Subtyping *Cryptosporidium ubiquitum*, a Zoonotic Pathogen Emerging in Humans

Na Li, Lihua Xiao, Keri Alderisio, Kristin Elwin, Elizabeth Cebelinski, Rachel Chalmers, Monica Santin, Ronald Fayer, Martin Kvac, Una Ryan, Bohumil Sak, Michal Stanko, Yaqiong Guo, Lin Wang, Longxian Zhang, Jinzhong Cai, Dawn Roellig, and Yaoyu Feng

Cryptosporidium ubiquitum is an emerging zoonotic pathogen. In the past, it was not possible to identify an association between cases of human and animal infection. We conducted a genomic survey of the species, developed a subtyping tool targeting the 60-kDa glycoprotein (gp60) gene, and identified 6 subtype families (XIIa–XIIf) of *C. ubiquitum*. Host adaptation was apparent at the gp60 locus; subtype XIIa was found in ruminants worldwide, subtype families XIIb–XIId were found in rodents in the United States, and XIIe and XIIf were found in rodents in the Slovak Republic. Humans in the United States were infected with isolates of subtypes XIIb–XIId, whereas those in other areas were infected primarily with subtype XIIa isolates. In addition, subtype families XIIb and XIId were detected in drinking source water in the United States. Contact with *C. ubiquitum*–infected sheep and drinking water contaminated by infected wildlife could be sources of human infections.

Cryptosporidium infection is a leading cause of diarrhea in humans (*1*). Five *Cryptosporidium* species—*C. hominis*, *C. parvum*, *C. meleagridis*, *C. felis*, and *C. canis*—are responsible for most cases of cryptosporidiosis in humans. Among them, *C. hominis* and *C. parvum* are the most common etiologic agents, and the latter is responsible for most zoonotic infections (*2*). In recent years, *C. ubiquitum,* previously known as the cervine genotype, has been emerging as another major zoonotic species that infects persons. It has been found in humans worldwide, primarily in industrialized nations (*3–11*). In the United Kingdom, more human cases of cryptosporidiosis have been attributed to *C. ubiquitum* than to *C. canis* (*9*).

C. ubiquitum is of public health concern because of its wide geographic distribution and broad host range. Of all *Cryptosporidium* spp. identified by molecular diagnostic tools, it infects the greatest variety of host species (*12*). *C. ubiquitum* has been commonly detected in domestic and wild ruminants (sheep, goats, mouflon sheep, blesboks, nyalas, white-tailed deer, Père David's deer, sika deer, ibexes, buffalos, and yaks), rodents (squirrels, chipmunks, woodchucks, beavers, porcupines, deer mice, house mice, and gerbils), carnivores (raccoons), and primates (lemurs and humans) (*12–16*). It has also been found in drinking source water, storm water runoff, stream sediment, and wastewater in various geographic locations (*17–22*).

Thus far, showing an association between human and animal cases of *C. ubiquitum* infection has not been possible because of the lack of suitable genetic markers for subtyping. For *C. parvum*, *C. hominis*, and some genetically related species, the most commonly used marker for subtyping is the 60-kDa glycoprotein gene (gp60, also called gp40/15). Sequence analysis of the gp60 gene has been used in studies of the genetic diversity, host adaptation, infection sources, and transmission dynamics of these *Cryptosporidium* spp. (*2*). However, it has been suggested that a single locus, such as gp60, is not a reliable marker of *C. parvum* and *C. hominis* population structure because genetic recombination may occur (*23*).

Author affiliations: East China University of Science and Technology, Shanghai, China (N. Li, Y. Guo, L. Wang, Y. Feng); Centers for Disease Control and Prevention, Atlanta, Georgia, USA (N. Li, L. Xiao, Y. Guo, D. Roellig); New York City Department of Environmental Protection, Flushing, New York, USA (K. Alderisio); UK *Cryptosporidium* Reference Unit, Swansea, UK (K. Elwin, R. Chalmers); Minnesota Department of Health, St. Paul, Minnesota, USA (E. Cebelinski); US Department of Agriculture, Beltsville, Maryland, USA (M. Santin, R. Fayer); Academy of Science of Czech Republic, České Budějovice, Czech Republic (M. Kvac, B. Sak); Murdoch University, Perth, Australia (U. Ryan); Slovak Academy of Sciences, Košice, Slovakia (M. Stanko); Henan Agricultural University, Zhengzhou, China (L. Zhang); and Qinghai Academy of Veterinary Medicine and Animal Science, Xining, China (J. Cai)

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Because *C. ubiquitum* is genetically distant from *C. hominis* and *C. parvum*, its homologue of the gp60 gene has thus far not been identified (*24*). In this study, we identified the gp60 gene of *C. ubiquitum* by whole-genome sequencing and used it to develop a subtyping technique to characterize specimens from humans, various animals, and drinking source water.

Materials and Methods

Specimens

DNA extracts from 188 *C. ubiquitum*–positive specimens (collected during 2002–2012) were used, including those from animals, humans, and drinking source water. Animal specimens were obtained from various species of ruminants and rodents, a horse, a raccoon, and a primate, Verreaux's sifaka (*Propithecus verreauxicoquereli*). Animal specimens were collected in the United States, Peru, Brazil, the United Kingdom, Spain, the Czech Republic, the Slovak Republic, Turkey, Algeria, South Africa, China, Nepal, and Australia (Table 1). Human specimens were obtained from the United States, Canada, Peru, the United Kingdom, and Turkey (Table 1). Water samples were collected from storm water and river water in the United States. The storm water samples were collected from a drinking-source watershed in New York where most of the rodent specimens were also collected (*13*,*17*). These specimens were initially found to be positive for *C. ubiquitum* by DNA sequence analysis of an ≈830-bp fragment of the small-subunit rRNA gene (*25*).

Subtyping Marker

To identify a subtyping marker for *C. ubiquitum*, we sequenced the genome of an isolate from a specimen (33496) from a Verreaux's sifaka by 454 technology using a GS FLX+ System (454 Life Sciences, Branford, CT, USA). This specimen was selected for whole-genome sequencing because of the high number of oocysts present, the availability of ample fecal materials for isolation of oocysts by sucrose and cesium chloride gradient flotation

Table 1. Origin and gp60 subtype identity of *Cryptosporidium ubiquitum* specimens from human, animals, and water, 2002–2012

Host group/species	Total no. samples	Source location (no. samples)	Subtype family (no. samples)
Rodent			
Eastern chipmunk	2	USA (2)	XIIb (1), XIId (1)
Eastern gray squirrel	2	USA (2)	XIId (2)
Red squirrel	1	USA (1)	XIId (1)
Woodchuck	1	USA (1)	XIId (1)
Beaver	1	USA (1)	XIId (1)
Ring-tailed porcupine	2	USA (2)	XIIc (2)
Goat through porcupine*	3	USA (3)	XIIc (3)
Yellow-necked field mouse	2	Slovak Republic (2)	XIIe (1), XIIf (1)
Striped field mouse		Slovak Republic (2)	XIIe (2)
Carnivore			
Raccoon	1	USA (1)	XIId (1)
Parissodactyla			
Horse	1	UK (1)	XIIa (1)
Ruminant			
Sheep	56	USA (14), Peru (1), Brazil (3), Spain (9), UK (4), Turkey (1), China (18), Australia (6)	XIIa (56)
Goat	1	Algeria (1)	XIIa (1)
Yak	3	China (3)	XIIa (3)
Buffalo	1	South Africa (1)	XIIa (1)
Alpaca	1	Peru (1)	XIIa (1)
Swamp deer	3	Nepal (3)	XIIa (3)
Impala	1	South. Africa (1)	XIIa (1)
Blesbok	1	Czech Republic (1)	XIIa (1)
Nyala	1	Czech Republic (1)	XIIa (1)
Nonhuman primate			
Verreaux's sifaka	1	USA (1)	XIIb (1)
Human	41	USA (25)	XIIb (9), XIIc (4), XIId (12)
		UK (13)	XIIa (8), XIIb (3), XIId (2)
		Turkey (1)	XIIa (1)
		Peru (1)	XIIa (1)
		Canada (1)	XIIa (1)
Water			
Storm water	15	USA (15)	XIIb (15)
Source water	3	USA (3)	XIIb (2), XIId (1)

*Experimentally infected with specimen from a porcupine.

and immunomagnetic separation, and minor contamination from nontarget organisms in extracted DNA. Of the 3,030 assembled contigs of 11.4 MB nucleotides generated from 1,069,468 sequence reads, 1contig (no. 0067), consisting of 45,014 bp, had a high sequence similarity to the 5′ and 3′ ends of the gp60 gene and the flanking intergenic regions. Alignment of the contig 0067 sequence with the nucleotide sequences of the *C. parvum* gp60 gene (AF203016 and AY048665) led to the identification of sequences conserved between *C. ubiquitum* and *C. parvum*, which were used to design a nested PCR that amplified the entire coding region of the gp60 gene, except for the 54 nt at the 3′ end. The sequences of primers used in primary and secondary PCR were 5′-TTTACCCACACATCTG-TAGCGTCG-3′ (Ubi-18S-F1) and 5′-ACGGACGGAAT-GATGTATCTGA-3′ (Ubi-18S-R1), and 5′-ATAGGT-GATAATTAGTCAGTCTTTAAT-3′ (Ubi-18S-F2) and 5′-TCCAAAAGCGGCTGAGTCAGCATC-3′ (Ubi-18S-R2), which amplified an expected PCR product of 1,044 and 948 bp, respectively.

PCR

The partial *C. ubiquitum* gp60 gene was amplified by nested PCR in a total volume of 50 mL, containing 1 mL of DNA (primary PCR) or 2 mL of the primary PCR product (secondary PCR), primers at a concentration of 0.25 µM (Ubi-18S-F1 and Ubi-18S-R1) or 0.5 µM (Ubi-18S-F2 and Ubi-18S-R2), 0.2 µM deoxyribonucleotide triphosphate mix (Promega, Madison, WI, USA), 3 µM $MgCl_2$ (Promega), 1 × GeneAmp PCR buffer (Applied Biosystems, Foster City, CA, USA), and 1.25 U of Taq DNA polymerase (Promega). The primary PCR reactions also contained 400 ng/mL nonacetylated bovine serum albumin (Sigma, St. Louis, MO, USA) to reduce PCR inhibition. PCR amplification consisted of an initial denaturation at 94°C for 5 min; 35 cycles at 94°C for 45 s, 45 s at 58°C (primary PCR) or at 55°C (secondary PCR), 1 min at 72°C; and a final extension for 7 min at 72°C. Both positive (DNA from the sifaka specimen) and negative (reagent-grade water) controls were used in each PCR run.

DNA Sequence Analysis

Products of the secondary gp60 PCR were sequenced in both directions on an ABI 3130 Genetic Analyzer (Applied Biosystems). The sequences were assembled by using ChromasPro 1.32 (www.technelysium.com.au/ChromasPro.html), edited by using BioEdit 7.04 (www.mbio.ncsu.edu/BioEdit/bioedit.html), and aligned by using ClustalX 2.1 (www.clustal.org/). To assess the genetic relatedness of various subtype families of *C. ubiquitum*, we constructed a neighbor-joining tree by using MEGA 5.05 (www.megasoftware.net/). The reliability of cluster formation was evaluated by the bootstrap method with 1,000 replicates. To assess potential recombination among various subtype families, we used DnaSP 5.10 (www.ub.es/dnasp/) to calculate recombination rates on the basis of segregating sites (excluding insertions and deletions). Unique nucleotide sequences derived from this work were deposited in GenBank under accession nos. JX412915–JX412926 and KC204979–KC204985.

Statistical Analysis

We compared the difference in the distribution of *C. ubiquitum* XIIa and non-XIIa subtype families between rodents and ruminants and between humans in the United States and the United Kingdom by using a χ^2 test implemented in SPSS 20.0 for Windows software (IBM Corp., Armonk, NY, USA). The difference was considered significant when the p value obtained was <0.05.

Results

Features of the gp60 Gene of *C. ubiquitum*

The gp60 gene in contig 0067 in the whole-genome sequencing of specimen 33496 was 945 bp in length, coding for a peptide that consisted of 315 aa. Except for the 5′ and 3′ regions, the gp60 gene of *C. ubiquitum* had no obvious similarity to the gp60 genes of *C. parvum* and *C. hominis* at the nucleotide level. At the amino acid level, the sequences shared 43%–48% sequence identity with those of *C. parvum* and *C. hominis* (Figure 1). The gene has the same structure of gp60 in *C. parvum* and *C. hominis*, with the first 19 aa coding for a signal peptide and the last 20 aa for a transmembrane domain. As in *C. parvum* and *C. hominis*, upstream of the transmembrane domain, the *C. ubiquitum* gp60 gene sequence had a C-terminus hydrophobic region that is likely linked to a glycosylphosphatidylinositol anchor, 2 potential N-linked glycosylation sites, and numerous O-linked glycosylation sites (*26*,*27*). However, no TCA/TCG/TCT trinucleotide repeats were seen in the 5′ region of the gp60 gene of *C. parvum*, *C. hominis,* and related species (*28*), and no N-terminal amino acids, DVSVE, were found between the putative cleavage site of the signal peptide and trinucleotide repeats (*27*). The putative furin cleavage site RSRR or KSISKR between gp40 and gp15 of *C. parvum* and *C. hominis* (*29*) was not found in *C. ubiquitum* (Figure 1).

