Pseudogenization of UDP-glucuronosyltransferase (UGT) 1A6 in *Felidae*:

Potential role of diet and evidence for similar events in other carnivore species

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Abstract

Environmental exposure to toxic compounds is proposed to have a major role in the evolution of the drug metabolizing enzymes in animals. In this study, we explored the relationship between the level of exposure to plant-derived phenolic toxins from the diet within the order Carnivora and the accumulation of multiple inactivating genetic mutations (pseudogenization) in the major phenol detoxification enzyme, UDP-glucuronosyltransferase (UGT) 1A6. We found evidence for pseudogenization of the *UGT1A6* gene in all 19 Felidae species studied. Furthermore out of 44 other species evaluated, both brown hyena and Northern elephant seal showed inactivating *UGT1A6* mutations. An exhaustive literature review identified 29 out of 46 species evaluated as hypercarnivores (or true carnivores), which should have minimal exposure to dietary phytotoxins. Importantly, all species with *UGT1A6* defects were hypercarnivores, supporting a critical role for diet in the pseudogenization of *UGT1A6*, and suggesting these species may also be susceptible to pollutant bioaccumulation.

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1 Introduction

1.1 Species differences in drug metabolism and the role of diet in the evolution of genes encoding drug metabolizing enzymes

Great variability has been observed among species with respect to their drug metabolizing capacity. For example, mammalian species have a higher capacity to detoxify drugs compared to non-mammalian species (Gibson & Skett, 2001). One of the mechanisms for this type of interspecies difference in drug metabolism is the loss of ability to express one (or several) of the many enzymes responsible for the metabolism of drugs or xenobiotic compounds. Loss of enzyme expression may have arisen in a species because of a defect in the gene coding a particular enzyme (Gibson & Skett, 2001) that was not under evolutionary selection pressure to be maintained in a functional state (the so-called "use it or lose it" hypothesis).

Drug metabolizing enzymes do not exist solely for the purpose of metabolizing synthetic human-made drugs or toxic compounds. They most likely evolved to metabolize toxic compounds from the environment. One leading theory that has been used to explain the evolution of drug metabolizing enzymes in animals is that they arose in response to the presence of toxins in some plants used for food, thereby enabling a broader selection of foods and a survival advantage for animals consuming them (Court & Greenblatt, 2000). These plant toxins (phytotoxins), in turn, might have evolved in plants as a defense against plant eating animals. In the absence of the need to metabolize phytotoxins as in the case of hypercarnivores whose diet is mainly comprised of animal matter, genes largely responsible for metabolizing these exogenous compounds could become functionless over several generations because of a lack of evolutionary selection pressures. Since planar phenolic compounds represent a significant proportion of toxins found in many plants, and uridine diphosphoglucuronosyltransferase (UGT) 1A6 is the main enzyme detoxifying planar phenolics, inactivating mutations in this gene might be present in species that don't rely on plants as a source of their diet (Court, 2001).

1.2 Glucuronidation and UDP-glucuronosyltransferases (UGTs)

The process of metabolism of most xenobiotics can be divided into two phases. Phase I reactions are oxidation, reduction, hydrolysis, and so on, chemical modifications that can enable Phase II metabolism. Phase II metabolism involves conjugation of compounds with glucuronic acid, sulfate, glycine, cysteine, methyl or acetyl groups. In this way drugs are changed into nontoxic water-soluble products, which are easily excreted (Gibson & Skett, 2001).

Uridine diphosphoglucuronosyltransferases or UDP-glucuronosyltransferases (UGTs) are the group of enzymes responsible for catalyzing glucuronidation, which is one of the most important conjugation reactions in Phase II metabolism. Glucuronidation is an essential pathway to detoxify many xenobiotics, among them many drugs, dietary chemicals, environmental pollutants, chemical carcinogens and endogenous compounds. Thus, UGTs are of toxicological and physiological importance (Miners et al., 2002). UGTs have been classified into families and subfamilies based on gene sequence divergence, with all known UGTs of importance in drug metabolism being included in the UGT 1A, 2A and 2B subfamilies (Mackenzie et al., 1997). The subfamily UGT1 is important in the glucuronidation of bilirubin, xenobiotic amines and phenols (Nagar & Remmel, 2006). UGT1A6 glucuronidates many planar phenolic compounds like acetaminophen (paracetamol) and acetyl salicylic acid (aspirin), while the enzyme UGT1A1 is important for the metabolism of the endogenous compound, bilirubin which is a toxic breakdown product of hemoglobin (Court & Greenblatt, 2000).

1.3 UGT1A6

UGT1A6 is important not only from a pharmacological point of view but is also equally important from a toxicological perspective. The absence or presence of functionality of UGT1A6 which metabolizes xenobiotics is of immense importance in terms of the capacity to minimize the accumulation of toxic products from the environment in the body. If UGT1A6 enzyme function is greatly reduced or becomes dysfunctional in animals living

in the wild, they would be more susceptible to rising levels of phenolic toxins in the environment like polychlorinated biphenyls (PCBs) and bisphenolA. Thus the inactivation of UGT1A6 has implications from the conservation point of view. Specifically the identification of species where this gene is inactive or has very low activity might help identify the species at risk from increasing levels of human made environmental toxic compounds.

The likelihood of having an elaborate and extensive system to metabolize plant toxins should be higher in herbivores, compared with carnivores, which are less likely to be exposed to dietary phytotoxins. In general, herbivores are recognized as possessing a greater capacity to metabolize and eliminate many drugs that are phytotoxin-like chemicals compared with carnivores. This has been found to be true for lagomorphs (rabbits), that have purely herbivorous ancestors, and are still herbivores in the wild and in captivity. Due to extensive gene duplications they have a very complex pattern of drug metabolizing genes. For example, they possess at least 5 gene copies of the important glucuronidation enzyme, UGT1A6 (Q. Li et al., 2000). In contrast, it has been shown that multiple mutations are present in the *UGT1A6* sequence of cat (*Felis catus*) and margay (*Felis wiedii*), representative species of the family Felidae, both of which are considered carnivores (Court & Greenblatt, 2000).

1.4 Pseudogenes and UGT1A6

Pseudogenization is the process by which a functional gene becomes non-functional or a pseudogene (Go et al., 2005). A pseudogene is a sequence of DNA that is very similar to a normal gene but has been altered slightly such that it is non-functional (Cohen & Givol, 1983). These genes develop different nucleotide sequences, insertion or deletion at some crucial points resulting in the formation of a premature stop codon compared to the paralogous functional gene. It might form by duplication of genomic DNA or by retrotransposition (Mighell et al., 2000). It might not be able to transcribe or translate and even if the protein is produced it might not be functional. Court and Greenblatt (2000) showed that *UGT1A6* is a pseudogene in domestic cat and margay with delete-

rious genetic mutations and is unlikely to produce a functional enzyme.

Most animals form glucuronides as major metabolites of acetyl salicylic acid (aspirin), chloramphenicol, benzoic acid, morphine, and acetaminophen (Jernigan, 1989). About 4 decades ago, it was recognized that domestic cats differed significantly from other mammals in the ability to form glucuronide conjugates of certain xenobiotics, particularly low molecular weight phenolic compounds (Court & Greenblatt, 1997). Similar observations were made for lions (*Panthera leo*), African civets (*Viverra civetta*), spotted hyenas (*Crocuta crocuta*) and forest genets (*Genetta pardina*) (Hartiala, 1954; Capel et al., 1974; French et al., 1974; Caldwell et al., 1975; Court & Greenblatt, 2000). Thus phenolic drugs that require glucuronidation for metabolism and excretion may be toxic to these animals. One example is the toxicity of the standard phenolic analgesic acetaminophen (e.g. Tylenol®) and acetyl salicylic acid (aspirin) in cats (Court & Greenblatt, 1997). Knowledge of species differences in drug metabolism is specially important in the field of veterinary medicine in which a drug beneficial to one species might be harmful to the other because of interspecies difference in drug metabolizing capacity.

Although, to date, all species shown to have inactivating mutations in the *UGT1A6* gene including cat, margay, puma, Florida panther, and serval are hypercarnivores (or "true carnivores") (Court & Greenblatt, 2000), but not all hypercarnivores appear to have developed adverse *UGT1A6* gene mutations. For example, the domestic ferret, which could be considered a representative hypercarnivore, shows slow glucuronidation of acetaminophen which is comparable to that of a cat, but no deleterious mutations could be identified in the *UGT1A6* gene (Court, 2001). Consequently, factors in addition to diet such as stressors which contribute to population decline and genetic bottlenecking may have played a role in the development of *UGT1A6* mutations in hypercarnivores, like the Felidae. However, as yet, not all Felidae and very few other carnivore species have been evaluated for the presence of *UGT1A6* mutations. Consequently, in this study, we expanded our search for *UGT1A6* mutations to include almost all Felidae and representative species from the order Carnivora (Aim 1).

1.5 Carnivora diets

In order to substantiate the role of exposure (or lack of exposure) to dietary phytotoxins in the process of pseudogenization of *UGT1A6* , it is important to know the natural dietary preferances of the animals of interest. Most animals belonging to the order Carnivora are on higher food chain. According to Bininda-Emonds et al. (1999), there are 271 extant species of Carnivora. However, not all Carnivora are carnivores ("meat eaters") and the relative content of animals and plants in the diet differs between species. For our purposes, Carnivora could be classified as hypercarnivores (or true carnivores), generalist carnivores (or omnivores) and hypocarnivores (or herbivores). However, studies defining the natural dietary habits of these species seem to be lacking. Consequently, in this study, we wanted to classify the species in the order Carnivora based on the relative amounts of animal and plant matter they consumed in their natural diet (Aim 2).

While evolving into their dietary niche, ancestors of the domestic cat, and probably other Felidae seem to have adopted a highly carnivorous diet. Cats require nutrients from animal tissues to meet their nutritional requirements and have a very high protein requirement relative to most other species (Jernigan, 1989). Cats cannot synthesize taurine from cysteine, vitamin A from carotene, or arachidonate from lineolate. Cats also require the amino acids arginine and methionine in their diet (Q. Li et al., 2000). These specific amino acid requirements of cats may have evolved as a consequence of the fact that their natural diet contains an abundance of each of these specific amino acids because of which the biosynthetic pathway was no longer needed in them.

1.6 Hypothesis and specific aims

In this research we planned to test the hypothesis that species with a defective *UGT1A6* gene, as indicated by the presence of multiple inactivating genetic mutations, are hypercarnivores. We had two specific aims to enable us to test this hypothesis.

Aim 1. To identify species with defective *UGT1A6* by sequencing of *UGT1A6* exon1 and

then correlate it with the animal's diet. Unlike *UGT1A6*, *UGT1A1* is responsible for the glucuronidation of endogenously generated compounds like bilirubin. So according to the hypothesis, there should be no difference in functionality and presence of inactivating gene mutations for *UGT1A1* between hypercarnivores and other species.

Aim 2. To identify hypercarnivores, primarily within the order Carnivora, through literature review. The aim of this study was to identify and classify species of interest based on their diet . We could then correlate this dietary classification of species with the pseudogenization of *UGT1A6* exon 1.

2 Materials and Methods

2.1 Sources of genomic DNA

Table 1 lists the type and source of samples used in this study to obtain genomic DNA (gDNA). Liver tissue from Indian mongoose *Herpestes javanicus* was collected in Hawaii by Dr. Michael Reed of Tufts Biology Department, stored in dry ice and shipped to our laboratory for storage at $-80\,^{\circ}$C. Blood samples were collected from 17 different species, preserved in EDTA, and stored at $-80\,^{\circ}$C. The genus and species names follow that of Nowak (2005, 2003). gDNA samples of 18 species were obtained from Dr. Melody Roelke and Dr. Stephen O' Brien (Laboratory of Genomic Diversity, National Cancer Institute (NCI), Frederick, MD, USA).

2.2 Genomic DNA extraction

gDNA was isolated from liver tissue by using DNAzol Reagent (Life Technologies, Inc., Grand Island, NY, USA, Cat. No. 10503- 027) according to the manufacturer's instruction. A spin column technique was used for gDNA extraction from blood samples preserved in EDTA with the QIA amp DNA Blood Mini Kit (Qiagen, Valencia, CA, USA, Cat no. 51104). The concentration of extracted DNA was measured using a NanoDrop ND-1000 UV-Vis Spectrophotometer (NanoDrop Technologies, Wilmington, Delaware USA.).

2.3 Design of polymerase chain reactions primers

All available *UGT1A1* and *1A6* exon 1 gene sequences of different mammalian species available in the GenBank database were downloaded and aligned to design *UGT1A1* and *UGT1A6* specific PCR primers. The DNA regions within and outside the exon 1 coding regions of the *UGT1A1* or *1A6* DNA which are highly conserved between species and yet different than other UGTs were selected so as not to amplify genes other than *UGT1A1* or *UGT1A6*. Oligonucleotide primers were synthesized by the Tufts Core

Facility at Tufts University, Boston, MA using a DNA synthesizer (ABI 394 and an Expedite 8909). Table 2 lists all PCR primers used in this study.

Table 1: *Source of gDNA used in the study*

Code name	Common name	Scientific name	Source of samples
	Blood samples		
Abi	Binturong	*Arctictis binturong*	Southwick's Zoo, Mendon, MA
Ccr	Spotted hyena	*Crocuta crocuta*	Tufts-SAH, North Grafton, MA
Plo	Raccoon	*Procyon lotor*	Tufts-Wildlife Clinic, North Grafton, MA
Uth	Asiatic black bear	*Ursus thibetanus*	Roger Williams Park and Zoo, Providence, RI
Uma	Polar bear	*Ursus maritimus*	Roger Williams Park and Zoo, Providence, RI
Rew	Red wolf	*Canis rufus*	Roger Williams Park and Zoo, Providence, RI
Cbr	Maned wolf	*Chrysocyon brachyurus*	White Oak Conservation Center, Yulee, FL
Fcn	Canada lynx	*Felis canadensis*	Tufts-Wildlife Clinic, North Grafton, MA
Fru	Bobcat	*Felis rufus*	Ecotarium, Worcester, MA
Fse	Serval	*Felis serval*	Tufts-SAH, North Grafton, MA
Fcc	Mountain lion	*Felis concolor*	Tufts Wildlife Clinic,, North Grafton, MA
Fc2	Florida panther	*Felis concolor coryi*	White Oak Conservation Center, Yulee, FL
Pti	Tiger	*Panthera tigris*	White Oak Conservation Center, Yulee, FL
Pun	Snow leopard	*Panthera uncia*	Roger Williams Park and Zoo, Providence, RI

Continued ...

Table 1: (continued)

Aju	Cheetah	*Acinonyx jubatus*	White Oak Conservation Center, Yulee, FL
	Tissue sample		
Hja	Mongoose	*Herpestes javanicus*	Dr. Michael Reed, Hawaii
	Extracted gDNA samples		
Vvu	Red fox	*Vulpes vulpes*	Tufts-Wildlife Clinic, North Grafton, MA
Cci	African civet	*Civettictis civetta*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Pbr	Brown hyena	*Parahyaena brunnea*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Pcr	Aardwolf	*Proteles cristatus*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Afu	Lesser red Panda	*Ailurus fulgens*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Fte	Asiatic golden cat	*Felis temminckii*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Fau	African golden cat	*Felis aurata*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Fbe	Leopard cat	*Felis bengalensis*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Fco	Pampas cat	*Felis colocolo*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Fge	Geoffroy's cat	*Felis geoffroyi*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Fti	Little spotted cat	*Felis tigrinus*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Ppa	Leopard	*Panthera pardus*	Laboratory of Genomic Diversity, NCI, Frederick, MD

Continued ...

Table 1: (continued)

Pon	Jaguar	*Panthera onca*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Ple	African lion	*Panthera leo*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Cur	Northern fur seal	*Callorhinus ursinus*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Afo	Southern fur seal	*Arctocephalus forsteri*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Pho	New Zealand sea lion	*Phocarctos hookeri*	Laboratory of Genomic Diversity, NCI, Frederick, MD
Man	Northern elephant seal	*Mirounga angustirostris*	Laboratory of Genomic Diversity, NCI, Frederick, MD

2.4 Polymerase Chain Reaction (PCR) and sequencing of genomic DNA

For most PCR reactions, Platinum PCR SuperMix or Platinum PCR SuperMix High Fidelity (Invitrogen, CA, USA), which contains all components except DNA, and primers were used according to the manufacturer's instruction. A mixture of separate PCR components (Table 3) was also prepared and used for some reactions.

Optimization of PCR reaction conditions was attempted using first gradient PCR and then touchdown PCR. Gradient PCR was for selected gDNA samples using annealing temperatures ranging from 50 °C to 72 °C in a thermal cycler (PTC200; MJ Research, Waltham, MA, USA). This worked only for some samples. Touchdown PCR (GeneAmp PCR System 9600, PE Applied Biosystems) was then used, which successfully amplified *UGT1A6* exon 1 and *UGT1A1* exon 1 in most of the study species.

The method used for touchdown PCR was denaturation at 95 °C for 10 min; then each cycle consisted of 15s or 30s of denaturation at 95 °C and then annealing at 60 °C to 45 °C for the first 30 cycles (decreasing by 0.5 °C per cycle) followed by 45 °C for the next 15 cycles; with extension at 72 °C for 1 minute at every cycle. A final cycle of 10 minute extension at 72 °C was also used. For optimization of some PCR reactions that amplified *UGT1A1*, up to 3 uL of 50mM MgS0$_4$ was added to the PCR mix. Table 4 lists primer pairs that were able to amplify the indicated sequences of the study species.

Table 4: *PCR primers that successfully amplified UGT1A6 and UGT1A1*

Species	UGT1A6 (Primer)	UGT1A1 (Primer)
Canada lynx	447-448; 449-450	490-491
Bobcat	447-448; 449-450	467-468 490-491
Serval	447-448	467-468; 490-491
Asiatic golden cat	473-450	490-491
African golden cat	473-450; 473-448	490-491
Leopard cat	473-450	490-491
Pampas cat	476-474	490-491
Geoffroy's cat	473-450	490-491
Little spotted cat	473-450	490-491
Margay	447-448; 449-450;476-477	467-468; 490-491
Mountain lion	447-448; 449-450	490-491
Florida panther	447-448; 449-450	490-491
Tiger	449-450	467-468
Snow leopard	476-477; 476-450; 476-475; 449-477	467-468; 490-491
Leopard	449-450	490-491
Jaguar	449-450	490-491
African lion	476-450; 473-450	490-491
Cheetah	447-448; 449-450	467-468; 490-491
Ferret	[a]	467-468
Binturong	447-448; 449-450; 473-474	467-468
African civet	476-474	490-491
Spotted hyena	447-448; 449-450; 473-450	490-491
Brown hyena	476-474; 447-448	490-491
Aardwolf	476-474; 473-474	490-491
Mongoose	449-450	490-491
Raccoon	447-448; 473-448	467-468

Table 4: (continued)

Lesser red panda	476-474	[b]
Asiatic black bear	447-448	467-468
Polar bear	447-448	467-468
Red wolf	447-448; 449-450	467-468
Maned wolf	447-448	467-468; 490-491
Red fox	447-448	467-468
Northern fur seal	[b]	490-491
Southern fur seal	[b]	490-491
New Zealand sea lion	[b]	490-491
Northern elephant seal	473-450; 447-448	490-491
Dog	449-450	467-468; 490-491

[a] *Not evaluated since sequence known (GenBank accession AF333815*)

[b] *None of the primer pairs were successful*

2.4.1 Analysis of PCR product

DNA was analysed by agarose gel electrophoresis with 1.2 % agarose (Fisher Chemical) in 1X TAE buffer or 1X Sodium boric acid buffer and ethidium bromide solution ((10 mg/ ml), Sigma, St. Louis, MO, USA). A 100bp DNA sizing ladder (Invitrogen, CA, USA) was used to estimate the size of PCR product. PCR products that showed a single band of the expected size were then sequenced.

2.4.2 Preparation of PCR product for sequencing

2uL of ExoSap-IT (USB, Cleveland, Ohio, USA) was mixed with 5uL of the PCR product. Then the mixture was incubated in a water bath at 37 °C for 15 minutes and then at 80 °C in hot block for 15 minutes. Sample was then stored at 4 °C until sequenced. This

method was used to prepare the PCR product for sequencing by degrading the primers and the dNTPs which would interfere with the sequencing reaction.

2.4.3 DNA Sequencing

The PCR products were sequenced by the DNA Sequencing Facility at Tufts University, Boston, MA, USA using a cycle sequencing technique with dye terminator chemistry and an automated DNA sequencer (ABI 3100, Foster City, CA, USA). DNA sequences were confirmed as being from *UGT1A1* and *UGT1A6* by sequence alignment and molecular phylogenetic analysis using Clustal W (Vector NTI 9.0) with all available *UGT1A1* and *UGT1A6* sequences.

2.4.4 *UGT1A1* and *UGT1A6* sequences from the Genbank database

All available *UGT1A1* and *UGT1A6* exon 1 sequences were downloaded from the Genbank database. The GenBank accession numbers are as follows:

1. AF104339 (UGT1A1); AF104337(UGT1A6)- Crab-eating macaque
2. DQ052657(UGT1A1); BC019861(UGT1A6)- Chimpanzee
3. M84125 (UGT1A1); M84130 (UGT1A6)- Human
4. AF093878 (UGT1A1); U09930(UGT1A6a); AY22719(UGT1A6b)- House mouse
5. U09030(UGT1A6)- Rabbit
6. AB008677(UGT1A6)- Cattle
7. AB018477(UGT1A6)- Sheep
8. D38065 (UGT1A1); D38061 (UGT1A6)- Norway rat
9. AF039137 (UGT1A1); AF064085(UGT1A6P)- Cat
10. NM 001003078(UGT1A6)- Dog
11. AF333815 (UGT1A6)- Ferret
12. AF177922(UGT1A6P)- Margay

2.5 Initial UGT sequence alignment and translation analysis

The Vector NTI WorkGroup 9.1 Data Management Software (Invitrogen, Carlsbad, CA) was used for initial sequence analysis. Clustal W, a multiple sequence alignment program and a component of Vector NTI was first used to align the DNA sequences, which helped to identify possible insertion or deletion mutations in the *UGT1A1* and *UGT1A6* exon 1 coding regions of the species under study with reference to the species with known functional sequences. This program was also used to perform translation analysis to identify possible premature stop codons.

2.6 Phylogenetic tree construction

All the *UGT1A1* and *UGT1A6* sequences were then aligned manually using Clustal X before phylogenetic analysis using PAUP. Human *UGT1A9* (GenBank accession number NM021027) was used as an outgroup. Phylogenetic trees were created using PAUP* Version 4.0b10 for 32-bit Microsoft Windows PAUP (Swofford, 2003). Neighbor- joining trees were constructed using the default parameters for the program. Sequence identity was confirmed and the phylogenetic relationship was obtained between species based upon the topology of the resultant tree.

2.7 Literature study

An exhaustive search of the scientific literature was conducted between December 2005 and June 2006 to classify the Carnivora based on their diet and also to identify potential species of interest for *UGT1A6* and *UGT1A1* sequence analysis. Literature reviewed included published papers, text books and various internet sources.

Search engines and other sources used for finding the relevant information were as follows-

1. Google scholar- Search engine
2. BIOSIS Previews- Article Databases
3. http://www.blackwell-synergy.com
4. BioOne- Electronic Journals Collection

5. Cambridge journals online
6. Scopus.com
7. References cited in published journals

The key words used in the different search engines included- "carnivore diet/s", "carnivore feeding ecology", "felid diet", "carnivore nutrition", "carnivore food", and "hypercarnivory".

