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Programmatic Access to Databases

Venkata P. Satagopam

(venkata.satagopam@uni.lu)

Research Scientist, Bioinformatics core

Luxembourg Centre for Systems Biomedicine (LCSB)

University of Luxembourg

Agenda

- Introduction
- NCBI E-utilities
- EMBL-EBI web services
- KEGG API
- bioCompendium API
- Reflect API

Web services

What is a web service?

- In the broadest sense a web service is any service available on the World Wide Web
- More commonly a web service is any service which is based on web technologies, which is intended for use by computer programs rather than people
- In some cases web service is specifically used to refer to services which use specific web services technologies:
 - Representational state transfer (REST): a software architecture style
 - Simple Object Access Protocol (SOAP): a messaging protocol for transporting information
 - Web Services Description Language (WSDL): a method for describing Web Services and their capabilities



NCBI E-Utilities

Entrez

- Entrez is NCBI's primary text search and retrieval system that integrates the PubMed database of biomedical literature with ~40 other literature and molecular databases including DNA and protein sequence, structure, gene, genome, genetic variation and gene expression

NCBI Resources How To Sign in to NCBI

Search NCBI databases

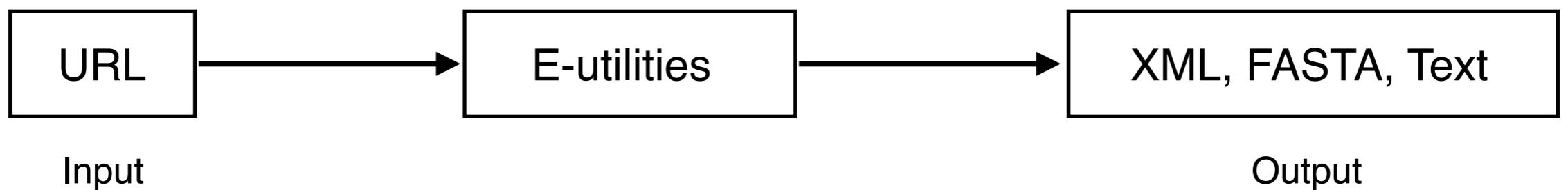
BRCA1

About 467,466 search results for "BRCA1"

Literature			Genes		
Books	794	books and reports	EST	381	expressed sequence tag sequences
MeSH	25	ontology used for PubMed indexing	Gene	12,771	collected information about gene loci
NLM Catalog	49	books, journals and more in the NLM Collections	GEO DataSets	2,140	functional genomics studies
PubMed	11,157	scientific & medical abstracts/citations	GEO Profiles	225,623	gene expression and molecular abundance profiles
PubMed Central	19,320	full-text journal articles	HomoloGene	65	homologous gene sets for selected organisms
Health			PopSet	91	sequence sets from phylogenetic and population studies
ClinVar	3,571	human variations of clinical significance	UniGene	320	clusters of expressed transcripts
dbGaP	4	genotype/phenotype interaction studies	Proteins		
GTR	286	genetic testing registry	Conserved Domains	49	conserved protein domains
MedGen	21	medical genetics literature and links	Protein	67,131	protein sequences
OMIM	165	online mendelian inheritance in man	Protein Clusters	19	sequence similarity-based protein clusters
PubMed Health	121	clinical effectiveness, disease and drug reports	Structure	237	experimentally-determined biomolecular structures
Genomes			Chemicals		
Assembly	0	genomic assembly information	BioSystems	1,288	molecular pathways with links to genes, proteins and chemicals
BioProject	132	biological projects providing data to NCBI	PubChem BioAssay	267	bioactivity screening studies
BioSample	211	descriptions of biological source materials	PubChem Compound	0	chemical information with structures, information and links
Clone	1,702	genomic and cDNA clones	PubChem Substance	197	deposited substance and chemical information
dbVar	1,046	genome structural variation studies			
Epigenomics	0	epigenomic studies and display tools			
Genome	6	genome sequencing projects by organism			
GSS	192	genome survey sequences			
Nucleotide	103,319	DNA and RNA sequences			
Probe	2,846	sequence-based probes and primers			
SNP	11,379	short genetic variations			
SRA	511	high-throughput DNA and RNA sequence read archive			
Taxonomy	0	taxonomic classification and nomenclature catalog			

