
HGVS

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hgvs is a Python package to parse, format, validate, normalize, and map biological sequence variants according to recommendations of the Human Genome Variation Society.

[Source](#) | [Documentation](#) | [Discuss](#) | [Issues](#)

Introduction

Genome, transcript, and protein sequence variants are typically reported using the [variation nomenclature](#) (“varnomen”) recommendations provided by the [Human Genome Variation Society \(HGVS\)](#) (Taschner and den Dunnen, 2011). Most variants are deceptively simple looking, such as `NM_021960.4:c.740C>T`. In reality, the varnomen standard provides for much more complex concepts and representations.

As high-throughput sequencing becomes commonplace in the investigation and diagnosis of disease, it is essential that communicating variants from sequencing projects to the scientific community and from diagnostic laboratories to health care providers is easy and accurate. The HGVS mutation nomenclature recommendations are generally accepted for the communication of sequence variation: they are widely endorsed by professional organizations, mandated by numerous journals, and the prevalent representation used by databases and interactive scientific software tools. The guidelines – originally devised to standardize the representation of variants discovered before the advent of high-throughput sequencing – are now approved by the HGVS and continue to evolve under the auspices of the Human Variome Project. Unfortunately, the complexity of biological phenomena and the breadth of the varnomen standard makes it difficult to implement the standard in software, which in turn makes using the standard in high-throughput analyses difficult.

This package, *hgvs*, is an easy-to-use Python library for parsing, representing, formatting, and mapping variants between genome, transcript, and protein sequences. The current implementation handles most (but not all) of the varnomen standard for precisely defined sequence variants. The intent is to centralize the subset of HGVS variant manipulation that is routinely used in modern, high-throughput sequencing analysis.

Features of the hgvs Package

- **Convenient object representation.** Manipulate variants conceptually rather than by modifying text strings. Classes model HGVS concepts such as *Interval*, intronic offsets (in *BaseOffsetPosition*), uncertainty, and types of variation (*hgvs.edit*).
- **A grammar-based parser.** *hgvs* uses *a formal grammar* to parse HGVS variants rather than string partitioning or regular expression pattern matching. This makes parsing easier to understand, extend, and validate.

- **Simple variant formatting.** Object representations of variants may be turned into HGVS strings simply by printing or “stringifying” them.
- **Robust variant mapping.** The package includes tools to map variants between genome, transcript, and protein sequences (*VariantMapper* and to perform liftover between two transcript via a common reference (*Projector*). The hgvs mapper is specifically designed to reliably handle regions reference-transcript indel discrepancy that are not covered by other tools.
- **Additional variant validation.** The package includes tools to validate variants, separate from syntactic validation provided by the grammar.
- **Extensible data sources.** Mapping and sequence data come from [UTA](#) by default, but the package includes a well-defined service interface that enables alternative data sources.
- **Extensive automated tests.** We run extensive automated tests consisting of all supported variant types on many genes for every single commit to the source code repository. Test results are displayed publicly and immediately.

Note: Some HGVS recommendations are intentionally absent. This package is primarily concerned with the subset of the [VarNomen](#) recommendations that are relevant for high-throughput sequencing. See [issues](#) for a full set of bugs and feature requests.

Related tools

- [Mutalyzer](#) provides a web interface to variant validation and mapping.
- [Counsyl hgvs package](#) provides functionality conceptually similar to that of the [Invitae hgvs package](#).

Getting Help

There are several ways to get help with the *hgvs* package.

The [hgvs-discuss mailing list](#) is the preferred way to reach the *hgvs* package authors. Please file bugs and feature requests on the [hgvs issue tracker](#).

If you have questions about the [Variation Nomenclature Recommendations](#), consider posting your questions to the [HGVS Facebook page](#).

Links

- [Variation Nomenclature Recommendations](#)
- [Human Genome Variation Society \(HGVS\)](#)
- [Parsley](#), an Python wrapper for the OMeta Parser Expression Grammar (PEG)
- [Universal Transcript Archive \(UTA\)](#)

References

A Python package for parsing, validating, mapping and formatting sequence variants using HGVS nomenclature.

Hart RK, Rico R, Hare E, Garcia J, Westbrook J, Fusaro VA
Bioinformatics. 31(2):268-70 (2014).

<https://www.ncbi.nlm.nih.gov/pubmed/25273102>

Describing structural changes by extending HGVS sequence variation nomenclature.

Taschner, P. E. M., & den Dunnen, J. T.
Human Mutation, 32(5), 507–11. (2011).

<http://www.ncbi.nlm.nih.gov/pubmed/21309030>

A formalized description of the standard human variant nomenclature in Extended Backus-Naur Form.

Laros, J. F. J., Blavier, A., den Dunnen, J. T., & Taschner, P. E. M.
BMC Bioinformatics, 12 Suppl 4(Suppl 4), S5. (2011).

<http://www.ncbi.nlm.nih.gov/pubmed/21992071>

Quick Start

This tutorial provides a comprehensive example of how to use the HGVS package. Specifically, we'll:

- install hgvs
- parse a transcript (c.) variant in MCL1 obtained from dbSNP
- project that variant to genomic coordinates (as a g. variant)
- project it back on to another transcript in the same gene
- deduce the amino acid change for that variant

We'll use [rs201430561](#) in MCL1. This gene has several transcripts, and therefore the genomic variant NC_000001.10:g.150550916G>A has several distinct transcript representations:

| transcript (c.) | protein (p.) |
|--------------------------|---------------------------|
| NM_001197320.1:c.281C>T | NP_001184249.1:p.Ser94Phe |
| NM_021960.4:c.740C>T | NP_068779.1:p.Ser247Phe |
| NM_182763.2:c.688+403C>T | <i>intronic</i> |

This variant was chosen because it has data in dbSNP for comparison and because it has an intronic variant to spice up the example.

Install hgvs

For this demo, you'll need hgvs (of course). We recommend that you install IPython as well. In a reasonably modern environment, the following should suffice:

```
$ pip install --upgrade setuptools
$ pip install hgvs ipython
```

More detailed installation instructions are in [Installing hgvs](#).

Parse the variant

To parse variants, we need to create an instance of the `hgvs.parser.Parser`. Since building the grammar is computationally expensive, you should create only one instance and use it for all parsing operations. Start `ipython`, then do this:

```
>>> import hgvs.parser
>>> hgvsparser = hgvs.parser.Parser()
>>> var_c1 = hgvsparser.parse_hgvs_variant('NM_001197320.1:c.281C>T')
```

Parsing a variant results in objects that represent the variant (rather than, say, Python dictionaries). A `SequenceVariant` object is comprised of an accession (`ac`), an HGVS sequence type (`c,g,m,n,r,p`), and 0 or more specific sequence changes (`posedit` – a `POS`ition and `ED`it).

```
>>> var_c1
SequenceVariant(ac=NM_001197320.1, type=c, posedit=281C>T)
```

The `posedit` is itself an object of the `hgvs.posedit.PosEdit` class:

```
>>> var_c1.posedit
PosEdit(pos=281, edit=C>T, uncertain=False)
```

The `pos` (position) and `edit` attributes are also objects that can represent intervals and more complex edit operations like indels. The `uncertain` flag enables representation of HGVS uncertainty (typically with parentheses around the uncertain component).

Finally, “stringifying” a variant regenerates an HGVS variant:

```
>>> str(var_c1)
'NM_001197320.1:c.281C>T'
```

Create an VariantMapper instance

Mapping variants between genomic (`g.`), transcript (`c.`), and protein (`p.`) sequences is performed by an instance of `hgvs.variantmapper.VariantMapper`. As with the parser, you need only one instance per session.

Variant mapping and validation requires access to external data, specifically exon structures, transcript alignments, and protein accessions. Right now, the only source of this data is via the UTA sister projects. (If you want more information on the architecture of HGVS, UTA, see [Introduction](#). However, you don’t really need to understand the architecture to use HGVS.)

First, connect to UTA via `hgvs.dataproviders.uta`:

```
>>> import hgvs.dataproviders.uta
>>> hdp = hgvs.dataproviders.uta.connect()
```

By default, you’ll connect to the public UTA database instance hosted by [Invitae](#).

Then, with that connection, instantiate a `VariantMapper`:

```
>>> import hgvs.variantmapper
>>> variantmapper = hgvs.assemblymapper.AssemblyMapper(hdp, assembly_name="GRCh37")
```

We can use this mapper to transform our transcript variant to a protein variant:

```
>>> variantmapper.c_to_p(var_c1)
SequenceVariant(ac=NP_001184249.1, type=p, posedit=(Ser94Phe))
```

Map our variant to the genome

Mapping between sequences is straightforward:

```
>>> var_g = variantmapper.c_to_g(var_c1)
>>> var_g
SequenceVariant(ac=NC_000001.10, type=g, posedit=150550916G>A)
>>> str(var_g)
'NC_000001.10:g.150550916G>A'
```

Notice that this agrees with dbSNP! Also notice that our C>T variant is on a minus-strand transcript, so the nucleotides are reverse complemented.