Since very few published papers included both plant and animal consumption information, other sources of information available on the web were also searched including zoo diet, commercial feed composition, and information on animal diets posted on university web pages. Insects were considered to be animal matter.

Table 2: *Oligonucleotide primer sequences*

PrimerID	Sequence 5' to 3'	Primer Type[a]	Primer position (bp)
	Primers for UGT1A6 exon1[b]		
PRI 447	TRGGKGACARGCTKCTGGTGGTYC	F	74 to 97
PRI 448	TYRARCACAAARTCRTAYYKTAASAGCCA	R	746 to 774
PRI 449	GGGCAAAATTCAGAGCCAGGAGAGGTAG	F	-145 to -118
PRI 450	CAAAGAGCCAAATGCACGAGGGA	R	921 to 943
PRI 473	GCAGCCCTGAAGCTGAGAGATCG	F	-73 to -51
PRI 474	ACTGACCTGAGACAGGACTCC	R	835 to 855
PRI 475	ACACACAGAGCGATCAAATGAGAAACC	R	861 to 886
PRI 476	GCTGGTGTCAGAGGTCAATCTGCTTC	F	174 to 199
PRI 477	CTGGTCTGGGATACTCGAACACAAAGTC	R	761 to 788
	Primers for UGT1A1 exon1[c]		
PRI 467	CCHRTRGATGGMAGCCACTGGC	F	100 to 121
PRI 468	GGGCCTRGRGTAATCYTTBACAAAGTC	R	775 to 801
PRI 490	GARGAVSTWCCCYGTSCCATTCC	F	228 to 250
PRI 491	CAAGKGDYBCATABGGGGARTAAACC	R	675 to 700

Nucleotide Codes: A= Adenine, T= Thymine, G= Guanine, C= Cytosine.

Degenerate nucleotide codes: R=AG, Y=CT, M=AC, K=GT, S=CG, B=CGT, D=AGT, H=ACT.

[a]*F is 5' or forward primer and R is 3' or reverse primer.*

[b]*Primer position with reference to the cat gDNA UGT1A6 sequence (GenBank Accession No.: AF064084.2). Nucleotide positions are relative to adenine of start codon (ATG) of cat UGT1A6P exon1 located at nucleotide position 315 bp of AF064084.2*

[c]*Primer position with reference to human gDNA UGT1A1 exon 1(GenBank Accession No.: M84125). Nucleotide positions are relative to adenine of start codon (ATG) of human UGT1A1 exon1 located at nucleotide position 85 bp of M84125.*

Table 3: *PCR reaction constituents in 200uL PCR tube*

Item	
PCR water	17.9uL
dNTP (10uM)	0.5uL
$MgCl_2$ (50uM)	1uL
PCR Buffer (10X)	2.5uL
Platinum *Taq* DNA Polymerase	0.1uL
Forward primer (5 pmoles / uL)	1uL
Reverse primer (5 pmoles / uL)	1uL
10-20 ng genomic DNA	1uL

3 Results

3.1 Comparative sequence analysis of *UGT1A6* and *UGT1A1* exon1 region in Felidae and representative Carnivora species

3.1.1 *UGT1A6* exon 1 sequences

The *UGT1A6* exon 1 sequence could be determined for all species except Southern fur seal, Northern fur seal, and New Zealand sea lion (all in the family Otariidae). Figure 1 (top) shows a portion of the Clustal W alignment of *UGT1A6* exon1. Figure 1 (bottom) shows the protein sequence generated with virtual translation of *UGT1A6* in Vector NTI including the corresponding position of the premature stop codon TGA first identified in the domestic cat.

Brown hyena and Northern elephant seal were the only species apart from the Felidae that showed premature stop codons. We had two individual brown hyena samples and both showed the premature stop codon at the same site as in the Felidae shown in Figure 2. However, we don't know if they represent the same subpopulation (related individuals) or come from different populations. Figure 3 is the DNA sequence chromatogram showing the position of the premature stop codon found in brown hyena. No other mutations were found in either brown hyena. The Northern elephant seal did not have this particular stop codon. Instead, as shown in Figure 4, the Northern elephant seal *UGT1A6* sequence showed an insertion of one nucleotide compared with other sequences. This resulted in a reading frame shift (Figure 7) with a premature stop codon about 40 amino acids after the shift. To see whether this was the only mutation, we manually removed the nucleotide inserted and repeated the translation. This corrected the amino acid mismatches (Figure 7), but also showed an "in-frame" stop codon at a position that is a tyrosine (Y) amino acid in human UGT1A6 (Figure 6).

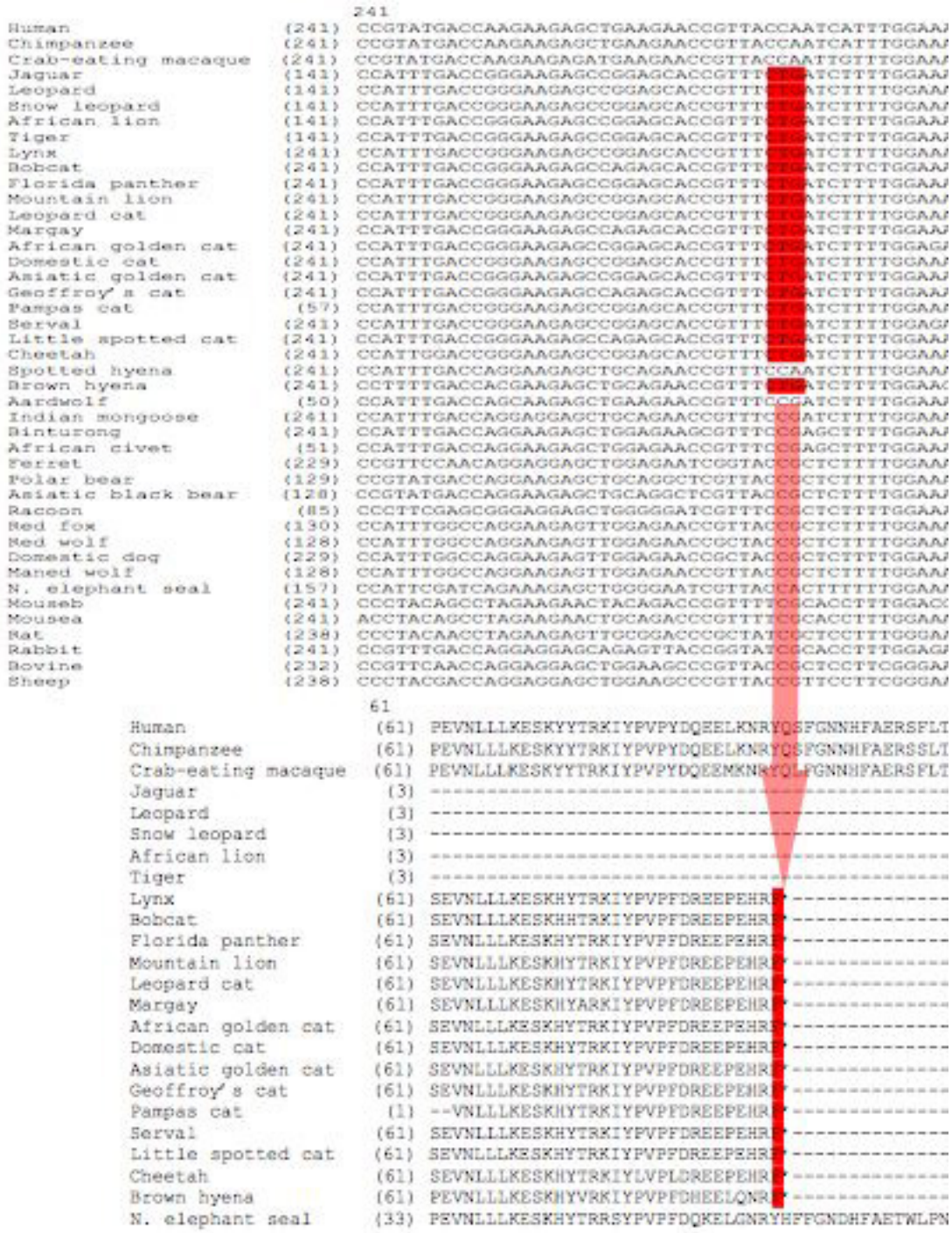


Figure 1: *Clustal W alignment of a segment of UGT1A6 exon 1 nucleotide sequence showing the stop codon TGA (top) and corresponding amino acid sequence (bottom) showing the position of the premature stop codon (*) . The nucleotide positions are relative to the start codon adenine of ATG in human and amino acid sequence positions are relative to the start translation methionine of human UGT1A6 sequence.*

```
                    251
Human       (251)  AAGAAGAGCTGAAGAACCGTTACCAATCATTTGGAA
Cat         (251)  GGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAA
B.Hyena1    (251)  ACGAAGAGCTGCAGAACCGTTTCTGATCTTTTGGAA
B.Hyena2    (251)  ACGAAGAGCTGCAGAACCGTTTCTGATCTTTTGGAA
```

Figure 2: *Clustal W alignment of UGT1A6 exon 1 nucleotide sequence of two individual brown hyenas aligned with cat and human sequence shows the premature stop codon TGA in brown hyena at the same position as in cats. The nucleotide positions are relative to the start codon ATG in humans.*

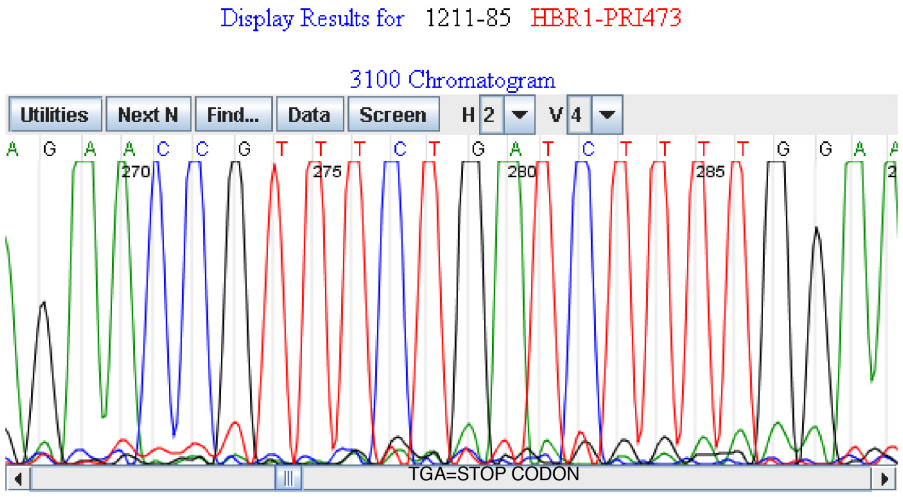


Figure 3: *Chromatogram showing the premature stop codon TGA in a brown hyena.*

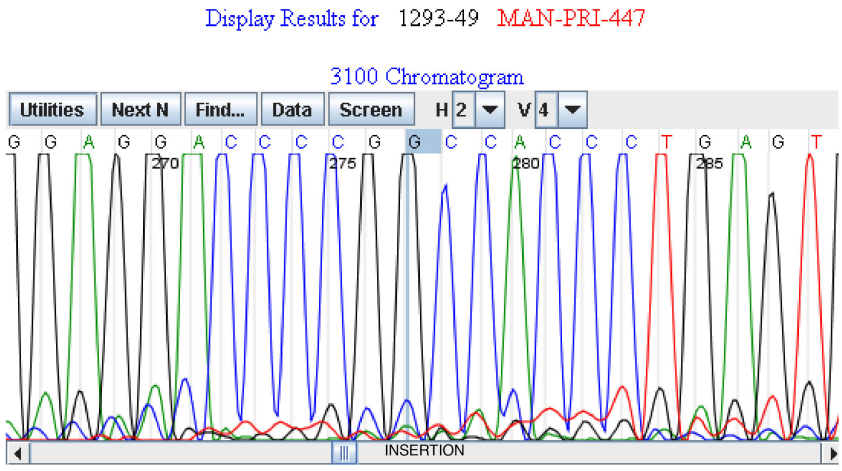


Figure 4: *Chromatogram of UGT1A6 exon1 of Northern elephant seal showing location of a single nucleotide insertion (highlighted nucleotide is same as that highlighted in figure 5)*

```
                                    388
Human                        (388)  CTGCAGGACAGGG-ACACCCTGAACT
Northern elephant seal       (304)  CTGGAGGACCCCGGCCACCCTGAGTG
```

Figure 5: *UGT1A6 exon 1 of Northern elephant seal showing position of a single nucleotide insertion compared to that of human. The nucleotide positions are relative to the start codon ATG in humans. The exact nucleotide inserted is not known since there appears to be other substitutions in this region.*

```
                                                          150
Human                              NCQSLLQDRDTLNFFKESKFDALFTD
N.E.Seal(Insertion removed)        NCQSLLEDPATLSVLRESKFDALFTE
N.E.Seal                           NCQSLLEDP***GHPECPQGEQVRCPFHR***
                                              ⇧Frameshift
```

Figure 6: *Alignment of amino acid sequence of Northern elephant seal and human. N. E. seal (Insertion removed) denotes the N. E. seal sequence translated after the nucleotide insertion (Figures 4 and 5) was manually removed. Amino acids positions are relative to the start translation methionine of human UGT1A6. Bold and italicized portion of N. E. seal represent the unmatching sequence which is caused by the frameshift mutation.*

Figure 7: *Alignment of amino acid sequence of Northern elephant seal and human. N. E. seal (insertion removed) denotes the N. E. seal sequence translated after the nucleotide insertion was manually removed. Amino acid sequence positions are relative to the start translation methionine of human UGT1A6. Note the presence of 2 premature stop codons (*) in N. E. seal sequence caused by the frame shift. However, even if the nucleotide insertion is removed, an in-frame premature stop codon (*) is present in N. E. seal (insertion removed) sequence.*

Table 8 shows the position, number and type of mutations observed in the *UGT1A6* exon 1 of felids, Northern elephant seal and brown hyena. In contrast to the brown hyena which only showed one mutation (stop codon), multiple mutations were observed in all the Felids and the Elephant seal consistent with this gene being a pseudogene in those species. Note that *UGT1A6* exon1 sequence of pampas cat in Table 8 is incomplete in that we were only able to sequence from bp 118 to bp 836.

Table 5: *Mutations observed in UGT1A6 exon 1 in Felidae, brown hyena and Northern elephant seal.*

Species	100bp deletion resulting in stop codon TGA (bp9-108)	Stop codon TGA (bp274-276)	4bp deletion (bp361-364)	Stop codon TAG (bp379-381)	1bp deletion (bp399-399)	1bp insertion (bp401-401)	Stop codon TAA (bp643-645)	9bp deletion (bp661-669)	1bp deletion (bp675-675)	Stop codon TGA (bp688-690)	2bp insertion (bp692-693)	1bp insertion (bp769-769)	1bp deletion (bp826-826)
Human													
Chimp.													
Crab eating macaque													
African lion	+	+		+	+			+	+				
Leopard	+	+		+	+			+	+				
Jaguar	+	+		+	+			+	+			+	
Tiger	+	+		+	+			+	+				
Snow leopard	+	+		+	+			+	+				
Fl. panther		+	+	+	+			+	+				
Mountain lion		+	+	+	+			+	+				
Cheetah		+		+	+			+	+				
Pampas cat	**?**	+		+	+			+	+			+	+
Geoffroy's cat		+		+	+			+	+				
Little spotted cat		+		+	+			+	+				
Margay		+		+	+			+	+				
African golden cat		+		+	+			+	+				
Serval		+		+	+			+	+		+		
Domestic cat		+		+	+			+	+				+
Lynx		+		+	+			+	+				
Bobcat		+		+	+			+	+				
Asiatic golden cat		+		+	+			+	+				
Leopard Cat		+		+	+			+	+				+
Brown hyena		+											
Northern elephant seal						+	+			+			

+ denotes the presence of mutation.

Nucleotide positions are relative to start codon ATG of human UGT1A6 exon1 (GenBank accession no.- M84130).

For pampas cat, it was only possible to evaluate sequences between bp 118 to bp 836.

3.1.2 *UGT1A1* exon 1 sequences

The *UGT1A1* exon 1 sequence could be determined for all species except for the lesser red panda. Sequence abnormalities were not detected in any of the *UGT1A1* sequences evaluated, which is consistent with the importance of this enzyme in glucuronidation of endogenous compounds (Figure 8).

```
                          351                                                   420
Human                (345) AATAAAAAAGGACTCTGCTATGCTTTTGTCTGGCTGTTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Chimpanzee           (345) AATAAAAAAGGACTCTGCTATGCTTTTGTCTGGCTGTTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Crab-eating macaque  (345) AATAAAAAAGGACTCTGCTATGCTTTTGTCTGGCTGTTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Jaguar                (46) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
Leopard               (40) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
Snow leopard          (63) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
African lion          (53) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
Tiger                (202) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
Lynx                  (52) GGTCAAGAAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTTATGGCC
Bobcat                (62) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Florida panther       (79) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Mountain lion         (76) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Leopard cat           (67) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTGCTGTACGACGAGGAACTGATGGCC
Margay                (52) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
African golden cat    (60) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Domestic cat         (345) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Asiatic golden cat    (57) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Geoffroy's cat        (64) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Pampas cat            (60) GGCCAAGAAGGACTCTGCTCGGTTTTTGTCTGCCTGCTCCCACTTACTGAACAACGAGAAGTTGAGGGCC
Serval                (80) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Little spotted cat    (53) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Cheetah               (79) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Spotted hyena         (71) AATCAAGAAGGACTCTGCTCTGCTTTTTTCTGCCTGCTCCCACCTACTGCACAACCAGGAGCTGATGGCC
Brown hyena           (76) AATCAAGAAGGACTCTGCTCTGCTTTTTTCTGCCTGCTCCCACCTACTGCACAACCAGGAGCTGATGGCC
Aardwolf              (65) GATCAAGAAGGACTCTGCTCTGCTTTTTTCTGCCTGCTCCCACCTACTGCACAACCAGGAGCTGATGGCC
Indian mongoose       (68) AATCCAGAAGGACTCTGCTCTGCTGTTTTCGGCCTGCTCCCACCTCCTGCACAACGAGGAGCTGATGGCT
Binturong            (202) GGTCAAGAAGGACTCTGCTCTGCTCTTCTCTGCCTGCTCCCACCTGCTGCACAACAAGGAGCTGATGGCC
African civet         (74) TGTACAGAAGAGCTCCGCTCTGCTTTTCTCTGCCTGCTCCCACTTGCTGCACAACAAGGAGCTGATGGCC
Ferret               (204) AGTCAAGGAGGACTCTGCCCTGATTTTTTCTGCCTGCTCCCACTTATTGCACAACAAGGAACTTATGGCC
Polar bear           (206) AGTCAAGGAGGACTCTGCCCTGATTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Asiatic black bear   (206) AGTCAAGGAGGACTCTGCCCTGATTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Racoon               (205) AGTCAAGAAGGACTCTGCCCTGCTTTTTTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTTATGGCC
Red fox              (203) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
Red wolf             (204) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
Domestic dog         (345) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
Maned wolf           (203) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
Southern fur seal     (42) AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
Northern fur seal     (55) AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
N. Z. sea lion        (43) AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
N. elephant seal      (68) AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
House mouse          (345) AGTCAAAAGGGATTCCAGTATGCTCCTAGCTGGCTGCTCCCACCTGCTGCACAATGCCGAGTTTATGGCC
Rat                  (351) AGTCAAAAGGGACTCCAGTATGCTGCTGTCTGGCTGCTCCCACCTTCTGCACAATGCCGAGTTTATGGCC
```

Figure 8: *Clustal X alignment of UGT1A1 exon 1 nucleotide sequence. No DNA sequence abnormalities were found.*

3.1.3 Phylogenetic analysis

Figure 9 and 10 show the molecular phylogenetic trees as neighbor joining trees generated using PAUP* Version 4.0b10 for 32-bit Microsoft Windows PAUP (Swofford, 2003) based

on the trimmed DNA sequence alignments.

The general topology of both *UGT1A1* and *UGT1A6* trees were similar to each other and were consistent with currently accepted phylogenetic relationships (Johnson et al., 2006). The only exceptions were ferret *UGT1A6* which was clustered with N. E. seal *UGT1A6* rather than with raccoon *UGT1A6* (as for *UGT1A1*).

3.2 Classification of Carnivora species based on their diet

3.2.1 Literature review

The purpose of this review was to classify representative species in the order Carnivora based on their natural diet. In particular, we wanted to identify those species with a diet consisting primarily of animals with little or no plant material, previously referred to as "hypercarnivores". We focused on all Felidae species, as well as Carnivora species for which we had DNA available for sequence analysis. The first step was to identify available literature that quantitatively reported the proportion of plant and animal matter these species consumed. However, while conducting the search we found a general lack of quantitative information for many of the species. For most Carnivora species where information was available, they only reported the different types of animals consumed and did not quantify the amount of plant material. Only 2 papers were found that reported the animal and plant matter the species consumed (expressed as a percent of total biomass) (Table 6). Although there were many more papers identified involving more species than the ones listed in Table 6, which addressed the types of plant and/ or animal matter consumed, it was not possible to convert the measurements used to a percent biomass estimate. So, reports that used units other than percent biomass were not included in Table 6, but are given in Table 8.