Entrez E-utilities

- The Entrez Programming Utilities (E-utilities) are a set of eight server-side programs that provide a stable interface into the Entrez query and database system at the NCBI
- The E-utilities use a fixed URL syntax that translates a standard set of input parameters into the values necessary for various NCBI software components to search for and retrieve the requested data



E-utilities

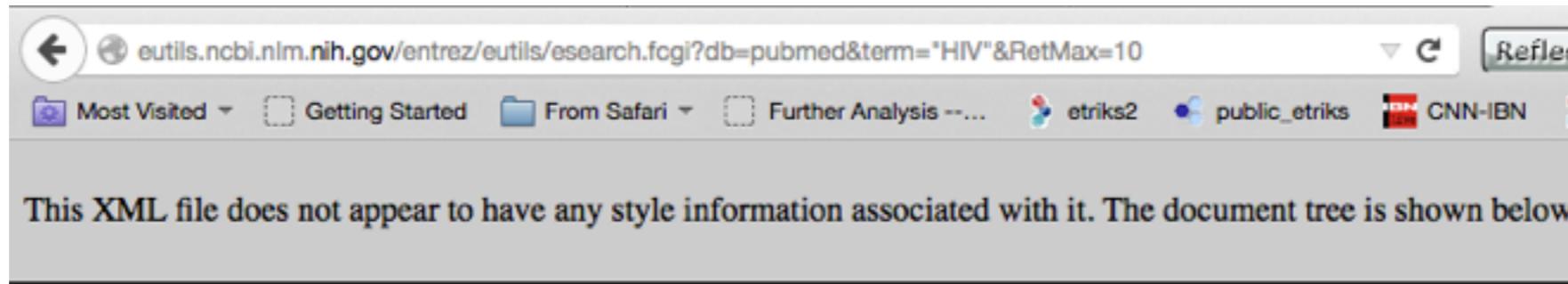
- The base URL: <http://eutils.ncbi.nlm.nih.gov/entrez/eutils/>
- Eight server-side programs :
 - ESearch - Searching a Database
 - ESummary - Downloading Document Summaries
 - EFetch - Downloading Full Records
 - EPost - Uploading UIDs to Entrez
 - ELink - Finding Related Data Through Entrez Links
 - EInfo - Getting Database Statistics and Search Fields
 - EGQuery - Performing a Global Entrez Search
 - ESpell - Retrieving Spelling Suggestions

ESearch

- Input - text query
- Output - list of matching UIDs
- Syntax: ***esearch.fcgi?db=<database>&term=<query>***
 - Input: Entrez database (&db); Any Entrez text query (&term)
 - Output: List of UIDs matching the Entrez query
 - Example: Get the PubMed IDs (PMIDs) for articles about HIV
 - *http://eutils.ncbi.nlm.nih.gov/entrez/eutils/esearch.fcgi?db=pubmed& term=%22HIV%22*

ESearch example results

- [http://eutils.ncbi.nlm.nih.gov/entrez/eutils/esearch.fcgi?
db=pubmed&term=%22HIV%22&RetMax=10](http://eutils.ncbi.nlm.nih.gov/entrez/eutils/esearch.fcgi?db=pubmed&term=%22HIV%22&RetMax=10)



```
--<eSearchResult>
<Count>279597</Count>
<RetMax>10</RetMax>
<RetStart>0</RetStart>
--<IdList>
<Id>25566523</Id>
<Id>25566406</Id>
<Id>25566338</Id>
<Id>25566247</Id>
<Id>25565899</Id>
<Id>25565898</Id>
<Id>25565897</Id>
<Id>25565872</Id>
<Id>25565510</Id>
<Id>25565509</Id>
</IdList>
<TranslationSet/>
--<TranslationStack>
--<TermSet>
<Term>"HIV"[All Fields]</Term>
<Field>All Fields</Field>
<Count>279619</Count>
<Explode>N</Explode>
</TermSet>
<OP>GROUP</OP>
</TranslationStack>
<QueryTranslation>"HIV"[All Fields]</QueryTranslation>
</eSearchResult>
```