Amplification of gp60 gene of *C. ubiquitum*

Of the 188 DNA preparations of *C. ubiquitum*, 149 yielded PCR products of the expected size, and 145 were successfully sequenced, including 86 from animals, 41 from humans, and 18 from water (Table 1). Nucleotide sequences of isolates from 31 specimens were identical to those of the *C. ubiquitum* reference sequence (contig 0067 from specimen 33496). The remaining sequences had nucleotide

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                    10         20         30         40         50         60         70
C. parvum   MRLSLIIVLL SVIVSAVFSA PAVPLRGTLK DVPVEGSSSS SSSSSSSSSS SSSSSSSSST S--TVAPANK
C. hominis  MRLSLIIVLL SVIVSAVFSA PAVPLRGTLK DVSVEGSSSS SSSSSSSSTV APAPKKERTV EGGTEGKNGE
C. ubiquitum MRFLLAIVSL SVFISVVFSA PGVPLRGTLK E---DDSTNV STTTAAPKKI IVRSTEEGTT P--TAPTTTP

                    80         90        100        110        120        130        140
C. parvum   ARTG-EDAEG SQDSSGTEAS GSQ-GSEEEG SEDDG----- ---QTSAASQ PTTPAQSEG- ATTETIEATP
C. hominis  SSPGSEEQDG GKEDGGKEDG GKEDGGKEDG GKENGEGDTV DGVQTGSGSQ -VTPSESAGT ATESTATTTP
C. ubiquitum STTAPTAAPT TVSTTAPSGS GVDPTSTDGD EKTDT----- ---DTGSGTT ---------- DETVTTTPDP

                   150        160        170        180        190        200        210
C. parvum   KEECGTSFVM WFGEGTPAAT LKCGAYTIVY APIKDQTDPA PRYISGEVTS VTFEKSDNTV KIKVNGQDFS
C. hominis  KEECGTSFVM WFEKGTPVAT LKCGDYTIVY APIKDQTDPA PRYISGEVTS VSFEKSESTV TIKVNGKEFS
C. ubiquitum MEKCGTSFVM WFVSGVPVTT LECGSYTMVY GPVENETNPA ARYVSGTVTT VTYDASNK-- KLMVNNQEFA

                   220        230        240        250        260        270        280
C. parvum   TLSANSSSPT ENGG--SAGQ ASSRSRRSLS EETS-EAAAT VDLFAFTLDG GKRIEVAVPN VEDASKRDKY
C. hominis  TLSANSSSPT KDNGESSDSH VQSRSRRSLA EENG-ETVAT VDLFAFTLDG GRRIEVAVPK DENADKRSEY
C. ubiquitum TLSTDSSQPT --------TA TTAPAARLLA EDTVTEAVTM TDLYTFTLKG GKAISVGVPA NQDESKRDKY

                   290        300        310        320        330        340
C. parvum   SLVADDKPFY TG--ANSGTT NGVYRLNENG DLVDKDNTVL LKDAGSSAFG LRYIVPSVFA IFAALFVL
C. hominis  SLVADDKPFY TG--ANSGIT NGVYKLDENG NLVDKDNEVL LKDAGSSAFG FKYIVPSVFA IFAALFVL
C. ubiquitum SLSADNQVFY TGTASNSGVT SGIFKLNENG DLVDPSNTVV LKDADSAAFG FRYIIPSVFA IFAAFFMF
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Figure 1. Deduced amino acid sequence of the gp60 gene of *Cryptosporidium ubiquitum* compared with sequences of *C. parvum* and *C. hominis*. gp60 sequences from *C. ubiquitum*, *C. parvum* (GenBank accession no. AF022929), and *C. hominis* (GenBank accession no. ACQ82748) were aligned by using ClustalX (www.clustal.org/). Potential N-linked glycosylation sites are indicated in boldface and italic type, and predicted O-linked glycosylation sites are indicated in boldface and underlined type. The first 19 aa coding for a signal peptide are highlighted in green, and the last 20 aa for a transmembrane domain are highlighted in blue. The signal peptide cleavage site in the N terminal and furin proteolytic cleavage site between gp40 and gp15 of *C. parvum* and *C. hominis* are highlighted in yellow and red, respectively. The furin cleavage site is not present in *C. ubiquitum*. Dashes denote nucleotide deletions.

differences of 8.2%–38.2% from the reference (Table 2). The gp60 nt sequences of *C. ubiquitum* differed from each other in length at most by 171 bp, with all insertions/deletions in trinucleotide, thus maintaining the reading frame (online Technical Appendix Figure; wwwnc.cdc.gov/EID/article/20/2/12-1797-Techapp1.pdf). Most of the length differences were due to 4 sequences generated from rodents in the Slovak Republic. The remaining sequences differed from each other in length by at most 12 bp. Most nucleotide sequence polymorphism occurred in the 3′ half of the gene (online Technical Appendix).

Nomenclature of *C. ubiquitum* Subtype Families

The nucleotide sequences of the gp60 gene of *C. ubiquitum* formed 6 subtype families in a neighbor-joining analysis (Figure 2). They were named XIIa, XIIb, XIIc, XIId, XIIe, and XIIf, in concordance with the established nomenclature of gp60 subtype families (*24*). Subtype families XIIe and XIIf formed a cluster highly divergent from the dominant cluster of the 4 subtype families of XIIa, XIIb, XIIc, and XIId (Figure 2). In the dominant cluster, XIIc and XIId diverged at the 3′ end, and the 3′ end of the gene of XIIc had a high identity to XIIa, an indication of possible genetic recombination at the gp60 locus (online Technical Appendix). Indeed, DnaSP analysis (www.ub.edu/dnasp/) revealed a minimum of 23 potential recombination events among the 6 subtype families (XIIa–XIIf), and 7 recombination events among the 4 subtype families (XIIa–XIId) in the dominant *C. ubiquitum* cluster. Pairwise recombination event comparisons revealed that the genetic recombination was mostly between XIIa and other subtype families (Table 2).

Within the XIIa subtype, minor sequence differences were found among specimens, leading to the formation of 3

Table 2. Nucleotide sequence similarity (lower triangular matrix) and potential genetic recombination events (upper triangular matrix) among *Cryptosporidium ubiquitum* subtype families at the gp60 locus*

	XIIa	XIIb	XIIc	XIId	XIIe	XIIf
XIIa		1	1	1	1	1
XIIb	87.2		0	0	0	0
XIIc	89.5	91.8		0	0	0
XIId	87.2	90.0	94.5		0	0
XIIe	63.1	69.6	62.2	60.6		0
XIIf	71.5	61.8	70.7	69.5	70.9	

*Nucleotide sequence similarity is indicated by the percentage identity between each pair of sequences compared.

Figure 2. Genetic relationship among 6 *Cryptosporidium ubiquitum* subtype families (XIIa–XIIf) in animals as indicated by a neighbor-joining analysis of the partial gp60 gene. The XIIa subtype family contains all specimens from domestic and wild ruminants, whereas the remaining subtype families contain all specimens from rodents and other wildlife. Within the XIIa subtype family, 1, 2, and 3 denote subtypes 1, 2, and 3, which differ from each other by a few nucleotides. Bootstrap values are indicated along branches. Scale bar indicates 0.02 nucleotide substitutions per site.

common subtypes (subtypes 1–3) and several rare subtypes with a single nucleotide substitution each (for example, 19716, 35147, 37827, 37828, and 37830). A few nucleotide substitutions were also seen in the subtype family XIId (online Technical Appendix). These subtypes within subtype families XIIa and XIId could not be named using the subtype nomenclature based on the number of trinucleotide repeats TCA, TCG, and TGT (*24*) because of the lack of such repeats in the gp60 gene of *C. ubiquitum* (online Technical Appendix).

Subtype Families in Animals

Among 86 isolates from animal specimens characterized, all 68 isolates from Old and New World ruminants belonged to the XIIa subtype family, including 56 from ovine specimens from the United States, Peru,

Brazil, Spain, the United Kingdom, Turkey, China, and Australia; 1 from a goat specimen from Algeria; 3 from yak specimens from China; 1 from an alpaca specimen from Peru; and 7 from 5 species of wild ruminants from Nepal, the Czech Republic, and South Africa. One isolate from an equine specimen from the United Kingdom also belonged to the XIIa subtype family. In contrast, XIIb, XIIc, and XIId subtypes were all seen in specimens from several species of rodents and a few other wildlife species (1 raccoon and 1 Verreaux's sifaka) in the United States, and XIIe and XIIf were seen in specimens from field mice in the Slovak Republic (Table 1, Figure 2). The difference in the distribution of XIIa and non-XIIa subtype families between ruminants and rodents was significant ($\chi^2 = \infty$; $p < 0.001$). This was also the case when the comparison was made with only specimens from the United States ($\chi^2 = 26.00$; $p<0.001$).

Subtype Families in Humans

Among 41 isolates from human specimens successfully subtyped, 25 from the United States belonged to the subtype families of XIIb (*9*), XIIc (*4*), and XIId (*12*); 13 isolates from the United Kingdom belonged to the subtype families of XIIa (*8*), XIIb (*3*), and XIId (*2*); and 3 isolates from Turkey, Peru, and Canada belonged to the XIIa subtype family (Table 1; Figure 3). The difference between the distribution of XIIa and non-XIIa subtype families in humans the United States and United Kingdom was significant ($\chi^2 = 19.49$; $p<0.001$).

Subtype Families in Water

Among 18 water samples from the United States, all 15 storm water samples were collected from a drinking source watershed, and 2 river water samples had the XIIb subtype family. Another river water sample revealed organisms from the XIId subtype family (Table 1).

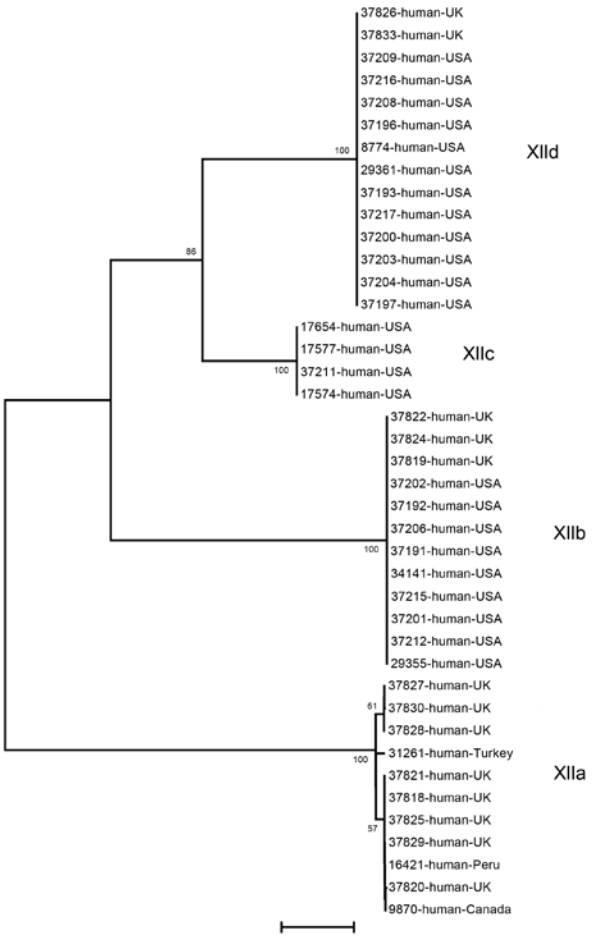

Figure 3.Genetic relationship among 4 *Cryptosporidium ubiquitum* subtype families (XIIa–XIId) in humans as indicated by a neighbor-joining analysis of the partial gp60 gene. The XIIa subtype family is seen in humans in most locations except the United States, where humans are infected with subtype families XIIb, XIIc, and XIId. Bootstrap values are indicated along branches. Scale bar indicates 0.01 nucleotide substitutions per site.

Discussion

The gp60 gene currently is the most commonly used genetic marker for subtyping *Cryptosporidium* spp., including several notable species that are pathogenic to humans and a few pathogenic species/genotypes that are not found in humans. These gp60-based tools have been used effectively in epidemiologic studies of cryptosporidiosis transmission in humans and farm animals (*2*). However, identifying the gp60 gene of the major emerging human-pathogenic species, *C. ubiquitum*, has been challenging (*24*). In this study, we utilized recent developments in next-generation sequencing technology and conducted a genomic survey of 1 *C. ubiquitum* specimen to identify its gp60 gene. On the basis of results from this sequence survey, we developed a gp60-based *C. ubiquitum* subtyping tool. The application of this new tool in the analysis of specimens from humans, animals, and water has shown the existence of host adaptation in *C. ubiquitum* infections, and the findings suggest that sheep and rodents are a key source of *C. ubiquitum* transmission to humans, possibly through direct human contact with infected animals or by contamination of drinking source water.

The gp60 gene of *C. ubiquitum* has extensive sequence differences from the gp60 gene of other *Cryptosporidium* spp. Nucleotide sequences of the near complete gp60 gene obtained from the 6 *C. ubiquitum* subtype families all showed extremely low identity with those of *C. parvum*, *C. hominis*, and related species. Even in the primer regions, substantial nucleotide differences occurred between *C. ubiquitum* and other species/genotypes. These nucleotide

sequence differences could be responsible for the inability of commonly used gp60 primers that were designed on the basis of *C. parvum* and *C. hominis* sequences, to amplify the *C. ubiquitum* gp60 gene (*24*).

The sequence differences between the gp60 gene in *C. ubiquitum* and the gp60 gene in other *Cryptosporidium* spp. may affect its functions. Unlike the gp60 gene of all 11 previously characterized *Cryptosporidium* spp. and genotypes (*24*), the trinucleotide repeats of TCA/TCG/TCT, which code for the polyserine tract at the 5′ end of the gene, commonly used to differentiate subtypes within each subtype family, were not observed in the gp60 gene sequence of *C. ubiquitum*. Previous research suggested that subtypes with short serine repeats may be selectively favored in humans over long repeats (*23*). Other unique features of the gp60 gene in *C. ubiquitum* include the absence of the signal peptide cleavage site in the N terminal and furin proteolytic cleavage site between gp40 and gp15. These differences could affect the processing and transport of the gp60 protein.

Although *C. ubiquitum* has the most broad host range among *Cryptosporidium* spp., the subtype data generated provide evidence that infection with this species has led to host adaptation. All field specimens from domestic and wild ruminants in both the New and Old World belonged to the XIIa subtype family. Despite its common occurrence in both domestic and wild ruminants in many geographic areas, subtype family XIIa has not been found in rodents in the United States and the Slovak Republic. Nevertheless, this host adaptation is not strict host specificity; *C. ubiquitum* of the XIIc subtype family was experimentally transmitted from a ring-tailed porcupine to goats, and the XIIa subtype family was found in an isolate from 1 equine specimen from the United Kingdom (Table 1 and [*12*]).

In contrast to the US findings, subtype family XIIa appears to be more commonly seen in *C. ubiquitum* isolates that infect humans in other areas. Thus, 8 of 13 cases of human infection in the United Kingdom and all 3 cases in humans from 3 other countries were caused by isolates of the subtype family XIIa. The source of *C. ubiquitum* infections in humans is not entirely clear. Because of the common occurrence of the XIIa subtype family in sheep, contact with sheep could be a frequent source of human infection in the United Kingdom and other industrialized nations. Indeed, among the 8 persons infected with XIIa in the United Kingdom, 4 had contact with sheep, 2 with so-called farm animals, and 1 with dogs. The remaining 5 case-patients with infections caused by subtypes XIIb and XIId in the United Kingdom reported no contact with sheep, although 4 reported contact with pets (dogs, cats, or pet birds), which are not known hosts of *C. ubiquitum*. One case-patient who was infected with *C. ubiquitum* of the XIIb subtype reported swimming in pools and had sick family members, indicating potential acquisition of the infection through another transmission route.