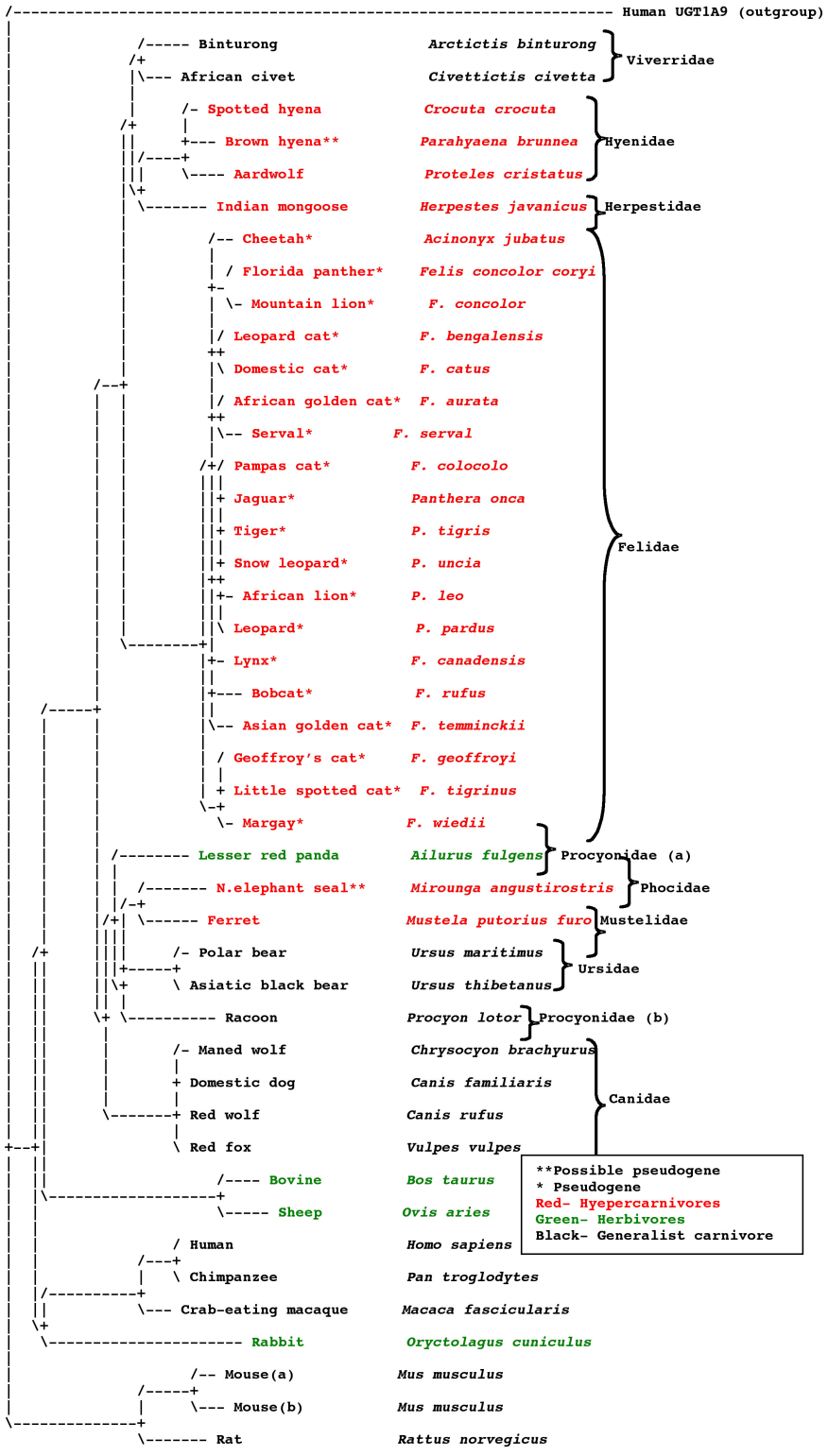


Figure 9: *Neighbor- joining tree (PAUP) of UGT1A6 exon 1 nucleotide sequence*

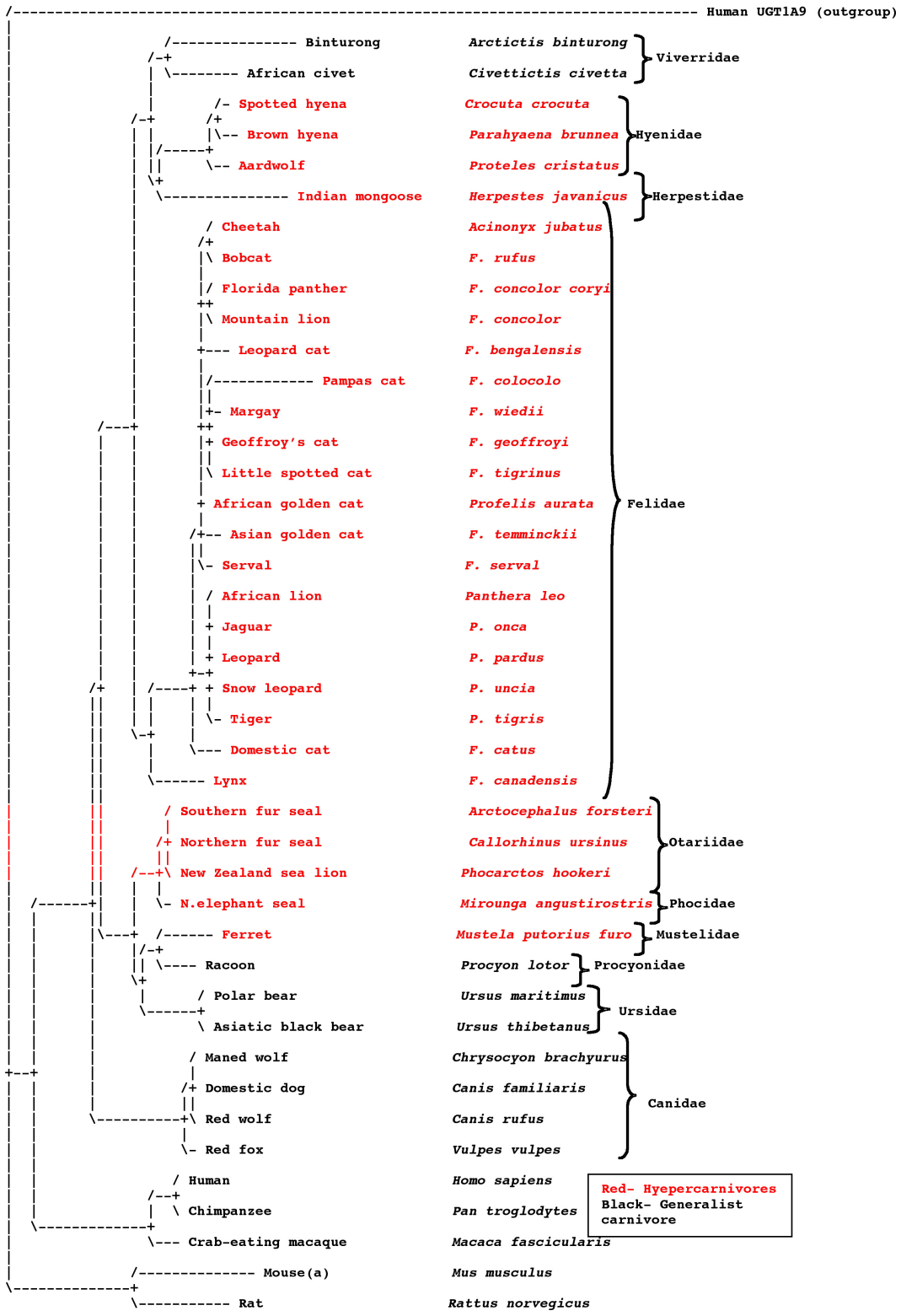


Figure 10: *Neighbor- joining tree (PAUP) of UGT1A1 exon 1 nucleotide sequence*

Table 6: *Published literature that quantitated plant and animal content of carnivora species*

Genus	Species	Common Name	Animal Matter	Plant Matter	Unidentified	Reference
Diet expressed in terms of % biomass						
Canis	*adustus*	Side- striped jackal	60%	32%	8%	(Nowak, 2005)
Chrysocyon	*brachyurus*	Maned wolf	45.4%	54.6%	-	(Juarez & Marinho-Filho, 2002)
Lycalopex	*vetulus*	Hoary fox	38.4%	61.5%	-	(Juarez & Marinho-Filho, 2002)
Cerdocyon	*thous*	Crab-eating Fox	43.6%	56.4%	-	(Juarez & Marinho-Filho, 2002)

3.2.2 Protein content of commercial zoo diet

Table 7 lists the protein content of commercial diets that are currently being marketed (Mazuri, Nestle-Purina, St. Louis, MO) for exotic and domestic species from the exotic animal feeding resource, PMI Nutrition International [1]. Highest protein levels are used in diets designed for ferrets and felids (35-38%). Lowest protein levels are used in typical herbivore diets (14%). While the remaining species, primarily referred to as "omnivores" are intermediate (25-30.5%)

Table 7: *Protein content in the Mazuri diet*

Species	Crude Protein(% not less than)
Ferret	38
Small felines	36
Large felines	35
Polar bear	30.5
Canine	28.5
Omnivores (wide range), Bears, Wild pigs, Rodents, Beavers, Marmots, Porcupines, Flying Foxes, Raccoons, Opossums	25
Rabbit, Sheep	14

3.2.3 Criteria for dietary classification

Based on the preceding observations, the following 3 dietary classifications were proposed

1. Hypercarnivore (or "true carnivore"): Requires high protein diet (30.5% or more crude protein) and consumes more than 70% animals and less than 30% plant matter in its natural environment. This is best exemplified by the Felidae family.

[1] http://mazuri.com/

Date accessed- 06/09/06

2. Hypocarnivore (or "herbivore"): Consumes more than 90% plant matter and less than 10% animals in its natural environment. This is best exemplified by the Giant panda. Protein content of the diet is low (25% or less crude protein)

3. Generalist carnivore (or "omnivore"): Diet is intermediate between a hypercarnivore and hypocarnivore.

Using these criteria the Carnivora species of interest (with available DNA for analysis) as well as species with known UGT1A1 and UGT1A6 sequences were placed into one of the 3 categories as shown in Table 8. In summary, out of 38 Carnivora species evaluated, 29 species (including all 19 Felidae) were classified as hypercarnivores, 8 species were classified as generalist carnivores, and 1 species (the red panda) was classified as a hypocarnivore. Polar bears were problematic since during winter they are hypercarnivores but during the summer they also consume much non-animal food (berries, etc.) and so they could be considered "opportunistic generalist carnivores". We classified them simply as generalist carnivores for the purposes of this study. Regarding the 8 species outside of the order Carnivora with known UGT1A1 and UGT1A6 sequences, all primates (human, crab-eating macaque, chimpanzee) and rodents (rat, mouse) were determined to be generalist carnivores, while the ruminants (cow and sheep) were considered hypocarnivores.

Table 8: *Classification of species based on observed diet or inferred from the literature*

Common name	Scientific name	Diet classification	Reference
Felidae			
Domestic cat	*Felis catus*	Hypercarnivore	Biró et al. (2005)
Canada lynx	*Felis canadensis*	Hypercarnivore	Nowak (2005), Stahl et al. (2002)
Bobcat	*Felis rufus*	Hypercarnivore	McLean et al. (2005)
Serval	*Felis serval*	Hypercarnivore	www.honoluluzoo.org (Date accessed-06/09/06)
Asiatic golden cat	*Felis temminckii*	Hypercarnivore	Nowak (2005)
African golden cat	*Felis aurata*	Hypercarnivore	Nowak (2005)
Leopard cat	*Felis bengalensis*	Hypercarnivore	Nowak (2005)
Pampas cat	*Felis colocolo*	Hypercarnivore	Nowak (2005)
Geoffroy's cat	*Felis geoffroyi*	Hypercarnivore	Manfredi et al. (2004)
Little spotted cat	*Felis tigrinus*	Hypercarnivore	[a]Foate, K. (2003). leopardus tigrinus (on-line), animal diversity web.
Margay	*Felis wiedii*	Hypercarnivore	www.bbc.co.uk/nature/wildfacts/factfiles/44.shtml (Date accessed- 06/09/06)
Mountain lion	*Felis concolor*	Hypercarnivore	Novack et al. (2005)

Table 8: (continued)

Florida panther	*Felis c. coryi*	Hypercarnivore	Novack et al. (2005)
Tiger	*Panthera tigris*	Hypercarnivore	Karanth and Sunquist (1995)
Snow leopard	*Panthera uncia*	Hypercarnivore	Nowak (2005)
Leopard	*Panthera pardus*	Hypercarnivore	Karanth and Sunquist (1995)
Jaguar	*Panthera onca*	Hypercarnivore	Novack et al. (2005)
African lion	*Panthera leo*	Hypercarnivore	www.honoluluzoo.org (Date accessed-06/09/06)
Cheetah	*Acinonyx jubatus*	Hypercarnivore	www.honoluluzoo.org (Date accessed-06/09/06)
Viverridae			
Binturong	*Arctictis binturong*	Generalist carnivore	www.honoluluzoo.org (Date accessed-06/09/06)
African civet	*Civettictis civetta*	Generalist carnivore	[b]Shalu, T. (2000). civettictis civetta (on-line), animal diversity web.
Hyenidae			
Spotted hyena	*Crocuta crocuta*	Hypercarnivore	Silvestre et al. (2000) www.honoluluzoo.org (Date accessed-06/09/06)
Brown hyena	*Parahyaena brunnea*	Hypercarnivore	Nowak (2005), [c] Reavill, C. (2000). parahyaena brunnea (on-line), animal diversity web.
Aardwolf	*Proteles cristatus*	Hypercarnivore	Williams et al. (1997)

Table 8: (continued)

Herpestidae			
Mongoose	*Herpestes javanicus*	Hypercarnivore	[d]Lutz, J. (2003). herpestes javanicus (on-line), animal diversity web.
Mustelidae			
Domestic ferret	*Mustela putorius furo*	Hypercarnivore	www.oregonzoo.org (Date accessed-06/09/06)
Procyonidae			
Raccoon	*Procyon lotor*	Generalist carnivore	Schoonover and Marshall (1951)
Lesser red Panda	*Ailurus fulgens*	Hypocarnivore	[e]Heath, T., and Platnick, J. (1999). ailurus fulgens (on-line), animal diversity web.
Ursidae			
Asiatic black bear	*Ursus thibetanus*	Generalist carnivore	Hwang et al. (2002),Huygens et al. (2003)
Polar bear	*Ursus maritimus*	Generalist carnivore	www.wwf.org.uk (Date accessed-06/09/06)
Canidae			
Domestic dog	*Canis familiaris*	Generalist carnivore	
Red wolf	*Canis rufus*	Hypercarnivore	Nowak (2005)
Maned wolf	*Chrysocyon brachyurus*	Generalist carnivore	Juarez and Marinho-Filho (2002)
Red fox	*Vulpes vulpes*	Generalist carnivore	Baltrunaite (2002)

Table 8: (continued)

Otariidae			
Northern fur seal	*Callorhinus ursinus*	Hypercarnivore	Nowak (2005)
Southern fur seal	*Arctocephalus forsteri*	Hypercarnivore	Nowak (2005)
N. Z. sea lion	*Phocarctos hookeri*	Hypercarnivore	Nowak (2005)
Phocidae			
N. elephant seal	*Mirounga angustirostris*	Hypercarnivore	Nowak (2005)
Hominidae			
Human	*Homo sapiens*	Generalist carnivore	Nowak (1999a)
Chimpanzee	*Pan troglodytes*	Generalist carnivore	Nowak (1999a)
Cercopithecidae			
Crab-eating macaque	*Macaca fascicularis*	Generalist carnivore	Nowak (1999a)
Bovidae			
Bovine	*Bos taurus*	Hypocarnivore	Nowak (1999b)
Sheep	*Ovis aries*	Hypocarnivore	Nowak (1999b)
Muridae			
Rat	*Rattus norvegicus*	Generalist carnivore	Nowak (1999b)
Mouse	*Mus musculus*	Generalist carnivore	Nowak (1999b)

Table 8: (continued)

Leporidae			
Rabbit	*Oryctolagus cuniculus*	Herbivore	Nowak (1999b)

[a] *http://animaldiversity.ummz.umich.edu/site/accounts/information/Leopardus_tigrinus.html(Date accessed: 06/08/06)*

[b] *http://animaldiversity.ummz.umich.edu/site/accounts/information/Civettictis_civetta.html (Date accessed: 06/09/06)*

[c] *http://animaldiversity.ummz.umich.edu/site/accounts/information/Parahyaena _brunnea.html (Date accessed: 06/09/06)*

[d] *http://animaldiversity.ummz.umich.edu/site/accounts/information/Herpestes _javanicus.html (Date accessed- 06/09/06)*

[e] *http://animaldiversity.ummz.umich.edu/site/accounts/information/Ailurus _fulgens.html (Date accessed- 06/09/06)*

3.2.4 Correlation of diet with *UGT1A6* gene defects

The molecular phylogenetic relationships shown in Figures 9 and 10 were further refined to include information regarding the dietary classification of each species. The color red in the trees designates hypercarnivores, green designates hypocarnivores and black designates generalist carnivores. Figure 9 shows that *UGT1A6* is only defective in Carnivora species that are hypercarnivores (Felidae, brown hyena and Northern elephant seal). All other hypercarnivores (ferret, mongoose, aardwolf and spotted hyena), generalist carnivores and hypocarnivores showed no genetic lesions in *UGT1A6*.

4 Discussion

The most important result of this research is that we found multiple inactivating mutations in the *UGT1A6* exon 1 sequence of all 19 species in the Felidae family we evaluated (Table 5). The presence of multiple mutations is consistent with the *UGT1A6* gene being a pseudogene, and not simply a common polymorphism with the potential for some individuals within a species to lack these mutations.

Interestingly, 5 of the mutations (2 premature stop codons, and deletions at 3 positions; Table 5) were common to all the Felidae species studied suggesting that these 5 mutations may have arisen in a common ancestral species. Based on a recently established timeline of the phylogenetic relationships among Felidae species (Johnson et al., 2006), these mutations, most likely occured more than 10.8 million years ago. The first Felidae-like carnivores appeared during the Oligocene Epoch around 35 million years ago Johnson et al. (2006). Later, during the late Miocene, the true cat species evolved. Study of dental and skull morphology indicates that these species may have become hypercarnivores before 15 million years ago (Morris, 2002).

Although we know the likely timeline, we do not as yet know the reason for fixation of the founding mutations in the Felidae lineage. One of the possible scenarios could be that due to the loss of functionality and selection pressure, deleterious mutations might have occurred in the *UGT1A6* gene of the ancestors of the modern felids. Fixation of the mutation then might have occured either through genetic drift (neutral evolution) or through genetic selection associated with the energy cost of producing a nonfunctional enzyme. However, this does not appear to have occured with other hypercarnivores such as ferrets suggesting that an additional factor (or factors) might be involved. In particular, establishment of nonfunctional genes such as this within an entire population is more likely at times when the species population is severely restricted (i.e. a population bottleneck) and followed by rapid amplification of the genetic trait when the population recovers (founder effect)(Stearns & Hoekstra, 2000). Following fixation of the founding mutation (pseudogenization), further mutations would then be possible probably as a

result of neutral evolution in parallel with speciation (Stearns & Hoekstra, 2000; Kimura, 1968). In support of this, we have seen several lineage-specific additional mutations, including a 100 bp deletion in all the Panthera species studied, and a 4 bp deletion in the mountain lion and Florida panther subspecies. Several additional insertion/deletion mutations were also found in jaguar, pampas cat, serval, domestic cat, and leopard cat.

Brown hyena and Northern elephant seal were the only other (non-Felidae) species to have inactivating mutations in *UGT1A6* . Interestingly, the 2 brown hyena DNA samples showed a single inactivating *UGT1A6* mutation (in-frame premature stop codon) that was identical to one of the 5 ancestral Felidae mutations. There are several explanations for this observation. Firstly, since hyena and Felidae are closely related, it may represent an ancestral mutation that was fixed in the felid lineage and possibly maintained as a polymorphism in the brown hyena but not in spotted hyena and aardwolves, which are more closely related to brown hyena. Secondly, it may represent an independent event that occurred at the same position that is highly prone to mutation (Duncan & Miller, 1980). Specifically, the ancestral codon at this position in closely related species including aardwolf, Indian mongoose, African civet and binturong is CGA which normally codes for the amino acid arginine. It is well known that methylated cytosine can spontaneously deaminate to thymidine thereby creating the stop codon TGA from CGA (Duncan & Miller, 1980). In either case, since no other aberrant mutations were found, the premature stop codon probably represents either a fixed mutation that occured recently or is a polymorphism (with allelic variants CGA and TGA) in the entire population and by chance the individual animals we sampled were homozygous variant for that polymorphism. Consequently, future work is needed to determine the prevalence of this mutation in the entire brown hyena population through study of many more, unrelated individuals.

In contrast to brown hyena, Northern elephant seal showed at least 2 inactivating mutations that make it more likely pseudogenization of *UGT1A6* rather than genetic polymorphism. Again, evaluation of more, unrelated individual animals would help clarify

this. We were unable to successfully amplify and sequence *UGT1A6* in the closely related Otariidae species. This was not a problem related to poor DNA quality since we could easily amplify *UGT1A1*. Consequently, either *UGT1A6* is not present in Otariidae, or the sequence at all of our primer sites in *UGT1A6* is quite different from *UGT1A6* in all other species. In future work the presence of a *UGT1A6* region of DNA in these species could be confirmed by low stringency genomic DNA hydridization analysis using a probe specific for *UGT1A6* as was previously done for cat *UGT1A6* (Court & Greenblatt, 2000). Furthermore, with molecular biology techniques such as inverse PCR, as was used for ferret and cat *UGT1A6*, it may be possible to obtain surrounding *UGT1A6* sequence in the Northern elephant seal and design PCR primers that are more specific to the Otariidae *UGT1A6* (if present).

Evidence from this study supports our hypothesis that all species that have *UGT1A6* defects (Felidae species, Northern elephant seal, and brown hyena) are hypercarnivores. The fact that the *UGT1A6* mutations in these 3 groups of animals may have arisen independently supports the notion of a common environmental factor such as diet in influencing the ability of these mutations to become fixed in the species. Again as in the Felidae, there are probably factors in addition to diet required to enable the fixation of the mutation. Interestingly, both the Northern elephant seal and brown hyena are known to have severely reduced populations in recent history, which may have promoted this defect (Hoelzel et al., 2002; Rohland et al., 2005). This possibility is of major concern from the species conservation and restoration point of view. When an animal species is about to go extinct and the few remaining animals at the zoo are bred to bring their population to surviving levels, deleterious genes are more likely to be retained and amplified in their offspring (Hedrick & Kalinowski, 2000).

Animals that are generalists are assumed to be better adapted to changing environments (Morris, 2002) while animals that are specialists, such as the hypercarnivores may be more at risk. Living organisms get exposed to a wide variety of environmental chemicals, which either exist naturally or because of humans (Watkins & Klaassen, 1986). *UGT1A6* plays an important role in the detoxification of many compounds including environmental

toxicants (Saeki et al., 2005). Consequently, inactivation of this gene may enhance the effects of environmental toxicity. This might be particularly true in the case of elephant seals whose environment is being increasingly polluted. This shows the importance from the conservation point of view of identifying species with dysfunctional *UGT1A6* that are more likely at risk from increasing levels of human made environmental toxic compounds.

Polychlorinated biphenyls (PCBs) are toxic environmental compounds which are poorly degraded and are metabolised slowly so even low levels lead to bioaccumulation. These chemicals mostly are in the environment because of their industrial use and accumulate in land and water resulting in bioaccumulation in the animals (Rice et al., 2003; Niimi, 1996). This poses a potential danger to humans and animals. The atmospheric contamination has contributed to the contamination of plants leading to the bioaccumulation in animals feeding on them (Rice et al., 2003). These stressors might be contributing to the diseases in these animals. The animals like elephant seals which lacks proper metabolism for these phenolic toxins might be in the danger in terms of growth, reproduction and survival.

Diclofenac is a nonsteroidal anti-inflammatory drug metabolized through the process of glucuronidation. The mortality of vultures in South Asia has been found to be due to consumption of livestock carcasses treated with diclofenac before they died (Swan et al., 2006). This has led to the rapid decline in vulture population of South Asia. This shows the ecological consequences of phenolic toxic compounds in the animals which have defect in glucuronidating them. This could be due to bioaccumulation of toxic compounds that the animal acquires from the pollutants of natural or human-made origin affecting their growth, reproduction or survival. Thus, the study of UGTs in carnivore birds could be an interesting future study.