Since you'll probably want to access the position, now is a good time to explore the posedit structure:

First, a posedit consists of a position and an edit. Positions are **always** intervals, even if their string representation looks like a simple integer. Interval bounds are referred to with `start` and `end` attributes. As with edits, they may also be uncertain.

```
>>> var_g.posedit.pos
Interval(start=150550916, end=150550916, uncertain=False)
```

Start and end coordinates are polymorphic (can have multiple representations). For genomic positions, these are instances of `SimplePosition`:

```
>>> var_g.posedit.pos.start
SimplePosition(base=150550916, uncertain=False)
```

For c. (cDNA) and r. (RNA) sequences, which have intron offsets and can be measured from sequence start, CDS start, or CDS end (stop codon), coordinates are more complex:

```
>>> var_c1.posedit.pos.start
BaseOffsetPosition(base=281, offset=0, datum=Datum.CDS_START, uncertain=False)
```

Either way, the sequence coordinate may be accessed via the `base` attribute:

```
>>> var_g.posedit.pos.start.base
150550916
>>> type(var_g.posedit.pos.start.base)
<type 'int'>
```

Map the genomic variant to another transcript

To map our genomic variant to another transcript, we need to provide a transcript accession. One way to get those is to ask the data provider:

```
>>> # [tx['tx_ac'] for tx in hdp.get_tx_for_gene('MCL1')]
[... 'NM_182763.2' ...]
```

Let's map to the transcript for which this is an intronic variant.

```
>>> var_c2 = variantmapper.g_to_c(var_g, 'NM_182763.2')
>>> var_c2
SequenceVariant(ac=NM_182763.2, type=c, posedit=688+403C>T)
>>> var_c2.posedit.pos.start
BaseOffsetPosition(base=688, offset=403, datum=Datum.CDS_START, uncertain=False)
```

And, if we attempt to infer a protein consequence for this variant, we get the expected uncertain interpretation:

```
>>> var_p2 = variantmapper.c_to_p(var_c2)
>>> var_p2
SequenceVariant(ac=NP_877495.1, type=p, posedit=None)
>>> str(var_p2)
'NP_877495.1:p.?'
```

Installing hgvs

Supported Platforms

hgvs is developed primarily on Ubuntu systems and has been reported to work on Mac. Other platforms and dependency versions are expected to work but have not been tested. Reports of successful operation on other platforms (and patches to enable this) are appreciated. **Python 2 is required.** (Python 3 support is in progress.)

Install Prerequisites

hgvs currently requires PostgreSQL client libraries. (We are planning to switch to a REST interface and eliminate this dependency in the 0.5.0 release.) On Ubuntu, try:

```
apt-get install libpq-dev
```

On a Mac with homebrew:

```
brew install postgresql
```

Use a virtual environment

Users are encouraged to use *virtualenv*. If you don't have *virtualenv* and *virtualenvwrapper* installed already:

```
$ sudo apt-get install virtualenvwrapper
```

Then (using *virtualenvwrapper*):

```
$ mkvirtualenv hgvs-test
```

mkvirtualenv will automatically activate your *virtualenv* and usually change the prompt to indicate this.

(Alternatively, type *virtualenv hgvs-test*, then *source hgvs-test/bin/activate*.)

Installing from PyPI

Ensure you have a current *setuptools* package:

```
$ pip install setuptools --upgrade
```

You're now ready to install *hgvs* via *pip*:

```
$ pip install hgvs
```

hgvs will install dependencies automatically.

Installing from source

Note: Users (non-developers) should prefer the PyPI installation. There is no advantage to installing from source.

Fetch the source code:

```
$ git clone https://github.com/biocommons/hgvs
```

Then:

```
$ cd hgvs
$ make install
```

Installing SeqRepo (optional)

`seqrepo` provides an easy and efficient mechanism to maintain a local sequence database.

Install `seqrepo`:

```
$ pip install biocommons.seqrepo
```

Then, choose a file path that has at least 10GB of space available. By default, `seqrepo` will use `/usr/local/share/seqrepo/`. Make that directory:

```
$ mkdir /usr/local/share/seqrepo
```

Download an instance of the human sequence set:

```
$ seqrepo -r /usr/local/share/seqrepo pull
```

You can skip the `-r` if you use the default `/usr/local/share/seqrepo/`. This step will take 10-30 minutes, or more for slow connections.

As with UTA, you tell `hgvs` to use this feature via an environment variable:

```
$ export HGVS_SEQREPO_DIR=/usr/local/share/seqrepo/20160906
```

Local Installation of UTA

The easiest way to install UTA locally is to use the docker image:

```
$ docker run -d --name uta_20170117 -p 15032:5432 biocommons/uta:uta_20170117
```

If you do this, then set:

```
$ export UTA_DB_URL=postgresql://anonymous@localhost:15032/uta/uta_20170117
```

If you don't set this variable, `hgvs` will use the remote `uta` database.

Test your installation

`hgvs` installs `hgvs-shell`, a command line tool based on IPython. It's a convenience utility that imports and initializes frequently-used components. Try this:

```
(default-2.7) snafu$ hgvs-shell
INFO:root:Starting hgvs-shell 1.0.0a1
INFO:biocommons.seqrepo:biocommons.seqrepo 0.3.1
INFO:hgvs.dataproviders.seqfetcher:Using SeqRepo(/usr/local/share/seqrepo/master)
↳sequence fetching
INFO:hgvs.dataproviders.uta:connected to postgresql://anonymous:anonymous@localhost/
↳uta_dev/uta_20170117...

In [1]: v = hp.parse_hgvs_variant("NM_033089.6:c.571C>G")

In [2]: am37.c_to_g(v)
INFO:biocommons.seqrepo.fastadir.fastadir:Opening for reading: /usr/.../1472015601.
↳985206.fa.bgz
Out[2]: SequenceVariant(ac=NC_000020.10, type=g, posedit=278801C>G)

In [3]: am38.c_to_g(v)
INFO:biocommons.seqrepo.fastadir.fastadir:Opening for reading: /usr/.../1472026864.
↳4364622.fa.bgz
Out[3]: SequenceVariant(ac=NC_000020.11, type=g, posedit=298157C>G)
```

Package Versioning

hgvs uses [semantic versioning](#). For a version *x.y.z*, incrementing *x*, *y*, or *z* denotes backward-incompatible changes, feature additions, and bug fixes respectively.

Version numbers for released code come directly from the repository tag. Therefore, PyPI version 0.1.2 corresponds exactly to the repository commit tagged as 0.1.2.

Users (i.e., non-developers) are encouraged to use the PyPI releases and to specify versions to stay within minor releases for API stability. For example, a line like:

```
hgvs>=1.0, <2
```

in `setup.py` or `requirements.txt` indicates that version 1.0 (any patch level) is required, and that future 1.x-series releases are acceptable.

Key Concepts

This section is intended for all users and provides an understanding of key concepts and components of the *hgvs* package.

Reference Sequence Types

The HGVS Recommendations provide for six types of reference sequences. Because the type influences the syntax and object representation in the *hgvs* package, it is important to understand these distinctions. A summary of the types follows:

| Type | Sequence | Coordinates | Datum | Example |
|------|----------|-------------|-------------------|-----------------------------|
| 7. | DNA | Continuous | Sequence start | NC_000007.13:g.21582936G>A |
| 13. | DNA | Continuous | Sequence start | NC_012920.1:m.8993T>C |
| 3. | DNA | Base-Offset | Translation start | NM_001277115.1:c.351+115T>C |
| 14. | DNA | Base-Offset | Sequence start | NM_000518.4:n.76_92del |
| 18. | RNA | Base-Offset | Sequence start | NR_111984.1:r.44g>a |
| 16. | AA | Continuous | Sequence start | NP_001264044.1:p.(Ala25Thr) |

Datum refers to the definition for position 1 in the sequence. “Sequence start” means the first position of the sequence. “Translation start” means the position of the ATG that typically starts translation (only for coding transcripts).

Continuous coordinates are the familiar ordinal counting (1, 2, 3, ...). There are no breaks for intervening sequence.

Base-Offset coordinates use a base position, which is an index in the specified sequence, and an optional offset from that base position. Non-zero offsets refer to non-coding sequence, such as 5' UTR, 3' UTR, or intronic position. Examples are 22 (with a zero offset), 22+6, and *6.

Variant Object Representation

HGVS variants are represented using classes that represent elemental concepts of an HGVS sequence variant. Each of the objects contains references to data that define the objects; those data may be Python built in types such as integers (int) or strings (unicode), or they may be other classes in the hgvs package.

For example, a variant parsed like this:

```
>>> import hgvs.parser
>>> hgvsparser = hgvs.parser.Parser()
>>> var = hgvsparser.parse_hgvs_variant('NM_001197320.1:c.281C>T')
```

will generate an object tree like the following:

Fig. 1.1: A typical object tree created by parsing a variant. Vertices show the property name with property type in parentheses.

For that variant, the properties may be obtained easily by dot lookup:

```
>>> var.ac
'NM_001197320.1'
>>> var.type
'c'
>>> var.posedit
PosEdit(pos=281, edit=C>T, uncertain=False)
>>> var.posedit.pos
BaseOffsetInterval(start=281, end=281, uncertain=False)
>>> var.posedit.pos.start, var.posedit.pos.end
```

```
(BaseOffsetPosition(base=281, offset=0, datum=Datum.CDS_START, uncertain=False),
BaseOffsetPosition(base=281, offset=0, datum=Datum.CDS_START, uncertain=False))
>>> var.posedit.edit
NARefAlt(ref='C', alt='T', uncertain=False)
```

The object representation makes it easy to modify variants conceptually rather than textually. For example, if the previous variant was inferred rather than sequenced, we might wish to declare that it is uncertain, which then causes the stringified version to contain the edit in parentheses:

```
>>> var.posedit.uncertain = True
>>> unicode(var)
u'NM_001197320.1:c.(281C>T)'
```

Variant Mapping Tools

Variant mapping is supported by several modules. Most users will likely be content with `hgvs.variant.AssemblyMapper`. For completeness, it may help to understand how all of the mappers relate to each other.

hgvs.intervalmapper.IntervalMapper

The `IntervalMapper` maps pairs of contiguous sequence intervals to each other. It is the “lowest” component of the mapping hierarchy and “knows” nothing about biological sequences.

hgvs.transcriptmapper.TranscriptMapper

The `TranscriptMapper` uses `IntervalMapper` to map pairs of exon segments (typically exons in the transcript and genomic sequences). It must be instantiated with a transcript accession, reference accession, and alignment method, and provides functions to map sequence intervals (not variants) for the specified alignment. It also accommodates strand orientation.

hgvs.variantmapper.VariantMapper

The `VariantMapper` uses *hgvs.transcriptmapper.TranscriptMapper* to provide `g<->r`, `r<->c`, `g<->c`, and `c->p` transformations for `SequenceVariant` objects. As with the `TranscriptMapper`, it must be instantiated with an appropriate transcript, reference, and alignment method.

hgvs.assemblymapper.AssemblyMapper

`VariantMapper` requires that the caller provide a transcript accession and an appropriate reference sequence, which in turn requires knowing the correct reference sequence. The alignment method is also required. While the `VariantMapper` interface serves the general case of mapping to any sequence (including patch sequences), it is burdensome for the most common case. `AssemblyMapper` wraps `VariantMapper` to provide identical mapping functionality that is tailored for mapping between a transcript and a primary assembly.

hgvs.projector.Projector

`Projector` maps variants between transcripts using a common reference and alignment method. For example, this tool can transfer a variant from one RefSeq to another, or even from an Ensembl transcript to a RefSeq.