Drinking untreated water contaminated by wildlife might be a potential source of *C. ubiquitum* infections in the United States. All US *C. ubiquitum* specimens from humans characterized in this study belonged to the same subtype families found in wild rodents in this country. Because persons in the United States usually have little direct contact with wild rodents, direct zoonotic transmission of *C. ubiquitum* infection is probably less important in this country. This is supported by the absence of the XIIa subtype family in infected humans in the United States. Although XIIa is clearly common in sheep in the United States, the density of sheep is lower than it is in the United Kingdom. *C. ubiquitum* is one of the most common *Cryptosporidium* spp. in drinking source water in the United States (*17–19*). In this study, XIIb and XIId were detected in drinking source water in the United States, and most water samples were collected from the same watershed where US rodent specimens had been collected.

In conclusion, data generated thus far have shown host adaptation in *C. ubiquitum* at the gp60 locus and some potential geographic differences in the epidemiology of *C. ubiquitum* infections in humans. These finding highlight the need for subtype analysis of unusual *Cryptosporidium* species to clarify the sources and transmission dynamics of zoonotic cryptosporidiosis in rural areas.

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Dr Li is a lecturer at East China University of Science and Technology. Her research interest focuses on the molecular epidemiology of zoonotic parasites.

References

1. Kotloff KL, Nataro JP, Blackwelder WC, Nasrin D, Farag TH, Panchalingam S, et al. Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): a prospective, case-control study. Lancet. 2013;382:209–22. http://dx.doi.org/10.1016/S0140-6736(13)60844-2
2. Xiao L. Molecular epidemiology of cryptosporidiosis: an update. Exp Parasitol. 2010;124:80–9. http://dx.doi.org/10.1016/j.exppara.2009.03.018

3. Ong CS, Eisler DL, Alikhani A, Fung VW, Tomblin J, Bowie WR, et al. Novel *Cryptosporidium* genotypes in sporadic cryptosporidiosis cases: first report of human infections with a cervine genotype. Emerg Infect Dis. 2002;8:263–8. http://dx.doi.org/10.3201/eid0803.010194
4. Feltus DC, Giddings CW, Schneck BL, Monson T, Warshauer D, McEvoy JM. Evidence supporting zoonotic transmission of *Cryptosporidium* in Wisconsin. J Clin Microbiol.2006;44:4303–8. http://dx.doi.org/10.1128/JCM.01067-06
5. Trotz-Williams LA, Martin DS, Gatei W, Cama V, Peregrine AS, Martin SW, et al. Genotype and subtype analyses of *Cryptosporidium* isolates from dairy calves and humans in Ontario. Parasitol Res. 2006;99:346–52. http://dx.doi.org/10.1007/s00436-006-0157-4
6. Blackburn BG, Mazurek JM, Hlavsa M, Park J, Tillapaw M, Parrish M, et al. Cryptosporidiosis associated with ozonated apple cider. Emerg Infect Dis. 2006;12:684–6. http://dx.doi.org/10.3201/eid1204.050796
7. Davies AP, Campbell B, Evans MR, Bone A, Roche A, Chalmers RM. Asymptomatic carriage of protozoan parasites in children in day care centers in the United Kingdom. Pediatr Infect Dis J. 2009;28:838–40. http://dx.doi.org/10.1097/INF.0b013e31819d646d
8. Chalmers RM, Elwin K, Thomas AL, Guy EC, Mason B. Long-term *Cryptosporidium* typing reveals the aetiology and species-specific epidemiology of human cryptosporidiosis in England and Wales, 2000 to 2003.Euro Surveill. 2009;14:pii=19086.
9. Elwin K, Hadfield SJ, Robinson G, Chalmers RM. The epidemiology of sporadic human infections with unusual cryptosporidia detected during routine typing in England and Wales, 2000–2008. Epidemiol Infect. 2012;140:673–83. http://dx.doi.org/10.1017/S0950268811000860
10. Molloy SF, Smith HV, Kirwan P, Nichols RA, Asaolu SO, Connelly L, et al. Identification of a high diversity of *Cryptosporidium* species genotypes and subtypes in a pediatric population in Nigeria. Am J Trop Med Hyg.2010;82:608–13. http://dx.doi.org/10.4269/ajtmh.2010.09-0624
11. Cieloszyk J, Goni P, Garcia A, Remacha MA, Sanchez E, Clavel A. Two cases of zoonotic cryptosporidiosis in Spain by the unusual species *Cryptosporidium ubiquitum* and *Cryptosporidium felis*. Enferm Infecc Microbiol Clin. 2012;30:549–51. http://dx.doi.org/10.1016/j.eimc.2012.04.011
12. Faye R, Santin M, Macarisin D. *Cryptosporidium ubiquitum* n. sp. in animals and humans. Vet Parasitol. 2010;172:23–32. http://dx.doi.org/10.1016/j.vetpar.2010.04.028
13. Feng Y, Alderisio KA, Yang W, Blancero LA, Kuhne WG, Nadareski CA, et al. *Cryptosporidium* genotypes in wildlife from a New York watershed. Appl Environ Microbiol. 2007;73:6475–83. http://dx.doi.org/10.1128/AEM.01034-07
14. Ziegler PE, Wade SE, Schaaf SL, Chang YF, Mohammed HO. *Cryptosporidium* spp. from small mammals in the New York City watershed. J Wildl Dis. 2007;43:586–96. http://dx.doi.org/10.7589/0090-3558-43.4.586
15. da Silva AJ, Caccio S, Williams C, WonK Y, Nace EK, Whittier C, et al. Molecular and morphologic characterization of a *Cryptosporidium* genotype identified in lemurs. Vet Parasitol. 2003;111:297–307. http://dx.doi.org/10.1016/S0304-4017(02)00384-9
16. Elwin K, Chalmers RM. Contemporary identification of previously reported novel *Cryptosporidium* isolates reveals *Cryptosporidium bovis* and the cervine genotype in sheep (*Ovis aries*). Parasitol Res. 2008;102:1103–5. http://dx.doi.org/10.1007/s00436-008-0935-2
17. Jiang J, Alderisio KA, Xiao L. Distribution of *Cryptosporidium* genotypes in storm event water samples from three watersheds in New York. Appl Environ Microbiol. 2005;71:4446–54. http://dx.doi.org/10.1128/AEM.71.8.4446-4454.2005
18. Yang W, Chen P, Villegas EN, Landy RB, Kanetsky C, Cama V, et al. *Cryptosporidium* source tracking in the Potomac River watershed. Appl Environ Microbiol. 2008;74:6495–504. http://dx.doi.org/10.1128/AEM.01345-08
19. Jellison KL, Lynch AE, Ziemann JM. Source tracking identifies deer and geese as vectors of human-infectious *Cryptosporidium* genotypes in an urban/suburban watershed. Environ Sci Technol. 2009;43:4267–72. http://dx.doi.org/10.1021/es900081m
20. Nichols RA, Connelly L, Sullivan CB, Smith HV. Identification of *Cryptosporidium* species and genotypes in Scottish raw and drinking waters during a one-year monitoring period. Appl Environ Microbiol. 2010;76:5977–86. http://dx.doi.org/10.1128/AEM.00915-10
21. Zhou L, Singh A, Jiang J, Xiao L. Molecular surveillance of *Cryptosporidium* spp. in raw wastewater in Milwaukee: implications for understanding outbreak occurrence and transmission dynamics. J Clin Microbiol.2003;41:5254–7. http://dx.doi.org/10.1128/JCM.41.11.5254-5257.2003
22. Van Dyke MI, Ong CS, Prystajecky NA, Isaac-Renton JL, Huck PM. Identifying host sources, human health risk and indicators of *Cryptosporidium* and *Giardia* in a Canadian watershed influenced by urban and rural activities. J Water Health. 2012;10:311–23. http://dx.doi.org/10.2166/wh.2012.131
23. Widmer G. Meta-analysis of a polymorphic surface glycoprotein of the parasitic protozoa *Cryptosporidium parvum* and *Cryptosporidium hominis*. Epidemiol Infect. 2009;137:1800–8. http://dx.doi.org/10.1017/S0950268809990215
24. Feng Y, Lal AA, Li N, Xiao L. Subtypes of *Cryptosporidium* spp. in mice and other small mammals. Exp Parasitol. 2011;127:238–42. http://dx.doi.org/10.1016/j.exppara.2010.08.002
25. Xiao L, Sulaiman IM, Ryan UM, Zhou L, Atwill ER, Tischler ML, et al. Host adaptation and host-parasite co-evolution in *Cryptosporidium*: implications for taxonomy and public health. Int J Parasitol. 2002;32:1773–85. http://dx.doi.org/10.1016/S0020-7519(02)00197-2
26. Cevallos AM, Zhang X, Waldor MK, Jaison S, Zhou X, Tzipori S, et al. Molecular cloning and expression of a gene encoding *Cryptosporidium parvum* glycoproteins gp40 and gp15.Infect Immun. 2000;68:4108–16. http://dx.doi.org/10.1128/IAI.68.7.4108-4116.2000
27. Leav BA, Mackay MR, Anyanwu A, O'Connor RM, Cevallos AM, Kindra G, et al. Analysis of sequence diversity at the highly polymorphic Cpgp40/15 locus among *Cryptosporidium* isolates from human immunodeficiency virus-infected children in South Africa. Infect Immun. 2002;70:3881–90. http://dx.doi.org/10.1128/IAI.70.7.3881-3890.2002
28. Strong WB, Gut J, Nelson RG. Cloning and sequence analysis of a highly polymorphic *Cryptosporidium parvum* gene encoding a 60-kilodalton glycoprotein and characterization of its 15- and 45-kilodalton zoite surface antigen products. Infect Immun. 2000;68:4117–34. http://dx.doi.org/10.1128/IAI.68.7.4117-4134.2000
29. Wanyiri JW, O'Connor R, Allison G, Kim K, Kane A, Qiu J, et al. Proteolytic processing of the *Cryptosporidium* glycoprotein gp40/15 by human furin and by a parasite-derived furin-like protease activity. Infect Immun. 2007;75:184–92. http://dx.doi.org/10.1128/IAI.00944-06

Address for correspondence: Yaoyu Feng, State Key Laboratory of Bioreactor Engineering, School of Resources and Environmental Engineering, East China University of Science and Technology, Shanghai 200237, People's Republic of China; email: yyfeng@ecust.edu.cn

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Subtyping *Cryptosporidium ubiquitum,* a Zoonotic Pathogen Emerging in Humans

Technical Appendix

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                                   10        20        30        40        50        60        70        80        90        100
                          ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil        TGAGATTTTTACTCGCTATCGTATCACTCTCCGTTTTCATCTCAGTTGTATTCTCAGCTCCAGGTGTTCCACTCAGAGGTACATTGAAAGAGGATGACAG
36624-sheep-Brazil        ....................................................................................................
36623-sheep-Brazil        ....................................................................................................
36630-sheep-Spain         ....................................................................................................
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36627-sheep-Spain         ....................................................................................................
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36626-sheep-Spain         ....................................................................................................
36634-sheep-USA           ....................................................................................................
36637-sheep-USA           ....................................................................................................
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37768-sheep-USA           ....................................................................................................
37774-sheep-USA           ....................................................................................................
37777-sheep-USA           ....................................................................................................
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37773-sheep-USA           ....................................................................................................
37771-sheep-USA           ....................................................................................................
6478-blesbok-Czech Republic ..................................................................................................
6482-nyala-Czech Republic ....................................................................................................
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36737-sheep-China         ....................................................................................................
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38152-sheep-Australia     ....................................................................................................
34049-sheep-China         ....................................................................................................
37635-sheep-Turkey        ....................................................................................................
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30238-swamp deer-Nepal    ....................................................................................................
30243-swamp deer-Nepal    ....................................................................................................
32563-impala-S.Africa     ....................................................................................................
32560-buffallo-S.Africa   ....................................................................................................
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37820-human-UK            ....................................................................................................
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37815-sheep-UK            ....................................................................................................
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6141-storm-water-USA      ....................................................................................................
8062-storm-water-USA      ....................................................................................................
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37826-human-UK                  .............A................T.......................................................
37833-human-UK                  .............A................T.......................................................
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36642-porcupine-USA             ....................................................................................
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36640-porcupine via goat-USA    ....................................................................................
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17577-human-USA                 ....................................................................................
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17574-human-USA                 ....................................................................................
37640-field mouse-Slovak Repub  ..........G....T................A..A.......................GA....A.............T..A..G.......TA.C
37642-field mouse-Slovak Repub  ..........G....T................A..A.......................GA....A.............T..A..G.......TA.C
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37646-field mouse-Slovak Repub  .............TTT.............................C............GA..................T.............T..C
AF114166-C. parvum-gp60 gene    .......G.CG...AT........T.........A.AG....C.C...........C....CC.............A..T..A..G..T.T.CCTGT
Clustal Consensus               ******* *  **   ******** ******  ** *  **** * ** ********* **    ** *********** ** ** ** ** * *
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17577-human-USA                 ..................................--------..............................-.......----------------
37211-human-USA                 ..................................--------..............................-.......----------------
17574-human-USA                 ..................................--------..............................-.......----------------
37640-field mouse-Slovak Repub  C.GCG.TAGCTCG.....C................--------................T..A.....T....G..GT.GCTGGTGCTACTCCAAC
37642-field mouse-Slovak Repub  C.GCG.TAGCTCG.....C................--------................T..A.....T....G..GT.GCTGGTGCTACTCC---
37644-field mouse-Slovak Repub  C.GCG.TAGCTCG.....C................--------................T..A.....T....G..GT.GCTGGTGCTACTCCAAC
37646-field mouse-Slovak Repub  .GG.G.TAGC.CG.....T................--------................A..A.....T....GTTGT.CCAGGTGCTGCT-----
AF114166-C. parvum-gp60 gene    .GAGGG..C.T..TCGTC.TC.TCATC-------------------..C...A...TCATC.T.ATCATCAT..T.....T.------------------
Clustal Consensus                         *     *  *                      ** *** ***     *           * **