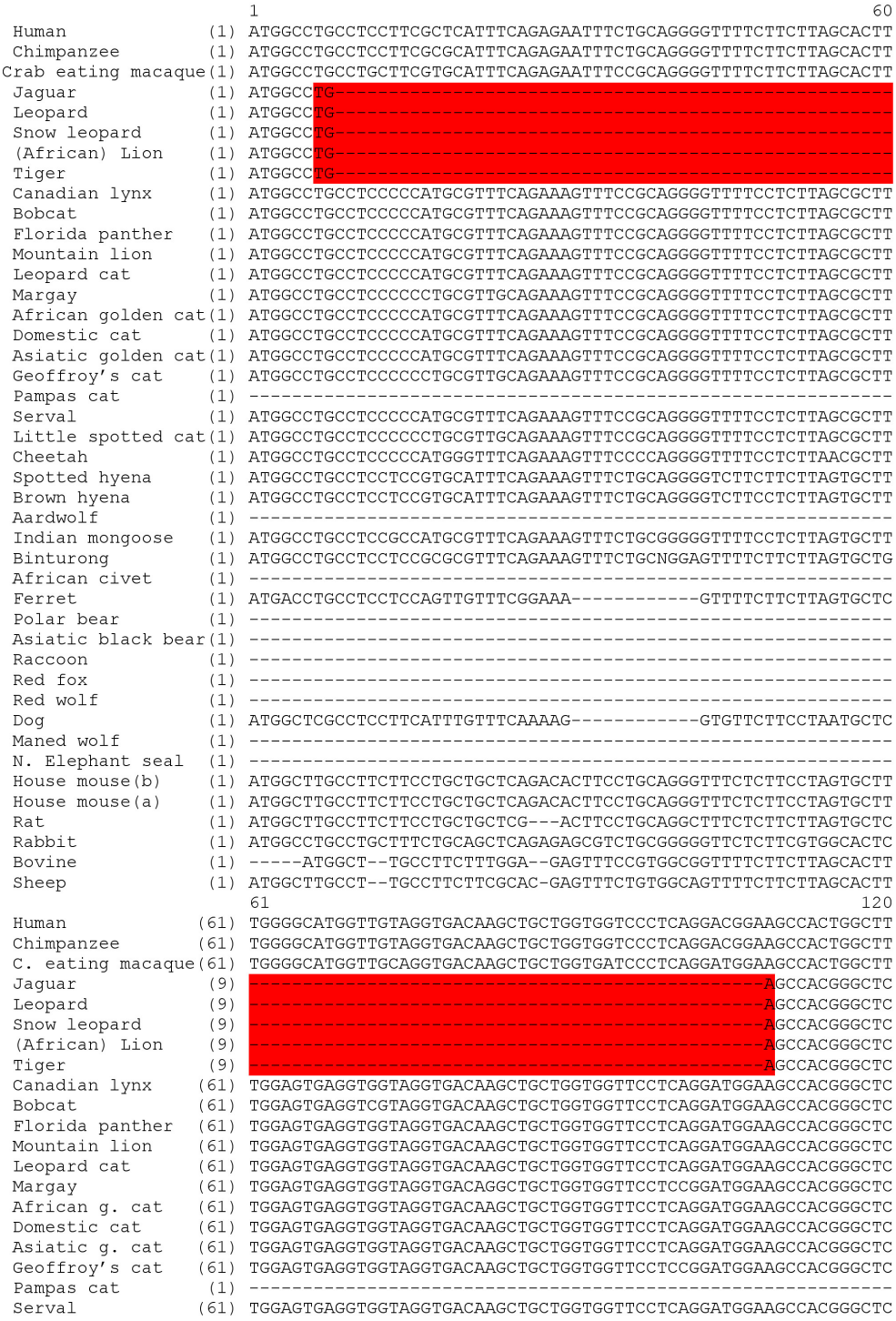
With regards to the categorization of the species based on their diet, the major limitation was the lack of sufficient information for most species. Even if there were many studies conducted with respect to the food the animals consumed, most of the studies concentrated on the type of animals the hypercarnivores consumed and didn't take into

account the plant matter during the analysis. So more observational studies of carnivores in their natural environment needs to be done to assess the amount of both the animal and plant matter they consume.

Finally, Felidae species appear to have other metabolic adaptations to a hypercarnivorous diet. In addition to *UGT1A6*, the domestic cat also exhibits deficiencies in other enzyme systems that are related to their diet (Court & Greenblatt, 2000). Being on top of the food chain, cats rely on nutrients from animal tissues to meet their requirements. They cannot synthesize taurine from cysteine, vitamin A from carotene and arachidonate from lineolate. The inability to synthesize vitamin A from carotenoids is because of the complete deletion of an enzyme required for the oxidation of carotene to retinal (Morris, 2002). Their metabolism is better adapted to protein utilization compared to fat and carbohydrate utilization. They lack the enzyme salivary amylase, which is responsible for the initial CHO digestion (Jernigan, 1989). The domestic cats apparently prefer food flavored with animal products like fats and meat. So, in contrast to taste preferences of dogs and people, cats may not be attracted to foods with sweet taste or they might not be able to detect the sweetness of sugars (Jernigan, 1989). A recent study by X. Li et al. (2005) indicated that cats lack the ability to detect sweet stimuli. This could be due to the adaptation to the highly specialized animal diet, which generally lack carbohydrates and simple sugars. Sweet taste is sensed by a special taste bud receptor which is the product of two genes. One of these genes was found to be a pseudogene in cats (X. Li et al., 2005) and also in several other Felidae species including lion and tiger. This is an interesting parallel to the presence of a pseudogene *UGT1A6* in cats and other Felidae. In future work, it would be interesting to determine whether all species that lack a functional *UGT1A6* also lack this sweet receptor. Furthermore, it would be interesting to determine whether defects of other gene products related to an adaptation to a hypercarnivorous diet are present in the domestic cat and also whether these findings in the domestic cat extrapolate to all other Felidae species.

Appendices

A Clustal W alignment of *UGT1A6* exon1 sequence.