Fig. 1.2: Mapping tools available in the `hgvs` package. `r1` is a genomic reference (e.g., NC_000014.8). `t1` and `t2` are transcripts (e.g., NM_000551.2). `p1` is a protein sequence (e.g., NP_012345.6).

External Data Sources

Variant mapping and validation requires access to external data, specifically exon structures, transcript alignments, accessions, and sequences. In order to isolate the hgvs package from the myriad choices and tradeoffs, these data are provided through an implementation of the (abstract) Data Provider Interface (`hgvs.dataproviders.interface`). Currently, the only concrete implementation of the data provider interface uses UTA, an archive of transcripts, transcript sequences, and transcript-reference sequence alignments.

Invitae provides a public UTA instance at `uta.biocommons.org:5432` (PostgreSQL). `hgvs` uses this public UTA instance by default, so most users won't need to worry about this aspect of the hgvs package. However, a docker image of UTA is also available; see *Installing hgvs* for details.

Alternatively, users may implement their own providers that conform to the data providers interface. See `hgvs.dataproviders.uta` for an example.

Examples

The following examples are derived directly from IPython notebooks in the hgvs source code `examples` directory.

Creating a SequenceVariant from scratch

0. Overview

A SequenceVariant consists of an accession (a string), a sequence type (a string), and a PosEdit, like this:

```
var = hgvs.variant.SequenceVariant(ac='NM_01234.5', type='c', posedit=...)
```

Unsurprisingly, a PosEdit consists of separate position and Edit objects. A position is generally an Interval, which in turn is comprised of SimplePosition or BaseOffsetPosition objects. An edit is a subclass of Edit, which includes classes like NAREfAlt for substitutions, deletions, and insertions) and Dup (for duplications).

Importantly, each of the objects we're building has a rule in the parser, which means that you have the tools to serialize and deserialize (parse) each of the components that we're about to construct.

1. Make an Interval to defined a position of the edit

```
import hgvs.location
import hgvs.posedit
```

```
start = hgvs.location.BaseOffsetPosition(base=200, offset=-6, datum=hgvs.location.CDS_
↳ START)
start, str(start)
```

```
(BaseOffsetPosition(base=200, offset=-6, datum=1, uncertain=False), '200-6')
```

```
end = hgvs.location.BaseOffsetPosition(base=22, datum=hgvs.location.CDS_END)
end, str(end)
```

```
(BaseOffsetPosition(base=22, offset=0, datum=2, uncertain=False), '*22')
```

```
iv = hgvs.location.Interval(start=start, end=end)
iv, str(iv)
```

```
(Interval(start=200-6, end=*22, uncertain=False), '200-6_*22')
```

2. Make an edit object

```
import hgvs.edit, hgvs.posedit
```

```
edit = hgvs.edit.NARefAlt(ref='A', alt='T')  
edit, str(edit)
```

```
(NARefAlt(ref=A, alt=T, uncertain=False), 'A>T')
```

```
posedit = hgvs.posedit.PosEdit(pos=iv, edit=edit)  
posedit, str(posedit)
```

```
(PosEdit(pos=200-6_*22, edit=A>T, uncertain=False), '200-6_*22A>T')
```

3. Make the variant

```
import hgvs.variant
```

```
var = hgvs.variant.SequenceVariant(ac='NM_01234.5', type='c', posedit=posedit)  
var, str(var)
```

```
(SequenceVariant(ac=NM_01234.5, type=c, posedit=200-6_*22A>T),  
'NM_01234.5:c.200-6_*22A>T')
```

Important: The hgvs package intentionally permits callers to create invalid variants. For example, the above interval is incompatible with a SNV. See `hgvs.validator.Validator` for validation options.

4. Update your variant

The stringification happens on-the-fly. That means that you can update components of the variant and see the effects immediately.

```
import copy
```

```
var2 = copy.deepcopy(var)  
var2.posedit.pos.start.base=456  
str(var2)
```

```
'NM_01234.5:c.456-6_*22A>T'
```

```
var2 = copy.deepcopy(var)  
var2.posedit.edit.alt='CT'  
str(var2)
```

```
'NM_01234.5:c.200-6_*22delAinsCT'
```

```
var2 = copy.deepcopy(var)
var2.posedit.pos.end.uncertain=True
str(var2)
```

```
'NM_01234.5:c.200-6_(*22)A>T'
```

Manuscript Example

```
import hgvs
hgvs.__version__
```

```
'0.3dev-283858cb6466'
```

Parse an HGVS string into a Python structure

```
import hgvs.parser
hp = hgvs.parser.Parser()
var_c1 = hp.parse_hgvs_variant('NM_182763.2:c.688+403C>T')
var_c1, var_c1.posedit.pos.start
```

```
(SequenceVariant(ac=NM_182763.2, type=c, posedit=688+403C>T),
 BaseOffsetPosition(base=688, offset=403, datum=1, uncertain=False))
```

Open the UTA public data source for mapping and validation

```
import hgvs.dataproviders.uta
hdp = hgvs.dataproviders.uta.connect()
```

Project transcript variant NM_182763.2:c.688+403C>T to GRCh37 primary assembly using splign alignments

```
import hgvs.variantmapper
vm = hgvs.assemblymapper.AssemblyMapper(
    hdp, assembly_name='GRCh37', alt_aln_method='splign')
var_g = vm.c_to_g(var_c1)
var_g
```

```
SequenceVariant(ac=NC_000001.10, type=g, posedit=150550916G>A)
```

Project genomic variant to a new transcript

```
vm.relevant_transcripts(var_g)
```

```
['NM_182763.2', 'NM_021960.4', 'NM_001197320.1']
```

```
var_c2 = vm.g_to_c(var_g, 'NM_001197320.1')
var_c2
```

```
SequenceVariant(ac=NM_001197320.1, type=c, posedit=281C>T)
```

Infer protein changes for these transcript variants

```
var_p1 = vm.c_to_p(var_c1)
var_p2 = vm.c_to_p(var_c2)
var_p1, var_p2
```

```
(SequenceVariant(ac=NP_877495.1, type=p, posedit=?),
 SequenceVariant(ac=NP_001184249.1, type=p, posedit=(Ser94Phe)))
```

Format the results by “stringification”

```
print("""mapped {var_c1} ({var_p1})
      to {var_c2} ({var_p2})
      via {var_g}""").format(
    var_c1=var_c1, var_p1=var_p1,
    var_c2=var_c2, var_p2=var_p2,
    var_g=var_g)
```

```
mapped NM_182763.2:c.688+403C>T (NP_877495.1:p.?)
      to NM_001197320.1:c.281C>T (NP_001184249.1:p.(Ser94Phe))
      via NC_000001.10:g.150550916G>A
```

Validate a variant

```
import hgvs.validator
import hgvs.exceptions
vr = hgvs.validator.Validator(hdp=hdp)
try:
    vr.validate( hp.parse_hgvs_variant('NM_001197320.1:c.281C>T') )
    vr.validate( hp.parse_hgvs_variant('NM_001197320.1:c.281A>T') )
except hgvs.exceptions.HGVSError as e:
    print(e)
```

```
NM_001197320.1:c.281A>T: Variant reference does not agree with reference sequence
```

Automated liftover of NM_001261456.1:c.1762A>G (rs509749) to NM_001261457.1 via GRCh37

Automatically project variant from one transcript to another via common reference.

http://www.ncbi.nlm.nih.gov/projects/SNP/snp_ref.cgi?rs=509749

```
import hgvs.parser
hgvsparser = hgvs.parser.Parser()
var_cl = hgvsparser.parse_hgvs_variant('NM_001261456.1:c.1762A>G')
```

```
import hgvs.dataproviders.uta
hdp = hgvs.dataproviders.uta.connect()
```

```
import hgvs.projector
pj = hgvs.projector.Projector(hdp=hdp,
                              alt_ac='NC_000001.10',
                              src_ac=var_cl.ac,
                              dst_ac='NM_001261457.1')
```

```
pj.project_variant_forward(var_cl)
```

```
SequenceVariant(ac=NM_001261457.1, type=c, posedit=1534A>G)
```

Manual liftover of NM_001261456.1:c.1762A>G (rs509749) to NM_001261457.1 via GRCh37