ESummary

- Input - list of UIDs
- output - corresponding document summaries
- Syntax: ***esummary.fcgi?db=<database>&id=<uid_list>***
 - Input: List of UIDs(&id); Entrez database(&db)
 - Output: XML DocSums
- Example: Get DocSums for PubMed ids:
25566523,25566406,25566338
- [http://eutils.ncbi.nlm.nih.gov/entrez/eutils/esummary.fcgi?
db=pubmed&id=25566523,25566406,25566338](http://eutils.ncbi.nlm.nih.gov/entrez/eutils/esummary.fcgi?db=pubmed&id=25566523,25566406,25566338)

ESummary example results

This XML file does not appear to have any style information associated with it. The document tree is shown below.

```
- <eSummaryResult>
- <DocSum>
<Id>25566523</Id>
<Item Name="PubDate" Type="Date">2014</Item>
<Item Name="EPubDate" Type="Date">2014 Dec 22</Item>
<Item Name="Source" Type="String">Front Public Health</Item>
- <Item Name="AuthorList" Type="List">
<Item Name="Author" Type="String">Paz-Soldan VA</Item>
<Item Name="Author" Type="String">Alban RE</Item>
<Item Name="Author" Type="String">Dimos Jones C</Item>
<Item Name="Author" Type="String">Powell AR</Item>
<Item Name="Author" Type="String">Oberhelman RA</Item>
</Item>
<Item Name="LastAuthor" Type="String">Oberhelman RA</Item>
- <Item Name="Title" Type="String">
    Patient Reported Delays in Seeking Treatment for Tuberculosis among Adult and Pediatric TB Patients and TB Patients Co-Infected with HIV in Lima, Peru: A Qualitative Study.
</Item>
<Item Name="Volume" Type="String">2</Item>
<Item Name="Issue" Type="String"/>
<Item Name="Pages" Type="String">281</Item>
- <Item Name="LangList" Type="List">
<Item Name="Lang" Type="String">English</Item>
</Item>
<Item Name="NlmUniqueID" Type="String">101616579</Item>
<Item Name="ISSN" Type="String"/>
<Item Name="EISSN" Type="String">2296-2565</Item>
- <Item Name="PubTypeList" Type="List">
<Item Name="PubType" Type="String">Journal Article</Item>
</Item>
<Item Name="RecordStatus" Type="String">PubMed - as supplied by publisher</Item>
<Item Name="PubStatus" Type="String"/>
- <Item Name="ArticleIds" Type="List">
<Item Name="doi" Type="String">10.3389/fpubh.2014.00281</Item>
<Item Name="pubmed" Type="String">25566523</Item>
<Item Name="eid" Type="String">25566523</Item>
<Item Name="rid" Type="String">25566523</Item>
</Item>
<Item Name="DOI" Type="String">10.3389/fpubh.2014.00281</Item>
- <Item Name="History" Type="List">
```

EFetch

- Input - list of UIDs
- output - corresponding data records
- Syntax: ***efetch.fcgi?db=<database>&id=<uid_list>&rettype=<retrieval_type>&retmode=<retrieval_mode>***
- Input: List of UIDs (&id); Entrez database (&db); Retrieval type (&rettype); Retrieval mode (&retmode) –
- Output: Formatted data records as specified
- Example: Download the abstract of PubMed ID 24333432
- <http://eutils.ncbi.nlm.nih.gov/entrez/eutils/efetch.fcgi?db=pubmed&id=24333432&rettype=abstract&retmode=txt>

EFetch example results

The screenshot shows a web browser window with the URL eutils.ncbi.nlm.nih.gov/entrez/eutils/efetch.fcgi?db=pubmed&id=24333432&rettype=abstract&retmode=text. The browser's address bar and toolbar are visible at the top. Below the toolbar, the page content starts with a reference citation:

1. Biochem Biophys Res Commun. 2014 Jan 10;443(2):598-603. doi:
10.1016/j.bbrc.2013.12.020. Epub 2013 Dec 11.

GSK3 β negatively regulates HIF1 α mRNA stability via nucleolin in the MG63 osteosarcoma cell line.