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Little spotted cat(61) TGGAGTGAGGTGGTAGGTGACAAGCTGCTGGTGGTTCCTCCGGATGGAAGCCACGGGCTC
Cheetah           (61) TGGAGTGGGGGGGNAGGNGACAAGCTGCTGGNGGTTCCNCAGGANGGAAGCCCCGGGCTC
Spotted hyena     (61) TGGGGTGAGGTTGTAGCTGACAAGCTGCTGGTGGTCCCTCAGGATGGAAGCCACTGGCTC
Brown hyena       (61) TGGGGTGAGGTTGTAGCTGACAAGCTGCTGGTGGTCCCTCAGGATGGAAGCCACTGGCTC
Aardwolf           (1) ------------------------------------------------------------
Indian mongoose   (61) TGGGGTGAGGTTGTAGGTGACAAGCTGCTGGTGGTGCCTCAGGACGGAAGCCACTGGCTC
Binturong         (61) TGGGGAGAGGTCGTATGTGACAAGCTGCTGGGGGTGCCTCAGGATGGAAGCCACTGGCTC
African civet      (1) ------------------------------------------------------------
Ferret            (49) TGGGGGGAGGTTGTAGGTGACAGGCTGCTGGTGGTCCCTCAGGATGGAAGCCACTGGCTC
Polar bear         (1) ----------------------------------------------------------ACTGGCTC
Asiatic black bear (1) ----------------------------------------------------------CTGGCTC
Raccoon            (1) ------------------------------------------------------------
Red fox            (1) ----------------------------------------------------CACTGGCTC
Red wolf           (1) ----------------------------------------------------CTGGCTC
Dog               (49) TGGGGGGAGGCTGTAGGTGACAAGCTTCTGGTGGTCCCTCAGGACGGAAGCCACTGGCTC
Maned wolf         (1) ----------------------------------------------------CTGGCTC
N. Elephant seal   (1) ------------------------CTGCTGGTGGTTCCTCAGGATGGAAGCCACTGGCTC
House mouse(b)    (61) TGGGCCTCAGTTCTAGGTGACAAGCTGCTGGTGGTCCCCCAGGATGGAAGCCACTGGCTT
House mouse(a)    (61) TGGGCCTCAGTTCTAGGTGACAAGCTGCTGGTGGTCCCCCAGGATGGAAGCCACTGGCTT
Rat               (58) TGGGGCTCAGTTCTAGGTGACAAGCTGCTGGTGGTCCCCCAGGATGGCAGCCACTGGCTT
Rabbit            (61) TGGGGCACGGTGCTGGGTGACAGGCTGCTGGTGGTGCCCCAGGATGGAAGCCACTGGCTT
Bovine            (52) TGGGGCTTCACCCTGGGGGACAGGCTGCTGGTGGTCCCTCAGGATGGAAGCCACTGGCTC
Sheep             (58) TGGGGCTTCGCCCTGGGGGACAGGCTGCTGGTGGTCCCTCAGGATGGAAGCCACTGGCTC
                        121                                                     180
Human           (121) AGTATGAAGGATATAGTTGAGGTTCTCAGTGACCGGGGTCATGAGATTGTAGTGGTGGTG
Chimpanzee      (121) AGTATGAAGGATATAGTTGAGGTTCTCAGTGACCGGGGTCACGAGATTGTAGTGGTGGTG
C. eating macaque(121) AGTATGAAGGATATAGTTGAAGTTCTCAGTGACCGGGGGCATGACATTGTAGTGGTGGTG
Jaguar           (21) AGTCTGAAGGACACAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Leopard          (21) AGTCTGAAGGACACAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Snow leopard     (21) AGTCTGAAGGACACAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
(African) Lion   (21) AGTCTGAAGGACACAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Tiger            (21) AGTCTGAAGGACACAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Canadian lynx   (121) AGTCTGAAGGATGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Bobcat          (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Florida panther (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGATGTGGTAGTGCTGGTG
Mountain lion   (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACGTGGTAGTGCTGGTG
Leopard cat     (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACGTGGTAGTGCTGGTG
Margay          (121) AGTCTGAAGGACACAGCTGAGCTTCTCAGTGAGAAGGGACATGACATGGTGGTGCTGGTG
African g. cat  (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACGTGGTAGTGCTGGTG
Domestic cat    (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACGTGGTAGTGCTGGTG
Asiatic g. cat  (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Geoffroy's cat  (121) AGTCTGAAGGACACAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Pampas cat         (1) ------------------------------------------------------------
Serval          (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGTGAGAAGGGACATGACGTGGTAGTGCTGGTG
L. spotted cat  (121) AGTCTGAAGGACACAGTTGAGCTTCTCAGTGAGAAGGGACATGACATGGTAGTGCTGGTG
Cheetah         (121) AGTCTGAAGGACGCAGTTGAGCTTCTCAGCGAGAAGGGACATGACGTGGTAGTGCTGGTG
Spotted hyena   (121) AGTATGAAGGAGATAGTTGAGTTCCTCAGTGAGAAGGGGCATGACATTGTAGTGCTGGTG
Brown hyena     (121) AGTATGAAGGAGATAGTTGAGTTCCTCAGTGAGAAGGGCCATGACATTGTAGTGCTGGTG
Aardwolf           (1) ------------------------------------------------------------
Indian mongoose (121) AGTATGAAGGAGATAGTTGAGCTCCTCAGTGAGAAGGGACATGACCTTGTAGTGCTGGTG
Binturong       (121) AGTATGAAGGAGATAGTTGAGCACCTCAGTGAGAAGGGACATGATATTGTAGTGCTGGCG
African civet      (1) ------------------------------------------------------------
Ferret          (109) AGTATGAAGGACATAGTTGAGCTCCTCAGTGAGAAGGGGCATGACATTGTGGTGCTGGTG
Polar bear        (9) AGTATGAAGGACATAGTTGAGCTCCTCAGTGAGAAGGGGCATGACATTGTGGTGCTGGTG
Asiatic black bear (8) AGTATGAAGGACATAGTTGAGCTCCTCAGTGAGAAGGGGCATGACATTGTGGTGCTGGTG
Raccoon            (1) ----------------------------------GGGCATGACTTTGTGGTGCTGGTG
Red fox           (10) AGTATGGAGAACATAGTTGAGCTCCTCAGTGAGAAGGGGCATGACATTGTGGTGCTGGTG
Red wolf           (8) AGTATGGAGAACATAGTTGAGCTCCTCAGTGAGAAGGGGCATGACATTGTGGTGCTGGTG
Dog             (109) AGTATGGAGAACATAGTTGAGCTCCTCAGTGAGAAGGGGCATGACATTGTGGTGCTGGTG
Maned wolf         (8) AGTATGGAGAACATAGTTGAGCTCCTCAGTGAGAAGGGGCATGACATTGTGGTGCTGGTG
N. Elephant seal  (37) AGTATGAAGGACATAGTTGAGCTCCTCAGTCAGAGGGGGCACAACATTGTGGTGCTGGTA
House mouse(b)  (121) AGCATGAAGGAGATAGTGGAGCATCTCAGTGAACGAGGACATGACATTGTGGTCCTAGTG
House mouse(a)  (121) AGCATGAAGGAGATAGTAGAACATCTCAGTGAACGAGGACATGACATTATGGTCCTAGTG
Rat             (118) AGCATGAAGGAGATAGTGGAGCACCTCAGTGAACGCGGACACGACATTGTGGTGCTAGTG
Rabbit          (121) AGCATGCAGGACATAGTTGAGGCTCTTGGGGCGAGGGGGCATGAAATCGTGGTGCTGGTG
Bovine          (112) AGCATGAAGGACATCGTTGAGCATCTCAGTGAGAAAGGGCATGAGATCGTGGTGGTGGTG
Sheep           (118) AGCATGAAGGACATCACTGAACGTCTCAGCGAGAAAGGGCATGAGATCGTGGTGGTGGTG
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                          181                                                 240
Human               (181) CCTGAAGTTAATTTGCTTTTGAAAGAATCCAAATACTACACAAGAAAAATCTATCCAGTG
Chimpanzee          (181) CCTGAAGTTAATTTGCTTTTGAAAGAATCCAAATACTACACAAGAAAAATCTATCCAGTG
C. eating macaque   (181) CCTGAAGTCAATTTGCTTTTGAAAGAATCCAAATACTACACAAGAAAAATCTATCCAGTG
Jaguar               (81) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Leopard              (81) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Snow leopard         (81) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
(African) Lion       (81) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Tiger                (81) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Canadian lynx       (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Bobcat              (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACCACACGAGAAAAATCTATCCAGTG
Florida panther     (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Mountain lion       (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Leopard cat         (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Margay              (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACGCGAGAAAAATCTATCCAGTG
African golden cat(181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Domestic cat        (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Asiatic golden cat(181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Geoffroy's cat      (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Pampas cat            (1) ----AGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Serval              (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Little spotted cat(181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Cheetah             (181) TCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCTAGTG
Spotted hyena       (181) CCAGAGGTCAATCTGCTTCTGAAAGAATCCAAACACTACATGAGAAAAATCTACCCAGTG
Brown hyena         (181) CCAGAGGTCAATCTGCTTCTGAAAGAATCCAAACACTACGTGAGAAAAATCTACCCAGTG
Aardwolf              (1) ------------TCTGCTTCTGAAAGAATCCAAACACTACATGAGAAAAATCCACCCAGTG
Indian mongoose     (181) CCAGAGGTCAATCTGCTTCTGAAGGAATCCAAACACTACAGGAGAAAAACCTACCCAGTG
Binturong           (181) CCAGAGGTCAATCTGATTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
African civet         (1) ----------ATCTGCTTCTGAAGGAATCCAAACACTACACGAGAAAAATCTATCCAGTG
Ferret              (169) CCAGAAGTCAATTTGCTTCTGAAGGAGTCCAAGCACTACACAAGAAAAACCTATCCAGTG
Polar bear           (69) CCAGAAGTCAATTTGCTTCTGAAGGAATCCAAGCACTATGCGAGAAAAATCTACCCGGTG
Asiatic black bear   (68) CCAGAAGTCAATTTGCTTCTGAAGGAATCCAAGCACTACGCGAGAAAAATCTACCCGGTG
Raccoon              (25) CCCCAAAGCAATCTGCTTCGAAATGAATCCTCGCACTACACGAGAAGGATCTATCCAGTG
Red fox              (70) CCAGAAGTCAATTTGCTTCTGAAGGAATCCAAACACTACACGAGACAAATCTACTCAGTG
Red wolf             (68) CCAGAAGTCAATTTGCTTCTGAAGGAATCCAAACACTACACGAGACAAATCTACTCAGTG
Dog                 (169) CCAGAAGTCAATTTGCTTCTGAAGGAATCCAAACACTACACGAGACAAATCTACTCAGTG
Maned wolf           (68) CCAGAAGTCAATTTGCTTCTGAAGGAATCCAAACACTACACGAGACAAATCTACTCAGTG
N. Elephant seal     (97) CCAGAAGTCAATTTGCTTCTGAAGGAATCCAAGCACTACACAAGAAGAAGCTACCCGGTG
House mouse (b)     (181) CCAGAAGTCAATTTGCTTTTGGGAGAATCCAAATACTACAGGAGGAAAATTTTCTCAGTT
House mouse (a)     (181) CCAGAAGTCAATTTGCTTTTGGGAGAATCCAAATACTACAGGAGGAAAATCTTCTCAGTT
Rat                 (178) CCAGAAGTCAATTTGCTTTTGGGAGAATCCAAATACTACAGGAGGAAAAGCTTCCCGGTC
Rabbit              (181) CCAGAAGTCAACTTGCTCTTGAGAGAATCCAGGTTCTACACGAGGAGAATCTACCCAGTG
Bovine              (172) CCTGAAGTCAACCTGCTCCTCCAAGAGTCCAAGCACTACACAAGGAAAATCCACCCAGTG
Sheep               (178) CCCAAAGTCAACCTGCTCCTCCAAGAGTCCAAGCACTACACAAGGAGAATCCACCCAGTG
                          241                                                 300
Human               (241) CCGTATGACCAAGAAGAGCTGAAGAACCGTTACCAATCATTTGGAAACAATCACTTTGCT
Chimpanzee          (241) CCGTATGACCAAGAAGAGCTGAAGAACCGTTACCAATCATTTGGAAACAATCACTTTGCT
Crab e. macaque     (241) CCGTATGACCAAGAAGAGATGAAGAACCGTTACCAATTGTTTGGAAACAATCACTTTGCT
Jaguar              (141) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Leopard             (141) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Snow leopard        (141) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
(African) Lion      (141) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Tiger               (141) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Canadian lynx       (241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Bobcat              (241) CCATTTGACCGGGAAGAGCCAGAGCACCGTTTCTGATCTTCTGGAAACAGTCACTTCGCT
Florida panther     (241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCACT
Mountain lion       (241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCACT
Leopard cat         (241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Margay              (241) CCATTTGACCGGGAAGAGCCAGAGCACCGTTTCTGATCTTTTGGAAATAGTCACTTCGCT
African golden cat(241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAGATTGTCACTTCGCT
Domestic cat        (241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Asiatic golden cat(241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Geoffroy's cat      (241) CCATTTGACCGGGAAGAGCCAGAGCACCGTTTCTGATCTTTTGGAAATAGTCACTTCGCT
Pampas cat           (57) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Serval              (241) CCATTTGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAGATTGTCACTTTGCT
Little spotted cat(241) CCATTTGACCGGGAAGAGCCAGAGCACCGTTTCTGATCTTTTGGAAATAGTCACTTCGCT
Cheetah             (241) CCATTGGACCGGGAAGAGCCGGAGCACCGTTTCTGATCTTTTGGAAACAGTCACTTCGCT
Spotted hyena       (241) CCATTTGACCAGGAAGAGCTGCAGAACCGTTTCCAATCTTTTGGAAACAATCACTTTGTG
Brown hyena         (241) CCTTTTGACCACGAAGAGCTGCAGAACCGTTTCTGATCTTTTGGAAGCAATCACTTTGTG
Aardwolf             (50) CCATTTGACCAGCAAGAGCTGAAGAACCGTTTCCGATCTTTTGGAAACAATCACTTTGTG
Indian mongoose     (241) CCATTTGACCAGGAGGAGCTGCAGAACCGTTTCCGATCTTTTGGAAATAATCACTTTGCG
Binturong           (241) CCATTTGACCAGGAAGAGCTGGAGAAGCGTTTCCGAGCTTTTGGAAACAATCACTTTGCT
African civet        (51) CCATTTGACCAGGAAGAGCTGGAGAACCGTTTCCGAGCTTTTGGAAACAATCACTTTGCT
Ferret              (229) CCGTTCCAACAGGAGGAGCTGGAGAATCGGTACCGCTCTTTTGGAAACAATCACTTTGCT
Polar bear          (129) CCGTATGACCAGGAAGAGCTGCAGGCTCGTTACCGCTCTTTTGGAAACAATCACTTTGCT
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Asiatic black bear(128) CCGTATGACCAGGAAGAGCTGCAGGCTCGTTACCGCTCTTTTGGAAACAATCACTTTGCT
Racoon             (85) CCCTTCGAGCGGGAGGAGCTGGGGGATCGTTTCCGCTCTTTTGGAAACAATCACTTTGCT
Red fox           (130) CCATTTGGCCAGGAAGAGTTGGAGAACCGTTACCGCTCTTTTGGAAAGAACCACTTTGCT
Red wolf          (128) CCATTTGGCCAGGAAGAGTTGGAGAACCGCTACCGCTCTTTTGGAAAGAATCACTTTGCT
Dog               (229) CCATTTGGCCAGGAAGAGTTGGAGAACCGCTACCGCTCTTTTGGAAAGAATCACTTTGCT
Maned wolf        (128) CCATTTGGCCAGGAAGAGTTGGAGAACCGTTACCGCTCTTTTGGAAAGAATCACTTTGCT
N. Elephant seal  (157) CCATTCGATCAGAAAGAGCTGGGGAATCGTTACCACTTTTTTGGAAACGATCACTTTGCT
House mouse(b)    (241) CCCTACAGCCTAGAAGAACTACAGACCCGTTTTCGCACCTTTGGACGCAACCAGTTTGTT
House mouse(a)    (241) ACCTACAGCCTAGAAGAACTGCAGACCCGTTTTCGCACCTTTGGAAACAACCACTTTCTT
Rat               (238) CCCTACAACCTAGAAGAGTTGCGGACCCGCTATCGCTCCTTTGGGAACAACCACTTTGCT
Rabbit            (241) CCGTTTGACCAGGAGGAGCAGAGTTACCGGTATCGCACCTTTGGAGAAAAGCACTTTACT
Bovine            (232) CCGTTCAACCAGGAGGAGCTGGAAGCCCGTTACCGCTCCTTCGGGAAACACCACTTTTCT
Sheep             (238) CCCTACGACCAGGAGGAGCTGGAAGCCCGTTACCGTTCCTTCGGGAAACACCACTTTTCT
                         301                                                 360
Human             (301) GAGCGATCATTCCTAACTGCTCCTCAGACAGAGTACAGGAATAACATGATTGTTATTGGC
Chimpanzee        (301) GAGCGATCATCCCTGACTGCTCCTCAGACAGAGTACAGGAATAACATGATCGTTATTGGC
Crab e. macaque   (301) GAGCGATCATTCCTGACTGCTCCTCAGACAGAGTACAGGAATAACATGGTCGTTATTGGC
Jaguar            (201) GAGAGGTGGCTCCTGAACCCTGCTGTGCGGGAGGACAGGAATACCATGATTGTTACCGAC
Leopard           (201) GAGAGGTGGCTCCTGAACCCTGCTGTGCGGGAGGACAGGAATACCATGATTGTTACCGAC
Snow leopard      (201) GAGAGGTGGCTCCTGAACCCTGCTGTGCGGGAGGACAGGAATACCATGATTGTTACCGAC
(African) Lion    (201) GAGAGGTGGCTCCTGAACCCTGCTGTGCGGGAGGACAGGAATACCATGATTGTTACCGAC
Tiger             (201) GAGAGGTGGCTCCTGAACCCTGCTGTGCGGGAGGACAGGAATACCATGATTGTTACCGAC
Canadian lynx     (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Bobcat            (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Florida panther   (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Mountain lion     (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Leopard cat       (301) GAGAGGTGGCTCCTGAACCCGGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Margay            (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCGTGATTGTTACCGAC
African golden cat(301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Domestic cat      (301) GAGAGGTGGCTCCTGAACCCGGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Asiatic golden cat(301) GAGAGGTGGCTCCTGAACCCTGCTGCGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Geoffroy's cat    (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCGTGATTGTTACCGAC
Pampas cat        (117) GAGAGGTGGCTCCTGAACCCTGCTGTGCGGGAGGACAGGAATACCATGATTGTTACCGAC
Serval            (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCATGATCGTTACCNAC
Little spotted cat(301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCGTGATTGTTACCGAC
Cheetah           (301) GAGAGGTGGCTCCTGAACCCTGCTGTGAGGGAGGACAGGAATACCATGATTGTTACCGAC
Spotted hyena     (301) GAGAAAGGGCTCCTGAGCGCTGCTCTGATGGAGTACAGGAATAGCATGATTATTCTTGAC
Brown hyena       (301) GAGAAAGGGCTCCTGAGCGCTGCTCTGATGGAGTACAGGAATAGCATGATTATCCTTGAC
Aardwolf          (110) GAGAAAGGGCTCCTGAGCGCTGCTTTGATAGAGTACAGGAATAGCATGATTATTCTTGAC
Indian mongoose   (301) GAGAGAGGGCTCCTGAGCGCCGCTCCGATGGAATACAGGAATACCATGATTGTTATTGAC
Binturong         (301) GAGAGATGGCTCCTGAACGCTGCTCTGATGGAGTACAGGAACACCATGATTATTCTGGAC
African civet     (111) GAGAGATGGCTCCTGAACGCTGCTCTGATGGAGTACAGGAACACCATGATTGTTCTTGAC
Ferret            (289) GAGAGATGGCTCCTGAACGCTGCTCAGATGGAATACAGGAATAGCATGATTGTTATTGAC
Polar bear        (189) GAGAGATGGCTCCTGAACGCGGCTCAAACGGAGTACAGGAATAACATGATTGTTATTGAC
Asiatic black bear(188) GAGAGATGGCTCCTGAACGCGGCTCAAACGGAGTACAGGAATAACATGATTGTTATTGAC
Racoon            (145) GAGAGATGCTTCCTGAACGCTGCTCAGGGGGAGGACAGGAACAACATGATCGGTATTGAC
Red fox           (190) GAGAGATGGCTCCTGAACGCTGCTCAGATGGAGTACAGAAATAACATGATTGTTATTGAC
Red wolf          (188) GAGAGATGGCTCCTGAACGCTGCTCAGATGGAGTACAGAAATAGCATGATTGTTATTGAC
Dog               (289) GAGAGATGGCTCCTGAACGCTGCTCAGATGGAGTACAGAAATAGCATGATTGTTATTGAC
Maned wolf        (188) GAGAGATGGCTCCTGAACACTGCTCAGATGGAGTACAGAAATAGCATGATTGTTATTGAC
N. Elephant seal  (217) GAGACATGGCTCCCGAACGCTGCTCAGATGGAGTACAGGAATAGCATGATGGTTATTGAC
House mouse(b)    (301) CCTGGTGCCCCCCTGATGGGTCCTCTAAGAGAGTACAGGAACAGCATGCTTACATTGGAG
House mouse(a)    (301) CCCGGTGCCTCCCTGATGGGTCCTCTAAGAGAGTACAGGAACAACATGATTGTCGTGGAC
Rat               (298) GCCAGTTCCCCCCTGATGGCTCCTCTAAGAGAGTACAGGAACAACATGATTGTCATTGAC
Rabbit            (301) GACAGGTCCTGGCTGAGCGGGCCTCAGACGGAATACAGGAATAACATGGTTGTGATTGAC
Bovine            (292) CCACGCTGGTTGGTGACTGCCCCTGTGGTGGAGTATAGGAACAACATGATTGTCATCAAT
Sheep             (298) CCACGCTGGCTGGTGACTGCCCCTATGGTGGAGTATAGGAACAACATGATCGTCATCAAC
                         361                                                 420
Human             (361) CTGTACTTCATCAACTGCCAGAGCCTCCTGCAGGACAGGG-ACACCCTGAACTTCTTTAA
Chimpanzee        (361) CTGTACTTCATCAACTGCCAGAGCCTCCTGCAGGACAGGG-ACACCCTGAACTTCTTTAA
Crab e. macaque   (361) ATGTACTTCATCAACTGCCAGAGCCTCCTGCAGGACGTGG-GCACCCTGAACTTCCTCAA
Jaguar            (261) ACGTACTTCGCCAACCGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Leopard           (261) ACGTACTTCGCCAACCGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Snow leopard      (261) ACGTACTTCGCCAACCGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
(African) Lion    (261) ACGTACTTCGCCAACCGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Tiger             (261) ACGTACTTCGCCAACCGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Canadian lynx     (361) ACATACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Bobcat            (361) ACATACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Florida panther   (361) ----ACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Mountain lion     (361) ----ACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Leopard cat       (361) ACGTACTTCGCCAACTGCTAGAGCCCCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Margay            (361) ACATACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
African golden cat(361) ACGTACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Domestic cat      (361) ACGTACTTCGCCAACTGCTAGAGCCCCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
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Asiatic golden cat(361) ACGTACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Geoffroy's cat    (361) ACATACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Pampas cat        (177) ACGTACTTTGCCAACCGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Serval            (361) ACGTACTTCGCCGACCGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Little spotted cat(361) ACATACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGTTTCCTCAG
Cheetah           (361) ACGTACTTCGCCAACTGCTAGAGCCTCCTGGAGGACTC-G-CCACCTTGAGCTTCCTCAG
Spotted hyena     (361) ATGTGGTTCACCAACTGCCAGAGCCTCCTGGGGGACTCCG-CCACCCTGAGTTTCCTCAA
Brown hyena       (361) ATGTGGTTCACCAACTGCCAGAGCCTCCTGGGGGACTCCG-CCACCCTGAGCTTCCTCAA
Aardwolf          (170) ATGTGGTTCACCAACTGCCAGAGCCTCCTGGGGGACTCCA-CAACCCTGAGTTTCCTCAA
Indian mongoose   (361) ATGTACTTCACCAGCTGCCAGAGCCTTCTGGGGGACCCCG-CCACCCTGCGCTTCCTCCG
Binturong         (361) ATGTGGTTCACCAGCTGCCAGAGCCTCCTGGAGGACTCCG-CCACCCTGAGTTTCCTCAG
African civet     (171) ATGTACTTCACCAACTGCCAGAGCCTCCTGGAGGACTCCG-CCACCCTGAGTTTCCTCAG
Ferret            (349) ATGTATTTCACCACCTGCCAGAGCCTCCTGGAGGACACAG-CCACCCTGAGTGTCCTCAG
Polar bear        (249) ATGTACTTCACCAACTGCCAGAGCCTCCTGGAGGACGCGG-CCACCCTGAGCGTCCTCCG
Asiatic black bear(248) ATGTACTTCACCAACTGCCAGAGCCTCCTGGAGGACGCGG-CCACCCTGAGCGTCCTCCG
Racoon            (205) ATGTACTTCACCAACTGCCAGAGCCTCCTGGAGGACTCGG-CCACCCTGAGCGTCCTCAG
Red fox           (250) ATGTACTTCACCAACTGCCAGAGCCTTCTGGAGGACTCGG-CCACGCTCAGTGTCCTCAG
Red wolf          (248) ATGTACTTCACCAACTGCCAGAGCCTTCTGGAGGACTCGG-CCACGCTCAGTGTCCTCAG
Dog               (349) ATGTACTTCACCAACTGCCAGAGCCTTCTGGAGGACTCGG-CCACGCTCAGTGTCCTCAG
Maned wolf        (248) ATGTACTTCACCAACTGCCAGAGCCTTCTGGAGGACTCGG-CCACGCTCAGTGTCCTCAG
N. Elephant seal  (277) ATGTACTTCACCAACTGCCAGAGCCTCCTGGAGGACCCCGGCCACCCTGAGTGTCCTCAG
House mouse(b)    (361) ATGTTCTTTTCCAACTGCCAGAGCCTCCTGAAGGACTCTG-CCACCCTCAGCTTCCTCAG
House mouse(a)    (361) ATGTTCTTTTCCAACTGCCAGAGCCTCCTGAAGGACTCTG-CCACCCTCAGCTTCCTCAG
Rat               (358) ATGTGCTTTTTCAGCTGCCAGAGCCTCCTGAAGGACTCGG-CCACCCTCAGCTTCCTCAG
Rabbit            (361) ATGTACTTCATCAACTGCCAGAGCCTGCTGAGACACGGCG-ACACCTTGGATTTCCTCAG
Bovine            (352) ATGTACTTTCTCAACTGCCAGAGTCTCCTGAGGCACTCAG-ACACCCTGCGCTTCCTCCG
Sheep             (358) ATGTACTTTCTCAACTGCCAGAGTCTCCTGAGGCACTCGG-GAACCCTGCGCTTCCTCCG
                         421                                                     480
Human             (420) GGAGAGCAAGTTTGATGCTCTTTTCACAGACCCAGCCTTACCCTGTGGGGTGATCCTGGC
Chimpanzee        (420) GGAGAGCAAGTTTGATGCTCTTTTCACAGACCCAGCCTTACCCTGTGGGGTGATCCTGGC
Crab e. macaque   (420) GGAGAGCAAGTTCGATGCTCTTTTCACAGACCCAGCCTTACCCTGTGGGGTGATCCTGGC
Jaguar            (319) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Leopard           (319) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Snow leopard      (319) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
(African) Lion    (319) GGAGAGCAAGTTCAACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Tiger             (319) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Canadian lynx     (419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Bobcat            (419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGACCTTGGC
Florida panther   (415) GGAGAGCAAGTTCAACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Mountain lion     (415) GGAGAGCAAGTTCAACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Leopard cat       (419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Margay            (419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
African golden cat(419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATNTTGGC
Domestic cat      (419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Asiatic golden cat(419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Geoffroy's cat    (419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Pampas cat        (235) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Serval            (419) GGGGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Little spotted cat(419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Cheetah           (419) GGAGAGCAAGTTCGACACCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Spotted hyena     (420) GGAGAGCAAATTCGACGTCCTCTTCACAGACCCAGCCCTACCCTGTGGGGTGATCTTGGC
Brown hyena       (420) GGAGAGCAAATTCGATGTCCTCTTCACAGACCCAGCCCTGCCCTGTGGGGTGATCTTGGC
Aardwolf          (229) GGAGAGCAAATTCGACATCCTCTTCACAGACCCGGCCCTACCCTGTGGCGTGATCCTGGC
Indian mongoose   (420) GGAGAGCAAGTTCGACGCCCTCTTCACAGACCCAGCTCTACCCTGTGGGGTGATCTTGGC
Binturong         (420) GGAGAGCAAGTTCGACGCCCTCTTCACAGACCCGGCCCTCCCCTGTGGGGTGATCTTGGC
African civet     (230) GGAGAGCAAGTTCGACGCCCTCTTCACAGACCCAGCCCTCCCTTGTGGGGTGATCTTGGC
Ferret            (408) GGAGAGCAAGTTCGATGCCCTTTTCACAGACCCAGCCCTACCCTGCGGGGTGATCCTGGC
Polar bear        (308) GAAGAGCAAGTTCGATGCCCTTTTCACAGACCCGGCCCTACCCTGCGGGGTGATCCTGGC
Asiatic black bear(307) GAAGAGCAAGTTCGATGCCCTTTTCACAGACCCGGCCCTACCCTGCGGGGTGATCCTGGC
Racoon            (264) GGAGAGCAAGTTCGATGCCCTTTTCACAGACCCAGCCCTACCCTGCGGGGTGATCCTGGC
Red fox           (309) GCAGAGCAAGTTCGATGCCCTTTTCACAGACCCAGCTCTGCCCTGTGGGGTGATCCTGGC
Red wolf          (307) GCAGAGCAAGTTCGATGCCCTTTTCACAGACCCAGCTCTGCCCTGTGGGGTGATCCTGGC
Dog               (408) GCAGAGCAAGTTCGATGCCCTTTTCACAGACCCAGCTCTGCCCTGTGGGGTGATCCTGGC
Maned wolf        (307) GCAGAGCAAATTCGATGCCCTTTTCACAGACCCAGCTCTGCCCTGTGGGGTGATCCTGGC
N. Elephant seal  (337) GGAGAGCAAGTTCGATGCCCTTTTCACAGAACCAGCCCTACCCTGCGGGGTCATCCTGGC
House mouse(b)    (420) GGAGAACAAGTTTGATGCTCTGTTCACAGACCCAGCCATGCCCTGTGGTGTGATCCTGGC
House mouse(a)    (420) GGAGAACAAGTTTGATGCTCTGTTCACAGACCCAGCCATGCCCTGTGGTGTGATCCTGGC
Rat               (417) GGAGAACCAGTTTGATGCTCTGTTCACAGACCCGGCCATGCCCTGTGGTGTGATCCTGGC
Rabbit            (420) GGCGGGCAAGTTCGATGCTCTTTTCACAGACCCGGCCTTACCCTGTGGTGTGATCCTGGC
Bovine            (411) GGAGAACAAGTTCGACGCCCTGTTCACAGACCCGGCCTTACCTTGCGGGGTGATCCTGGC
Sheep             (417) GGAGAGCAAGTTCGATGCCCTGTTCACAGACCCGGCCTTACCTTGCGGGGTGATCCTGGC
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                          481                                                 540
Human               (480) TGAGTATTTGGGCCTACCATCTGTGTACCTCTTCAGGGGTTTTCCGTGTTCCCTGGAGCA
Chimpanzee          (480) TGAGTATTTGGGCCTACCATCTGTGTACCTCTTCAGGGGTTTTCCGTGTTCCCTGGAGCA
Crab e. macaque     (480) TGAGTATTTGGGCCTACCCTCCGTGTACCTCTTCAGGGGTTTTCCGTGTTCCCTGGAGCA