http://www.ncbi.nlm.nih.gov/projects/SNP/snp_ref.cgi?rs=509749

```
import hgvs.dataproviders.uta
import hgvs.variantmapper
import hgvs.parser
```

```
hdp = hgvs.dataproviders.uta.connect()
variantmapper = hgvs.variantmapper.VariantMapper(hdp)
hgvsparser = hgvs.parser.Parser()
```

```
var_cl = hgvsparser.parse_hgvs_variant('NM_001261456.1:c.1762A>G')
var_pl = variantmapper.c_to_p(var_cl, None)
var_cl, var_pl
```

```
(SequenceVariant(ac=NM_001261456.1, type=c, posedit=1762A>G),
 SequenceVariant(ac=MD5_e999a940ca422ec8cab9bc3cc64e0d7d, type=p,
 ↪posedit=(Met588Val)))
```

```
var_g = variantmapper.c_to_g(var_cl, 'NC_000001.10')
var_g
```

```
SequenceVariant(ac=NC_000001.10, type=g, posedit=160793560A>G)
```

```
txs = hdp.get_tx_for_gene('LY9')
txs
```

```
[('LY9', 30, 1998, 'ENST00000263285', 'NC_000001.10', 'genebuild'),
 ('LY9', 1, 583, 'ENST00000368039', 'NC_000001.10', 'genebuild'),
 ('LY9', 0, 1648, 'ENST00000392203', 'NC_000001.10', 'genebuild'),
 ('LY9', 0, 1833, 'ENST00000368037', 'NC_000001.10', 'genebuild'),
 ('LY9', 211, 1024, 'ENST00000368035', 'NC_000001.10', 'genebuild'),
```

```
[ 'LY9', 50, 1616, 'ENST00000341032', 'NC_000001.10', 'genebuild'],
[ 'LY9', 170, 1751, 'ENST00000368041', 'NC_000001.10', 'genebuild'],
[ 'LY9', 1094, 1907, 'ENST00000368040', 'NC_000001.10', 'genebuild'],
[ 'LY9', 114, 2040, 'NM_001261456.1', 'AC_000133.1', 'salign'],
[ 'LY9', 114, 2040, 'NM_001261456.1', 'NC_000001.10', 'blat'],
[ 'LY9', 114, 2040, 'NM_001261456.1', 'NC_000001.10', 'salign'],
[ 'LY9', 114, 2040, 'NM_001261456.1', 'NC_018912.2', 'salign'],
[ 'LY9', 114, 696, 'NM_001033667.2', 'AC_000133.1', 'salign'],
[ 'LY9', 114, 696, 'NM_001033667.2', 'NC_000001.10', 'blat'],
[ 'LY9', 114, 696, 'NM_001033667.2', 'NC_000001.10', 'salign'],
[ 'LY9', 114, 696, 'NM_001033667.2', 'NC_018912.2', 'salign'],
[ 'LY9', 114, 2082, 'NM_002348.3', 'AC_000133.1', 'salign'],
[ 'LY9', 114, 2082, 'NM_002348.3', 'NC_000001.10', 'blat'],
[ 'LY9', 114, 2082, 'NM_002348.3', 'NC_000001.10', 'salign'],
[ 'LY9', 114, 2082, 'NM_002348.3', 'NC_018912.2', 'salign'],
[ 'LY9', 114, 1812, 'NM_001261457.1', 'AC_000133.1', 'salign'],
[ 'LY9', 114, 1812, 'NM_001261457.1', 'NC_000001.10', 'blat'],
[ 'LY9', 114, 1812, 'NM_001261457.1', 'NC_000001.10', 'salign'],
[ 'LY9', 114, 1812, 'NM_001261457.1', 'NC_018912.2', 'salign']]
```

```
var_c2 = variantmapper.g_to_c(var_g, 'NM_001261457.1', alt_aln_method='salign')
var_p2 = variantmapper.c_to_p(var_c2, None)
var_c2, var_p2
```

```
(SequenceVariant(ac=NM_001261457.1, type=c, posedit=1534A>G),
 SequenceVariant(ac=MD5_921ebefe79bff479f4bfa17e133fc084, type=p,
 ↪posedit=(Met512Val)) )
```

Reference Manual

Grammar

Grammar Overview

Note: This section is being written.

Provide an overview of the grammar rules Also consider a document link to the grammar itself

HGVS Railroad Diagram

Generated from hgvs (<https://github.com/biocommons/hgvs>)

1b1f788ef473+ default tip

See the source code for the OMeta-based grammar

Variants

Intervals

Localized Edits

Positions

Edits (sequence changes)

Sequences

Residues

Remaining rules

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Variants

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Modules

Module Overview

| Module | Classes | Description |
|---|---|--|
| <i>Variant Object Representation</i> | | |
| <i>hgvs.edit</i> | <i>hgvs.edit.AAExt</i> <i>hgvs.edit.AAFs</i> <i>hgvs.edit.AARefAlt</i> <i>hgvs.edit.AASub</i> <i>hgvs.edit.Dup</i> <i>hgvs.edit.Edit</i> <i>hgvs.edit.NACopy</i> <i>hgvs.edit.NADupN</i> <i>hgvs.edit.NARefAlt</i> <i>hgvs.edit.Repeat</i> | <i>hgvs.edit</i> classes implement various kinds of sequence edits. For nucleic acids, these edits are independent of location; amino acids edits currently contain the location. |
| <i>hgvs.hgvsposition</i> | <i>hgvs.hgvsposition.</i> <i>HGVSPosition</i> | A non-standard representation of a sequence location without an edit. For example, NM_012345.6:c.72+5_73-2. |
| <i>hgvs.location</i> | <i>hgvs.location.AAPosition</i> <i>hgvs.location.</i> <i>BaseOffsetPosition</i> <i>hgvs.location.Interval</i> <i>hgvs.location.</i> <i>SimplePosition</i> | Various kinds of locations. Interval is a span from start to end; the others are points in a sequence. |
| <i>hgvs.posedit</i> | <i>hgvs.posedit.PosEdit</i> | A position+edit (really, an interval and edit). |
| <i>hgvs.variant</i> | <i>hgvs.variant.</i> <i>SequenceVariant</i> | A sequence variant of any type (g, c, m, r, n, p). A <i>SequenceVariant</i> is returned by <i>hgvs.parser.Parser</i> , and it is the input and output type for <i>hgvs.variantmapper.VariantMapper</i> operations. |
| <i>Parsing and Formatting</i> | | |
| <i>hgvs.parser</i> | <i>hgvs.parser.Parser</i> | |
| <i>Coordinate, Interval, and Variant Mapping/Transformation</i> | | |
| <i>hgvs.intervalmapper</i> | <i>hgvs.intervalmapper.</i> <i>IntervalMapper</i> <i>hgvs.intervalmapper.</i> <i>Interval</i> <i>hgvs.intervalmapper.</i> <i>IntervalPair</i> | |
| 1.6. Reference Manual | <i>hgvs.intervalmapper.</i> <i>CIGARElement</i> | 27 |
| <i>hgvs.projector</i> | | |

Top-level module

hgvs is a package to parse, format, and manipulate biological sequence variants. See <https://github.com/biocommons/hgvs/> for details.

Example use:

```
>>> import hgvs.dataproviders.uta
>>> import hgvs.parser
>>> import hgvs.variantmapper
```

```
# start with these variants as strings >>> hgvs_g, hgvs_c = "NC_000007.13:g.36561662C>T",
"NM_001637.3:c.1582G>A"

# parse the genomic variant into a Python structure >>> hp = hgvs.parser.Parser() >>> var_g =
hp.parse_hgvs_variant(hgvs_g) >>> var_g SequenceVariant(ac=NC_000007.13, type=g, posedit=36561662C>T)

# SequenceVariants are composed of structured objects, e.g., >>> var_g.posedit.pos.start SimplePosi-
tion(base=36561662, uncertain=False)

# format by stringification >>> str(var_g) 'NC_000007.13:g.36561662C>T'

# initialize the mapper for GRCh37 with splign-based alignments >>> hdp = hgvs.dataproviders.uta.connect() >>>
am = hgvs.assemblymapper.AssemblyMapper(hdp, ... assembly_name="GRCh37", alt_aln_method="splign", ... re-
place_reference=True)

# identify transcripts that overlap this genomic variant >>> transcripts = am.relevant_transcripts(var_g) >>>
sorted(transcripts) ['NM_001177506.1', 'NM_001177507.1', 'NM_001637.3']

# map genomic variant to one of these transcripts >>> var_c = am.g_to_c(var_g, "NM_001637.3") >>> var_c Se-
quenceVariant(ac=NM_001637.3, type=c, posedit=1582G>A) >>> str(var_c) 'NM_001637.3:c.1582G>A'

# CDS coordinates use BaseOffsetPosition to support intronic offsets >>> var_c.posedit.pos.start BaseOffsetPosi-
tion(base=1582, offset=0, datum=Datum.CDS_START, uncertain=False)
```

Configuration

hgvs.config

The hgvs package uses a single, package-wide configuration instance to control package behavior. The hgvs.config module provides that configuration instance, via the `hgvs.global_config` variable.

You should not import hgvs.config directly.

Config are read from an ini-format file. `hgvs.config` implements a thin wrapper on the ConfigParser instance in order to provide *attribute* based lookups (rather than key). It also returns heuristically typed values (e.g., "True" becomes True).

Although keys are settable, they are stringified on setting and type-inferred on getting, which means that round-tripping works only for str, int, and boolean.

```
>>> import hgvs.config
```

hgvs.config.global_config

Package-wide ("global") configuration, initialized with package defaults. Setting configuration in this object will change global behavior of the hgvs package.

`global_config`, an instance of `:ref:hgvs.config.Config`, supports reading ini-like files that updates


```
class hgvs.config.Config(extended_interpolation=True)
    Bases: object

    provides an attribute-based lookup of configparser sections and settings.

    read_stream(flo)
        read configuration from ini-formatted file-like object
```

```
class hgvs.config.ConfigGroup(section)
    Bases: object
```

The defaults are:

```
[mapping]
alt_aln_method = splign
assembly = GRCh38
in_par_assume = X
inferred_p_is_uncertain = True
normalize = True
replace_reference = True

[formatting]
p_3_letter = True
p_term_asterisk = False

[normalizer]
cross_boundaries = False
shuffle_direction = 3
validate = True
window_size = 20

[lru_cache]
maxsize = 100
```

Variant Object Representation

hgvs.edit

Representation of edit operations in HGVS variants

NARefAlt and AARefAlt are abstractions of several major variant types. They are distinguished by whether the ref and alt elements of the structure. The HGVS grammar for NA and AA are subtly different (e.g., the ref AA in a protein substitution is part of the location).

```
class hgvs.edit.AAExt(ref=None, alt=None, aaterm=None, length=None, uncertain=False)
    Bases: hgvs.edit.Edit

    aaterm

    alt

    format(conf=None)

    length

    ref

    type
        return the type of this Edit

    Returns edit type (str)
```

uncertain**class** hgvs.edit.**AAFs** (*ref=None, alt=None, length=None, uncertain=False*)Bases: *hgvs.edit.Edit***alt****format** (*conf=None*)**length****ref****type**

return the type of this Edit

Returns edit type (str)**uncertain****class** hgvs.edit.**AARefAlt** (*ref=None, alt=None, uncertain=False*)Bases: *hgvs.edit.Edit***alt****format** (*conf=None*)**ref****type**

return the type of this Edit

Returns edit type (str)**uncertain****class** hgvs.edit.**AASub** (*ref=None, alt=None, uncertain=False*)Bases: *hgvs.edit.AARefAlt***format** (*conf=None*)**type**

return the type of this Edit

Returns edit type (str)**class** hgvs.edit.**Conv** (*from_ac=None, from_type=None, from_pos=None, uncertain=False*)Bases: *hgvs.edit.Edit*