                                         210       220       230       240       250       260       270       280       290       300
                                ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil              ------------------------------G---CTCCT------------ACTACTCCTAG-------------------TACTACT----------
36624-sheep-Brazil              ------------------------------.---.....------------..........-------------------.......----------
36623-sheep-Brazil              ------------------------------.---.....------------..........-------------------.......----------
36630-sheep-Spain               ------------------------------.---.....------------..........-------------------.......----------
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36627-sheep-Spain               ------------------------------.---.....------------..........-------------------.......----------
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36634-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
36637-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37766-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
36636-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37769-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37767-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37768-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37774-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37777-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37776-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37775-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37772-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37773-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
37771-sheep-USA                  ------------------------------.---.....----------.........----------------------.......----------
6478-blesbok-Czech Republic      ------------------------------.---.....----------.........----------------------.......----------
6482-nyala-Czech Republic        ------------------------------.---.....----------.........----------------------.......----------
34023-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
36737-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34022-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
38161-sheep-Australia            ------------------------------.---.....----------.........----------------------.......----------
38157-sheep-Australia            ------------------------------.---.....----------.........----------------------.......----------
38156-sheep-Australia            ------------------------------.---.....----------.........----------------------.......----------
38154-sheep-Australia            ------------------------------.---.....----------.........----------------------.......----------
38153-sheep-Australia            ------------------------------.---.....----------.........----------------------.......----------
38152-sheep-Australia            ------------------------------.---.....----------.........----------------------.......----------
34049-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
37635-sheep-Turkey               ------------------------------.---.....----------.........----------------------.......----------
34043-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34047-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34055-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34011-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34038-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34044-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34032-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34060-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34048-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
36745-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
36785-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34025-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
34034-sheep-China                ------------------------------.---.....----------.........----------------------.......----------
19141-yak-China                  ------------------------------.---.....----------.........----------------------.......----------
19142-yak-China                  ------------------------------.---.....----------.........----------------------.......----------
28682-yak-China                  ------------------------------.---.....----------.........----------------------.......----------
30241-swamp deer-Nepal           ------------------------------.---.....----------.........----------------------.......----------
30238-swamp deer-Nepal           ------------------------------.---.....----------.........----------------------.......----------
30243-swamp deer-Nepal           ------------------------------.---.....----------.........----------------------.......----------
32563-impala-S.Africa            ------------------------------.---.....----------.........----------------------.......----------
32560-buffallo-S.Africa          ------------------------------.---.....----------.........----------------------.......----------
31261-human-Turkey               ------------------------------.---.....----------.........----------------------.......----------
37828-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
37830-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
37827-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
31570-sheep-Spain                ------------------------------.---.....----------.........----------------------.......----------
37820-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
37811-sheep-UK                   ------------------------------.---.....----------.........----------------------.......----------
37809-sheep-UK                   ------------------------------.---.....----------.........----------------------.......----------
37813-sheep-UK                   ------------------------------.---.....----------.........----------------------.......----------
37815-sheep-UK                   ------------------------------.---.....----------.........----------------------.......----------
37808-equine-UK                  ------------------------------.---.....----------.........----------------------.......----------
36629-sheep-Spain                ------------------------------.---.....----------.........----------------------.......----------
36628-sheep-Spain                ------------------------------.---.....----------.........----------------------.......----------
18165-sheep-Peru                 ------------------------------.---.....----------.........----------------------.......----------
37821-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
37818-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
37825-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
37829-human-UK                   ------------------------------.---.....----------.........----------------------.......----------
16421-human-Peru                 ------------------------------.---.....----------.........----------------------.......----------
9870-human-Canada                ------------------------------.---.....----------.........----------------------.......----------
19716-alpaca-Peru                ------------------------------.---.....----------.........----------------------.......----------
35147-goat-Algeria               ------------------------------.---.....----------.........----------------------.......----------
18868-chipmunk-USA               ------------------------------A..G..CC-----TACT.........----------------------.......----------
33456-sifaka-USA                 ------------------------------A..G..CC-----TACT.........----------------------.......----------
37822-human-UK                   ------------------------------A..G..CC-----TACT.........----------------------.......----------
37824-human-UK                   ------------------------------A..G..CC-----TACT.........----------------------.......----------
37819-human-UK                   ------------------------------A..G..CC-----TACT.........----------------------.......----------
37202-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
37192-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
37206-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
37191-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
34141-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
37215-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
37201-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
37212-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
29355-human-USA                  ------------------------------A..G..CC-----TACT.........----------------------.......----------
8512-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
8513-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
5397-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
6140-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
8509-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
8469-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
6141-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
8062-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
6143-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
6144-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
8514-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
8510-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
6317-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
7370-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
7163-storm-water-USA             ------------------------------A..G..CC-----TACT.........----------------------.......----------
15529-river-water-USA            ------------------------------A..G..CC-----TACT.........----------------------.......----------
14874-river-water-USA            ------------------------------A..G..CC-----TACT.........----------------------.......----------
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18371-eastern gray squirrel-US   ------------------------------A..------------------.......----------------------.....----------
18370-eastern gray squirrel-US   ------------------------------A..------------------.......----------------------.....----------
14886-eastern gray squirrel-US   ------------------------------A..------------------.......----------------------.....----------
14223-beaver-USA                 ------------------------------A..------------------.......----------------------.....----------
13266-red squirrel-USA           ------------------------------A..------------------.......----------------------.....----------
37200-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37203-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37204-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37197-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37217-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37193-human-USA                  ------------------------------A..------------------.......----------------------.....----------
29361-human-USA                  ------------------------------A..------------------.......----------------------.....----------
8774-human-USA                   ------------------------------A..------------------.......----------------------.....----------
37196-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37208-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37216-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37209-human-USA                  ------------------------------A..------------------.......----------------------.....----------
37826-human-UK                   ------------------------------A..------------------.......----------------------.....----------
37833-human-UK                   ------------------------------A..------------------.......----------------------.....----------
22508-river-water-USA            ------------------------------A..------------------.......----------------------.....----------
13264-woodchuck-USA              ------------------------------A..------------------.......----------------------.....----------
12963-raccoon-USA                ------------------------------A..------------------.......----------------------.....----------
36641-porcupine-USA              ------------------------------A..G..CC--------T.........----------------------.....----------
36642-porcupine-USA              ------------------------------A..G..CC--------T.........----------------------.....----------
36638-porcupine via goat-USA     ------------------------------A..G..CC--------T.........----------------------.....----------
36639-porcupine via goat-USA     ------------------------------A..G..CC--------T.........----------------------.....----------
36640-porcupine via goat-USA     ------------------------------A..G..CC--------T.........----------------------.....----------
17654-human-USA                  ------------------------------A..G..CC--------T.........----------------------.....----------
17577-human-USA                  ------------------------------A..G..CC--------T.........----------------------.....----------
37211-human-USA                  ------------------------------A..G..CC--------T.........----------------------.....----------
17574-human-USA                  ------------------------------A..G..CC--------T.........----------------------.....----------
37640-field mouse-Slovak Repub   TACTCCTGGTGCAGCAGCAACAACTCCTGGT.CTA.....GGTGCAGCAGCA..A......G.----------------.G.....CCTGGTGCAG
37642-field mouse-Slovak Repub   ------TGGTGCAGCAGCAACAACTCCTGGT.CTA.....GGTGCAGCAGCA..A......G.----------------.G.....CCTGGTGCAG
37644-field mouse-Slovak Repub   TACTCCTGGTGCAGCAGCAACAACTCCTGGT.CTA.....GGTGCAGCAGCA..A......G.----------------.G.....CCTGGTGCAG
37646-field mouse-Slovak Repub   ------------------------------.CTA....C-------------..C..C....C----------------.G.G..----------
AF114166-C. parvum-gp60 gene     ------------------------------------------AACCGTCG.AC.AG.A.A----------------..AGG.AAGAACT----
Clustal Consensus                                                                 *  *                              *    *
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                                 310       320       330       340       350       360       370       380       390       400
                                 ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil               -------------G  CTCCTACT  GCTGCTCCCACTACTGTTAGTACTACC    GCTCCTTCTGGCGGCGGTGTTACTC----------
36624-sheep-Brazil               ---------------.--------.--------------------------------------------------------------
36623-sheep-Brazil               ---------------.--------.--------------------------------------------------------------
36630-sheep-Spain                ---------------.--------.--------------------------------------------------------------
36631-sheep-Spain                ---------------.--------.--------------------------------------------------------------
36633-sheep-Spain                ---------------.--------.--------------------------------------------------------------
36627-sheep-Spain                ---------------.--------.--------------------------------------------------------------
36632-sheep-Spain                ---------------.--------.--------------------------------------------------------------
36626-sheep-Spain                ---------------.--------.--------------------------------------------------------------
36634-sheep-USA                  ---------------.--------.--------------------------------------------------------------
36637-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37766-sheep-USA                  ---------------.--------.--------------------------------------------------------------
36636-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37769-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37767-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37768-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37774-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37777-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37776-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37775-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37772-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37773-sheep-USA                  ---------------.--------.--------------------------------------------------------------
37771-sheep-USA                  ---------------.--------.--------------------------------------------------------------
6478-blesbok-Czech Republic      ---------------.--------.--------------------------------------------------------------
6482-nyala-Czech Republic        ---------------.--------.--------------------------------------------------------------
34023-sheep-China                ---------------.--------.--------------------------------------------------------------
36737-sheep-China                ---------------.--------.--------------------------------------------------------------
34022-sheep-China                ---------------.--------.--------------------------------------------------------------
38161-sheep-Australia            ---------------.--------.--------------------------------------------------------------
38157-sheep-Australia            ---------------.--------.--------------------------------------------------------------
38156-sheep-Australia            ---------------.--------.--------------------------------------------------------------
38154-sheep-Australia            ---------------.--------.--------------------------------------------------------------
38153-sheep-Australia            ---------------.--------.--------------------------------------------------------------
38152-sheep-Australia            ---------------.--------.--------------------------------------------------------------
34049-sheep-China                ---------------.----..T...--------------------------------------------------------------
37635-sheep-Turkey               ---------------.----..T...--------------------------------------------------------------
34043-sheep-China                ---------------.----..T...--------------------------------------------------------------
34047-sheep-China                ---------------.----..T...--------------------------------------------------------------
34055-sheep-China                ---------------.----..T...--------------------------------------------------------------
34011-sheep-China                ---------------.----..T...--------------------------------------------------------------
34038-sheep-China                ---------------.----..T...--------------------------------------------------------------
34044-sheep-China                ---------------.----..T...--------------------------------------------------------------
34032-sheep-China                ---------------.----..T...--------------------------------------------------------------
34060-sheep-China                ---------------.----..T...--------------------------------------------------------------
34048-sheep-China                ---------------.----..T...--------------------------------------------------------------
36745-sheep-China                ---------------.----..T...--------------------------------------------------------------
36785-sheep-China                ---------------.----..T...--------------------------------------------------------------
34025-sheep-China                ---------------.----..T...--------------------------------------------------------------
34034-sheep-China                ---------------.----..T...--------------------------------------------------------------
19141-yak-China                  ---------------.----..T...--------------------------------------------------------------
19142-yak-China                  ---------------.----..T...--------------------------------------------------------------
28682-yak-China                  ---------------.----..T...--------------------------------------------------------------
30241-swamp deer-Nepal           ---------------.----..T...--------------------------------------------------------------
30238-swamp deer-Nepal           ---------------.----..T...--------------------------------------------------------------
30243-swamp deer-Nepal           ---------------.----..T...--------------------------------------------------------------
32563-impala-S.Africa            ---------------.----..T...--------------------------------------------------------------
32560-buffallo-S.Africa          ---------------.----..T...--------------------------------------------------------------
31261-human-Turkey               ---------------.----..T...--------------------------------------------------------------
37828-human-UK                   ---------------.--------.--------------------------------------------------------------
37830-human-UK                   ---------------.--------.--------------------------------------------------------------
37827-human-UK                   ---------------.--------.--------------------------------------------------------------
31570-sheep-Spain                ---------------.--------.T.------------------------------------------------------------
37820-human-UK                   ---------------.--------.T.------------------------------------------------------------
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37811-sheep-UK                  ----------.---------T------------------------------------------------------
37809-sheep-UK                  ----------.---------T------------------------------------------------------
37813-sheep-UK                  ----------.---------T------------------------------------------------------
37815-sheep-UK                  ----------.---------T------------------------------------------------------
37808-equine-UK                 ----------.---------T------------------------------------------------------
36629-sheep-Spain               ----------.---------T------------------------------------------------------
36628-sheep-Spain               ----------.---------T------------------------------------------------------
18165-sheep-Peru                ----------.---------T------------------------------------------------------
37821-human-UK                  ----------.---------T------------------------------------------------------
37818-human-UK                  ----------.---------T------------------------------------------------------
37825-human-UK                  ----------.---------T------------------------------------------------------
37829-human-UK                  ----------.---------T------------------------------------------------------
16421-human-Peru                ----------.---------T------------------------------------------------------
9870-human-Canada               ----------.---------T------------------------------------------------------
19716-alpaca-Peru               ----------.---------T------------------------------------------------------
35147-goat-Algeria              ----------.---------T------------------------------------------------------
18868-chipmunk-USA              ----------.---------..C----------------------------------------A--------GA--
33456-sifaka-USA                ----------.---------..C----------------------------------------A--------GA--
37822-human-UK                  ----------.---------..C----------------------------------------A--------GA--
37824-human-UK                  ----------.---------..C----------------------------------------A--------GA--
37819-human-UK                  ----------.---------..C----------------------------------------A--------GA--
37202-human-USA                 ----------.---------..C----------------------------------------A--------GA--
37192-human-USA                 ----------.---------..C----------------------------------------A--------GA--
37206-human-USA                 ----------.---------..C----------------------------------------A--------GA--
37191-human-USA                 ----------.---------..C----------------------------------------A--------GA--
34141-human-USA                 ----------.---------..C----------------------------------------A--------GA--
37215-human-USA                 ----------.---------..C----------------------------------------A--------GA--
37201-human-USA                 ----------.---------..C----------------------------------------A--------GA--
37212-human-USA                 ----------.---------..C----------------------------------------A--------GA--
29355-human-USA                 ----------.---------..C----------------------------------------A--------GA--
8512-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
8513-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
5397-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
6140-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
8509-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
8469-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
6141-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
8062-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
6143-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
6144-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
8514-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
8510-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
6317-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
7370-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
7163-storm-water-USA            ----------.---------..C----------------------------------------A--------GA--
15529-river-water-USA           ----------.---------..C----------------------------------------A--------GA--
14874-river-water-USA           ----------.---------..C----------------------------------------A--------GA--
18371-eastern gray squirrel-US  ----------.---------..C--T-------------------------------------A-----------
18370-eastern gray squirrel-US  ----------.---------..C--T-------------------------------------A-----------
14886-eastern gray squirrel-US  ----------.---------..C--T-------------------------------------A-----------
14223-beaver-USA                ----------.---------..C--T-------------------------------------A-----------
13266-red squirrel-USA          ----------.---------..C--T-------------------------------------A-----------
37200-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37203-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37204-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37197-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37217-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37193-human-USA                 ----------.---------..C--T-------------------------------------A-----------
29361-human-USA                 ----------.---------..C--T-------------------------------------A-----------
8774-human-USA                  ----------.---------..C--T-------------------------------------A-----------
37196-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37208-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37216-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37209-human-USA                 ----------.---------..C--T-------------------------------------A-----------
37826-human-UK                  ----------.---------..C--T-------------------------------------A-----------
37833-human-UK                  ----------.---------..C--T-------------------------------------A-----------
22508-river-water-USA           ----------.---------..C--T-------------------------------------A-----------
13264-woodchuck-USA             ----------.---------..C--T-------------------------------------A-----------
12963-raccoon-USA               ----------.---------..C--T-------------------------------------A-----------
36641-porcupine-USA             ----------.---------..C------------------------------------------------GA--
36642-porcupine-USA             ----------.---------..C------------------------------------------------GA--
36638-porcupine via goat-USA    ----------.---------..C------------------------------------------------GA--
36639-porcupine via goat-USA    ----------.---------..C------------------------------------------------GA--
36640-porcupine via goat-USA    ----------.---------..C------------------------------------------------GA--
17654-human-USA                 ----------.---------..C------------------------------------------------GA--
17577-human-USA                 ----------.---------..C------------------------------------------------GA--
37211-human-USA                 ----------.---------..C------------------------------------------------GA--
17574-human-USA                 ----------.---------..C------------------------------------------------GA--
37640-field mouse-Slovak Repub  CAGCAACAACTCCT.GTG..A.....CCT.G....A.T...C...G.GC......TCCTGGT...A..A..CCT..T.C.AC.....CTGGTGCTACTAC
37642-field mouse-Slovak Repub  CAGCAACAACTCCT.GTG..A.....CCT.G....A.T...C...G.GC......TCCTGGT...A..A..CCT..T.C.AC.....CTGGTGCTACTAC
37644-field mouse-Slovak Repub  CAGCAACAACTCCT.GTG..A.....CCT.G....A.T...C...G.GC......TCCTGGT...A..A..CCT..T.C.AC.....CTGGTGCTACTAC
37646-field mouse-Slovak Repub  ---------------.GTGT.A.C.......T......TGTGG.A.G.GT...C..T--------.....GTG.CA..T.T.ACC.........GCTCCTGT
AF114166-C. parvum-gp60 gene    ---------------.GAGAAGACG.AGAA.GCAG..AAGA.T..AG.G.....GAAG----------.......TA..CAG.G.T..GAAGAGGAA-----
Clustal Consensus                              *         *                *   *  ***              **       *         *
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                                          410       420       430       440       450       460       470       480       490       500
                                ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil              ------------------------------C------------TA--------------------GCACTGAT------------GGAGATGAGACT---
36624-sheep-Brazil              ------------------------------.------------..--------------------........------------............---
36623-sheep-Brazil              ------------------------------.------------..--------------------........------------............---
36630-sheep-Spain               ------------------------------.------------..--------------------........------------............---
36631-sheep-Spain               ------------------------------.------------..--------------------........------------............---
36633-sheep-Spain               ------------------------------.------------..--------------------........------------............---
36627-sheep-Spain               ------------------------------.------------..--------------------........------------............---
36632-sheep-Spain               ------------------------------.------------..--------------------........------------............---
36626-sheep-Spain               ------------------------------.------------..--------------------........------------............---
36634-sheep-USA                 ------------------------------.------------..--------------------........------------............---
36637-sheep-USA                 ------------------------------.------------..--------------------........------------............---
37766-sheep-USA                 ------------------------------.------------..--------------------........------------............---
36636-sheep-USA                 ------------------------------.------------..--------------------........------------............---
37769-sheep-USA                 ------------------------------.------------..--------------------........------------............---
37767-sheep-USA                 ------------------------------.------------..--------------------........------------............---
37768-sheep-USA                 ------------------------------.------------..--------------------........------------............---
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37774-sheep-USA                  ------------------------------.------------..------------------------.......------------.............---
37777-sheep-USA                  ------------------------------.------------..------------------------.......------------.............---
37776-sheep-USA                  ------------------------------.------------..------------------------.......------------.............---
37775-sheep-USA                  ------------------------------.------------..------------------------.......------------.............---
37772-sheep-USA                  ------------------------------.------------..------------------------.......------------.............---
37773-sheep-USA                  ------------------------------.------------..------------------------.......------------.............---
37771-sheep-USA                  ------------------------------.------------..------------------------.......------------.............---
6478-blesbok-Czech Republic      ------------------------------.------------..CT----------------------A......------------.............---
6482-nyala-Czech Republic        ------------------------------.------------..CT----------------------A......------------.............---
34023-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
36737-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34022-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
38161-sheep-Australia            ------------------------------.------------..CT----------------------A......------------.............---
38157-sheep-Australia            ------------------------------.------------..CT----------------------A......------------.............---
38156-sheep-Australia            ------------------------------.------------..CT----------------------A......------------.............---
38154-sheep-Australia            ------------------------------.------------..CT----------------------A......------------.............---
38153-sheep-Australia            ------------------------------.------------..CT----------------------A......------------.............---
38152-sheep-Australia            ------------------------------.------------..CT----------------------A......------------.............---
34049-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
37635-sheep-Turkey               ------------------------------.------------..------------------------.......------------.............---
34043-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34047-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34055-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34011-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34038-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34044-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34032-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34060-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34048-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
36745-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
36785-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34025-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
34034-sheep-China                ------------------------------.------------..CT----------------------A......------------.............---
19141-yak-China                  ------------------------------.------------..CT----------------------A......------------.............---
19142-yak-China                  ------------------------------.------------..CT----------------------A......------------.............---
28682-yak-China                  ------------------------------.------------..CT----------------------A......------------.............---
30241-swamp deer-Nepal           ------------------------------.------------..CT----------------------A......------------.............---
30238-swamp deer-Nepal           ------------------------------.------------..CT----------------------A......------------.............---
30243-swamp deer-Nepal           ------------------------------.------------..CT----------------------A......------------.............---
32563-impala-S.Africa            ------------------------------.------------..CT----------------------A......------------.............---
32560-buffallo-S.Africa          ------------------------------.------------..CT----------------------A......------------.............---
31261-human-Turkey               ------------------------------.------------..CT----------------------A......------------.............---
37828-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37830-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37827-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
31570-sheep-Spain                ------------------------------.------------..CT----------------------A......------------.............---
37820-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37811-sheep-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37809-sheep-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37813-sheep-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37815-sheep-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37808-equine-UK                  ------------------------------.------------..CT----------------------A......------------.............---
36629-sheep-Spain                ------------------------------.------------..CT----------------------A......------------.............---
36628-sheep-Spain                ------------------------------.------------..CT----------------------A......------------.............---
18165-sheep-Peru                 ------------------------------.------------..CT----------------------A......------------.............---
37821-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37818-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37825-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
37829-human-UK                   ------------------------------.------------..CT----------------------A......------------.............---
16421-human-Peru                 ------------------------------.------------..CT----------------------A......------------.............---
9870-human-Canada                ------------------------------.------------..CT----------------------A......------------.............---
19716-alpaca-Peru                ------------------------------.------------..CT----------------------A......------------.............---
35147-goat-Algeria               ------------------------------.------------..CT----------------------A......------------.............---
18868-chipmunk-USA               ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
33456-sifaka-USA                 ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37822-human-UK                   ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37824-human-UK                   ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37819-human-UK                   ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37202-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37192-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37206-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37191-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
34141-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37215-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37201-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
37212-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
29355-human-USA                  ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
8512-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
8513-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
5397-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
6140-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
8509-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
8469-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
6141-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
8062-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
6143-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
6144-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
8514-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
8510-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
6317-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
7370-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
7163-storm-water-USA             ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
15529-river-water-USA            ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
14874-river-water-USA            ------------------------------.------------..CT----------------------A.......GGA---------.AT..GA.....GAT
18371-eastern gray squirrel-US   ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
18370-eastern gray squirrel-US   ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
14886-eastern gray squirrel-US   ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
14223-beaver-USA                 ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
13266-red squirrel-USA           ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
37200-human-USA                  ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
37203-human-USA                  ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
37204-human-USA                  ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
37197-human-USA                  ------------------------------.------------..CT----------------------A.......GGAGAG------.AT..GA.....GAT
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37217-human-USA                  ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
37193-human-USA                  ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
29361-human-USA                  ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
8774-human-USA                   ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
37196-human-USA                  ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
37208-human-USA                  ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
37216-human-USA                  ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
37209-human-USA                  ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
37826-human-UK                   ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
37833-human-UK                   ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
22508-river-water-USA            ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
13264-woodchuck-USA              ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
12963-raccoon-USA                ------------------------------.-------------..CT------------------A........GGAGAG------.AT..GA.....GAT
36641-porcupine-USA              ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
36642-porcupine-USA              ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
36638-porcupine via goat-USA     ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
36639-porcupine via goat-USA     ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
36640-porcupine via goat-USA     ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
17654-human-USA                  ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
17577-human-USA                  ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
37211-human-USA                  ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
17574-human-USA                  ------------------------------.-------------..CT------------------A........GGA---------.AT..GA.....GAT
37640-field mouse-Slovak Repub   TCCTGGTGCTACTACTCCTGGTGCTACTA.TCCTGGTGCTAC..CTCCTGGTGCTACTACTGGTACT....G.ACTACTGGAACA.TT....GTT.CGGG
37642-field mouse-Slovak Repub   TCCTGGTGCTACTACTCCTGGTGCTACTA.TCCTGGTGCTAC..CTCCTGGTGCTACTACTGGTACT....G.ACTACTGGAACA.TT....GTT.CGGG
37644-field mouse-Slovak Repub   TCCTGGTGCTACTACTCCTGGTGCTACTA.TCCTGGTGCTAC..CTCCTGGTGCTACTACTGGTACT....G.ACTACTGGAACA.TT....GTT.CGGG
37646-field mouse-Slovak Repub   TACTGGTGTTACCACTGTTG---------.TCCAGGTGTTCCC.CT------------------ACAG.C...............TT....GC...GGA
AF114166-C. parvum-gp60 gene     ------------------------------GGTAGTGAAGACGAT--------------GGCCAA...AG.GCT---------.CTTCCC.AC.CACT
Clustal Consensus                                                                                 *   *          *          *