Jaguar              (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Leopard             (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Snow leopard        (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
(African) Lion      (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCGGGGGCTTCCCACGCTCCCTGGGGCA
Tiger               (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Canadian lynx       (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTTTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Bobcat              (479) AGAGCACCTAGGCCTGCCCTCCATGTATCTTTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Florida panther     (475) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Mountain lion       (475) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Leopard cat         (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Margay              (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCATGCTCCCTGGGGCA
African golden cat(479) AGAGTACCTAGGCCTGCCCTCCATGTGTCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Domestic cat        (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Asiatic golden cat(479) AGAGTACCTAGGCCTGCCCTCCATGTATCTTTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Geoffroy's cat      (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Pampas cat          (295) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Serval              (479) AGAGTACCTAGGCCTGCCCTCCATGTGTCTCTTCAGGGTCTTCCCACGCTCCCTGGGGCA
Little spotted cat(479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Cheetah             (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Spotted hyena       (480) AGAGTACCTGGGCCTGCCCTCCGTATATCTCTTCAGGGGCTTCCCATGCTCCTTGGAGCA
Brown hyena         (480) AGAGTACCTGGGCCTGCCCTCCGTATATCTCTTCAGGGGCTTCCCATGCTCCTTGGAGCA
Aardwolf            (289) AGAGTACCTGGGCCTGCCCTCCGTATATCTCTTCAGGGGCTTCCCATGCTCCTTGGAGCA
Indian mongoose     (480) GGAGTACCTGGGCCTGCCCTCTGTGTATCTCTTCAGGGGCTTCCCGTGCTCCCTGGAGCA
Binturong           (480) AGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCGTGCTCCCTGGAGCA
African civet       (290) AGAGTACCTGGGCCTGCCCTCTGTGTATCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Ferret              (468) TGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Polar bear          (368) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Asiatic black bear(367) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Racoon              (324) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGTTTCCCGTGCTCCCTGGAGCA
Red fox             (369) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Red wolf            (367) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Dog                 (468) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Maned wolf          (367) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
N. Elephant seal    (397) CGAGTACCTGAGCCTGCCCTCTGTGTACCTCTTCGGGGGCTTCCCATGCTCCCTGGAGCA
House mouse(b)      (480) TGAGTATCTCAACCTGCCCTCTGTCTACCTCTTCAGAGGTTTCCCATGCTCTCTGGAACA
House mouse(a)      (480) TGAGTATCTCAACCTGCCCTCTGTCTACCTCTTCAGAGGTTTCCCATGCTCTCTGGAACA
Rat                 (477) TGAGTATCTCAAGCTGCCTTCCGTCTACCTCTTCAGAGGTTTCCCATGCTCTCTGGAGCA
Rabbit              (480) TGAGTACCTGGGCCTGCCCTCCGTGTACCTGTTCAGGGGCTTCCCCTGTTCCCTGGAGCA
Bovine              (471) CGAGTACCTGAACCTGCCCTCCGTGTATCTCTTCAGGGGCTTCCCCTGTGCCCTGGAGAA
Sheep               (477) CGAGTACCTGAACCTGCCCTCTGTGTATCTCTTCAGGGGCTTTCCCTGTGCCCTGGAGAA
                          541                                                 600
Human               (540) TACATTCAGCAGAAGCCCAGACCCTGTGTCCTACATTCCCAGGTGCTACACAAAGTTTTC
Chimpanzee          (540) TACATTCAGCAGAAGCCCAGACCCTGTGTCCTACATTCCCAGGTGCTACACAAAGTTTTC
Crab e. macaque     (540) TACATTCAGCAGAAGCCCAAACCCTGTGTCCTATATTCCCAGGTGCTACACAAAGTTTTC
Jaguar              (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Leopard             (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Snow leopard        (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
(African) Lion      (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Tiger               (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACA-TCAGTTCTC
Canadian lynx       (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Bobcat              (539) CGCGATCACCCAGAGCCCGAACCCCGCATCCTACGTTCCCAGATGCTACACTCAGTTCTC
Florida panther     (535) CACAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTATACTCAGTTCTC
Mountain lion       (535) CACAATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTATACTCAGTTCTC
Leopard cat         (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Margay              (539) CGCAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTACGCTCAGTTCTC
African golden cat(539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Domestic cat        (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Asiatic golden cat(539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Geoffroy's cat      (539) CGCAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Pampas cat          (355) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Serval              (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Little spotted cat(539) CGCAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Cheetah             (539) CGCAATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Spotted hyena       (540) CGCGATCAGCAGAAGCCCAAACCCTGGGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Brown hyena         (540) CGTGATCAGCAGAAGCCCAAACCCTGGGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Aardwolf            (349) CGCGATCAACAGAAGCCCAAACCCTGGGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Indian mongoose     (540) CGCGATCAGCAGGAGCCCAAACCCTGTGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Binturong           (540) CGCCATCAGCAGGAGCCCAAACCCTGTGTCCTACGTTCCCAGATGCTACACTAAGTTCTC
African civet       (350) CGCGATCAGCAGGAGCCCAAACCCTGTGTCCCACATTCCCAGGTGCTACACTCAGTTCTC
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                          481                                                 540
Human              (480) TGAGTATTTGGGCCTACCATCTGTGTACCTCTTCAGGGGTTTTCCGTGTTCCCTGGAGCA
Chimpanzee         (480) TGAGTATTTGGGCCTACCATCTGTGTACCTCTTCAGGGGTTTTCCGTGTTCCCTGGAGCA
Crab e. macaque    (480) TGAGTATTTGGGCCTACCCTCCGTGTACCTCTTCAGGGGTTTTCCGTGTTCCCTGGAGCA
Jaguar             (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Leopard            (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Snow leopard       (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
(African) Lion     (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCGGGGGCTTCCCACGCTCCCTGGGGCA
Tiger              (379) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Canadian lynx      (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTTTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Bobcat             (479) AGAGCACCTAGGCCTGCCCTCCATGTATCTTTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Florida panther    (475) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Mountain lion      (475) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Leopard cat        (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Margay             (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCATGCTCCCTGGGGCA
African golden cat(479) AGAGTACCTAGGCCTGCCCTCCATGTGTCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Domestic cat       (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Asiatic golden cat(479) AGAGTACCTAGGCCTGCCCTCCATGTATCTTTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Geoffroy's cat     (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Pampas cat         (295) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Serval             (479) AGAGTACCTAGGCCTGCCCTCCATGTGTCTCTTCAGGGTCTTCCCACGCTCCCTGGGGCA
Little spotted cat(479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCCTGGGGCA
Cheetah            (479) AGAGTACCTAGGCCTGCCCTCCATGTATCTCTTCAGGGGCTTCCCACGCTCCTTGGGGCA
Spotted hyena      (480) AGAGTACCTGGGCCTGCCCTCCGTATATCTCTTCAGGGGCTTCCCATGCTCCTTGGAGCA
Brown hyena        (480) AGAGTACCTGGGCCTGCCCTCCGTATATCTCTTCAGGGGCTTCCCATGCTCCTTGGAGCA
Aardwolf           (289) AGAGTACCTGGGCCTGCCCTCCGTATATCTCTTCAGGGGCTTCCCATGCTCCTTGGAGCA
Indian mongoose    (480) GGAGTACCTGGGCCTGCCCTCTGTGTATCTCTTCAGGGGCTTCCCGTGCTCCCTGGAGCA
Binturong          (480) AGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCGTGCTCCCTGGAGCA
African civet      (290) AGAGTACCTGGGCCTGCCCTCTGTGTATCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Ferret             (468) TGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Polar bear         (368) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Asiatic black bear(367) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Racoon             (324) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGTTTCCCGTGCTCCCTGGAGCA
Red fox            (369) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Red wolf           (367) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Dog                (468) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
Maned wolf         (367) CGAGTACCTGGGCCTGCCCTCCGTGTACCTCTTCAGGGGCTTCCCATGCTCCCTGGAGCA
N. Elephant seal   (397) CGAGTACCTGAGCCTGCCCTCTGTGTACCTCTTCGGGGGCTTCCCATGCTCCCTGGAGCA
House mouse(b)     (480) TGAGTATCTCAACCTGCCCTCTGTCTACCTCTTCAGAGGTTTCCCATGCTCTCTGGAACA
House mouse(a)     (480) TGAGTATCTCAACCTGCCCTCTGTCTACCTCTTCAGAGGTTTCCCATGCTCTCTGGAACA
Rat                (477) TGAGTATCTCAAGCTGCCTTCCGTCTACCTCTTCAGAGGTTTCCCATGCTCTCTGGAGCA
Rabbit             (480) TGAGTACCTGGGCCTGCCCTCCGTGTACCTGTTCAGGGGCTTCCCCTGTTCCCTGGAGCA
Bovine             (471) CGAGTACCTGAACCTGCCCTCCGTGTATCTCTTCAGGGGCTTCCCCTGTGCCCTGGAGAA
Sheep              (477) CGAGTACCTGAACCTGCCCTCTGTGTATCTCTTCAGGGGCTTTCCCTGTGCCCTGGAGAA
                          541                                                 600
Human              (540) TACATTCAGCAGAAGCCCAGACCCTGTGTCCTACATTCCCAGGTGCTACACAAAGTTTTC
Chimpanzee         (540) TACATTCAGCAGAAGCCCAGACCCTGTGTCCTACATTCCCAGGTGCTACACAAAGTTTTC
Crab e. macaque    (540) TACATTCAGCAGAAGCCCAAACCCTGTGTCCTATATTCCCAGGTGCTACACAAAGTTTTC
Jaguar             (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Leopard            (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Snow leopard       (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
(African) Lion     (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Tiger              (439) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACA-TCAGTTCTC
Canadian lynx      (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Bobcat             (539) CGCGATCACCCAGAGCCCGAACCCCGCATCCTACGTTCCCAGATGCTACACTCAGTTCTC
Florida panther    (535) CACAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTATACTCAGTTCTC
Mountain lion      (535) CACAATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTATACTCAGTTCTC
Leopard cat        (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Margay             (539) CGCAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTACGCTCAGTTCTC
African golden cat(539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Domestic cat       (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Asiatic golden cat(539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Geoffroy's cat     (539) CGCAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Pampas cat         (355) CGCGATCAGCCAGAGCCCGAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Serval             (539) CGCGATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Little spotted cat(539) CGCAATCAGCCAGAGCCCAAACCCTGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Cheetah            (539) CGCAATCAGCCAGAGCCCAAACCCCGCATCCTACATTCCCAGATGCTACACTCAGTTCTC
Spotted hyena      (540) CGCGATCAGCAGAAGCCCAAACCCTGGGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Brown hyena        (540) CGTGATCAGCAGAAGCCCAAACCCTGGGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Aardwolf           (349) CGCGATCAACAGAAGCCCAAACCCTGGGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Indian mongoose    (540) CGCGATCAGCAGGAGCCCAAACCCTGTGTCCTACATTCCCAGATGCTACACTCAGTTCTC
Binturong          (540) CGCCATCAGCAGGAGCCCAAACCCTGTGTCCTACGTTCCCAGATGCTACACTAAGTTCTC
African civet      (350) CGCGATCAGCAGGAGCCCAAACCCTGTGTCCCACATTCCCAGGTGCTACACTCAGTTCTC
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Domestic cat       (659) ---------CCTTC-GTATTCAAAGTATGAA--GGCCTTGCATCCAATATCCTCAAGAGA
Asiatic golden cat(659) ---------CCTTC-GTATTCAAAGTATGAA--GACCTTGCATCCAATATCCTCAAGAGA
Geoffroy's cat     (659) ---------CCTTC-GTATTCAAAGTATGAA--GACCTTGCATCCAATATCCTCAAGAGA
Pampas cat         (475) ---------CCTTC-GTATTCAAAGTATGAA--GACCCTGCATCCAATATCCTCAAGAGA
Serval             (659) ---------CCTTC-GTATTCAAAGTATGAATGGACCTTGCATCCAATATCCTCAAGAGA
Little spotted cat(659) ---------CCTTC-GTATTCAAAGTATGAA--GACCTTGCATCCAATATCCTCAAGAGA
Cheetah            (659) ---------CCTTT-GTATTCAAAGTATGAA--GACCTTGCATCCAACATCCTCAAGAGA
Spotted hyena      (660) TTTATTCTACCTTCTGTATTCAAAGTATGAA--GACCTCGCATCCAATATCCTCAAGAGA
Brown hyena        (660) TTTATTCTACCTTCTATATTCAAAGTATGAA--GACCTCGCATCCAATATCCTCAAGAGA
Aardwolf           (469) TTTATTCTACCTTCTGTATTCAAAGTACGAA--GACCTCGCATCCAATATCCTCAAGAGA
Indian mongoose    (660) CATATTCTACCTTCTGTATTCAAAGTATGAA--GACCTCGCATCCAGCATCCTCAAGAGA
Binturong          (660) TATATTCCACCTTCTGTATTCAAAGTATGAA--GACCTCGCATCCAATATGCTCAAGAGA
African civet      (470) TATATTTTACCTTCTGTATTCAAAGTATGAA--GACCTCGCATCCGATATCCTCAAGAGA
Ferret             (648) TCTGTTCCACTGTCTGTACTCGAAGTACGAA--GACCTCGCCTCCAACATCCTCAAGAGG
Polar bear         (548) TCTGTTCTACTGTCTGTATTCCAAGTATGAA--GACCTTGCCTCCAACATCCTCAAGAGA
Asiatic black bear(547) TCTGTTCTACTGTCTGTATTCCAAGTATGAA--GACCTTGCCTCCAACATCCTCAAGAGA
Racoon             (504) TCTGTTCCACTGTCTGTACTCAAAGTACGAA--GACCTCGCCTCCCGTATCCTCAAGAGA
Red fox            (549) CCTGTTCTACTGTCTGTATTCAAAGTACGAA--GACCTTGCATCCAATATCCTCAAGAGA
Red wolf           (547) CCTGTTCTACTGTCTGTATTCAAAGTACGAA--GACCTTGCATCCAATATCCTCAAGAGA
Dog                (648) CCTGTTCTACTGTCTGTATTCAAAGTACGAA--GACCTTGCATCCAATATCCTCAAGAGA
Maned wolf         (547) CCTGTTCTACTGTCTGTATTCAAAGTACGAA--GACCTTGCATCCAATATCCTCAAGAGA
N. Elephant seal   (577) TCTGTTCTAATGCCTGTATTCAAAGTATGAA--GACCTCCCCTCCAATATCCTCAAGAGA
House mouse(b)     (660) CCTATATTATTGTCTGTATTCAAAGTATGAA--ATCATTGCCTCAGACCTCCTCAAGAGA
House mouse(a)     (660) CCTATATTATTGTCTGTATTCAAAGTATGAA--ATCATTGCCTCAGACCTCCTCAAGAGA
Rat                (657) CCTTTATCATTGTCTGTACTCAAAGTATGAG--ATCCTTGCCTCAGACCTCCTCAAGAGA
Rabbit             (660) TCTATTTTACTGTCTGTATTCAAAGTATGAG--GACCTGGCGGTAGAGCTCCTCAAGAGG
Bovine             (651) TCTGCTCTACGCGCTGTATTCCAAGTACGAA--GACCTGGCAGGGGAAGTCCTTGGGAGA
Sheep              (657) TTTGCTCTATGCGCTGTATTCCAAGTACGAA--GACCTGGCGGAGGAAGTCCTTGGGAGA
                                 721                                           780
Human              (718) GATGTGGATATAATCACCTTATATCAGAAGGTCTCTGTTTGGCTGTTA-AGATATGACTT
Chimpanzee         (718) GATGTGGATATAATCACCTTATATCAGAAGGTCTCTGTTTGGCTGTTA-AGATATGACTT
Crab e. macaque    (718) GATGTGGATGTAATCACCTTATATCAGAAGGTCTCTGTTTGGCTGTTA-AGATATGACTT
Jaguar             (607) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTAACGATACGACTT
Leopard            (607) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Snow leopard       (607) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-TGATACGACTT
(African) Lion     (607) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Tiger              (606) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Canadian lynx      (707) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Bobcat             (707) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Florida panther    (703) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Mountain lion      (703) GACGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCCGTTA-CGATACGACTT
Leopard cat        (707) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CAATACGACTT
Margay             (707) GATGTGCACTTACCCACCTTGTGTCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
African golden cat(707) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Domestic cat       (707) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CAATACGACTT
Asiatic golden cat(707) GATGTGCACTTATCCACCTTGCATCGGAAGGGCTCCATCTGGCTGTTA-CGATACGACTT
Geoffroy's cat     (707) GATGTGCACTTACTCGCCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Pampas cat         (523) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTAACGATACGACTT
Serval             (709) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Little spotted cat(707) GATGTGCACTTACTCGCCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Cheetah            (707) GATGTGCNCTTACCCACCTTGTATCGGAAGGGCTCCGTCTGGCTGTTA-CGATACGACTT
Spotted hyena      (718) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCATTTGGCTCTTA-AGATATGACTT
Brown hyena        (718) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTTCATTTGGCTGTTA-AGATACGACTT
Aardwolf           (527) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCATTTGGCTGTTG-AGATACGACTT
Indian mongoose    (718) GGTGTGGACTTACCCACCTTGTATCGGAAGGGCTCCATTTGGCTGTTA-AGATATGACTT
Binturong          (718) GATGTGCACTTGCCCACTTTGTATCGGAAGGGCTCCCTTTGGCTCTTA-CAATACGACTT
African civet      (528) GATGTGTACTTACCCGCCTTGTATCGGAAGGGCCCCCTTTGGCTGTTA-AGATATGACTT
Ferret             (706) GATGTGCACCTACCCACCTTGTATCAGAAGGGCTCCATCTGGCTCTTA-AGATATGACTT
Polar bear         (606) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCATTTGGCTCTTA-CAATACGACTT
Asiatic black bear(605) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCATTTGGCTCTTA-CAATACGACTT
Racoon             (562) GATGTGCACTTACCCACCTTGTATCGGAAGGGCTCCATTTGGCTCTTA-CAATACAACTT
Red fox            (607) GATGTGCACTTACCCACCTTGTATCGGAACGGCTCCATTTGGCTCTTA-CAATACGACTT
Red wolf           (605) GATGTGCACTTACCCACCTTGTATCGGAACGGCTCCATTTGGCTCTTA-CAATACGACTT
Dog                (706) GATGTGCACTTACCCACCTTGTATCGGAACGGCTCCATTTGGCTGTTA-AGATATGACTT
Maned wolf         (605) GATGTGCACTTACCCACCTTGTATTGGAACGGCTCCATTTGGCTCTTA-CAATACGA---
N. Elephant seal   (635) GATGTGCACGTACCCACCTTGTATCGGAAGGGCTCCGTTTGGCTCTTA------------
House mouse(b)     (718) GATGTGTCCCTACCTTCCTTACACCAGAA---TTCTCTGTGGCTGTTA-CGGTACGATTT
House mouse(a)     (718) GATGTGTCCCTACCTTCCTTACACCAGAA---TTCTCTGTGGCTGTTA-CGGTACGATTT
Rat                (715) GATGTGTCCCTACCTGCCTTACACCAGAA---CTCTCTGTGGCTGTTA-CGGTATGATTT
Rabbit             (718) GAAGTGGACCTGCCCACCTTATTTCAGAAGGACCCCGTGTGGCTGCTA-AGATACGACTT
Bovine             (709) CAGGTGCACTTGCCGGCCTTGTATCGGAAGGCCTCCATTTGGCTGTTA-AGATACGACTT
Sheep              (715) CAGGTGCACTTGCCGGCCTTGTATCAGAAGGCCTCCATTTGGCTGCTA-AGATACGACTT
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                          781                                                 840
Human               (777) TGTGCTTGAATATCCTAGGCCGGTCATGCCCAACATGGTCTTCATTGGAGGTATCAACTG
Chimpanzee          (777) TGTGCTTGAATATCCTAGGCCGGTCATGCCCAACATGGTCTTCATTGGAGGTATCAACTG
Crab e. macaque     (777) TGTACTTGAGTATCCTAGGCCAGTCATGCCCAACATGGTCTTCATTGGAGGTACCAACTG
Jaguar              (667) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAATTG
Leopard             (666) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAATTG
Snow leopard        (666) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGATGAATTG
(African) Lion      (666) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAATTG
Tiger               (665) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAATTG
Canadian lynx       (766) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Bobcat              (766) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACAGGGTTTTCATTGGAGGGACCAACTA
Florida panther     (762) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Mountain lion       (762) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Leopard cat         (766) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCAT-GGAGGGACCAACCT
Margay              (766) TGTGTTCAAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
African golden cat(766) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Domestic cat        (766) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCAT-GGAGGGACCAACCT
Asiatic golden cat(766) GGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGGCCAACTG
Geoffroy's cat      (766) TGTGTTCAAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Pampas cat          (583) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCAT-GGAGG-ACCA----
Serval              (768) TGTGTTCGAGTACCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Little spotted cat(766) TGTGTTCAAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Cheetah             (766) TGTGTTCGAGTATCTCAGACCAGTCATGCCCAACATGGTTTTTATTGGAGGGACCAACTG
Spotted hyena       (777) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGNAGGGANCAACTG
Brown hyena         (777) TGTGTTCGAGTATCCCGGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Aardwolf            (586) TGTGTTCGAGTATCCCAGACCGGTCATGCCCAACATGGTTT-CATCGGAGACCA------
Indian mongoose     (777) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTC----------------
Binturong           (777) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACATGGTCTTCATTGGAGGGACCAACTG
African civet       (587) TGTGCTCGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Ferret              (765) TGTGTTTGAATATCCCAGACCCCGTCTGCCTAACATGGTTTTCGTTGGAGGGAGCAATTG
Polar bear          (665) ------------------------------------------------------------
Asiatic black bear(664) T-----------------------------------------------------------
Racoon              (621) TGTGCTCAAAA--------------------------------------------------
Red fox             (666) T-----------------------------------------------------------
Red wolf            (664) T-----------------------------------------------------------
Dog                 (765) TGTGTTTGAGTATCCCAGACCAGTCATGCCCAACATGGTTTTCATTGGAGGGACCAACTG
Maned wolf          (661) ------------------------------------------------------------
N. Elephant seal    (683) ------------------------------------------------------------
House mouse(b)      (774) TGTGTTCGAATATCCCAGGCCGGTCATGCCCAACATGATCTTCCTTGGAGGGATCAACTG
House mouse(a)      (774) TGTGTTCGAATATCCCAGGCCGGTCATGCCCAACATGATCTTCCTAGGAGGGATCAACTG
Rat                 (771) TGTGTTCGAATACCCCCGGCCAGTCATGCCCAACATGATCTTCATTGGAGGGACCAACTG
Rabbit              (777) TGTGTTTGAGTACCCCAGGCCGGTGATGCCCAACATGGTGCTCATTGGCGGGATCAACTG
Bovine              (768) TGTGTTCGAGTATCCCAGACCAGTCATGCCCAACACGGTCCTCATCGGAGGGTCCAGCTG
Sheep               (774) TGTGTTCGAGTATCCCAGACCAGTGATGCCCAACATGGTCTTCATCGGAGGGTC-AGCTG
                          841                     866
Human               (837) T-AAGAAGAGGAAAGACTTGTCTCAG
Chimpanzee          (837) T-AAGAAGAGGAAAGACTTGTCTCAC
Crab e. macaque     (837) T-AAGAAGAGGAAAGACCTGTCTGAG
Jaguar              (727) C-AAGGAAAAGGGAGTCCTGTCTCAG
Leopard             (726) C-AAGGAAAAGGGAGTCCTGTCTCAG
Snow leopard        (726) C-AAGGAAAAGGGAGTCCTGTCTCAG
(African) Lion      (726) C-AAGGAAAAGGGAGTCCTGTCTCAG
Tiger               (725) C-AAGGAAAAGGGAGTCCTGTCTCAG
Canadian lynx       (826) C-AAGGAAAAGGGAGTCCTGTCTCAG
Bobcat              (826) C-AAGGAAAAGGGAGTCCTGTCTCAG
Florida panther     (822) C-AAGGAAAAGGGAGTCCTGTCTCAG
Mountain lion       (822) C-AAGGAAAAGGGAGTCACGTCTCAG
Leopard cat         (825) C-AAGGAAAAGGGAGTCCTGTCTCAG
Margay              (826) C-AAGGAAAAGGGAGTCCTGTCTCAG
African golden cat(826) C-AAGGAAAAGGGAGTCCTGTCTCAG
Domestic cat        (825) C-AAGGAAAAGGGAGTCCTGTCTCAG
Asiatic golden cat(826) C-AAGGAAAAGGGAGTCCTGTCTCAG
Geoffroy's cat      (826) C-AAGGAAAAGGGAGTCCTGTCTCAG
Pampas cat          (637) --------------------------
Serval              (828) C-AAGGAAAAGGGAGTCCTGTCTCAG
Little spotted cat(826) C-AAGGAAAAGGGAGTCCTGTCTCAG
Cheetah             (826) C-AAGGAAAAGGGAGTCCTGTCTCAG
Spotted hyena       (837) C-AAGGAAAAGGGAGTCCTGTCTCAG
Brown hyena         (837) C-AAGAAAAAGGGAGTCCTGTCTCAG
Aardwolf            (639) --------------------------
Indian mongoose     (820) --------------------------
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Binturong          (837) C-AAGGAAAAGGGAGTCCTG------
African civet      (647) C-AAGAAAAAGGGAGTCCTGTCTCAG
Ferret             (825) C-AAGAAGATGGGGGTCCTGTCTCAG
Polar bear         (665) --------------------------
Asiatic black bear(665) --------------------------
Racoon             (632) --------------------------
Red fox            (667) --------------------------
Red wolf           (665) --------------------------
Dog                (825) C-AAGATGAAGGGAGTCCTGCCTCAG
Maned wolf         (661) --------------------------
N. Elephant seal   (683) --------------------------
House mouse (b)    (834) T-AAGAAGAAGGGAAAGCTGACTCAG
House mouse (a)    (834) T-AAGAAGAAGGGAAAGCTGACTCAG
Rat                (831) C-AAGAAGAAGGGGAACCTGTCTCAG
Rabbit             (837) C-AAGAAGCCGGACGTCCTGTCTCAG
Bovine             (828) C-AAGAAACAGGGCGTCCTGTCTCAG
Sheep              (833) CCAAGAAACAAGGCATCCTGCCTCGG
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B Clustal W alignment of *UGT1A1* exon1 sequence.