Conversion

from_ac**from_pos****from_type****type**

return the type of this Edit

Returns edit type (str)**uncertain****class** hgvs.edit.**Dup** (*ref=None, uncertain=False*)Bases: *hgvs.edit.Edit***format** (*conf=None*)

ref**ref_s**

returns a string representing the ref sequence, if it is not None and smells like a sequence

type

return the type of this Edit

Returns edit type (str)**uncertain****class** hgvs.edit.**Edit**Bases: `object`**format** (*conf=None*)**class** hgvs.edit.**Inv** (*ref=None, uncertain=False*)Bases: `hgvs.edit.Edit`

Inversion

ref**ref_n**returns an integer, either from the *seq* instance variable if it's a number, or None otherwise**ref_s****type**

return the type of this Edit

Returns edit type (str)**uncertain****class** hgvs.edit.**NACopy** (*copy=None, uncertain=False*)Bases: `hgvs.edit.Edit`

Represent copy number variants (Invitae-specific use)

This class is intended for Invitae use only and does not represent a standard HGVS concept. The class may be changed, moved, or removed without notice.

copy**type**

return the type of this Edit

Returns edit type (str)**uncertain****class** hgvs.edit.**NARefAlt** (*ref=None, alt=None, uncertain=False*)Bases: `hgvs.edit.Edit`

represents substitutions, deletions, insertions, and indels.

Variables

- **ref** – reference sequence or length
- **alt** – alternate sequence
- **uncertain** – boolean indicating whether the variant is uncertain/undetermined

alt

format (*conf=None*)

ref

ref_n

returns an integer, either from the *ref* instance variable if it's a number, or the length of *ref* if it's a string, or *None* otherwise

```
>>> NRefAlt("ACGT").ref_n
4
>>> NRefAlt("7").ref_n
7
>>> NRefAlt(7).ref_n
7
```

ref_s

returns a string representing the *ref* sequence, if it is not *None* and smells like a sequence

```
>>> NRefAlt("ACGT").ref_s
u'ACGT'
>>> NRefAlt("7").ref_s
7
>>> NRefAlt(7).ref_s
7
```

type

return the type of this *Edit*

Returns edit type (str)

uncertain

class hgvs.edit.Repeat (*ref=None, min=None, max=None, uncertain=False*)

Bases: *hgvs.edit.Edit*

format (*conf=None*)

max

min

ref

type

return the type of this *Edit*

Returns edit type (str)

uncertain

hgvs.hgvsposition

Represent partial HGVS tags that refer to a position without alleles

class hgvs.hgvsposition.HGVSPosition (*ac, type, pos*)

Bases: *object*

HGVSPosition – Represent partial HGVS tags that refer to a position without alleles

Parameters

- **ac** (*str*) – sequence accession
- **type** (*str*) – type of sequence and coordinate

- **pos** (*str*) – sequence position

ac**pos****type****hgvs.location**

Provides classes for dealing with the locations of HGVS variants

This module provides for Representing the location of variants in HGVS nomenclature, including:

- integers and integer intervals (e.g., NC_012345.6:g.3403243_3403248A>C)
- CDS positions and intervals (e.g., NM_01234.5:c.56+12_56+14delAC)
- CDS stop coordinates (e.g., NM_01234.5:c.*13A>C)

Classes:

- *SimplePosition* – a simple integer
- *BaseOffsetPosition* – a position with datum, base, and offset for c. and r. coordinates
- *AAPosition* – an amino acid position (with AA)
- *Interval* – an interval of Positions

class hgvs.location.**AAPosition** (*base=None, aa=None, uncertain=False*)

Bases: *object*

aa**base****format** (*conf=None*)**is_uncertain**

return True if the position is marked uncertain or undefined

pos

return base, for backward compatibility

uncertain**validate** ()

class hgvs.location.**BaseOffsetInterval** (*start=None, end=None, uncertain=False*)

Bases: *hgvs.location.Interval*

BaseOffsetInterval isa Interval of BaseOffsetPositions. The only additional functionality over Interval is to ensure that the dutum of end and start are compatible.

check_datum ()

class hgvs.location.**BaseOffsetPosition** (*base=None, offset=0, datum=<Datum.SEQ_START: 1>, uncertain=False*)

Bases: *object*

Class for dealing with CDS coordinates in transcript variants.

This class models CDS positions using a *base* coordinate, which is measured relative to a specified *datum* (CDS_START or CDS_END), and an *offset*, which is 0 for exonic positions and non-zero for intronic positions.

Positions and offsets are 1-based, with no 0, per the HGVS recommendations. (If you're using this with UTA, be aware that UTA uses interbase coordinates.)

| hgvs | datum | base | offset | meaning |
|--------|-----------|------|--------|--|
| r.55 | SEQ_START | 55 | 0 | RNA position 55 |
| c.55 | CDS_START | 55 | 0 | CDS position 55 |
| c.55 | CDS_START | 55 | 0 | CDS position 55 |
| c.55+1 | CDS_START | 55 | 1 | intronic variant +1 from boundary |
| c.-55 | CDS_START | -55 | 0 | 5' UTR variant, 55 nt upstream of ATG |
| c.1 | CDS_START | 1 | 0 | start codon |
| c.1234 | CDS_START | 1234 | 0 | stop codon (assuming CDS length is 1233) |
| c.*1 | CDS_END | 0 | 1 | STOP + 1 |
| c.*55 | CDS_END | 0 | 55 | 3' UTR variant, 55 nt after STOP |

base

datum

format (*conf*)

is_intronic

returns True if the variant is intronic (if the offset is None or non-zero)

is_uncertain

return True if the position is marked uncertain or undefined

offset

uncertain

validate ()

class hgvs.location.**Interval** (*start=None, end=None, uncertain=False*)

Bases: *object*

end

format (*conf=None*)

is_uncertain

return True if the position is marked uncertain or undefined

start

uncertain

validate ()

class hgvs.location.**SimplePosition** (*base=None, uncertain=False*)

Bases: *object*

base

format (*conf*)

is_uncertain

return True if the position is marked uncertain or undefined

uncertain

validate ()

hgvs.posedit

implements a (position,edit) tuple that represents a localized sequence change

class hgvs.posedit.**PosEdit** (*pos=None, edit=None, uncertain=False*)

Bases: `object`

represents a **simple** variant, consisting of a single position and edit pair

edit

format (*conf=None*)

Formatting the string of PosEdit

length_change (*on_error_raise=True*)

Returns the net length change for this posedit.

The method for computing the net length change depends on the type of variant (dup, del, ins, etc). The `length_change` method hides this complexity from callers.

Parameters

- **self** (hgvs.posedit.PosEdit) – a PosEdit instance
- **on_error_raise** (*bool*) – whether to raise an exception on errors

Returns A signed int for the net change in length. Negative values imply net deletions, 0 implies a balanced insertion and deletion (e.g., SNV), and positive values imply a net insertion.

Raises **HGVSUnsupportedOperationError** – When determining the length for this variant type is ill-defined or unsupported.

There are many circumstances in which the net length change cannot be determined, is ill-defined, or is unsupported. In these cases, the result depends on the value of *on_error_raise*: when *on_error_raise* is True, an exception is raised; when False, the exception is caught and *None* is returned. Callers might wish to pass *on_error_raise=False* in list comprehensions to avoid dealing with exceptions.

pos

uncertain

validate ()

hgvs.sequencevariant

represents simple sequence-based variants

class hgvs.sequencevariant.**SequenceVariant** (*ac, type, posedit*)

Bases: `object`

represents a basic HGVS variant. The only requirement is that each component can be stringified; for example, passing `pos` as either a string or an `hgvs.location.CDSInterval` (for example) are both intended uses

ac

fill_ref (*hdp*)

format (*conf=None*)

Formatting the stringification of sequence variants

Parameters **conf** – a dict comprises formatting options. None is to use global settings.

See `hgvs.config`.

```
posedit
type
validate()
```

Parsing and Formatting

hgvs.parser

Provides parser for HGVS strings and HGVS-related conceptual components, such as intronic-offset coordinates

```
class hgvs.parser.Parser(grammar_fn=u'/home/docs/.cache/Python-Eggs/hgvs-
1.0.0.post4.dev1+gfaf41fc-py2.7.egg-tmp/hgvs/_data/hgvs.pymeta',      ex-
pose_all_rules=False)
```

Bases: `object`

Provides comprehensive parsing of HGVS variant strings (*i.e.*, variants represented according to the Human Genome Variation Society recommendations) into Python representations. The class wraps a Parsing Expression Grammar, exposing rules of that grammar as methods (prefixed with `parse_`) that parse an input string according to the rule. The class exposes all rules, so that it's possible to parse both full variant representations as well as components, like so:

```
>>> hp = Parser()
>>> v = hp.parse_hgvs_variant("NM_01234.5:c.22+1A>T")
>>> v
SequenceVariant(ac=NM_01234.5, type=c, posedit=22+1A>T)
>>> v.posedit.pos
BaseOffsetInterval(start=22+1, end=22+1, uncertain=False)
>>> i = hp.parse_c_interval("22+1")
>>> i
BaseOffsetInterval(start=22+1, end=22+1, uncertain=False)
```

The `parse_hgvs_variant` and `parse_c_interval` methods correspond to the `hgvs_variant` and `c_interval` rules in the grammar, respectively.

Because the methods are generated on-the-fly and depend on the grammar that is loaded at runtime, a full list of methods is not available in the documentation. However, the list of rules/methods is available via the `rules` instance variable.