                                 510       520       530       540       550       560       570       580       590       600
                                 ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil               ACTGACAC---TGGTAGTGGTACTAC------CGGCGAAACAGTTACAACTACTCCTGACCCAATGGAGAAATGCGGTCTTTCATTCGTCATGTGGTTTG
36624-sheep-Brazil               ........---...............------.......................................................................
36623-sheep-Brazil               ........---...............------.......................................................................
36630-sheep-Spain                ........---...............------.......................................................................
36631-sheep-Spain                ........---...............------.......................................................................
36633-sheep-Spain                ........---...............------.......................................................................
36627-sheep-Spain                ........---...............------.......................................................................
36632-sheep-Spain                ........---...............------.......................................................................
36626-sheep-Spain                ........---...............------.......................................................................
36634-sheep-USA                  ........---...............------.......................................................................
36637-sheep-USA                  ........---...............------.......................................................................
37766-sheep-USA                  ........---...............------.......................................................................
36636-sheep-USA                  ........---...............------.......................................................................
37769-sheep-USA                  ........---...............------.......................................................................
37767-sheep-USA                  ........---...............------.......................................................................
37768-sheep-USA                  ........---...............------.......................................................................
37774-sheep-USA                  ........---...............------.......................................................................
37777-sheep-USA                  ........---...............------.......................................................................
37776-sheep-USA                  ........---...............------.......................................................................
37775-sheep-USA                  ........---...............------.......................................................................
37772-sheep-USA                  ........---...............------.......................................................................
37773-sheep-USA                  ........---...............------.......................................................................
37771-sheep-USA                  ........---...............------.......................................................................
6478-blesbok-Czech Republic      ........---...............------.......................................................................
6482-nyala-Czech Republic        ........---...............------.......................................................................
34023-sheep-China                ........---...............------.......................................................................
36737-sheep-China                ........---...............------.......................................................................
34022-sheep-China                ........---...............------.......................................................................
38161-sheep-Australia            ........---...............------.......................................................................
38157-sheep-Australia            ........---...............------.......................................................................
38156-sheep-Australia            ........---...............------.......................................................................
38154-sheep-Australia            ........---...............------.......................................................................
38153-sheep-Australia            ........---...............------.......................................................................
38152-sheep-Australia            ........---...............------.......................................................................
34049-sheep-China                ........---...............------.......................................................................
37635-sheep-Turkey               ........---...............------.......................................................................
34043-sheep-China                ........---...............------.......................................................................
34047-sheep-China                ........---...............------.......................................................................
34055-sheep-China                ........---...............------.......................................................................
34011-sheep-China                ........---...............------.......................................................................
34038-sheep-China                ........---...............------.......................................................................
34044-sheep-China                ........---...............------.......................................................................
34032-sheep-China                ........---...............------.......................................................................
34060-sheep-China                ........---...............------.......................................................................
34048-sheep-China                ........---...............------.......................................................................
36745-sheep-China                ........---...............------.......................................................................
36785-sheep-China                ........---...............------.......................................................................
34025-sheep-China                ........---...............------.......................................................................
34034-sheep-China                ........---...............------.......................................................................
19141-yak-China                  ........---...............------.......................................................................
19142-yak-China                  ........---...............------.......................................................................
28682-yak-China                  ........---...............------.......................................................................
30241-swamp deer-Nepal           ........---...............------.......................................................................
30238-swamp deer-Nepal           ........---...............------.......................................................................
30243-swamp deer-Nepal           ........---...............------.......................................................................
32563-impala-S.Africa            ........---...............------.......................................................................
32560-buffallo-S.Africa          ........---...............------.......................................................................
31261-human-Turkey               ........---...............------.......................................................................
37828-human-UK                   ........----..A..........------.......................................................................
37830-human-UK                   ........----..A..........------.......................................................................
37827-human-UK                   ........----..A..........------.......................................................................
31570-sheep-Spain                ........---...............------.......................................................................
37820-human-UK                   ........---...............------.......................................................................
37811-sheep-UK                   ........---...............------.......................................................................
37809-sheep-UK                   ........---...............------.......................................................................
37813-sheep-UK                   ........---...............------.......................................................................
37815-sheep-UK                   ........---...............------.......................................................................
37808-equine-UK                  ........---...............------.......................................................................
36629-sheep-Spain                ........---...............------.......................................................................
36628-sheep-Spain                ........---...............------.......................................................................
18165-sheep-Peru                 ........---...............------.......................................................................
37821-human-UK                   ........---...............------.......................................................................
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37818-human-UK                  ........---.............------.......................................................AC.....................
37825-human-UK                  ........---.............------.......................................................AC.....................
37829-human-UK                  ........---.............------.......................................................AC.....................
16421-human-Peru                ........---.............------.......................................................AC.....................
9870-human-Canada               ........---.............------.......................................................AC.....................
19716-alpaca-Peru               ........---.............------.......................................................AC.....................
35147-goat-Algeria              ........---.............------.......................................................AC.....................
18868-chipmunk-USA              ........---.............------..A....................................................AC.....................
33456-sifaka-USA                ........---.............------..A....................................................AC.....................
37822-human-UK                  ........---.............------..A....................................................AC.....................
37824-human-UK                  ........---.............------..A....................................................AC.....................
37819-human-UK                  ........---.............------..A....................................................AC.....................
37202-human-USA                 ........---.............------..A....................................................AC.....................
37192-human-USA                 ........---.............------..A....................................................AC.....................
37206-human-USA                 ........---.............------..A....................................................AC.....................
37191-human-USA                 ........---.............------..A....................................................AC.....................
34141-human-USA                 ........---.............------..A....................................................AC.....................
37215-human-USA                 ........---.............------..A....................................................AC.....................
37201-human-USA                 ........---.............------..A....................................................AC.....................
37212-human-USA                 ........---.............------..A....................................................AC.....................
29355-human-USA                 ........---.............------..A....................................................AC.....................
8512-storm-water-USA            ........---.............------..A....................................................AC.....................
8513-storm-water-USA            ........---.............------..A....................................................AC.....................
5397-storm-water-USA            ........---.............------..A....................................................AC.....................
6140-storm-water-USA            ........---.............------..A....................................................AC.....................
8509-storm-water-USA            ........---.............------..A....................................................AC.....................
8469-storm-water-USA            ........---.............------..A....................................................AC.....................
6141-storm-water-USA            ........---.............------..A....................................................AC.....................
8062-storm-water-USA            ........---.............------..A....................................................AC.....................
6143-storm-water-USA            ........---.............------..A....................................................AC.....................
6144-storm-water-USA            ........---.............------..A....................................................AC.....................
8514-storm-water-USA            ........---.............------..A....................................................AC.....................
8510-storm-water-USA            ........---.............------..A....................................................AC.....................
6317-storm-water-USA            ........---.............------..A....................................................AC.....................
7370-storm-water-USA            ........---.............------..A....................................................AC.....................
7163-storm-water-USA            ........---.............------..A....................................................AC.....................
15529-river-water-USA           ........---.............------..A....................................................AC.....................
14874-river-water-USA           ........---.............------..A....................................................AC.....................
18371-eastern gray squirrel-US  ........TGA.............------..AT.....................................................
18370-eastern gray squirrel-US  ........TGA.............------..AT.....................................................
14886-eastern gray squirrel-US  ........TGA.............------..AT.....................................................
14223-beaver-USA                ........TGA.............------..AT.....................................................
13266-red squirrel-USA          ........TGA.............------..AT.....................................................
37200-human-USA                 ........TGA.............------..AT.....................................................
37203-human-USA                 ........TGA.............------..AT.....................................................
37204-human-USA                 ........TGA.............------..AT.....................................................
37197-human-USA                 ........TGA.............------..AT.....................................................
37217-human-USA                 ........TGA.............------..AT.....................................................
37193-human-USA                 ........TGA.............------..AT.....................................................
29361-human-USA                 ........TGA.............------..AT.....................................................
8774-human-USA                  ........TGA.............------..AT.....................................................
37196-human-USA                 ........TGA.............------..AT.....................................................
37208-human-USA                 ........TGA.............------..AT.....................................................
37216-human-USA                 ........TGA.............------..AT.....................................................
37209-human-USA                 ........TGA.............------..AT.....................................................
37826-human-UK                  ........TGA.............------..AT.....................................................
37833-human-UK                  ........TGA.............------..AT.....................................................
22508-river-water-USA           ........TGA.............------..AT.....................................................
13264-woodchuck-USA             ........TGA.............------..AT.....................................................
12963-raccoon-USA               ........TGA.............------..AT.....................................................
36641-porcupine-USA             ........---.............------..A.....................................T.....................
36642-porcupine-USA             ........---.............------..A.....................................T.....................
36638-porcupine via goat-USA    ........---.............------..A.....................................T.....................
36639-porcupine via goat-USA    ........---.............------..A.....................................T.....................
36640-porcupine via goat-USA    ........---.............------..A.....................................T.....................
17654-human-USA                 ........---.............------..A.....................................T.....................
17577-human-USA                 ........---.............------..A.....................................T.....................
37211-human-USA                 ........---.............------..A.....................................T.....................
17574-human-USA                 ........---.............------..A.....................................T.....................
37640-field mouse-Slovak Repub  GA...A------....C...AGA.GA------T.CT.GT..T.CA...........A......GCC...C.G.................T.....................
37642-field mouse-Slovak Repub  GA...A------....C...AGA.GA------T.CT.GT..T.CA...........A......GCC...C.G.................T.....................
37644-field mouse-Slovak Repub  GA...A------....C...AGA.GA------T.CT.GT..T.CA...........A......GCC...C.G.................T.....................
37646-field mouse-Slovak Repub  GGA..G-------...GA.ACA.G.......T..T..G..T.GG...GT......C.......CT........T...........T..T.....................
AF114166-C. parvum-gp60 gene    ...CCAG.TCAAA..GAA..CG.A..------TAC......CA.AGA.G.....------..AA..AG.......CAC......T..A........C.
Clustal Consensus                          *                  *  **      *  ******      *   **  * ** **   ****** ** ******** *
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                                610       620       630       640       650       660       670       680       690       700
                                ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil              TTAGTGGTACTCCAGTTACAACTCTCGAATGTGGACCTTACACCATGGTATATGGACCAGTTGAAGGGGAGACTAACCCTGCAGCAAGGTATGTCTCTGG
36624-sheep-Brazil              ....................................................................................................
36623-sheep-Brazil              ....................................................................................................
36630-sheep-Spain               ....................................................................................................
36631-sheep-Spain               ....................................................................................................
36633-sheep-Spain               ....................................................................................................
36627-sheep-Spain               ....................................................................................................
36632-sheep-Spain               ....................................................................................................
36626-sheep-Spain               ....................................................................................................
36634-sheep-USA                 ....................................................................................................
36637-sheep-USA                 ....................................................................................................
37766-sheep-USA                 ....................................................................................................
36636-sheep-USA                 ....................................................................................................
37769-sheep-USA                 ....................................................................................................
37767-sheep-USA                 ....................................................................................................
37768-sheep-USA                 ....................................................................................................
37774-sheep-USA                 ....................................................................................................
37777-sheep-USA                 ....................................................................................................
37776-sheep-USA                 ....................................................................................................
37775-sheep-USA                 ....................................................................................................
37772-sheep-USA                 ....................................................................................................
37773-sheep-USA                 ....................................................................................................
37771-sheep-USA                 ....................................................................................................
6478-blesbok-Czech Republic     ....................................................................................................
6482-nyala-Czech Republic       ....................................................................................................
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34023-sheep-China                 ..................................................................................
36737-sheep-China                 ..................................................................................
34022-sheep-China                 ..................................................................................
38161-sheep-Australia             ..................................................................................
38157-sheep-Australia             ..................................................................................
38156-sheep-Australia             ..................................................................................
38154-sheep-Australia             ..................................................................................
38153-sheep-Australia             ..................................................................................
38152-sheep-Australia             ..................................................................................
34049-sheep-China                 ..................................................................................
37635-sheep-Turkey                ..................................................................................
34043-sheep-China                 ..................................................................................
34047-sheep-China                 ..................................................................................
34055-sheep-China                 ..................................................................................
34011-sheep-China                 ..................................................................................
34038-sheep-China                 ..................................................................................
34044-sheep-China                 ..................................................................................
34032-sheep-China                 ..................................................................................
34060-sheep-China                 ..................................................................................
34048-sheep-China                 ..................................................................................
36745-sheep-China                 ..................................................................................
36785-sheep-China                 ..................................................................................
34025-sheep-China                 ..................................................................................
34034-sheep-China                 ..................................................................................
19141-yak-China                   ..................................................................................
19142-yak-China                   ..................................................................................
28682-yak-China                   ..................................................................................
30241-swamp deer-Nepal            ..................................................................................
30238-swamp deer-Nepal            ..................................................................................
30243-swamp deer-Nepal            ..................................................................................
32563-impala-S.Africa             ..................................................................................
32560-buffallo-S.Africa           ..................................................................................
31261-human-Turkey                ..................................................................................
37828-human-UK                    ..................................................................................
37830-human-UK                    ..................................................................................
37827-human-UK                    ..................................................................................
31570-sheep-Spain                 ..................................................................................
37820-human-UK                    ..................................................................................
37811-sheep-UK                    ..................................................................................
37809-sheep-UK                    ..................................................................................
37813-sheep-UK                    ..................................................................................
37815-sheep-UK                    ..................................................................................
37808-equine-UK                   ..................................................................................
36629-sheep-Spain                 ..................................................................................
36628-sheep-Spain                 ..................................................................................
18165-sheep-Peru                  ..................................................................................
37821-human-UK                    ..................................................................................
37818-human-UK                    ..................................................................................
37825-human-UK                    ..................................................................................
37829-human-UK                    ..................................................................................
16421-human-Peru                  ..................................................................................
9870-human-Canada                 ..................................................................................
19716-alpaca-Peru                 ..................................................................................
35147-goat-Algeria                ..................................................................................
18868-chipmunk-USA                .......CGT.........................T................C...........GAAT.............
33456-sifaka-USA                  .......CGT.........................T................C...........GAAT.............
37822-human-UK                    .......CGT.........................T................C...........GAAT.............
37824-human-UK                    .......CGT.........................T................C...........GAAT.............
37819-human-UK                    .......CGT.........................T................C...........GAAT.............
37202-human-USA                   .......CGT.........................T................C...........GAAT.............
37192-human-USA                   .......CGT.........................T................C...........GAAT.............
37206-human-USA                   .......CGT.........................T................C...........GAAT.............
37191-human-USA                   .......CGT.........................T................C...........GAAT.............
34141-human-USA                   .......CGT.........................T................C...........GAAT.............
37215-human-USA                   .......CGT.........................T................C...........GAAT.............
37201-human-USA                   .......CGT.........................T................C...........GAAT.............
37212-human-USA                   .......CGT.........................T................C...........GAAT.............
29355-human-USA                   .......CGT.........................T................C...........GAAT.............
8512-storm-water-USA              .......CGT.........................T................C...........GAAT.............
8513-storm-water-USA              .......CGT.........................T................C...........GAAT.............
5397-storm-water-USA              .......CGT.........................T................C...........GAAT.............
6140-storm-water-USA              .......CGT.........................T................C...........GAAT.............
8509-storm-water-USA              .......CGT.........................T................C...........GAAT.............
8469-storm-water-USA              .......CGT.........................T................C...........GAAT.............
6141-storm-water-USA              .......CGT.........................T................C...........GAAT.............
8062-storm-water-USA              .......CGT.........................T................C...........GAAT.............
6143-storm-water-USA              .......CGT.........................T................C...........GAAT.............
6144-storm-water-USA              .......CGT.........................T................C...........GAAT.............
8514-storm-water-USA              .......CGT.........................T................C...........GAAT.............
8510-storm-water-USA              .......CGT.........................T................C...........GAAT.............
6317-storm-water-USA              .......CGT.........................T................C...........GAAT.............
7370-storm-water-USA              .......CGT.........................T................C...........GAAT.............
7163-storm-water-USA              .......CGT.........................T................C...........GAAT.............
15529-river-water-USA             .......CGT.........................T................C...........GAAT.............
14874-river-water-USA             .......CGT.........................T................C...........GAAT.............
18371-eastern gray squirrel-US    ......................C.....G...................T..C..G...A....T.............
18370-eastern gray squirrel-US    ......................C.....G...................T..C..G...A....T.............
14886-eastern gray squirrel-US    ......................C.....G...................T..C..G...A....T.............
14223-beaver-USA                  ......................C.....G...................T..C..G...A....T.............
13266-red squirrel-USA            ......................C.....G...................T..C..G...A....T.............
37200-human-USA                   ......................C.....G...................T..C..G...A....T.............
37203-human-USA                   ......................C.....G...................T..C..G...A....T.............
37204-human-USA                   ......................C.....G...................T..C..G...A....T.............
37197-human-USA                   ......................C.....G...................T..C..G...A....T.............
37217-human-USA                   ......................C.....G...................T..C..G...A....T.............
37193-human-USA                   ......................C.....G...................T..C..G...A....T.............
29361-human-USA                   ......................C.....G...................T..C..G...A....T.............
8774-human-USA                    ......................C.....G...................T..C..G...A....T.............
37196-human-USA                   ......................C.....G...................T..C..G...A....T.............
37208-human-USA                   ......................C.....G...................T..C..G...A....T.............
37216-human-USA                   ......................C.....G...................T..C..G...A....T.............
37209-human-USA                   ......................C.....G...................T..C..G...A....T.............
37826-human-UK                    ......................C.....G...................T..C..G...A....T.............
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37833-human-UK                  ....................C.....G...................T..C..G...A....T...............................
22508-river-water-USA           ....................C.....G...................T..C..G...A....T...............................
13264-woodchuck-USA             ....................C.....G...................T..C..G...A....T...............................
12963-raccoon-USA               ....................C.....G...................T..C..G...A....T...............................
36641-porcupine-USA             ........................G...................T..C..G...A....T...............................
36642-porcupine-USA             ........................G...................T..C..G...A....T...............................
36638-porcupine via goat-USA    ........................G...................T..C..G...A....T...............................
36639-porcupine via goat-USA    ........................G...................T..C..G...A....T...............................
36640-porcupine via goat-USA    ........................G...................T..C..G...A....T...............................
17654-human-USA                 ........................G...................T..C..G...A....T...............................
17577-human-USA                 ........................G...................T..C..G...A....T...............................
37211-human-USA                 ........................G...................T..C..G...A....T...............................
17574-human-USA                 ........................G...................T..C..G...A....T...............................
37640-field mouse-Slovak Repub  ..G.....GT.........G........C......G.......................A.G..T..T.G......A..............G.....
37642-field mouse-Slovak Repub  ..G.....GT.........G........C......G.......................A.G..T..T.G......A..............G.....
37644-field mouse-Slovak Repub  ..G.....GT.........G........C......G.......................A.G..T..T.G......A..............G.....
37646-field mouse-Slovak Repub  .......AGT..................G......G..........T.....C..G........G..T..A........G........A...........
AF114166-C. parvum-gp60 gene    GAGAA.....C....C.G.G..AT.GA.G.....TG.C.....T..C..C....C...TA.AA...ACC.A..AG.T..C...C....A...A.......
Clustal Consensus                    **    **** * * **  *  * *****  * ***** ** ** ** *  **  *  *     * *   * ** *** **** *** * *****