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                    1                                                    70
Human          (1) ------ATGGCTGTGGAGTCCCAGGGCGGACGCCCACTTGTCCTGGGCCTGCTGCTGTGTGTGCTGGGCC
Chimpanzee     (1) ------ATGGCTGTGGAGTCCCAGGGCGGACGCCCACTTGTCCTGGGCCTGCTGCTGTGTGTGCTGGGCC
Crab e.macaque (1) ------ATGGCTGTGGAGTCCCAAGGCAGACATCCACTTGTCCTGGGCCTGCTGCTGTGTGTGCTGGGCC
Jaguar         (1) ----------------------------------------------------------------------
Leopard        (1) ----------------------------------------------------------------------
Snow leopard   (1) ----------------------------------------------------------------------
African lion   (1) ----------------------------------------------------------------------
Tiger          (1) ----------------------------------------------------------------------
Canadian lynx  (1) ----------------------------------------------------------------------
Bobcat         (1) ----------------------------------------------------------------------
Florida panther(1) ----------------------------------------------------------------------
Mountain lion  (1) ----------------------------------------------------------------------
Leopard cat    (1) ----------------------------------------------------------------------
Margay         (1) ----------------------------------------------------------------------
African g. cat (1) ----------------------------------------------------------------------
Domestic cat   (1) ------ATGGCAGCGAGGTCCCGGGGGCCACGTCCGCTTGTGCTGAGCCTGCTGCTGTGTGCCCTGAATC
Asiatic g. cat (1) ----------------------------------------------------------------------
Geoffroy's cat (1) ----------------------------------------------------------------------
Pampas cat     (1) ----------------------------------------------------------------------
Serval         (1) ----------------------------------------------------------------------
L. spotted cat (1) ----------------------------------------------------------------------
Cheetah        (1) ----------------------------------------------------------------------
Spotted hyena  (1) ----------------------------------------------------------------------
Brown hyena    (1) ----------------------------------------------------------------------
Aardwolf       (1) ----------------------------------------------------------------------
Indian mongoose(1) ----------------------------------------------------------------------
Binturong      (1) ----------------------------------------------------------------------
African civet  (1) ----------------------------------------------------------------------
Ferret         (1) ----------------------------------------------------------------------
Polar bear     (1) ----------------------------------------------------------------------
Asiatic b. bear(1) ----------------------------------------------------------------------
Raccoon        (1) ----------------------------------------------------------------------
Red fox        (1) ----------------------------------------------------------------------
Red wolf       (1) ----------------------------------------------------------------------
Dog            (1) ------ATGGCAGCAGAGGCCCCGGGGCCACGTCCGCTGGTCCTGGGCCTGCTGCTGTGCGCCTTGAGTG
Maned wolf     (1) ----------------------------------------------------------------------
S. fur seal    (1) ----------------------------------------------------------------------
N. fur seal    (1) ----------------------------------------------------------------------
N.Z.sea lion   (1) ----------------------------------------------------------------------
N.elephant seal(1) ----------------------------------------------------------------------
House mouse    (1) -----GTGGTGTGCTGGAGCTCGCGTTTGCTTCTGCTTCTTCCGTACCTTCTGTTGTGTGTGTTCGGTC
Rat            (1) ATGTCCGTGGTGTGCCGGAGCTCATGTTCGCTTCTGCTTCTTCCGTGCCTTCTGCTGTGTGTGTTGGGTC
                   71                                                   140
Human         (65) CAGTGGTGTCCCATGCTGGGAAGATACTGTTGATCCCAGTGGATGGCAGCCACTGGCTGAGCATGCTTGG
Chimpanzee    (65) CAGTGGTGTCCCATGCTGGGAAGATACTGTTGATCCCAGTGGATGGCAGCCACTGGCTGAGCATGCTTGG
Crab e.macaque(65) CAGTGCTGTGCCATGCTGGGAAGATGCTGTTGATCCCAGTGGATGGCAGCCACTGGCTGAGCATGCTTGG
Jaguar         (1) ----------------------------------------------------------------------
Leopard        (1) ----------------------------------------------------------------------
Snow leopard   (1) ----------------------------------------------------------------------
African lion   (1) ----------------------------------------------------------------------
Tiger          (1) ----------------------------------------------------------------------
Canadian lynx  (1) ----------------------------------------------------------------------
Bobcat         (1) ----------------------------------------------------------------------
Florida panther(1) ----------------------------------------------------------------------
Mountain lion  (1) ----------------------------------------------------------------------
Leopard cat    (1) ----------------------------------------------------------------------
Margay         (1) ----------------------------------------------------------------------
African g. cat (1) ----------------------------------------------------------------------
Domestic cat  (65) CCCTTCTGTCCCAGGGCGGGAAGCTGTTGTTGGTCCCAATGGATGGCAGCCACTGGCTGAGCTTGTTCGG
Asiatic g. cat (1) ----------------------------------------------------------------------
Geoffroy's cat (1) ----------------------------------------------------------------------
Pampas cat     (1) ----------------------------------------------------------------------
Serval         (1) ----------------------------------------------------------------------
L. spotted cat (1) ----------------------------------------------------------------------
Cheetah        (1) ----------------------------------------------------------------------
Spotted hyena  (1) ----------------------------------------------------------------------
Brown hyena    (1) ----------------------------------------------------------------------
Aardwolf       (1) ----------------------------------------------------------------------
Indian mongoose(1) ----------------------------------------------------------------------
Binturong      (1) ----------------------------------------------------------------------
African civet  (1) ----------------------------------------------------------------------
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Ferret          (1) ------------------------------------------------------------------------
Polar bear      (1) ------------------------------------------------------------------------
Asiatic b. bear(1) ------------------------------------------------------------------------
Raccoon         (1) ------------------------------------------------------------------------
Red fox         (1) ------------------------------------------------------------------------
Red wolf        (1) ------------------------------------------------------------------------
Dog            (65) CCCCTGTGTCCCAGGGTGGGAAGCTGCTGTTGATCCCCGTGGATGGCAGCCACTGGCTGAGCATGCTCGG
Maned wolf      (1) ------------------------------------------------------------------------
S. fur seal     (1) ------------------------------------------------------------------------
N. fur seal     (1) ------------------------------------------------------------------------
N.Z.sea lion    (1) ------------------------------------------------------------------------
N.elephant seal(1) ------------------------------------------------------------------------
House mouse    (65) CCTCTGCATCCCATGCTGGGAGGCTGTTAGTGTTCCCTATGGATGGAAGCCACTGGCTGAGTATGCTTGG
Rat            (71) CCTCTGCGTCCCATGCTGGGAAGCTGTTAGTGATCCCCATAGATGGCAGCCACTGGCTGAGTATGCTCGG
                    141                                                             210
Human         (135) GGCCATCCAGCAGCTGCAGCAGAGGGGACATGAAATAGTTGTCCTAGCACCTGACGCCTCGTTGTACATC
Chimpanzee    (135) GGCCATCCAGCAGCTGCAGCAGAGGGGACATGAAATAGTTGTCCTAGCACCTGACGCCTCGTTGTACATC
Crab e.macaque(135)GACCATCCAGCAGCTGCAGCAGAGGGGACATGAAATAGTTGTCCTAGCACCTGATGCCTCATTGTACATC
Jaguar          (1) ------------------------------------------------------------------------
Leopard         (1) ------------------------------------------------------------------------
Snow leopard    (1) ------------------------------------------------------------------------
African lion    (1) ------------------------------------------------------------------------
Tiger           (1) ---------GCGGCTGCACCAGCGGGGACACGACGTAGTGGTCATAGCTCCTGAGGCCTCCGTGTACATT
Canadian lynx   (1) ------------------------------------------------------------------------
Bobcat          (1) ------------------------------------------------------------------------
Florida panther(1) ------------------------------------------------------------------------
Mountain lion   (1) ------------------------------------------------------------------------
Leopard cat     (1) ------------------------------------------------------------------------
Margay          (1) ------------------------------------------------------------------------
African g. cat  (1) ------------------------------------------------------------------------
Domestic cat  (135) GGTCATCCAGCGGCTGCACCAGCGGGGACACGACGTAGTGGTCGTAGCTCCTGAGGCCTCCGTGTACATT
Asiatic g. cat  (1) ------------------------------------------------------------------------
Geoffroy's cat  (1) ------------------------------------------------------------------------
Pampas cat      (1) ------------------------------------------------------------------------
Serval          (1) ------------------------------------------------------------------------
L. spotted cat  (1) ------------------------------------------------------------------------
Cheetah         (1) ------------------------------------------------------------------------
Spotted hyena   (1) ------------------------------------------------------------------------
Brown hyena     (1) ------------------------------------------------------------------------
Aardwolf        (1) ------------------------------------------------------------------------
Indian mongoose(1) ------------------------------------------------------------------------
Binturong       (1) ---------GCAGTTGCACCAGCGGGGACATGACATAGTGGTCCTCGCGTCCGAGGCCGCCGTGTACATT
African civet   (1) ------------------------------------------------------------------------
Ferret          (1) -------GAGCAGCTGCACCAGAGGGGACATGACATGGTAGTCCTAGCTTCCGAGGCTTCCGTGCACATT
Polar bear      (1) -----GTCGGCAGCTGCACCAGAGGGGACATGACATAGTGGTCCTAGCTCCTGAGGCCTCCGTGCACATC
Asiatic b. bear(1) -----GTCGGCAGCTGCACCAGAGGGGACATGACATAGTGGTCCTAGCTCCTGAGGCCTCCGTGCACATC
Raccoon         (1) ------TCGGCAGCTGCACCAGAGGGGACATGACATAGTGGTCCTAGCTTCCGAGGCCTCCATGTACATC
Red fox         (1) --------AGCAGTTGCACCAGAGGGGACATGAGGTAGTGGTGATAGCTCCCGAGGCCTCTGTGCACATC
Red wolf        (1) -------CAGCAGTTGCACCAGAGGGGACATGAGGTAGTGGTGATAGCTTCCGAGGCTTCTGTGTACATC
Dog           (135) GGTCGTCAAGCAGTTGCACCAGAGGGGACATGAGGTAGTGGTGATAGCTTCCGAGGCTTCTGTGTACATC
Maned wolf      (1) --------AGCAGTTGCACCAGAGGGGACATGAGGTAGTGGTGATAGCTTCCGAGGCTTCTGTGTACATC
S. fur seal     (1) ------------------------------------------------------------------------
N. fur seal     (1) ------------------------------------------------------------------------
N.Z.sea lion    (1) ------------------------------------------------------------------------
N.elephant seal(1) ------------------------------------------------------------------------
House mouse   (135) AGTTATTCAGCAGCTCCAGCAGAAGGGGCACGAAGTTGTGGTCATAGCACCTGAAGCCTCAATACACATA
Rat           (141) AGTTATTCAGCAGCTCCAGCAAAAGGGGCACGAAGTGGTGGTCATAGCACCTGAAGCTTCGATACACATA
                    211                                                             280
Human         (205) AGAGACGGAGCATTTTACACCTTGAAGACGTACCCTGTGCCATTCCAAAGGGAGGATGTGAAAGAGTCTT
Chimpanzee    (205) AGAGACGGAGCATTTTACACCTTGAAGACGTACCCTGTGCCATTCCAAAGGGAGGATGTGAAAGAGTCTT
Crab e.macaque(205)AGAGAGGGAGCATTTTACACCTTGAAGACGTACCCTGTGCCATTCCAAAGGGAGGATGTGAAAGAGTCTT
Jaguar          (1) ------------------------------------------------------------------------
Leopard         (1) ------------------------------------------------------------------------
Snow leopard    (1) ------------------------------------------------------------------------
African lion    (1) ------------------------------------------------------------------------
Tiger          (62) AAAGAAGGAGCGTTTTACACCTTGAAGAGCTACCCCGTCCCATTCCGGAGGGAGGACGTGGAAGCATCTT
Canadian lynx   (1) ------------------------------------------------------------------------
Bobcat          (1) ------------------------------------------------------------------------
Florida panther(1) ------------------------------------------------------------AGCGTCTT
Mountain lion   (1) ------------------------------------------------------------GTCTT
Leopard cat     (1) ------------------------------------------------------------------------
Margay          (1) ------------------------------------------------------------------------
African g. cat  (1) ------------------------------------------------------------------------
Domestic cat  (205) AAAGAAGGAGCGTTTTACACCTTGAAGAGCTACCCCGTCCCATTCCGGAGGGAGGACGTGGAAGCGTCTT
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Asiatic g. cat (1) ------------------------------------------------------------------------
Geoffroy's cat (1) ------------------------------------------------------------------------
Pampas cat     (1) ------------------------------------------------------------------------
Serval         (1) ----------------------------------------------------------AAACGTCTT
L. spotted cat (1) ------------------------------------------------------------------------
Cheetah        (1) ----------------------------------------------------------AGCGTCTT
Spotted hyena  (1) ----------------------------------------------------------------------T
Brown hyena    (1) ----------------------------------------------------------------GGCTT
Aardwolf       (1) ------------------------------------------------------------------------
Indian mongoose(1) ------------------------------------------------------------------------
Binturong     (62) AAGGAAAACCCGATGTACACCTTGAAGAGCTACCCCGTGCCGTTCCGGAGGGAGGACGTGCAAGAGGCTT
African civet  (1) ----------------------------------------------------------------------CTT
Ferret        (64) AAAGAAGGAGCGTTCTACACCTTGAAGAGGTACCCTGTGCCATTCAGAAGGGAGGACGTGGAAGAAGCTT
Polar bear    (66) AAAGAAGCAGCATTTTACAGCTTGAAGAGGTACCCTGTGCCATTCCGAAGGGAGGACGTGGAAGCCACTT
Asiatic b. bear(66)AAAGAAGCAGCATTTTACAGCTTGAAGAGGTACCCTGTGCCATTCCGAAGGGAGGACGTGGAAGCCACTT
Raccoon       (65) AAAGAAGGAACATTTTACACCTTGAAGAGGTACCCTGTGCCATTCCGAAGGGAGGACATAGAAGGAGCTT
Red fox       (63) AAAGGAGCAGCATTTTACACCCTGAAGAGGTACCCTGTGCCATTCCGAAGGGAGGACGTGGAAGCCACTT
Red wolf      (64) AAAGGAGCAGCATTTTACACCCTGAAGAGGTACCCTGTGCCATTCCGAAGGGAGGACGTGGAAGCCACTT
Dog          (205) AAAGGAGCAGCATTTTACACCCTGAAGAGGTACCCTGTGCCATTCCGAAGGGAGGACGTGGAAGCCACTT
Maned wolf    (63) AAAGGAGCAGCATTTTACACCCTGAAGAGGTACCCTGTGCCATTCCGAAGGGAGGACGTGGAAGCCACTT
S. fur seal    (1) ------------------------------------------------------------------------
N. fur seal    (1) ------------------------------------------------------------------------
N.Z.sea lion   (1) ------------------------------------------------------------------------
N.elephant seal(1) ------------------------------------------------------------------------
House mouse  (205) AAAGAAGGATCATTTTACACTCTGAGGAAGTTCCCTGTGCCATTCCAGAAGGAAAATGTGACAGCTACTT
Rat          (211) AAAGAAGGATCATTTTACACTATGAGGAAGTACCCTGTGCCATTCCAAAATGAAAACGTGACAGCTGCTT
                   281                                                              350
Human        (275) TTGTTAGTCTCGGGCATAATGTTTTTGAGAATGATTCTTTCCTGCAGCGTGTGATCAAAACATACAAGAA
Chimpanzee   (275) TTGTTAGTCTCGGGCATAATGTTTTTGAGAATGATTCTTTCCTGCAGCGTGTGATCAAAACATACAAGAA
Crab e.macaque(275)TTGTTAGTCTTGGGCATAATGTTTTTGAGAATGATTCTTTCCTGCGGCGTGTGATCAAAACATACAAGAA
Jaguar         (1) --------------------------TGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Leopard        (1) -------------------------------GAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Snow leopard   (1) --------CTTGGGCTCGAGGTTTTTGGGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
African lion   (1) ------------------AGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Tiger        (132) TTACTGGTCTCGGGCTCGAGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Canadian lynx  (1) -------------------TGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCAAGACATACAAGAA
Bobcat         (1) ---------TCGGGCTCGGGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Florida panther(9) TTACTGGTCTCGGGCTCGGGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Mountain lion  (6) TTACTGGTCTCGGGCTCGGGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Leopard cat    (1) ----GGGTCTCGGGCTCGAGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCAAGACATACAAGAG
Margay         (1) -------------------GGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCAAGACATATAAGAG
African g. cat (1) -----------GGGCTCGGGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Domestic cat (275) TTACTGGTCTCGGGCTCGGGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGCGACGTACAAGAG
Asiatic g. cat (1) --------------CTCGAGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAAACATACAAGAG
Geoffroy's cat (1) -------TCTCGGGCTCGAGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCAAGACATATAAGAG
Pampas cat     (1) -----------GGGCTCGGCGTTTTTAAAAAGAACCCTTTCCTGCACCGTGTTGTCAAAACGAATAAAAG
Serval        (10) TTACTGGNCTCGGGCTCGGGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
L. spotted cat (1) ------------------GGTTTTTNGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCAAGACATATAAGAG
Cheetah        (9) TTACTGGTCTCGGGCTCGGGGTTTTTGAGAAGAAGCCTTTCCTGCAGCGTGTGGTCGAGACATACAAGAG
Spotted hyena  (2) TTATCAGTCTCGGGCATAATGTTTTTGAAA-GAAACCTTTCCTGCAGTATGCAGTCCAGATATACAAGAA
Brown hyena    (6) TTATCAGTCTCGGGCATAATGTTTTTGAAAAGAAACCTTTCCTGCAGTATGCAGTCCAGATATACAAGAA
Aardwolf       (1) ------GTCTCGGGCATAATGTTTTTGAGAAGAAACCTTTCCTGCAGTATGCAGTCCAGATATACAAGAG
Indian mongoose(1) ---TCGGTCTCGGACTTGCTGTTTTTGAGAAGAAACCTCTCCTGCAGTACGTGGTCCAGACGTACAAGAA
Binturong    (132) TCACCAGTCTTGGGCACAGTGTTTTCGAGAACAAGCCTTTCCTGCAGCGTGCGGTCCAGACCTACAAGAA
African civet  (4) TTGTCAGGCTTGGTTACAGTGTTTTTGAGAAGAAGCCTTTTCTGCAGCGTGTGGTCCAGACATACAAGAA
Ferret       (134) TTATCAAACTCGGGCACGGTGTCTTTGAGAATGAGCCTTTGCTGCAGCGTGTGGTCAAAACGTACAAGAA
Polar bear   (136) TTATCAGACTTGGGCACGGTGTTTTTGAGAATGACTCTTTGCTGCAGCGTGTGGTCAAAACGTACAAGAG
Asiatic b.bear(136)TTATCAGACTTGGGCACGGTGTTTTTGAGAATGACTCTTTGCTGCAGCGTGTGGTCAAAACGTACAAGAG
Raccoon      (135) TCCTCAAACTTGGGCACGGTGTCTTTGAGAATGAGCCTTTGCTGCAGCGTGTGGTCAAAACGTACAAGAA
Red fox      (133) TTATCAGCCTCGGGCGCGGTGTTTTTGAGAATGTGCCTTTGCTGCGGCGTGTGATCAAAACGTACAAGAA
Red wolf     (134) TTACCAGCCTCGGGCGCGGTGTTTTTGAGAATGTGCCTTTGCTGCGGCGTGTGATCAAAACGTACAAGAA
Dog          (275) TTACCAGCCTCGGGCGCGGTGTTTTTGAGAATGTGCCTTTGCTGCGGCGTGTGATCAAAACGTACAAGAA
Maned wolf   (133) TTACCAGCCTCGGGCGCGGTGTTTTTGAGAATGTGCCTTTGCTGCGGCGTGTGATCAAAACGTACAAGAA
S. fur seal    (1) ------------------------------AATGAGCCTTTGCTGCAGCGTGTGGTCAAAATGTATAAGAA
N. fur seal    (1) ------------------CGGTGTTTTTGATGATGAGCCTTTGCTGCAGCGTGTGGTCAAAATGTATAAGAA
N.Z.sea lion   (1) ----------------------------GAATGAGCCTTTGCTGCAGCGTGTGGTCAAAATGTATAAGAA
N.elephant seal(1) --TCAGACTTGGGCACGGTGTTTTTGAGAAAGAGCCTTTGCTGCAGCGTGTGGTCAAAACGTATAAGAA
House mouse  (275) TGGTGGAACTTGGACGGACTGCCTTTAATCAAGATTCTTTTCTGCTGCGCGTGGTCAAAATATATATGAA
Rat          (281) TTGTGGAACTTGGGCGGAGTGTCTTTGATCAAGATCCTTTTCTGCTGCGTGTGGTTAAAACATACAACAA
                   351                                                              420
Human        (345) AATAAAAAAGGACTCTGCTATGCTTTTGTCTGGCTGTTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Chimpanzee   (345) AATAAAAAAGGACTCTGCTATGCTTTTGTCTGGCTGTTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Crab e.macaque(345)AATAAAAAAGGACTCTGCTATGCTTTTGTCTGGCTGTTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Jaguar        (46) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
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Leopard       (40) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
Snow leopard  (63) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
African lion  (53) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
Tiger        (202) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACAAGGAGCTGATGGCC
Canadian lynx (52) GGTCAAGAAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTTATGGCC
Bobcat        (62) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Florida panther(79)GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Mountain lion (76) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Leopard cat   (67) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTGCTGTACGACGAGGAACTGATGGCC
Margay        (52) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
African g. cat(60) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Domestic cat (345) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Asiatic g. cat(57) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Geoffroy's cat(64) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Pampas cat    (60) GGCCAAGAAGGACTCTGCTCGGTTTTTGTCTGCCTGCTCCCACTTACTGAACAACGAGAAGTTGAGGGCC
Serval        (80) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
L. spotted cat(53) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Cheetah       (79) GGTCAAGAAGGACTCTGCTCTGCTTTTGTCTGCCTGCTCCCACTTACTGTACAACGAGGAGCTGATGGCC
Spotted hyena (71) AATCAAGAAGGACTCTGCTCTGCTTTTTTCTGCCTGCTCCCACCTACTGCACAACCAGGAGCTGATGGCC
Brown hyena   (76) AATCAAGAAGGACTCTGCTCTGCTTTTTTCTGCCTGCTCCCACCTACTGCACAACCAGGAGCTGATGGCC
Aardwolf      (65) GATCAAGAAGGACTCTGCTCTGCTTTTTTCTGCCTGCTCCCACCTACTGCACAACCAGGAGCTGATGGCC
Indian mongoose(68)AATCCAGAAGGACTCTGCTCTGCTGTTTTCGGCCTGCTCCCACCTCCTGCACAACGAGGAGCTGATGGCT
Binturong    (202) GGTCAAGAAGGACTCTGCTCTGCTCTTCTCTGCCTGCTCCCACCTGCTGCACAACAAGGAGCTGATGGCC
African civet (74) TGTACAGAAGAGCTCCGCTCTGCTTTTCTCTGCCTGCTCCCACTTGCTGCACAACAAGGAGCTGATGGCC
Ferret       (204) AGTCAAGGAGGACTCTGCCCTGATTTTTTCTGCCTGCTCCCACTTATTGCACAACAAGGAACTTATGGCC
Polar bear   (206) AGTCAAGGAGGACTCTGCCCTGATTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Asiatic b.bear(206)AGTCAAGGAGGACTCTGCCCTGATTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTCATGGCC
Raccoon      (205) AGTCAAGAAGGACTCTGCCCTGCTTTTTTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTTATGGCC
Red fox      (203) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
Red wolf     (204) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
Dog          (345) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
Maned wolf   (203) GGTCAAGGAGGACTCGGCTCTGCTTTTGTCTGCTTGCTCCCATTTACTGCATAACAAGGAGCTGATGGCC
S. fur seal   (42) AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
N. fur seal   (55) AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
N.Z.sea lion  (43) AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
N.elephant seal(68)AGTCAAGGAGGACTCTGCCCTGCTTTTGTCTGCCTGCTCCCACTTACTGCACAACAAGGAGCTAATGGCC
House mouse  (345) AGTCAAAAGGGATTCCAGTATGCTCCTAGCTGGCTGCTCCCACCTGCTGCACAATGCCGAGTTTATGGCC
Rat          (351) AGTCAAAAGGGACTCCAGTATGCTGCTGTCTGGCTGCTCCCACCTTCTGCACAATGCCGAGTTTATGGCC
                   421                                                          490
Human        (415) TCCCTGGCAGAAAGCAGCTTTGATGTCATGCTGACGGACCCTTTCCTTCCTTGCAGCCCCATCGTGGCCC
Chimpanzee   (415) TCCCTGGCAGAAAGCAGCTTTGATGTCATGCTGACGGACCCTTTCCTTCCTTGCAGCCCCATCGTGGCCC
Crab e.macaque(415)TCCCTTGCGGAAAGCAGCTTTGACGTCATGCTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Jaguar       (116) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Leopard      (110) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Snow leopard (133) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
African lion (123) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Tiger        (272) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Canadian lynx(122) TCCCTGGGGGAAAGCAGCTTTGATGCCGTGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Bobcat       (132) TCCCTGGCGGAAAGCGGCCTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Fl. Panther  (149) TCCCTGGCGGAAAGCGGCTTCGATGCCGTGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Mountain lion(146) TCCCTGGCGGAAAGCGGCTTCGATGCCGTGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Leopard cat  (137) TCCCTGGCGGAAAGCGGCTTCGATGCCGTGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Margay       (122) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