A few notable methods are listed below:

`parse_hgvs_variant()` parses any valid HGVS string supported by the grammar.

```
>>> hp.parse_hgvs_variant("NM_01234.5:c.22+1A>T")
SequenceVariant(ac=NM_01234.5, type=c, posedit=22+1A>T)
>>> hp.parse_hgvs_variant("NP_012345.6:p.Ala22Trp")
SequenceVariant(ac=NP_012345.6, type=p, posedit=Ala22Trp)
```

The `hgvs_variant` rule iteratively attempts parsing using the major classes of HGVS variants. For slight improvements in efficiency, those rules may be invoked directly:

```
>>> hp.parse_p_variant("NP_012345.6:p.Ala22Trp")
SequenceVariant(ac=NP_012345.6, type=p, posedit=Ala22Trp)
```

Similarly, components of the underlying structure may be parsed directly as well:


```

>>> hp.parse_c_posedit("22+1A>T")
PosEdit(pos=22+1, edit=A>T, uncertain=False)
>>> hp.parse_c_interval("22+1")
BaseOffsetInterval(start=22+1, end=22+1, uncertain=False)

```

Mapping

hgvs.assemblymapper

```

class hgvs.assemblymapper.AssemblyMapper(hdp, assembly_name=u'GRCh38',
                                          alt_aln_method=u'spalign', normalize=True,
                                          in_par_assume=u'X', replace_reference=True,
                                          *args, **kwargs)

```

Bases: *hgvs.variantmapper.VariantMapper*

Provides simplified variant mapping for a single assembly and transcript-reference alignment method.

AssemblyMapper is instantiated with an assembly name and alt_aln_method. These enable the following conveniences over VariantMapper:

- The assembly and alignment method are used to automatically select an appropriate chromosomal reference sequence when mapping from a transcript to a genome (i.e., c_to_g(...) and n_to_g(...)).
- A new method, relevant_transcripts(g_variant), returns a list of transcript accessions available for the specified variant. These accessions are candidates mapping from genomic to transcript coordinates (i.e., g_to_c(...) and g_to_n(...)).

Note: AssemblyMapper supports only chromosomal references (e.g., NC_000006.11). It does not support contigs or other genomic sequences (e.g., NT_167249.1).

Parameters

- **hdp** (*object*) – instance of hgvs.dataprovider subclass
- **replace_reference** (*bool*) – replace reference (entails additional network access)
- **assembly_name** (*str*) – name of assembly (“GRCh38.p5”)
- **alt_aln_method** (*str*) – genome-transcript alignment method (“spalign”, “blat”, “genewise”)
- **normalize** (*bool*) – normalize variants
- **in_par_assume** (*str*) – during x_to_g, assume this chromosome name if alignment is ambiguous

Raises **HGVSError subclasses** – for a variety of mapping and data lookup failures

c_to_g (*var_c*)

c_to_n (*var_c*)

c_to_p (*var_c*)

g_to_c (*var_g, tx_ac*)

g_to_n (*var_g, tx_ac*)

g_to_t (*var_g, tx_ac*)

n_to_c (*var_n*)

n_to_g (*var_n*)

relevant_transcripts (*var_g*)
 return list of transcripts accessions (strings) for given variant, selected by genomic overlap

t_to_g (*var_t*)

hgvs.variantmapper

Provides VariantMapper and AssemblyMapper to project variants between sequences using TranscriptMapper.

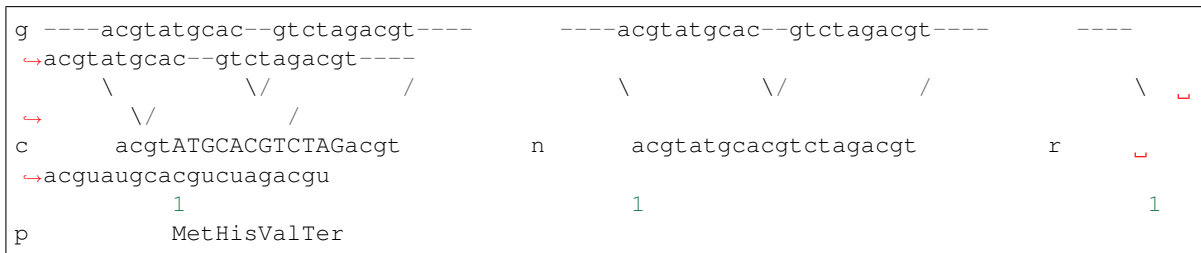
class hgvs.variantmapper.**VariantMapper** (*hdp, replace_reference=True*)
 Bases: object

Maps SequenceVariant objects between g., n., r., c., and p. representations.

g{c,n,r} projections are similar in that c, n, and r variants may use intronic coordinates. There are two essential differences that distinguish the three types:

- Sequence start: In n and r variants, position 1 is the sequence start; in c variants, 1 is the transcription start site.
- Alphabet: In n and c variants, sequences are DNA; in r. variants, sequences are RNA.

This differences are summarized in this diagram:



The g excerpt and exon structures are identical. The gn transformation, which is the most basic, accounts for the offset of the aligned sequences (shown with “1”) and the exon structure. The gc transformation is akin to gn transformation, but requires an addition offset to account for the translation start site (c.1). The CDS in uppercase. The gc transformation is akin to gn transformation with a change of alphabet.

Therefore, this code uses gn as the core transformation between genomic and c, n, and r variants: All cg and rg transformations use ng after accounting for the above differences. For example, c_to_g accounts for the transcription start site offset, then calls n_to_g.

All methods require and return objects of type *hgvs.sequencevariant.SequenceVariant*.

Parameters **replace_reference** (*bool*) – replace reference (entails additional network access)

c_to_g (*var_c, alt_ac, alt_aln_method=u'splign'*)

Given a parsed c. variant, return a g. variant on the specified transcript using the specified alignment method (default is “splign” from NCBI).

Parameters

- **var_c** (*hgvs.sequencevariant.SequenceVariant*) – a variant object
- **alt_ac** (*str*) – a reference sequence accession (e.g., NC_000001.11)
- **alt_aln_method** (*str*) – the alignment method; valid values depend on data source

Returns variant object (*hgvs.sequencevariant.SequenceVariant*)

Raises **HGVSInvalidVariantError** – if var_c is not of type “c”

c_to_n (*var_c*)

Given a parsed c. variant, return a n. variant on the specified transcript using the specified alignment method (default is “transcript” indicating a self alignment).

Parameters **var_c** (*hgvs.sequencevariant.SequenceVariant*) – a variant object

Returns variant object (*hgvs.sequencevariant.SequenceVariant*)

Raises **HGVSInvalidVariantError** – if var_c is not of type “c”

c_to_p (*var_c, pro_ac=None*)

Converts a c. SequenceVariant to a p. SequenceVariant on the specified protein accession Author: Rudy Rico

Parameters

- **var_c** (*SequenceVariant*) – hgvs tag
- **pro_ac** (*str*) – protein accession

Return type *hgvs.sequencevariant.SequenceVariant*

g_to_c (*var_g, tx_ac, alt_aln_method=u'splign'*)

Given a parsed g. variant, return a c. variant on the specified transcript using the specified alignment method (default is “splign” from NCBI).

Parameters

- **var_g** (*hgvs.sequencevariant.SequenceVariant*) – a variant object
- **tx_ac** (*str*) – a transcript accession (e.g., NM_012345.6 or ENST012345678)
- **alt_aln_method** (*str*) – the alignment method; valid values depend on data source

Returns variant object (*hgvs.sequencevariant.SequenceVariant*) using CDS coordinates

Raises **HGVSInvalidVariantError** – if var_g is not of type “g”

g_to_n (*var_g, tx_ac, alt_aln_method=u'splign'*)

Given a parsed g. variant, return a n. variant on the specified transcript using the specified alignment method (default is “splign” from NCBI).

Parameters

- **var_g** (*hgvs.sequencevariant.SequenceVariant*) – a variant object
- **tx_ac** (*str*) – a transcript accession (e.g., NM_012345.6 or ENST012345678)
- **alt_aln_method** (*str*) – the alignment method; valid values depend on data source

Returns variant object (*hgvs.sequencevariant.SequenceVariant*) using transcript (n.) coordinates

Raises **HGVSInvalidVariantError** – if var_g is not of type “g”

g_to_t (*var_g, tx_ac, alt_aln_method=u'splign'*)**n_to_c** (*var_n*)

Given a parsed n. variant, return a c. variant on the specified transcript using the specified alignment method (default is “transcript” indicating a self alignment).

Parameters **var_n** (*hgvs.sequencevariant.SequenceVariant*) – a variant object

Returns variant object (*hgvs.sequencevariant.SequenceVariant*)

Raises **HGVSInvalidVariantError** – if var_n is not of type “n”

`n_to_g` (*var_n*, *alt_ac*, *alt_aln_method*=*u'splign'*)

Given a parsed *n*. variant, return a *g*. variant on the specified transcript using the specified alignment method (default is “splign” from NCBI).

Parameters

- `var_n` (*hgvs.sequencevariant.SequenceVariant*) – a variant object
- `alt_ac` (*str*) – a reference sequence accession (e.g., NC_000001.11)
- `alt_aln_method` (*str*) – the alignment method; valid values depend on data source

Returns variant object (*hgvs.sequencevariant.SequenceVariant*)

Raises `HGVSInvalidVariantError` – if *var_n* is not of type “n”

`t_to_g` (*var_t*, *alt_ac*, *alt_aln_method*=*u'splign'*)

hgvs.intervalmapper

Mapping intervals between pairs of congruent segments

The `IntervalMapper` class is at the heart of mapping between aligned sequences. An instance of `uta.tools.intervalmapper.IntervalMapper` is constructed with an ordered list of `uta.tools.intervalmapper.IntervalPair` instances, each of which consists of two `uta.tools.intervalmapper.Interval` instances. The `IntervalMapper` class is unaware of strand/orientation; that issue is handled by the `uta.tools.transcriptmapper.TranscriptMapper` class.

