-Weinberg analysis showed the yeti species to be the most genetically stable out of the three species with no loci deviating from the Hardy-Weinberg equilibrium. The stability of the yeti's alleles is most likely due to the yeti's isolation for millions of years and the stability of the yeti's habitat. Humans showed two deviations from the Hardy-Weinberg equilibrium and Gorillas showed one. Each of these deviations resulted in a deficiency of heterozygotes. Analysis of genetic variability and the dendrogram showed that gorillas and yetis were more closely related than to humans, and that all three diverged from a common ancestor.

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