African g.cat(130) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Domestic cat (415) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Asiatic g.cat(127) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Geoffroy's cat(134)TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Pampas cat   (130) TCCCGGGGGAAAAGCGGTTTCAATGCCATGTTGACAAACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Serval       (150) TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
L. spotted cat(123)TCCCTGGCGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Cheetah      (149) TCCCTGGTGGAAAGCGGCTTCGATGCCATGTTGACAGACCCTTTCCTTCCTTGTGGCCCCATCGTGGCCC
Spotted hyena(141) TCCCTGGCGGAAAGCGGCTTCGATGCCGTGTTGACAGACCCTTTCCTTCCCTGCGGCCCCATCGTGGCCC
Brown hyena  (146) TCCCTGGTAGAAAGCGGCTTCGATGCCGTGTTGACAGACCCTTTCCTTCCCTGCGGCCCCATCGTGGCCC
Aardwolf     (135) TCCCTGGCGGGAAGCGGCTTCGATGCCGTGTTGACAGACCCTTTCCTTCCCTGCGGCCCCATCGTGGCCC
In.  mongoose(138) TCCCTGGCGGAAGGCAGCTTCGACGCCGTGCTGACGGACCCTTTCCTCCCCTGCGGCCCCATCGTGGCCC
Binturong    (272) TCCCTGGCGGAAAGCCGCTTCGACGCCGTGTTGACAGACCTTTTCATCCCCTGCGGCCCCATCGTGGCCC
African civet(144) TCCCTGGCGGAAAGCCACTTCGATGCCGTGTTGACAGACCCTTTCCTTCCCTGCGGCCCCATCGTGGCCC
Ferret       (274) TCCCTGGTGGAAAGCCGCTTCGATGCCGTGTTGGCAGACCCTTTCCTCCCTTGTGGCCCCATCGTGGCGC
Polar bear   (276) TCCCTGGTGGAAAGCAGCTTCGATGCCGTGTTGACAGACCCTTTCCTCCCTTGTGGCCCCATCGTGGCCC
Asiatic b.bear(276)TCCCTGGTGGAAAGCAGCTTCGATGCCGTGTTGACAGACCCTTTCCTCCCTTGTGGCCCCATCGTGGCCC
Raccoon      (275) TCCCTGGTGGAAAGCAGCTTTGATGCCGTGTTGACAGACCCTTTGCTCCCTTGTGGCCCCATCGTGGCGC
Red fox      (273) TCGCTGGCAGAAAGCAGCTTCGATGCTGTGTTGACGGACCCCTTCCTTCCTTGCGGTCCCATCGTGGCCC
Red wolf     (274) TCGCTGGCAGAGAGCAGCTTCGATGCTGTGTTGACGGACCCCTTCCTTCCTTGCGGTCCCATCGTGGCCC
Dog          (415) TCGCTGGCAGAGAGCAGCTTCGATGCTGTGTTGACGGACCCCTTCCTTCCTTGCGGTCCCATCGTGGCCC
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Maned wolf      (273) TCGCTGGCAGAGAGCAGCTTCGATGCTGTGTTGACGGACCCCTTCCTTCCTTGCGGTCCCATCGTGGCCC
S. fur seal     (112) TCGCTGGTGGAAAGCAGCTTCGATGCCGTGTTGACAGACCCTTTCCTCCCTTGTGGCCCCATCGTGGCCC
N. fur seal     (125) TCGCTGGTGGAAAGCAGCTTCGATGCCGTGTTGACAGACCCTTTCCTCCCTTGTGGCCCCATCGTGGCCC
N.Z.sea lion    (113) TCGCTGGTGGAAAGCAGCTTCGATGCCGTGTTGACAGACCCTTTCCTCCCTTGTGGCCCCATCGTGGCCC
N.elephant seal(138) TCGCTCGCGGAAAGCAACTTCGATGCTGTGTTGACAGACCCTTTCCTCCCTTGTGGCCCCATCGTGGCCC
House mouse     (415) TCTCTGGAAGAAAGTCACTTTGATGCTCTGCTGACAGACCCTTTCCTTCCCTGTGGCTCCATTGTGGCCC
Rat             (421) TCTCTGGAACAAAGCCACTTTGATGCTCTGCTGACAGACCCTTTCCTTCCGTGCGGCTCCATTGTGGCCC
                      491                                                           560
Human           (485) AGTACCTGTCTCTGCCCACTGTATTCTTCTTGCATGCACTGCCATGCAGCCTGGAATTTGAGGCTACCCA
Chimpanzee      (485) AGTACCTGTCTCTGCCCACTGTATTCTTCTTGCATGCACTGCCATGCAGCCTGGAATTTGAGGCTACCCA
Crab e.macaque  (485) AGTACCTGTCTCTGCCCACTGTATTCTTCTTGAATGCATTGCCATGCAGCCTGGAATCTGAGGCTACCCA
Jaguar          (186) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Leopard         (180) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Snow leopard    (203) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
African lion    (193) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGTGGCCTAGATTTTCAAGGTACCCG
Tiger           (342) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Canadian lynx   (192) TGTACCTGGCTCTGCCTGTCGTGTTTTTCTTGCACTCACTGCCATGTGGCCTGGATTTTCAAGGTACCCG
Bobcat          (202) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGCACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Florida panther(219) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGCACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Mountain lion   (216) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGCACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Leopard cat     (207) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Margay          (192) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCGTGCGGCCTAGATTTTCAAGGTACCCT
African g. cat  (200) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Domestic cat    (485) TGCGCCTGGCGCTGCCTGTCGTGTTCTTCTTGAACTCGCTGCCCTGCGGCCTAGATTTTCAAGGTACCCG
Asiatic g. cat  (197) TGCGCCTGGCGCTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAAATTCTCAAGGTACCCG
Geoffroy's cat  (204) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Pampas cat      (200) TGCCCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCGTGCGGCCTAGATTTTCAAGGTACCCG
Serval          (220) TGCGCCTGGCCCTGCTGGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
L. spotted cat  (193) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGAACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Cheetah         (219) TGCGCCTGGCACTGCCTGTCGTGTTCTTCTTGCACTCACTGCCATGCGGCCTAGATTTTCAAGGTACCCG
Spotted hyena   (211) TGTACCTGGAGCTGCCCGCCGTGTTCTTCTCGAACGCACTGCCATGCGGCCTAGATTTGCAAGGTACCCA
Brown hyena     (216) TGTACCTGGAGCTGCCCGCCGTGTTCTTCTCAAACGCACTGCCATGCGGCCTAGATTTGCAAGGTACCCA
Aardwolf        (205) TGTACCTGGAGCTGCCCGCCGTGTTCTTCTCGAACGCGCTGCCATGCGGCCTAGATTTGCAAGGTACCCA
Indian mongoose(208) TGCGCCTGGCGCTGCCCGTTGTGTTCTTCTCCCACAAACTGCCGTGTGGCCTAGATTTCCAAGGTACCCA
Binturong       (342) TGCACCTGGCGCTGCCTGCTGTGTTCTTCTTGAACGCGCTGCCGTGTGGAGTCGATTTTCAAGGTGCCCA
African civet   (214) TGCACCTGGCGCTGCCTGCTGTGTTCTTCTTGAACGTGCTGCCATGTGGCCTAGATTTTCAAGGTACCCA
Ferret          (344) TGTACCTGGGTCTGCCTGCTGTGTTCTTCTTGAATGCGCTGCCGTGTGGCCTAGATTTTCAAGGTACTCA
Polar bear      (346) TGTACCTGGCTCTGCCTGCCGTGTTCTTCTTGAATGCGCTGCCGTGTGGCCTAGATTCTCAAGGTACCCA
Asiatic b. bear(346) TGTACCTGGCTCTGCCTGCCGTGTTCTTCTTGAATGCGCTGCCGTGTGGCCTAGATTCTCAAGGTACCCA
Raccoon         (345) TGTACCTGGCTCTGCCTGCCGTGTTTTTCTTAAACTCGCTACCGTGTGGCCTGGATTTTCAAGGTACCCA
Red fox         (343) TGTACCTGGCCCTCCCTGCTGTGTTCTTCTTGCACGCACTGCCATGCAGCCTAGATTTTCAAGGTACCCA
Red wolf        (344) TGTACCTGGCCCTCCCTGCTGTGTTCTTCTTGCACGCACTGCCATGCAGCCTAGATTTTCAAGGTACCCA
Dog             (485) TGTACCTGGCCCTCCCTGCTGTGTTCTTCTTGCACGCACTGCCATGCAGCCTAGATTTTCAAGGTACCCA
Maned wolf      (343) TGTACCTGGCCCTCCCTGCTGTGTTTTTCTTGCACGCACTGCCATGCAGCCTAGATTTTCAAGGTACCCA
S. fur seal     (182) TGTACCTGGGTCTGCCTGCCGTGTTCTTCTTGAATGCGCTGCCGTGTGGCCTAGATTTTCAAGGTACCCT
N. fur seal     (195) TGTACCTGGGTCTGCCTGCCGTGTTCTTCTTGAATGCGCTGCCGTGTGGCCTAGATTTTCAAGGTACCCT
N.Z.sea lion    (183) TGTACCTGGGTCTGCCTGCCGTGTTCTTCTTGAATGCGCTGCCGTGTGGCCTAGATTTTCAAGGTACCCT
N.elephant seal(208) TGTACCTGGCTCTGCCTGCCGTGTTCTTCTTGAATGCGCTGCCGTGTGGCCTAGATTTTCAAGGTACCCA
House mouse     (485) AGTACCTGACTGTGCCCACTGTGTACTTCTTGAATAAATTGCCATGCAGCCTGGATTCAGAAGCTACCCA
Rat             (491) AGTACCTGTCTCTGCCTGCTGTGTACTTCTTGAATGCATTGCCATGCAGCCTGGATTTGGAAGCCACCCA
                      561                                                           630
Human           (555) GTGCCCCAACCCATTCTCCTACGTGCCCAGGCCTCTCTCCTCTCATTCAGATCACATGACCTTCCTGCAG
Chimpanzee      (555) GTGCCCCAACCCATTCTCCTACGTGCCCAGGCCTCTCTCCTCTCATTCAGATCACATGACCTTCCTGCAG
Crab e.macaque  (555) GTGCCCCAACCCATTCTCCTACGTGCCCAGGCCTCTGTCCGCTCATTCAGATCACATGACCTTCCTGCAG
Jaguar          (256) CTGTCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACACAGATCACATGACTTTCCTCCAG
Leopard         (250) CTGTCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTCCAG
Snow leopard    (273) CTGTCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTCCAG
African lion    (263) CTGTCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTCCAG
Tiger           (412) CTGTCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCGTAACTCAGATCACATGACTTTCCTCCAG
Canadian lynx   (262) GTGCCCCAGCCCACCATCTTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Bobcat          (272) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Florida panther(289) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Mountain lion   (286) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Leopard cat     (277) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Margay          (262) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
African g. cat  (270) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Domestic cat    (555) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Asiatic g. cat  (267) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAAATCACATGACTTTCCTACAG
Geoffroy's cat  (274) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Pampas cat      (270) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACCG
Serval          (290) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
L. spotted cat  (263) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Cheetah         (289) CTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Spotted hyena   (281) TTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACCTTCCTACAG
Brown hyena     (286) TTGCCCCAGCCCACCATCCTATGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACCTTCCTACAG
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Aardwolf       (275) TTGCCCCAGCCCACCATCCTACGTGCCCAGGGTTCTGTCCCTTAACTCAGATCACATGACCTTCCTACAG
Indian mongoose(278) ATGTCCCAGCCCACCGTCCTACGTGCCCAGGCCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACAG
Binturong      (412) TTGCCCCAGCCCCCCGTCCTACGTGCCCCGGGGCATGTCCCTTAACTCGGATCACATGACCTTCCCACAG
African civet  (284) TTGCCCCAGCCCACCATCCTATGTGCCCAGGAGTCTGTCCTTTAACTCAGATCACATGACCTTCCTACAG
Ferret         (414) GTGCCCCAACCCACCATCTTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTTTTACCA
Polar bear     (416) GTGCCCCAACCCACCATCCTATGTGCCCAGGCCTCTCTCCCTTAACTCTGATCACATGACCTTCTTACAG
Asiatic b. bear(416) GTGCCCCAACCCACCATCCTATGTGCCCAGGCCTCTCTCCCTTAACTCTGATCACATGACCTTCTNACAG
Raccoon        (415) GTGCCCCAGCCCACCATCTTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTTTTACCG
Red fox        (413) GTGCCCCAACCCACCATCCTATGTGCCCAGGACTCTGTCCCTTAACTCAGATCACATGACTTTCCTACAG
Red wolf       (414) GTGCCCCAACCCACCATCCTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACAG
Dog            (555) GTGCCCCAACCCACCATCCTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACAG
Maned wolf     (413) GTGCCCCAGCCCACCATCCTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACAG
S. fur seal    (252) GTGTCCCAACCCACCATCCTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACCG
N. fur seal    (265) GTGTCCCAACCCACCATCCTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACCG
N.Z.sea lion   (253) GTGTCCCAACCCACCATCCTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACCG
N.elephant seal(278) GTGTCCCAACCCACCATCCTATGTGCCCAGGGCTCTGTCCCTTAACTCAGATCACATGACCTTCCTACCG
House mouse    (555) ATGCCCCGTCCCATTGTCCTACGTGCCCAAGAGTTTGTCTTTCAACTCAGACCGCATGAACTTCCTACAG
Rat            (561) ATGCCCTGCTCCGTTGTCCTACGTGCCCAAGAGTTTGTCCTCGAACACAGATCGCATGAACTTCCTGCAG
                     631                                                         700
Human          (625) CGGGTGAAGAACATGCTCATTGCCTTTTCACAGAACTTTCTGTGCGACGTGGTTTATTCCCCGTATGCAA
Chimpanzee     (625) CGGGTGAAGAACATGCTCATTGCCTTTTCACAGAACTTTCTGTGCGACGTGGTTTATTCCCCGTATGCAA
Crab e.macaque (625) CGGGTGAAGAACATGCTCATTGCCTTTTCACAGAACTTTCTGTGCGACGTGGTTTATTCCCCATATGCAA
Jaguar         (326) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
Leopard        (320) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
Snow leopard   (343) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATGCAT
African lion   (333) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATGG--
Tiger          (482) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTATTCCCCATATGCAT
Canadian lynx  (332) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGAGCTTTCTGTGCAATGTGGTTTATTCCCCGTATGGAG
Bobcat         (342) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTAT----
Florida panther(359) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCATATGAAC
Mountain lion  (356) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATA---
Leopard cat    (347) CGGGTGAAGAACATGCTCATCCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
Margay         (332) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
African g. cat (340) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
Domestic cat   (625) CGGGTGAAGAACATGCTCATTCTTGGGTCAGAGGGCTTCCTGTGCAATGTGGTTTATTCCCCATATGCGT
Asiatic g. cat (337) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
Geoffroy's cat (344) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
Pampas cat     (340) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATGA--
Serval         (360) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCATATGCAT
L. spotted cat (333) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATGCAC
Cheetah        (359) CGGGTGAAGAACATGCTCATTCTTGTGTCAGAGGGCTTCCTGTGCAATGTGGTTTACTCCCCCTATG---
Spotted hyena  (351) CGGGTAAAGAACATGCTCATTCTCGCATCAGAGGGCTTTCTGTGCAACATGGTTTACTCCCCCTATG---
Brown hyena    (356) CGGGTAAAGAACATGCTCATTCTCGCATCAGAGGGCTTTCTGTGCAACATGGTTTACTCCCCCTATG---
Aardwolf       (345) CGGGTAAAGAACATGCTCATTCTCGCATCAGAGGGCTTCCTGTGCAACATGGTTTACTCCCCCTATG---
Indian mongoose(348) CGGGTGAAAAACATGCTCATTCTGGCGTCAGAGGGCTTTCTCTGCAACGTGGTTTACTCCCCCTATG---
Binturong      (482) CGGGTGAAGAACATGCTCATTCTGGCATTGGAGAGCTTTCTGTGTGACGTGGTTTATTCCCCATATGCGC
African civet  (354) CGGGTGAAGAACATACTCATTCTCGCATCAGAGGGCTTTCTGTGCAACGTGGTTTACTCCCCCTATG---
Ferret         (484) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAGCTTTCTGTGCAATGTGGTTTATTCCCCGTATGGAG
Polar bear     (486) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAACTTTCTGTGCAATGTGGTTTATTTGCCGTACGGAC
Asiatic b. bear(486) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAACTTTCTGTGCAATGTGGTTTATTTGCCGTACGGAC
Raccoon        (485) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAGCTTTCTGTGCAATGTGGTTTATTCCCCGTATGGAG
Red fox        (483) CGGGTGAAGAACATGCTCATTTTCTTGTCCGAGAGCTTTTTGTGCAATGTGGTTTATTCCCCATATGAGC
Red wolf       (484) CGGGTGAAGAACATGCTCATTTTCTTGTCCGAGAGCTTTTTGTGCAATGTGGTTTACTCCCCATATGAAC
Dog            (625) CGGGTGAAGAACATGCTCATTTTCTTGTCCGAGAGCTTTTTGTGCAATGTGGTTTACTCCCCATATGAAC
Maned wolf     (483) CGGGTGAAGAACATGCTCATTTTCTTGTCCGAGAGCTTTTTGTGCAATGTGGTTTACTCCCCATATGAAC
S. fur seal    (322) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAGCTTTCTGTGCAATGTGGTTTACTCCCCCTATG---
N. fur seal    (335) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAGCTTTCTGTGCAATGTGGTTTACTCCCCCTATGCGC
N.Z.sea lion   (323) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAGCTTTCTGTGCAATGTGGTTTACTCCCCCTATG---
N.elephant seal(348) CGGGTGAAGAACATGCTCATTTTCTTGTCAGAGAGCTTTCTGTGCAATGTGGTTTACTCCCCCTATG---
House mouse    (625) CGAGTGAAGAACGTGCTCCTGGCCGTGTCAGAGAACTTTATGTGCAGAGTGGTTTATTCCCCCTATGGGT
Rat            (631) CGGGTGAAGAACATGATTATTGCTTTGACAGAGAACTTTCTATGCAGAGTGGTTTACTCCCCCTATGGGT
                     701                                                         770
Human          (695) CCCTTGCCTCAGAATTCCTTCAGAGAGAGGTGACTGTCCAGGACCTATTGAGCTCTGCATCTGTCTGGCT
Chimpanzee     (695) CCCTTGCCTCAGAATTCCTTCAGAGAGAGGTGACTGTCCAGGACCTATTGAGCTCTGCATCTGTCTGGCT
Crab e.macaque (695) CCCTTGCCTCGGAATTCCTGCAGAGAGAGGTGACTGTCCAGAACCTATTGAGCTCTGCATCTGTCTGGCT
Jaguar         (393) ------------------------------------------------------------------------
Leopard        (387) ------------------------------------------------------------------------
Snow leopard   (413) CACTTGCTTCGGA-------------------------------------------------------------
African lion   (401) ------------------------------------------------------------------------
Tiger          (552) CACTTGCTTCGGAAGTCCTTCAGAAAGATGTGACTGTCCAGGACCTTATGGGCTCCGCATCGGTCTGGCT
Canadian lynx  (402) CACTTGCCTCAGAAGTCCTTCAGAAAGATGTGACTGTCCAGGACCTAATGGGCTCTGCGTCTGTCTGGCT
Bobcat         (408) ------------------------------------------------------------------------
Florida panther(429) CCCT--------------------------------------------------------------------
Mountain lion  (423) ------------------------------------------------------------------------
Leopard cat    (414) ------------------------------------------------------------------------
Margay         (399) ------------------------------------------------------------------------
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African g. cat  (407) ----------------------------------------------------------------------
Domestic cat    (695) CACTTGCTTCGGAAGTCCTTCAGAAAGATGTGACTGTCCAGGACCTTATGGGCTCCGCATCGGTCTGGCT
Asiatic g. cat  (404) ----------------------------------------------------------------------
Geoffroy's cat  (411) ----------------------------------------------------------------------
Pampas cat      (408) ----------------------------------------------------------------------
Serval          (430) CACTTGCTTCGGAAGTCCTGCAGAAAGATGTGACTGTCCAGGACCTTATGGGCTCCGCATC---------
L. spotted cat  (403) CCCTTGA-------------------------------------------------------------
Cheetah         (426) ----------------------------------------------------------------------
Spotted hyena   (418) ----------------------------------------------------------------------
Brown hyena     (423) ----------------------------------------------------------------------
Aardwolf        (412) ----------------------------------------------------------------------
Indian mongoose (415) ----------------------------------------------------------------------
Binturong       (552) CACTCGCCTCGGAAATCCTTCAGAGGGATGTGACCGTCCAGGACCTGATGGCCTCCGGGTCAGTCTGGCT
African civet   (421) ----------------------------------------------------------------------
Ferret          (554) CACTTGCCTCAGAAGTCCTTCAGAAAGATGTGACTGTCCAGGACCTGATGAGCTCTGCATCTGTCTGGAT
Polar bear      (556) CACTTGCCTCAGAAATCCTTCAGAAGGATGTGACTGTCCAGGACCTTTTGGGCTCCGGCTCTGTCTGGCT
Asiatic b. bear (556) CACTTGCCTCAGAAATCCTTCAGAAGGATGTGACTGTCCAGGACCTTTTGGGCTCCGGCTCTGTCTGGCT
Raccoon         (555) CACTTGCCTCAGAAGTCCTTCAGAAAGATGTGACTGTCCAGGACCTAATGGGCTCTGCGTCTGTCTGGCT
Red fox         (553) CACTTGCCTCGGAAGTCCTTCAGAAAGATGTGACAGTCCAGGAACTTATGGGCTCTGCATCCATCTGGCT
Red wolf        (554) CACTTGCCTCGGAAGTCCTTCAGAAAGATGTGACAGTCCAGGAACTTATGGGCTCTGCATCCATCTGGCT
Dog             (695) CACTTGCCTCGGAAGTCCTTCAGAAAGATGTGACAGTCCAGGAACTTATGGGCTCTGCATCCATCTGGCT
Maned wolf      (553) CACTTGCCTCGGAAGTCCTTCAGAAAGATGTGACAGTCCAGGAACTTATGGGCTCTGCATCCATCTGGCT
S. fur seal     (389) ----------------------------------------------------------------------
N. fur seal     (405) CCCTTGA-------------------------------------------------------------
N.Z.sea lion    (390) ----------------------------------------------------------------------
N.elephant seal (415) ----------------------------------------------------------------------
House mouse     (695) CACTTGCCACTGAAATCTTACAGAAAGAGGTGACTGTCCAGGATCTTCTGAGCCCTGCATCTATCTGGCT
Rat             (701) CACTTGCCACTGAAATCTTACAGAAAGAGGTGACTGTCAAGGACCTTCTTAGTCCTGACTCTATCTGGCT
                      771                                                                 840
Human           (765) GTTTAGAAGTGACTTTGTGAAGGATTACCCTAGGCCCATCATGCCCAATATGGTTTTTGTTGGTGGAATC
Chimpanzee      (765) GTTTAGAAGTGACTTTGTGAAGGATTACCCTAGGCCCATCATGCCCAATATGGTTTTCGTTGGTGGAATC
Crab e.macaque  (765) GCTTAGAAGTGACTTTGTGAAGGATTACCCTAGGCCCATCATGCCCAATATGGCTTTCATTGGTGGAATC
Jaguar          (393) ----------------------------------------------------------------------
Leopard         (387) ----------------------------------------------------------------------
Snow leopard    (426) ----------------------------------------------------------------------
African lion    (401) ----------------------------------------------------------------------
Tiger           (622) TTTCAGAAGTGACTTTGT--------------------------------------------------
Canadian lynx   (472) TCTCAAAAGAGACTTTGT--------------------------------------------------
Bobcat          (408) ----------------------------------------------------------------------
Florida panther (433) ----------------------------------------------------------------------
Mountain lion   (423) ----------------------------------------------------------------------
Leopard cat     (414) ----------------------------------------------------------------------
Margay          (399) ----------------------------------------------------------------------
African g. cat  (407) ----------------------------------------------------------------------
Domestic cat    (765) TTTCAGAAGTGACTTTGTAAAGGATTACTCCAGGCCCATCATGCCCAACATGGTTTTTATCGGTGGGATC
Asiatic g. cat  (404) ----------------------------------------------------------------------
Geoffroy's cat  (411) ----------------------------------------------------------------------
Pampas cat      (408) ----------------------------------------------------------------------
Serval          (491) ----------------------------------------------------------------------
L. spotted cat  (410) ----------------------------------------------------------------------
Cheetah         (426) ----------------------------------------------------------------------
Spotted hyena   (418) ----------------------------------------------------------------------
Brown hyena     (423) ----------------------------------------------------------------------
Aardwolf        (412) ----------------------------------------------------------------------
Indian mongoose (415) ----------------------------------------------------------------------
Binturong       (622) TTTCAGAAACGACTTTGTAAAG---------------------------------------------
African civet   (421) ----------------------------------------------------------------------
Ferret          (624) TCTCAGAAGTGACTTTGTAAAGGA-------------------------------------------
Polar bear      (626) TCTCAGAAGTGACTTTGTCAAAGAT-------------------------------------------
Asiatic b. bear (626) TCTCAGAAGTGACTTTGTCAA-----------------------------------------------
Raccoon         (625) TCTCAGAACAGACTTTGTC------------------------------------------------
Red fox         (623) TCTCAAAGGTGACTTTGTCAAA--------------------------------------------
Red wolf        (624) TCTCAAAGGTGACTTTGTC------------------------------------------------
Dog             (765) TCTCAAAGGTGACTTTGTCAAGGATTACTCCAGGCCCATCATGCCCAGCATGGTTTTTGTTGGTGGGATC
Maned wolf      (623) TCTCAAAGGTGACTTTGTCAAAGA--------------------------------------------
S. fur seal     (389) ----------------------------------------------------------------------
N. fur seal     (412) ----------------------------------------------------------------------
N.Z.sea lion    (390) ----------------------------------------------------------------------
N.elephant seal (415) ----------------------------------------------------------------------
House mouse     (765) GATGAGAAGTGACTTTGTGAAAGATTACCCCAGGCCCATCATGCCCAACATGGTTTTTATTGGTGGTATA
Rat             (771) GATGAGAAACGACTTTGTGAAAGATTACCCCAGGCCCATCATGCCCAACATGGTTTTTATTGGTGGGATA
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                          841                              870
Human             (835) AACTGCCTTCACCAAAATCCACTATCCCAG
Chimpanzee        (835) AACTGCCTTCACCAAAATCCACTATCCCAG
Crab e.macaque    (835) AACTGCCTTCACCAAAGTCCACTATCCCAG
Jaguar            (393) ----------------------------
Leopard           (387) ----------------------------
Snow leopard      (426) ----------------------------
African lion      (401) ----------------------------
Tiger             (640) ----------------------------
Canadian lynx     (490) ----------------------------
Bobcat            (408) ----------------------------
Florida panther   (433) ----------------------------
Mountain lion     (423) ----------------------------
Leopard cat       (414) ----------------------------
Margay            (399) ----------------------------
African g. cat    (407) ----------------------------
Domestic cat      (835) AACTGTGCCGGCAAAAACCCACTGTCCCAG
Asiatic g. cat    (404) ----------------------------
Geoffroy's cat    (411) ----------------------------
Pampas cat        (408) ----------------------------
Serval            (491) ----------------------------
L. spotted cat    (410) ----------------------------
Cheetah           (426) ----------------------------
Spotted hyena     (418) ----------------------------
Brown hyena       (423) ----------------------------
Aardwolf          (412) ----------------------------
Indian mongoose   (415) ----------------------------
Binturong         (644) ----------------------------
African civet     (421) ----------------------------
Ferret            (648) ----------------------------
Polar bear        (651) ----------------------------
Asiatic b. bear   (647) ----------------------------
Raccoon           (644) ----------------------------
Red fox           (645) ----------------------------
Red wolf          (643) ----------------------------
Dog               (835) AACTGTGCCAGCAAAAACCCACTATCCAAG
Maned wolf        (647) ----------------------------
S. fur seal       (389) ----------------------------
N. fur seal       (412) ----------------------------
N.Z.sea lion      (390) ----------------------------
N.elephant seal   (415) ----------------------------
House mouse       (835) AATTGCCTTCAGAAAAAGCCCCTATCCCAG
Rat               (841) AACTGCCTTCAGAAAAAAGCCCTATCCCAG
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