Cheng DD(1), Zhao HG(2), Yang YS(3), Hu T(1), Yang QC(4).

Author information:

(1)Department of Orthopedics, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, Shanghai 200233, China. (2)Department of Vascular Surgery, Shanghai Jiao Tong University Affiliated Ninth People's Hospital, Shanghai 200011, China. (3)Huazhong University of Science and Technology, Wuhan 430074, China. (4)Department of Orthopedics, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, Shanghai 200233, China. Electronic address:
tjyqc@163.com.

Hypoxia-inducible factor 1 α (HIF1 α) is a transcription factor involved in the growth, invasion and metastasis of malignant tumors. Glycogen synthase kinase 3 beta (GSK3 β) is a protein kinase involved in a variety of signaling pathways, such as the Wnt and NF- κ B pathways; this kinase can affect tumor progress through the regulation of transcription factor expression and apoptosis. Recent studies showed that GSK3 β was involved in the expression of HIF1 α . However, the effect of GSK3 β on HIF1 α expression in osteosarcoma cells remains unknown. To understand the relationship between GSK3 β and HIF1 α comprehensively, small RNA interference techniques, Western blot analyses, quantitative real-time PCR analyses and luciferase assays were used in our study. Experimental data revealed that inhibition of GSK3 β could increase HIF1 α protein levels and expression of its target genes by increasing the stability of the HIF1 α mRNA, not by affecting the HIF1 α protein stability, and that this process could be mediated by nucleolin.

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PMID: 24333432 [PubMed - indexed for MEDLINE]

Programmatic access to E-utilities (1/2)

- Write a perl script using ‘ESearch’
 - db: pubmed
 - query: '("HIV" OR "human immunodeficiency virus" OR "AIDS") AND ("mutation" OR "mutations" OR "mutants" OR "mutant" OR "mutagenesis" OR "mutagen") AND "The Journal of general virology"[Journal]'
 - Print the output to a file and report the total number of PubMed IDs

Programmatic access to E-utilities (2/2)

- Write a perl script using ‘EFetch’
 - db: pubmed
 - input: any PubMed ID
 - output: print corresponding year of publication, title and abstract

EMBL-EBI web-services

Web Services at EMBL-EBI

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Introduction

The [EMBL-EBI](#) provides programmatic access to various data resources and analysis tools via Web Services technologies.

Web Services is an integration and inter-operation technology. To ensure client and server software from various sources will work well together, the technology is built on open standards:

- Representational state transfer ([REST](#)): a software architecture style.
- Simple Object Access Protocol ([SOAP](#)): a messaging protocol for transporting information.
- Web Services Description Language ([WSDL](#)): a method for describing Web Services and their capabilities.

For the transport layer Web Services utilise common network protocols, typically the [Hypertext Transfer Protocol \(HTTP\)](#) used to provide access to web sites.

For an overview of Web Services technologies and short tutorials on using common programming languages and Web Services tool-kits see [Introduction to Web Services](#).

Important Note

We kindly ask users to submit NO MORE THAN 30 JOBS AT THE TIME AND NOT TO SUBMIT MORE JOBS UNTIL YOU HAVE OBTAINED RESULTS FOR THE LAST 30. There are many people using these services and a fair share policy has been implemented that allows us to block users that submit jobs in a manner that prevents others from using the service. This block may affect access to the EMBL-EBI Web Services for an entire organisation or a class B or C subnet. Also make sure you USE A REAL EMAIL ADDRESS in your submissions. Using a fake email means we cannot contact you and will very likely result in your jobs being killed and your IP, Organisation or entire domain being black-listed. We do apologise for any inconvenience this may cause.

Web Services

A list of Web Services provided by EMBL-EBI follows. For services from other providers (e.g. DDBJ, KEGG, NCBI, etc.) see services registries such as [BioCatalogue](#) or [seekda](#).