                                                 710       720       730       740       750       760       770       780       790       800
                                        ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil              GCCCGTTACTACGGTTACTTATGAAGAAAGCAGCAAGA------AACTCATGATCAATGGCCAGGAATTCGCCACTCTTTCCATGGATTCATCAAAACCA
36624-sheep-Brazil              ......................................------......................................................
36623-sheep-Brazil              ......................................------......................................................
36630-sheep-Spain               ......................................------......................................................
36631-sheep-Spain               ......................................------......................................................
36633-sheep-Spain               ......................................------......................................................
36627-sheep-Spain               ......................................------......................................................
36632-sheep-Spain               ......................................------......................................................
36626-sheep-Spain               ......................................------......................................................
36634-sheep-USA                 ......................................------......................................................
36637-sheep-USA                 ......................................------......................................................
37766-sheep-USA                 ......................................------......................................................
36636-sheep-USA                 ......................................------......................................................
37769-sheep-USA                 ......................................------......................................................
37767-sheep-USA                 ......................................------......................................................
37768-sheep-USA                 ......................................------......................................................
37774-sheep-USA                 ......................................------......................................................
37777-sheep-USA                 ......................................------......................................................
37776-sheep-USA                 ......................................------......................................................
37775-sheep-USA                 ......................................------......................................................
37772-sheep-USA                 ......................................------......................................................
37773-sheep-USA                 ......................................------......................................................
37771-sheep-USA                 ......................................------......................................................
6478-blesbok-Czech Republic     ......................................------......................................................
6482-nyala-Czech Republic       ......................................------......................................................
34023-sheep-China               ......................................------......................................................
36737-sheep-China               ......................................------......................................................
34022-sheep-China               ......................................------......................................................
38161-sheep-Australia           ......................................------......................................................
38157-sheep-Australia           ......................................------......................................................
38156-sheep-Australia           ......................................------......................................................
38154-sheep-Australia           ......................................------......................................................
38153-sheep-Australia           ......................................------......................................................
38152-sheep-Australia           ......................................------......................................................
34049-sheep-China               ......................................------......................................................
37635-sheep-Turkey              ......................................------......................................................
34043-sheep-China               ......................................------......................................................
34047-sheep-China               ......................................------......................................................
34055-sheep-China               ......................................------......................................................
34011-sheep-China               ......................................------......................................................
34038-sheep-China               ......................................------......................................................
34044-sheep-China               ......................................------......................................................
34032-sheep-China               ......................................------......................................................
34060-sheep-China               ......................................------......................................................
34048-sheep-China               ......................................------......................................................
36745-sheep-China               ......................................------......................................................
36785-sheep-China               ......................................------......................................................
34025-sheep-China               ......................................------......................................................
34034-sheep-China               ......................................------......................................................
19141-yak-China                 ......................................------......................................................
19142-yak-China                 ......................................------......................................................
28682-yak-China                 ......................................------......................................................
30241-swamp deer-Nepal          ......................................------......................................................
30238-swamp deer-Nepal          ......................................------......................................................
30243-swamp deer-Nepal          ......................................------......................................................
32563-impala-S.Africa           ......................................------......................................................
32560-buffallo-S.Africa         ......................................------......................................................
31261-human-Turkey              ......................................------......................................................
37828-human-UK                  ......................................------......................................................
37830-human-UK                  ......................................------......................................................
37827-human-UK                  ......................................------......................................................
31570-sheep-Spain               ......................................------......................................................
37820-human-UK                  ......................................------......................................................
37811-sheep-UK                  ......................................------......................................................
37809-sheep-UK                  ......................................------......................................................
37813-sheep-UK                  ......................................------......................................................
37815-sheep-UK                  ......................................------......................................................
37808-equine-UK                 ......................................------......................................................
36629-sheep-Spain               ......................................------......................................................
36628-sheep-Spain               ......................................------......................................................
18165-sheep-Peru                ......................................------......................................................
37821-human-UK                  ......................................------......................................................
37818-human-UK                  ......................................------......................................................
37825-human-UK                  ......................................------......................................................
37829-human-UK                  ......................................------......................................................
16421-human-Peru                ......................................------......................................................
9870-human-Canada               ......................................------......................................................
19716-alpaca-Peru               ......................................------......................................................
35147-goat-Algeria              .............A........................------......................................................
18868-chipmunk-USA              AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G...............CT.........C.....
33456-sifaka-USA                AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G...............CT.........C.....
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37822-human-UK                AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37824-human-UK                AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37819-human-UK                AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37202-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37192-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37206-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37191-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
34141-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37215-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37201-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
37212-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
29355-human-USA               AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
8512-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
8513-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
5397-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
6140-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
8509-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
8469-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
6141-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
8062-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
6143-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
6144-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
8514-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
8510-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
6317-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
7370-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
7163-storm-water-USA          AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
15529-river-water-USA         AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
14874-river-water-USA         AA.A..C..C..A...........T.C.....A.....------.G..T...G.....AA......G................CT.........C.....
18371-eastern gray squirrel-US AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
18370-eastern gray squirrel-US AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
14886-eastern gray squirrel-US AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
14223-beaver-USA              AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
13266-red squirrel-USA        AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37200-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37203-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37204-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37197-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37217-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37193-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
29361-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
8774-human-USA                AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37196-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37208-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37216-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37209-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37826-human-UK                AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
37833-human-UK                AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
22508-river-water-USA         AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
13264-woodchuck-USA           AA.A..C..C..A........C..TAC.....C.....------.G..T........A.......................CT...........T...
12963-raccoon-USA             AA.A..C..C..A........C..T.C.....C.....------.G..T........A.......................CT...........T...
36641-porcupine-USA           AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
36642-porcupine-USA           AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
36638-porcupine via goat-USA  AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
36639-porcupine via goat-USA  AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
36640-porcupine via goat-USA  AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
17654-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
17577-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
37211-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
17574-human-USA               AA.A..C..C..A........C..TAC.....C.....------.G..T........AA......................CT...........T...
37640-field mouse-Slovak Repub ...A........A..........CAC..C.GCTC...------.GA.T...G.T...A....................A.CT.....G.........
37642-field mouse-Slovak Repub ...A........A..........CAC..C.GCTC...------.GA.T...G.T...A....................A.CT.....G.........
37644-field mouse-Slovak Repub ...A........A..........CAC..C.GCTC...------.GA.T...G.T...A....................A.CT.....G.........
37646-field mouse-Slovak Repub A.AA..C..C..A..........T.C.....C.....------.G...........A.T..........A..C.....A.CT.....T...C.G...
AF114166-C. parvum-gp60 gene  TGAA.....AT.T..A..C.T....A.G..TGAT..T.CAGTTA..A...A.G.T..C..T.....T...AG......C..TGCTA.....AGT.GT...
Clustal Consensus                ** **  * ** ** *  **    *      * *      *  * * * * **    ***** ***   ** ** **     ****       ***