NOTE: Mapping at the boundaries around indels requires a choice. If seq B has an insertion relative to seq A, then mapping coordinate at the boundaries can either be minimal or maximal for both the start and end. Consider this alignment:

```

0          15  20          35          50
|=====|====|=====|=====|
|          |___/          ___/|
|          | /          / |
|=====|=====|====|=====|
0          15  30  35          50
      15M  5D  15M      5I  15M

segment 1: [ 0,15] ~ [ 0,15]
segment 2: [15,20] ~ [15,15]
segment 3: [20,35] ~ [15,30]
segment 4: [35,35] ~ [30,35]
segment 5: [35,50] ~ [35,50]

```

and these intervals around reference position 35:

```

interval 1: 34,36  -> 29,36 (no ambiguity)
interval 2: 35,35  -> 30,35 (reasonable)
interval 3: 34,35  -> 29,30 (minimal) or 29,35 (maximal)
interval 4: 35,36  -> 35,36 (minimal) or 30,36 (maximal)

```

So, for interval 3, `end_i=35` matches segment 3 and segment 4. Analogously for interval 4, `start_i=35` matches segment 4 and segment 5.

Currently, this code matches an interval `<start_i,end_i>` using the maximal `start_i` and minimal `end_i`.

class `hgvs.intervalmapper.CIGARElement` (*len*, *op*)
 Bases: `object`

represents elements of a CIGAR string and provides methods for determining the number of ref and tgt bases consumed by the operation

len

op

ref_len

returns number of nt/aa consumed in reference sequence for this edit

tgt_len

returns number of nt/aa consumed in target sequence for this edit

class hgvs.intervalmapper.**Interval** (*start_i, end_i*)

Bases: `object`

Represents a segment of a sequence in interbase coordinates (0-based, right-open).

end_i

len

start_i

class hgvs.intervalmapper.**IntervalMapper** (*interval_pairs*)

Bases: `object`

Provides mapping between sequence coordinates according to an ordered set of IntervalPairs.

Parameters **interval_pairs** (*list (of IntervalPair instances)*) – an ordered list of IntervalPair instances

Returns an IntervalMapper instance

static from_cigar (*cigar*)

Parameters **cigar** (*str.*) – a Compact Idiosyncratic Gapped Alignment Report string

Returns an IntervalMapper instance from the CIGAR string

interval_pairs

map_ref_to_tgt (*start_i, end_i, max_extent=False*)

map_tgt_to_ref (*start_i, end_i, max_extent=False*)

ref_intervals

ref_len

tgt_intervals

tgt_len

class hgvs.intervalmapper.**IntervalPair** (*ref, tgt*)

Bases: `object`

Represents a match, insertion, or deletion segment of an alignment. If a match, the lengths must be equal; if an insertion or deletion, the length of the ref or tgt must be zero respectively.

ref

tgt

hgvs.intervalmapper.**cigar_to_intervalpairs** (*cigar*)

For a given CIGAR string, return a list of (Interval,Interval) pairs. The length of the returned list will be equal to the number of CIGAR operations

hgvs.projector

Utility class that projects variants from one transcript to another via a common reference sequence.

```
class hgvs.projector.Projector(hdp, alt_ac, src_ac, dst_ac, src_alt_aln_method=u'spalign',  
                               dst_alt_aln_method=u'spalign')
```

Bases: `object`

The Projector class implements liftover between two transcripts via a common reference sequence.

Parameters

- **hdp** – HGVS Data Provider Interface-compliant instance (see `hgvs.dataproviders.interface.Interface`)
- **ref** – string representing the common reference assembly (e.g., GRCh37.p10)
- **src_ac** – string representing the source transcript accession (e.g., NM_000551.2)
- **dst_ac** – string representing the destination transcript accession (e.g., NM_000551.3)
- **src_alt_aln_method** – string representing the source transcript alignment method
- **dst_alt_aln_method** – string representing the destination transcript alignment method

This class assumes (and verifies) that the transcripts are on the same strand. This assumption obviates some work in flipping sequence variants twice unnecessarily.

```
project_interval_backward(c_interval)
```

project `c_interval` on the destination transcript to the source transcript

Parameters `c_interval` – an `hgvs.interval.Interval` object on the destination transcript

Returns `c_interval`: an `hgvs.interval.Interval` object on the source transcript

```
project_interval_forward(c_interval)
```

project `c_interval` on the source transcript to the destination transcript

Parameters `c_interval` – an `hgvs.interval.Interval` object on the source transcript

Returns `c_interval`: an `hgvs.interval.Interval` object on the destination transcript

```
project_variant_backward(c_variant)
```

project `c_variant` on the source transcript onto the destination transcript

Parameters `c_variant` – an `hgvs.sequencevariant.SequenceVariant` object on the source transcript

Returns `c_variant`: an `hgvs.sequencevariant.SequenceVariant` object on the destination transcript

```
project_variant_forward(c_variant)
```

project `c_variant` on the source transcript onto the destination transcript

Parameters `c_variant` – an `hgvs.sequencevariant.SequenceVariant` object on the source transcript

Returns `c_variant`: an `hgvs.sequencevariant.SequenceVariant` object on the destination transcript

hgvs.transcriptmapper

Provides coordinate (not variant) mapping operations between genomic (g), non-coding (n), cds (c), and protein (p) coordinates.

class hgvs.transcriptmapper.**TranscriptMapper** (*hdp, tx_ac, alt_ac, alt_aln_method*)

Bases: `object`

Provides coordinate (not variant) mapping operations between genomic (g), non-coding (n), cds (c), and protein (p) coordinates. All coordinates are 1-based inclusive, per the HGVS recommendations. All methods take `hgvs.location.Interval` objects.

Parameters

- **hdp** – HGVS Data Provider Interface-compliant instance (see `hgvs.dataproviders.interface.Interface`)
- **tx_ac** (*str*) – string representing transcript accession (e.g., NM_000551.2)
- **alt_ac** (*str*) – string representing the reference sequence accession (e.g., NM_000551.3)
- **alt_aln_method** (*str*) – string representing the alignment method; valid values depend on data source

c_to_g (*c_interval*)
convert a transcript CDS (c.) interval to a genomic (g.) interval

c_to_n (*c_interval*)
convert a transcript CDS (c.) interval to a transcript cDNA (n.) interval

g_to_c (*g_interval*)
convert a genomic (g.) interval to a transcript CDS (c.) interval

g_to_n (*g_interval*)
convert a genomic (g.) interval to a transcript cDNA (n.) interval

is_coding_transcript

n_to_c (*n_interval*)
convert a transcript cDNA (n.) interval to a transcript CDS (c.) interval

n_to_g (*n_interval*)
convert a transcript cDNA (n.) interval to a genomic (g.) interval

Validation and Normalization**hgvs.validator**

implements validation of hgvs variants

class hgvs.validator.**ExtrinsicValidator** (*hdp, strict=True*)

Attempts to determine if the HGVS name validates against external data sources

validate (*var, strict=None*)

class hgvs.validator.**IntrinsicValidator** (*strict=True*)

Bases: `object`

Attempts to determine if the HGVS name is internally consistent

validate (*var, strict=None*)

```
class hgvs.validator.Validator(hdp, strict=True)
    Bases: object

    invoke intrinsic and extrinsic validation

    validate(var, strict=None)
```

hgvs.normalizer

hgvs.normalizer

```
class hgvs.normalizer.Normalizer(hdp, cross_boundaries=False, shuffle_direction=3,
    alt_aln_method='splign', validate=True)
```

Bases: `object`

Perform variant normalization

Initialize and configure the normalizer

Parameters

- **hdp** – HGVS Data Provider Interface-compliant instance (see `hgvs.dataproviders.interface.Interface`)
- **cross_boundaries** – whether allow the shuffling to cross the exon-intron boundary
- **shuffle_direction** – shuffling direction
- **alt_aln_method** – sequence alignment method (e.g., splign, blat)
- **validate** – whether validating the input variant before normalizing

```
normalize(var)
```

Perform sequence variants normalization for single variant

External Data Providers

hgvs.dataproviders.interface

Defines the abstract data provider interface

```
class hgvs.dataproviders.interface.Interface(mode=None, cache=None)
```

Bases: `object`

Variant mapping and validation requires access to external data, specifically exon structures, transcript alignments, and protein accessions. In order to isolate the hgvs package from the myriad choices and tradeoffs, these data are provided through an implementation of the (abstract) HGVS Data Provider Interface.

As of June 2014, the only available data provider implementation uses the [Universal Transcript Archive \(UTA\)](#), a sister project that provides access to transcripts and genome-transcript alignments. [Invitae](#) provides a public UTA database instance that is used by default; see the [UTA](#) page for instructions on installing your own PostgreSQL or SQLite version. In the future, other implementations may be available for other data sources.

Pure virtual class for the HGVS Data Provider Interface. Every data provider implementation should be a subclass (possibly indirect) of this class.

Parameters

- **mode** (*str*) – cache mode (None[default lru cache], 'learn', 'run', 'verify')
- **cache** (*str*) – local cache file name


```

data_version ()
get_acs_for_protein_seq (seq)
get_assembly_map (assembly_name)
get_gene_info (gene)
get_pro_ac_for_tx_ac (tx_ac)
get_seq (ac, start_i=None, end_i=None)
get_similar_transcripts (tx_ac)
get_tx_exons (tx_ac, alt_ac, alt_aln_method)
get_tx_for_gene (gene)
get_tx_for_region (alt_ac, alt_aln_method, start_i, end_i)
get_tx_identity_info (tx_ac)
get_tx_info (tx_ac, alt_ac, alt_aln_method)
get_tx_mapping_options (tx_ac)
interface_version ()
required_version = None
schema_version ()

```

hgvs.dataproviders.uta

implements an hgvs data provider interface using UTA (<https://github.com/biocommons/uta>)

```
class hgvs.dataproviders.uta.ParseResult
```

```
    Bases: urlparse.ParseResult
```

Subclass of url.ParseResult that adds database and schema methods, and provides stringification.

```
    database
```

```
    schema
```

```
class hgvs.dataproviders.uta.UTABase (url, mode=None, cache=None)
```

```
    Bases: hgvs.dataproviders.interface.Interface
```

```
    data_version ()
```

```
    get_acs_for_protein_seq (seq)
```

returns a list of protein accessions for a given sequence. The list is guaranteed to contain at least one element with the MD5-based accession (MD5_01234abc...def56789) at the end of the list.

```
    get_assembly_map (assembly_name)
```

return a list of accessions for the specified assembly name (e.g., GRCh38.p5)

```
    get_gene_info (gene)
```

returns basic information about the gene.