Data Retrieval

Service	Clients	Description
ArrayExpress		Microarray data searching with ArrayExpress .
ChEBI Web Services	ChEBI Web Services	Entry retrieval from the ChEBI database.
ChEMBL Web Services	ChEMBL Web Services	Search data in, and retrieve data from the ChEMBL database
EB-eye (SOAP)	EB-eye (SOAP)	Database search using the EBI Search search engine (EB-eye).
EB-eye (REST)	EB-eye (REST)	Database search using the EBI Search search engine (EB-eye).
ENA Browser		Retrieval of sequence and associated records from ENA
Gene Expression Atlas API		Enriched database of summary statistics over a curated subset of ArrayExpress Archive

KEGG API

This is a brief specification document for the REST-style KEGG API.

[[Top](#) | [KEGG API](#) | [KEGG MEDICUS API](#) | [KEGG WebLinks](#) | [KEGG Database Entry Format](#)]

General form of the URL

URL form

```
http://rest.kegg.jp/<operation>/<argument>[ /<argument2> ][ /<option> ]
```

<operation> = info | list | find | get | conv | link

<argument> = <database> | <dbentries>

Database

```
<database> = KEGG database including KEGG organism (see Table 1)
```

Table 1. KEGG database names and abbreviations

Database	Name	Abbrev	kid	Remark
KEGG PATHWAY	pathway	path	map number	
KEGG BRITE	brite	br	br number	
KEGG MODULE	module	md	M number	
KEGG ORTHOLOGY	orthology	ko	K number	
KEGG GENOME	genome	genome	T number	
KEGG GENOMES	genomes	gn	T number	Composite database: genome + egenome + mgenome
KEGG GENES	genes	-	-	Composite database: consisting of KEGG organisms
KEGG LIGAND	ligand	ligand	-	Composite database: compound + glycan + reaction + rpair + rclass + enzyme
KEGG COMPOUND	compound	cpd	C number	Japanese version: compound_ja cpd_ja
KEGG GLYCAN	glycan	gl	G number	
KEGG REACTION	reaction	rn	R number	
KEGG RPAIR	rpair	rp	RP number	
KEGG RCLASS	rclass	rc	RC number	
KEGG ENZYME	enzyme	ec	-	
KEGG DISEASE	disease	ds	H number	Japanese version: disease_ja ds_ja
KEGG DRUG	drug	dr	D number	Japanese version: drug_ja dr_ja
KEGG DGROUP	dgroup	dg	DG number	Japanese version: dgroup_ja dg_ja
KEGG ENVIRON	environ	ev	E number	Japanese version: environ_ja ev_ja

Auxiliary databases, dgenes, egenes, mgenes, egenome and mgenome, may also be used.

Database entry

```
<dbentries> = <dbentry>1[+<dbentry>2...]
<dbentry> = <db:entry> | <kid> | <org:gene>
```



bioCompendium API

RESTful web services

- [http://biocompendium.embl.de]/[REST]/[method]/[arguments]

- Methods : GetSummary

GetPathways

GetSeqSimilarity

GetDomainSimilarity

GetSeqSimilarityClusters

GetDomainSimilarityClusters ... etc

Output formats : tsv, csv, xml, json

Use **POST request** to submit all parameters

Example

- `http://biocompendium.embl.de/REST/GetPathways/
Organism=human&IdDocType=ensembl_gene_id&Format=
tsv&GeneList=ENSG00000186652 ENSG00000147614
ENSG00000171142`