                                          810       820       830       840       850       860       870       880       890       900
                              ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil            ACCAC---AGCTACAACAACACCAGCAGCTAGGTTACT-TGCAGAAGGTGGCACT-------GCTACAGAAGCCGTCGCAATGACTGATCTATACACCT
36624-sheep-Brazil            .....---.............................-..............-......................................
36623-sheep-Brazil            .....---.............................-..............-......................................
36630-sheep-Spain             .....---.............................-..............-......................................
36631-sheep-Spain             .....---.............................-..............-......................................
36633-sheep-Spain             .....---.............................-..............-......................................
36627-sheep-Spain             .....---.............................-..............-......................................
36632-sheep-Spain             .....---.............................-..............-......................................
36626-sheep-Spain             .....---.............................-..............-......................................
36634-sheep-USA               .....---.............................-..............-......................................
36637-sheep-USA               .....---.............................-..............-......................................
37766-sheep-USA               .....---.............................-..............-......................................
36636-sheep-USA               .....---.............................-..............-......................................
37769-sheep-USA               .....---.............................-..............-......................................
37767-sheep-USA               .....---.............................-..............-......................................
37768-sheep-USA               .....---.............................-..............-......................................
37774-sheep-USA               .....---.............................-..............-......................................
37777-sheep-USA               .....---.............................-..............-......................................
37776-sheep-USA               .....---.............................-..............-......................................
37775-sheep-USA               .....---.............................-..............-......................................
37772-sheep-USA               .....---.............................-..............-......................................
37773-sheep-USA               .....---.............................-..............-......................................
37771-sheep-USA               .....---.............................-..............-......................................
6478-blesbok-Czech Republic   .....---.............................-..............-......................................
6482-nyala-Czech Republic     .....---.............................-..............-......................................
34023-sheep-China             .....---.............................-..............-......................................
36737-sheep-China             .....---.............................-..............-......................................
34022-sheep-China             .....---.............................-..............-......................................
38161-sheep-Australia         .....---.............................-..............-......................................
38157-sheep-Australia         .....---.............................-..............-......................................
38156-sheep-Australia         .....---.............................-..............-......................................
38154-sheep-Australia         .....---.............................-..............-......................................
38153-sheep-Australia         .....---.............................-..............-......................................
38152-sheep-Australia         .....---.............................-..............-......................................
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34049-sheep-China                ....---.......................-...............-------.......................................
37635-sheep-Turkey               ....---.......................-...............-------.......................................
34043-sheep-China                ....---.......................-...............-------.......................................
34047-sheep-China                ....---.......................-...............-------.......................................
34055-sheep-China                ....---.......................-...............-------.......................................
34011-sheep-China                ....---.......................-...............-------.......................................
34038-sheep-China                ....---.......................-...............-------.......................................
34044-sheep-China                ....---.......................-...............-------.......................................
34032-sheep-China                ....---.......................-...............-------.......................................
34060-sheep-China                ....---.......................-...............-------.......................................
34048-sheep-China                ....---.......................-...............-------.......................................
36745-sheep-China                ....---.......................-...............-------.......................................
36785-sheep-China                ....---.......................-...............-------.......................................
34025-sheep-China                ....---.......................-...............-------.......................................
34034-sheep-China                ....---.......................-...............-------.......................................
19141-yak-China                  ....---.......................-...............-------.......................................
19142-yak-China                  ....---.......................-...............-------.......................................
28682-yak-China                  ....---.......................-...............-------.......................................
30241-swamp deer-Nepal           ....---.......................-...............-------.......................................
30238-swamp deer-Nepal           ....---.......................-...............-------.......................................
30243-swamp deer-Nepal           ....---.......................-...............-------.......................................
32563-impala-S.Africa            ....---.......................-...............-------.......................................
32560-buffallo-S.Africa          ....---.......................-...............-------.......................................
31261-human-Turkey               ....---.......................-...............-------.......................................
37828-human-UK                   ....---.......................-...............-------.......................................
37830-human-UK                   ....---.......................-...............-------.......................................
37827-human-UK                   ....---.......................-...............-------.......................................
31570-sheep-Spain                ....---.......................-...............-------.......................................
37820-human-UK                   ....---.......................-...............-------.......................................
37811-sheep-UK                   ....---.......................-...............-------.......................................
37809-sheep-UK                   ....---.......................-...............-------.......................................
37813-sheep-UK                   ....---.......................-...............-------.......................................
37815-sheep-UK                   ....---.......................-...............-------.......................................
37808-equine-UK                  ....---.......................-...............-------.......................................
36629-sheep-Spain                ....---.......................-...............-------.......................................
36628-sheep-Spain                ....---.......................-...............-------.......................................
18165-sheep-Peru                 ....---.......................-...............-------.......................................
37821-human-UK                   ....---.......................-...............-------.......................................
37818-human-UK                   ....---.......................-...............-------.......................................
37825-human-UK                   ....---.......................-...............-------.......................................
37829-human-UK                   ....---.......................-...............-------.......................................
16421-human-Peru                 ....---.......................-...............-------.......................................
9870-human-Canada                ....---.......................-...............-------.......................................
19716-alpaca-Peru                ....---.............G.........-...............-------.......................................
35147-goat-Algeria               ....---.......................-...............-------.......................................
18868-chipmunk-USA               ....---.........G.............-.........--AT...------T.............A...........T........
33456-sifaka-USA                 ....---.........G.............-.........--AT...------T.............A...........T........
37822-human-UK                   ....---.........G.............-.........--AT...------T.............A...........T........
37824-human-UK                   ....---.........G.............-.........--AT...------T.............A...........T........
37819-human-UK                   ....---.........G.............-.........--AT...------T.............A...........T........
37202-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
37192-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
37206-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
37191-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
34141-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
37215-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
37201-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
37212-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
29355-human-USA                  ....---.........G.............-.........--AT...------T.............A...........T........
8512-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
8513-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
5397-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
6140-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
8509-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
8469-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
6141-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
8062-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
6143-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
6144-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
8514-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
8510-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
6317-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
7370-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
7163-storm-water-USA             ....---.........G.............-.........--AT...------T.............A...........T........
15529-river-water-USA            ....---.........G.............-.........--AT...------T.............A...........T........
14874-river-water-USA            ....---.........G.............-.........--AT...------T.............A...........T........
18371-eastern gray squirrel-US   ....CTC..G.T.TG........T.............C........C.A...-------.......................................
18370-eastern gray squirrel-US   ....CTC..G.T.TG........T.............C........C.A...-------.......................................
14886-eastern gray squirrel-US   ....CTC..G.T.TG........T.............C........C.A...-------.......................................
14223-beaver-USA                 ....CTC..G.T.TG........T.............C........C.A...-------.......................................
13266-red squirrel-USA           ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37200-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37203-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37204-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37197-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37217-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37193-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
29361-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
8774-human-USA                   ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37196-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37208-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37216-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37209-human-USA                  ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37826-human-UK                   ....CTC..G.T.TG........T.............C........C.A...-------.......................................
37833-human-UK                   ....CTC..G.T.TG........T.............C........C.A...-------.......................................
22508-river-water-USA            ....CTC..G.T.TG........T.............C........C.A...-------.......................................
13264-woodchuck-USA              ....CTC..G.T.TG........T.............C........C.A...-------.......................................
12963-raccoon-USA                ....CTC..G.T.TG........T.............C........C.A...-------.......................................
36641-porcupine-USA              ....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
36642-porcupine-USA              ....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
36638-porcupine via goat-USA     ....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
36639-porcupine via goat-USA     ....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
36640-porcupine via goat-USA     ....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
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17654-human-USA                 .....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
17577-human-USA                 .....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
37211-human-USA                 .....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
17574-human-USA                 .....CTC..G.T.TG..GA....T.............C........C.A...-------.......................................
37640-field mouse-Slovak Repub  ..TGG---.T.A.....---------.T....C.....CA...TA..---------------.......G..T...A...........G.T....GT.
37642-field mouse-Slovak Repub  ..TGG---.T.A.....---------.T....C.....CA...TA..---------------.......G..T...A...........G.T....GT.
37644-field mouse-Slovak Repub  ..TGG---.T.A.....---------.T....C.....CA...TA..---------------.......G..T...A...........G.T....GT.
37646-field mouse-Slovak Repub  ..GGG---.T.A.....---------.T...A..G...CA...T...A---------------.......G..T.................C.....T.
AF114166-C. parvum-gp60 gene    ..TGAAAAT.GCGG.T.TG.GGGTCAG...TCA.C.AGA.CA.....A.CA.T..CAGAGGAAA.C.GT.....T.CT....CCGTC...T.G.TTG...
Clustal Consensus               **              *         * *           ***                       *  ** ** *   ***     *** * *     *

                                         910       920       930       940       950       960       970       980       990       1000
                                ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
36625-sheep-Brazil              TCACCTTAAAGGGTGGTAAAGCCATTAGTGTAGGTGTGCCTGCTGTGGACGATTCAACTAAAAGAGACAAATACAGTTTATCCGCTGATAGCCAAACATT
36624-sheep-Brazil              ......................................................................................................
36623-sheep-Brazil              ......................................................................................................
36630-sheep-Spain               ......................................................................................................
36631-sheep-Spain               ......................................................................................................
36633-sheep-Spain               ......................................................................................................
36627-sheep-Spain               ......................................................................................................
36632-sheep-Spain               ......................................................................................................
36626-sheep-Spain               ......................................................................................................
36634-sheep-USA                 ......................................................................................................
36637-sheep-USA                 ......................................................................................................
37766-sheep-USA                 ......................................................................................................
36636-sheep-USA                 ......................................................................................................
37769-sheep-USA                 ......................................................................................................
37767-sheep-USA                 ......................................................................................................
37768-sheep-USA                 ......................................................................................................
37774-sheep-USA                 ......................................................................................................
37777-sheep-USA                 ......................................................................................................
37776-sheep-USA                 ......................................................................................................
37775-sheep-USA                 ......................................................................................................
37772-sheep-USA                 ......................................................................................................
37773-sheep-USA                 ......................................................................................................
37771-sheep-USA                 ......................................................................................................
6478-blesbok-Czech Republic     ......................................................................................................
6482-nyala-Czech Republic       ......................................................................................................
34023-sheep-China               ......................................................................................................
36737-sheep-China               ......................................................................................................
34022-sheep-China               ......................................................................................................
38161-sheep-Australia           ......................................................................................................
38157-sheep-Australia           ......................................................................................................
38156-sheep-Australia           ......................................................................................................
38154-sheep-Australia           ......................................................................................................
38153-sheep-Australia           ......................................................................................................
38152-sheep-Australia           ......................................................................................................
34049-sheep-China               ......................................................................................................
37635-sheep-Turkey              ......................................................................................................
34043-sheep-China               ......................................................................................................
34047-sheep-China               ......................................................................................................
34055-sheep-China               ......................................................................................................
34011-sheep-China               ......................................................................................................
34038-sheep-China               ......................................................................................................
34044-sheep-China               ......................................................................................................
34032-sheep-China               ......................................................................................................
34060-sheep-China               ......................................................................................................
34048-sheep-China               ......................................................................................................
36745-sheep-China               ......................................................................................................
36785-sheep-China               ......................................................................................................
34025-sheep-China               ......................................................................................................
34034-sheep-China               ......................................................................................................
19141-yak-China                 ......................................................................................................
19142-yak-China                 ......................................................................................................
28682-yak-China                 ......................................................................................................
30241-swamp deer-Nepal          ......................................................................................................
30238-swamp deer-Nepal          ......................................................................................................
30243-swamp deer-Nepal          ......................................................................................................
32563-impala-S.Africa           ......................................................................................................
32560-buffallo-S.Africa         ......................................................................................................
31261-human-Turkey              ......................................................................................................
37828-human-UK                  ......................................................................................................
37830-human-UK                  ...........................-..........................................................................
37827-human-UK                  ......................................................................................................
31570-sheep-Spain               ......................................................................................................
37820-human-UK                  ......................................................................................................
37811-sheep-UK                  ......................................................................................................
37809-sheep-UK                  ......................................................................................................
37813-sheep-UK                  ......................................................................................................
37815-sheep-UK                  ......................................................................................................
37808-equine-UK                 ......................................................................................................
36629-sheep-Spain               ......................................................................................................
36628-sheep-Spain               ......................................................................................................
18165-sheep-Peru                ......................................................................................................
37821-human-UK                  ......................................................................................................
37818-human-UK                  ......................................................................................................
37825-human-UK                  ......................................................................................................
37829-human-UK                  ......................................................................................................
16421-human-Peru                ......................................................................................................
9870-human-Canada               ......................................................................................................
19716-alpaca-Peru               ......................................................................................................
35147-goat-Algeria              ......................................................................................................
18868-chipmunk-USA              ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
33456-sifaka-USA                ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37822-human-UK                  ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37824-human-UK                  ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37819-human-UK                  ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37202-human-USA                 ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37192-human-USA                 ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37206-human-USA                 ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37191-human-USA                 ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
34141-human-USA                 ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
37215-human-USA                 ...................G........C.....C.....A...AACC.A..CGA..G...G.........................A...GGT...
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37201-human-USA                 ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
37212-human-USA                 ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
29355-human-USA                 ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
8512-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
8513-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
5397-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
6140-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
8509-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
8469-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
6141-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
8062-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
6143-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
6144-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
8514-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
8510-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
6317-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
7370-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
7163-storm-water-USA            ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
15529-river-water-USA           ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
14874-river-water-USA           ..................G........C.....C.....A...AACC.A..CGA..G...G...........................A...GGT...
18371-eastern gray squirrel-US  ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
18370-eastern gray squirrel-US  ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
14886-eastern gray squirrel-US  ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
14223-beaver-USA                ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
13266-red squirrel-USA          ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37200-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37203-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37204-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37197-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37217-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37193-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
29361-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
8774-human-USA                  ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37196-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37208-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37216-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37209-human-USA                 ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37826-human-UK                  ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
37833-human-UK                  ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
22508-river-water-USA           ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
13264-woodchuck-USA             ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
12963-raccoon-USA               ..................G................A..A.T.AAC..A..CC.......G...........................A....GT...
36641-porcupine-USA             ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
36642-porcupine-USA             ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
36638-porcupine via goat-USA    ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
36639-porcupine via goat-USA    ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
36640-porcupine via goat-USA    ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
17654-human-USA                 ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
17577-human-USA                 ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
37211-human-USA                 ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
17574-human-USA                 ..................G................A..A.T.AAC..A..CC.......G..............C..G..T.................
37640-field mouse-Slovak Repub  .T.....G..A........GCT.........G.....A..A....ATTC....G....C..G........G....C....AGT..C.............
37642-field mouse-Slovak Repub  .T.....G..A........GCT.........G.....A..A....ATTC....G....C..G........G....C....AGT..C.............
37644-field mouse-Slovak Repub  .T.....G..A........GCT.........G.....A..A....ATTC....G....C..G........G....C....AGT..C.............
37646-field mouse-Slovak Repub  ....T...........C..G..T................A...AAT..A...C.G...TTG........G........GAGT..C....A....G....
AF114166-C. parvum-gp60 gene    .T...C.TG.T.........AGA...GAA..G.C...A..AAAC..C..A...G..T............G........GGTT..A..CGATA..C.T..
Clustal Consensus               * **  *  * ***** **    ***   ** *  ** **          **          ******** ****  **    ** **     *    **
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                                         1010       1020       1030       1040       1050       1060       1070
                                ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|..
36625-sheep-Brazil              CTACACCGGTACTGCTACCAATAGTGGTACTACTAATGGAATCTTCAAATTGAACAATGATGGTGATTTAGT
36624-sheep-Brazil              ...........................................................................
36623-sheep-Brazil              ...........................................................................
36630-sheep-Spain               ...........................................................................
36631-sheep-Spain               ...........................................................................
36633-sheep-Spain               ...........................................................................
36627-sheep-Spain               ...........................................................................
36632-sheep-Spain               ...........................................................................
36626-sheep-Spain               ...........................................................................
36634-sheep-USA                 ...........................................................................
36637-sheep-USA                 ...........................................................................
37766-sheep-USA                 ...........................................................................
36636-sheep-USA                 ...........................................................................
37769-sheep-USA                 ...........................................................................
37767-sheep-USA                 ...........................................................................
37768-sheep-USA                 ...........................................................................
37774-sheep-USA                 ...........................................................................
37777-sheep-USA                 ...........................................................................
37776-sheep-USA                 ...........................................................................
37775-sheep-USA                 ...........................................................................
37772-sheep-USA                 ...........................................................................
37773-sheep-USA                 ...........................................................................
37771-sheep-USA                 ...........................................................................
6478-blesbok-Czech Republic     ...........................................................................
6482-nyala-Czech Republic       ...........................................................................
34023-sheep-China               ...........................................................................
36737-sheep-China               ...........................................................................
34022-sheep-China               ...........................................................................
38161-sheep-Australia           ...........................................................................
38157-sheep-Australia           ...........................................................................
38156-sheep-Australia           ...........................................................................
38154-sheep-Australia           ...........................................................................
38153-sheep-Australia           ...........................................................................
38152-sheep-Australia           ...........................................................................
34049-sheep-China               ...........................................................................
37635-sheep-Turkey              ...........................................................................
34043-sheep-China               ...........................................................................
34047-sheep-China               ...........................................................................
34055-sheep-China               ...........................................................................
34011-sheep-China               ...........................................................................
34038-sheep-China               ...........................................................................
34044-sheep-China               ...........................................................................
34032-sheep-China               ...........................................................................
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34060-sheep-China                 ..................................................................
34048-sheep-China                 ..................................................................
36745-sheep-China                 ..................................................................
36785-sheep-China                 ..................................................................
34025-sheep-China                 ..................................................................
34034-sheep-China                 ..................................................................
19141-yak-China                   ..................................................................
19142-yak-China                   ..................................................................
28682-yak-China                   ..................................................................
30241-swamp deer-Nepal            ..................................................................
30238-swamp deer-Nepal            ..................................................................
30243-swamp deer-Nepal            ..................................................................
32563-impala-S.Africa             ..................................................................
32560-buffallo-S.Africa           ..................................................................
31261-human-Turkey                ..................................................................
37828-human-UK                    ..................................................................
37830-human-UK                    ..................................................................
37827-human-UK                    ..................................................................
31570-sheep-Spain                 ..................................................................
37820-human-UK                    ..................................................................
37811-sheep-UK                    ..................................................................
37809-sheep-UK                    ..................................................................
37813-sheep-UK                    ..................................................................
37815-sheep-UK                    ..................................................................
37808-equine-UK                   ..................................................................
36629-sheep-Spain                 ..................................................................
36628-sheep-Spain                 ..................................................................
18165-sheep-Peru                  ..................................................................
37821-human-UK                    ..................................................................
37818-human-UK                    ..................................................................
37825-human-UK                    ..................................................................
37829-human-UK                    ..................................................................
16421-human-Peru                  ..................................................................
9870-human-Canada                 ..................................................................
19716-alpaca-Peru                 ..................................................................
35147-goat-Algeria                ..................................................................
18868-chipmunk-USA                ...T..T..........G..........GTC....G......A............G.GA.......C.....
33456-sifaka-USA                  ...T..T..........G..........GTC....G......A............G.GA.......C.....
37822-human-UK                    ...T..T..........G..........GTC....G......A............G.GA.......C.....
37824-human-UK                    ...T..T..........G..........GTC....G......A............G.GA.......C.....
37819-human-UK                    ...T..T..........G..........GTC....G......A............G.GA.......C.....
37202-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
37192-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
37206-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
37191-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
34141-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
37215-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
37201-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
37212-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
29355-human-USA                   ...T..T..........G..........GTC....G......A............G.GA.......C.....
8512-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
8513-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
5397-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
6140-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
8509-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
8469-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
6141-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
8062-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
6143-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
6144-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
8514-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
8510-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
6317-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
7370-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
7163-storm-water-USA              ...T..T..........G..........GTC....G......A............G.GA.......C.....
15529-river-water-USA             ...T..T..........G..........GTC....G......A............G.GA.......C.....
14874-river-water-USA             ...T..T..........G..........GTC....G......A............G.GA.......C.....
18371-eastern gray squirrel-US    ...T........A...G.G....C.....C....G....C.G............G.G........C.....
18370-eastern gray squirrel-US    ...T........A...G.G....C.....C....G....C.G............G.G........C.....
14886-eastern gray squirrel-US    ...T........A...G.G....C.....C....G....C.G............G.G........C.....
14223-beaver-USA                  ...T........A...G.G....C.....C....G....C.G............G.G........C.....
13266-red squirrel-USA            ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37200-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37203-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37204-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37197-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37217-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37193-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
29361-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
8774-human-USA                    ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37196-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37208-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37216-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37209-human-USA                   ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37826-human-UK                    ...T........A...G.G....C.....C....G....C.G............G.G........C.....
37833-human-UK                    ...T........A...G.G....C.....C....G....C.G............G.G........C.....
22508-river-water-USA             ...T........A...G.G....C.....C....G....C.G............G.G........C.....
13264-woodchuck-USA               ...T........A...G.G....C.....C....G....C.G............G.G........C.....
12963-raccoon-USA                 ...T........A...G.G....C.....C....G....C.G............G.G........C.....
36641-porcupine-USA               ..................................................G................
36642-porcupine-USA               ..................................................G................
36638-porcupine via goat-USA      ..................................................G................
36639-porcupine via goat-USA      ..................................................G................
36640-porcupine via goat-USA      ..................................................G................
17654-human-USA                   ..................................................G................
17577-human-USA                   ..................................................G................
37211-human-USA                   ..................................................G................
17574-human-USA                   ..................................................G................
37640-field mouse-Slovak Repub    ......T.........GT...C......GG............A..T.........G....G...........
37642-field mouse-Slovak Repub    ......T.........GT...C......GG............A..T.........G....G...........
37644-field mouse-Slovak Repub    ......T.........GT...C......GG............A..T.........G....G...........
37646-field mouse-Slovak Repub    ......T.........G.T..C......G...........G.G..T.........G.........C.....
AF114166-C. parvum-gp60 gene      ...T.....CG.A-------..C..C..C.....C.....TG...A..GG.....TG.GA.C..A..C..G..
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Clustal Consensus          *** ** **  *       * ** **    ** * ***  * *  *  *****  *  * ** ** ** **
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Technical Appendix Figure. Nucleotide alignment of the 60-kDa glycoprotein (gp60) gene of Cryptosporidium ubiquitum. Dots denote nucleotide identity to the sequence of specimen no. 36625, and dashes denote nucleotide deletions.