Method : `GetPathways`

Organism : `human`

GeneList : `ENSG00000186652 ENSG00000147614
ENSG00000171142`

IdDocType : `ensembl_gene_id`

Format : `tsv`

KeggPathwayID KeggPathwayName AdjustedP-Value GeneName KeggGeneId EnsemblGeneId hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V0A1 535 ENSG00000033627 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V1H 51606 ENSG00000047249 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V1B1 525 ENSG00000116039 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V1F 9296 ENSG00000128524 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V1E1 529 ENSG00000131100 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V0D2 245972 ENSG00000147614 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V1G3 127124 ENSG00000151418 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V1C1 528 ENSG00000155097 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V0D1 9114 ENSG00000159720 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V1E2 90423 ENSG00000171142 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V0A2 23545 ENSG00000185344 hsa05110 Vibrio cholerae infection 1.5290e-23 ATP6V0C 527 ENSG00000185883 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V1H 51606 ENSG00000047249 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V1B1 525 ENSG00000033627 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V1F 9296 ENSG00000128524 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V1E1 529 ENSG00000116039 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V0D2 245972 ENSG00000147614 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V1G3 127124 ENSG00000151418 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V1C1 528 ENSG00000155097 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V0D1 9114 ENSG00000159720 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V1E2 90423 ENSG00000171142 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V0A2 23545 ENSG00000185344 hsa05120 Epithelial cell signaling in Helicobacter pylori infection 1.0397e-22 ATP6V0C 527 ENSG00000185883 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0A1 535 ENSG00000033627 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1H 51606 ENSG00000047249 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP12A 479 ENSG00000075673 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1B1 525 ENSG00000116039 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1F 9296 ENSG00000128524 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1E1 529 ENSG00000131100 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0D2 245972 ENSG00000147614 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1C1 528 ENSG00000155097 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0D1 9114 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0C 527 ENSG00000185883 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1E2 90423 ENSG00000171142 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0A2 23545 ENSG00000185344 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0D2 245972 ENSG00000147614 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1G3 127124 ENSG00000151418 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1C1 528 ENSG00000155097 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0D1 9114 ENSG00000159720 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V1E2 90423 ENSG00000171142 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0A2 23545 ENSG00000185344 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP6V0C 527 ENSG00000185883 hsa00190 Oxidative phosphorylation 1.6616e-20 ATP4B 496 ENSG00000186009 hsa01100 Metabolic pathways 1.8721e-10 ATP6V0A1 535 ENSG00000033627 hsa01100 Metabolic pathways 1.8721e-10 ATP6V1H 51606 ENSG00000047249 hsa01100 Metabolic pathways 1.8721e-10 HEXB 3074 ENSG00000049860 hsa01100 Metabolic pathways 1.8721e-10 ATP6V1B1 525 ENSG00000116039 hsa01100 Metabolic pathways 1.8721e-10 GALE 2582 ENSG00000117308 hsa01100 Metabolic pathways 1.8721e-10 ATP6V1F 9296 ENSG00000128524 hsa01100 Metabolic pathways 1.8721e-10 ATP6V1E1 529 ENSG00000131100 hsa01100 Metabolic pathways 1.8721e-10 ATP6V0D2 245972 ENSG00000147614 hsa01100 Metabolic pathways 1.8721e-10 ATP6V1G3 127124 ENSG00000151418 hsa01100 Metabolic pathways 1.8721e-10 ATP6V0A2 23545 ENSG00000185344 hsa01100 Metabolic pathways 1.8721e-10 ATP6V0C 527 ENSG00000185883 hsa04142 Lysosome 6.1916e-10 ATP6V0A1 535 ENSG00000033627 hsa04142 Lysosome 6.1916e-10 ATP6V1H 51606 ENSG00000047249 hsa04142 Lysosome 6.1916e-10 HEXB 3074 ENSG00000049860 hsa04142 Lysosome 6.1916e-10 ATP6V0D2 245972 ENSG00000147614 hsa04142 Lysosome 6.1916e-10 ATP6V0D1 9114 ENSG00000159720 hsa04142 Lysosome 6.1916e-10 ATP6V0A2 23545 ENSG00000185344 hsa04142 Lysosome 6.1916e-10 ATP6V0C 527 ENSG00000185883 hsa04020 Calcium signaling pathway 1.2574e-05 ATP2B4 493 ENSG0000058668 hsa04020 Calcium signaling pathway 1.2574e-05 ATP2A3 489 ENSG0000074370 hsa04020 Calcium signaling pathway 1.2574e-05 ATP2B2 491 ENSG00000157087 hsa04020 Calcium signaling pathway 1.2574e-05 ATP2A2 488 ENSG00000174437 hsa04020 Calcium signaling pathway 1.2574e-05 ATP2A1 487 ENSG00000196296 hsa03430 Mismatch repair 1.9867e-05 MSH6 2956 ENSG00000116062 hsa03430 Mismatch repair 1.9867e-05 MLH3 27030 ENSG00000119684 hsa03430 Mismatch repair 1.9867e-05 PMS2 5395 ENSG00000122512 hsa04260 Cardiac muscle contraction 6.2022e-04 ATP1B3 483 ENSG0000069849 hsa04260 Cardiac muscle contraction 6.2022e-04 ATP1B2 482 ENSG00000129244 hsa04260 Cardiac muscle contraction 6.2022e-04 ATP2A2 488 ENSG00000174437 hsa04964 Proximal tubule bicarbonate reclamation 2.4880e-03 ATP1B3 483 ENSG0000069849 hsa04964 Proximal tubule bicarbonate reclamation 2.4880e-03 ATP1B2 482 ENSG00000129244 hsa05010 Alzheimer's disease 4.5499e-03 ATP2A3 489 ENSG00000074370 hsa05010 Alzheimer's disease 4.5499e-03 ATP2A2 488 ENSG00000174437 hsa05010 Alzheimer's disease 4.5499e-03 ATP2A1 487 ENSG00000196296 hsa04960 Aldosterone-regulated sodium reabsorption 5.6768e-03 ATP1B3 483 ENSG0000069849 hsa04960 Aldosterone-regulated sodium reabsorption 5.6768e-03 ATP1B2 482 ENSG00000129244 hsa05020 Amino sugar and nucleotide sugar metabolism 6.6764e-03 HEXB 3074 ENSG0000049860 hsa05020 Amino sugar and nucleotide sugar metabolism 6.6764e-03 GALE 2582 ENSG00000117308 hsa05210 Colorectal cancer 1.1014e-02 MSH6 2956 ENSG00000116062 hsa05210 Colorectal cancer 1.1014e-02 RAF1 5894 ENSG00000132155 hsa04115 p53 signaling pathway 1.1014e-02 ATM 472 ENSG00000149311 hsa04115 p53 signaling pathway 1.1014e-02 ATM 651610 ENSG00000149311 hsa05410 Hypertrophic cardiomyopathy (HCM) 1.6021e-02 IL6 3569 ENSG00000136244 hsa05410 Hypertrophic cardiomyopathy (HCM) 1.6021e-02 ATP2A2 488 ENSG00000174437 hsa04210 Apoptosis 1.6021e-02 ATM 472 ENSG00000149311 hsa04210 Apoptosis 1.6021e-02 ATM 651610 ENSG00000149311 hsa04916 Melanogenesis 2.0606e-02 POMC 5443 ENSG00000115138 hsa04916 Melanogenesis 2.0606e-02 RAF1 5894 ENSG00000132155 hsa05200 Pathways in cancer 2.1179e-02 MSH6 2956 ENSG00000116062 hsa05200 Pathways in cancer 2.1179e-02 RAF1 5894 ENSG00000132155 hsa05200 Pathways in cancer 2.1179e-02 IL6 3569 ENSG00000136244 hsa04110 Cell cycle 3.1270e-02 ATM 472 ENSG00000149311 hsa04110 Cell cycle 3.1270e-02 ATM 651610 ENSG00000149311 hsa00603 Glycosphingolipid biosynthesis - globo series 4.9945e-02 HEXB 3074 ENSG0000049860 hsa00511 Other glycan degradation 5.6998e-02 HEXB 3074 ENSG0000049860 hsa00604 Glycosphingolipid biosynthesis - ganglio series 6.0394e-02 HEXB 3074 ENSG0000049860 hsa00531 Glycosaminoglycan degradation 7.2036e-02 HEXB 3074 ENSG0000049860 hsa00052 Galactose metabolism 8.5356e-02 GALE 2582 ENSG00000117308 hsa05310 Asthma 9.7520e-02 PRG2 5553 ENSG00000186652 hsa05020 Prion diseases 1.0619e-01 IL6 3569 ENSG00000136244 hsa05219 Bladder cancer 1.1465e-01 RAF1 5894 ENSG00000132155 hsa05332 Graft-versus-host disease 1.1465e-01 IL6 3569 ENSG00000136244 hsa04621 NOD-like receptor 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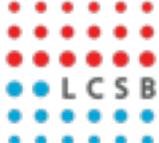
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