Parameters `gene` (*str*) – HGNC gene name

```

# database results hgnc | ATM maploc | 11q22-q23 descr | ataxia telangiectasia mutated sum-
mary | The protein encoded by this gene belongs to the PI3/PI4-kinase family. This... aliases |
AT1,ATA,ATC,ATD,ATE,ATDC,TEL1,TELO1 added | 2014-02-04 21:39:32.57125

```

get_pro_ac_for_tx_ac (*tx_ac*)

Return the (single) associated protein accession for a given transcript accession, or None if not found.

get_seq (*ac, start_i=None, end_i=None*)

get_similar_transcripts (*tx_ac*)

Return a list of transcripts that are similar to the given transcript, with relevant similarity criteria.

```
>> sim_tx = hdp.get_similar_transcripts('NM_001285829.1') >> dict(sim_tx[0]) { 'cds_eq': False,
'cds_es_fp_eq': False, 'es_fp_eq': True, 'tx_ac1': 'NM_001285829.1', 'tx_ac2': 'ENST00000498907' }
```

where:

- **cds_eq** means that the CDS sequences are identical
- **es_fp_eq** means that the full exon structures are identical (i.e., incl. UTR)
- **cds_es_fp_eq** means that the cds-clipped portions of the exon structures are identical (i.e., excluding UTR)
- **Hint:** “es” = “exon set”, “fp” = “fingerprint”, “eq” = “equal”

“exon structure” refers to the start and end coordinates on a specified reference sequence. Thus, having the same exon structure means that the transcripts are defined on the same reference sequence and have the same exon spans on that sequence.

get_tx_exons (*tx_ac, alt_ac, alt_aln_method*)

return transcript exon info for supplied accession (*tx_ac, alt_ac, alt_aln_method*), or None if not found

Parameters

- **tx_ac** (*str*) – transcript accession with version (e.g., ‘NM_000051.3’)
- **alt_ac** (*str*) – specific genomic sequence (e.g., NC_000011.4)
- **alt_aln_method** (*str*) – sequence alignment method (e.g., splign, blat)

```
# tx_exons = db.get_tx_exons('NM_199425.2', 'NC_000020.10', 'splign') # len(tx_exons) 3
```

tx_exons have the following attributes:

```
{
  'tes_exon_set_id' : 98390
  'aes_exon_set_id' : 298679
  'tx_ac'           : 'NM_199425.2'
  'alt_ac'          : 'NC_000020.10'
  'alt_strand'      : -1
  'alt_aln_method' : 'splign'
  'ord'             : 2
  'tx_exon_id'      : 936834
  'alt_exon_id'     : 2999028
  'tx_start_i'      : 786
  'tx_end_i'        : 1196
  'alt_start_i'     : 25059178
  'alt_end_i'       : 25059588
  'cigar'           : '410='
}
```

For example:

```
# tx_exons[0]['tx_ac'] 'NM_199425.2'
```

get_tx_for_gene (*gene*)

return transcript info records for supplied gene, in order of decreasing length

Parameters `gene` (*str*) – HGNC gene name

get_tx_for_region (*alt_ac*, *alt_aln_method*, *start_i*, *end_i*)
return transcripts that overlap given region

Parameters

- **alt_ac** (*str*) – reference sequence (e.g., NC_000007.13)
- **alt_aln_method** (*str*) – alignment method (e.g., splign)
- **start_i** (*int*) – 5' bound of region
- **end_i** (*int*) – 3' bound of region

get_tx_identity_info (*tx_ac*)
returns features associated with a single transcript.

Parameters `tx_ac` (*str*) – transcript accession with version (e.g., 'NM_199425.2')

```
# database output -[ RECORD 1 ]-+----- tx_ac | NM_199425.2 alt_ac | NM_199425.2
alt_aln_method | transcript cds_start_i | 283 cds_end_i | 1003 lengths | {707,79,410} hgnc | VSX1
```

get_tx_info (*tx_ac*, *alt_ac*, *alt_aln_method*)
return a single transcript info for supplied accession (*tx_ac*, *alt_ac*, *alt_aln_method*), or None if not found

Parameters

- **tx_ac** (*str*) – transcript accession with version (e.g., 'NM_000051.3')
- **alt_ac** (*str*) – specific genomic sequence (e.g., NC_000011.4)
- **alt_aln_method** (*str*) – sequence alignment method (e.g., splign, blat)

```
# database output -[ RECORD 1 ]-+----- hgnc | ATM cds_start_i | 385 cds_end_i | 9556 tx_ac |
NM_000051.3 alt_ac | AC_000143.1 alt_aln_method | splign
```

get_tx_mapping_options (*tx_ac*)
Return all transcript alignment sets for a given transcript accession (*tx_ac*); returns empty list if transcript does not exist. Use this method to discovery possible mapping options supported in the database

Parameters `tx_ac` (*str*) – transcript accession with version (e.g., 'NM_000051.3')

```
# database output -[ RECORD 1 ]-+----- hgnc | ATM cds_start_i | 385 cds_end_i | 9556 tx_ac |
NM_000051.3 alt_ac | AC_000143.1 alt_aln_method | splign -[ RECORD 2 ]-+----- hgnc | ATM
cds_start_i | 385 cds_end_i | 9556 tx_ac | NM_000051.3 alt_ac | NC_000011.9 alt_aln_method | blat
```

required_version = u'1.1'

schema_version ()

```
class hgvs.dataproviders.uta.UTA_postgresql(url, pooling=False, application_name=None,
mode=None, cache=None)
```

Bases: `hgvs.dataproviders.uta.UTABase`

```
hgvs.dataproviders.uta.connect(db_url=None, pooling=False, application_name=None,
mode=None, cache=None)
```

Connect to a UTA database instance and return a UTA interface instance.

Parameters

- **db_url** (*string*) – URL for database connection
- **pooling** (*bool*) – whether to use connection pooling (postgresql only)
- **application_name** (*str*) – log application name in connection (useful for debugging; PostgreSQL only)

When called with an explicit `db_url` argument, that `db_url` is used for connecting.

When called without an explicit argument, the function default is determined by the environment variable `UTA_DB_URL` if it exists, or `hgvs.datainterface.uta.public_db_url` otherwise.

```
>>> hdp = connect()
>>> hdp.schema_version()
'1.1'
```

The format of the `db_url` is `driver://user:pass@host/database` (the same as that used by SQLAlchemy). Examples:

A remote public postgresql database: `postgresql://anonymous:anonymous@uta.biocommons.org/uta'`

A local postgresql database: `postgresql://localhost/uta`

A local SQLite database: `sqlite:///tmp/uta-0.0.6.db`

For postgresql `db_urls`, `pooling=True` causes `connect` to use a `psycopg2.pool.ThreadedConnectionPool`.

Privacy Issues

This page provides details about how the `hgvs` package works, with a focus on privacy issues that users may have. The intent is to provide users with enough information to assess privacy concerns for their institutions.

What's not done

No biologically-relevant data are collected or aggregated from any use of the `hgvs` package for any purpose. Furthermore, variant manipulation is entirely local. Sequence variants are never sent over the network.

Some `hgvs` operations require additional data. For example, mapping variants between a genomic reference and a transcript requires transcript-specific alignment information. Currently, fetching additional data requires a network connection.

(We are considering whether and how to provide fully self-contained installations and do not require network access, but such is not available at this time.)

Data Provider Queries

`hgvs` requires a lot of specialized additional data to validate, normalize, and map variants. *All* queries for data are consolidated into a data provider interface that consists of 11 queries. The method signatures, including input arguments, are shown below with a discussion about privacy consequences.

fetch_seq(ac, start_i, end_i) This method fetches reference sequence in the context of the variant and is required in order to validate, normalize, and replace variant reference sequences. By sending accession and coordinates, it reveals a specific region of interest (and therefore genes and possible clinical conditions).

The current implementation, which fetches transcripts and genomic sequences from UTA, NCBI, and Ensembl, is a measure until we complete a comprehensive sequence archive.

data_version(), schema_version() Queries for meta data about the data provider.

get_acs_for_protein_seq(seq), get_gene_info(gene), get_tx_exons(tx_ac, alt_ac, alt_aln_method), get_tx_for_gene(gene), g

For all of these queries, the inputs are combinations of transcript accession, reference accession, gene name. These are likely too broad to constitute serious privacy concerns.

Information about current connections

The following is an example of the kinds of information available about a current connection as collected by PostgreSQL.

| | |
|------------------|--|
| datname | uta |
| username | anonymous |
| application_name | hgvs-shell/0.4.0rc2.dev20+n97ead5bf0fed.d20150831 |
| client_addr | 162.217.73.242 |
| client_hostname | invitae.static.monkeybrains.net |
| client_port | 38318 |
| backend_start | 2015-08-31 22:58:26.411654+00 |
| query_start | 2015-08-31 22:58:30.669956+00 |
| state_change | 2015-08-31 22:58:30.673533+00 |
| waiting | f |
| state | idle |
| query | select * from tx_exon_aln_v where tx_ac='NM_170707.3' and alt_ac='NC_000001.10' and alt_aln_method='splign' order by alt_start_i |

Several of these merit discussion.

application_name Upon connection using the UTA data provider, a string containing the name of the python script and hgvs version are passed to the postgresql server. The string typically looks like `hgvs-shell/0.4.0rc2.dev20+n97ead5bf0fed.d20150831`. Clients may override the `application_name` when calling `connect()`.

client_addr and client_hostname The source IP and hostname are available for current connections. For most clients, this will mean identifying an institution but not specific computers or individuals.

query The current or most recently executed query is visible. When accessed through the data provider, this field is limited to *Data Provider Queries*.

Historical connection information

Although we do have historical logs for database connections, they provide only date, time, and database connection. Currently, we do not log queries, although we might choose to periodically log certain queries for performance monitoring.

Contributing

hgvs is intended to be a community project. Contributions of source code, test cases, and documentation are welcome!

This section describes development conventions and practices for the hgvs project. The intention is to help developers get up-to-speed quickly.

Highlights

- Development occurs in the default branch. (Release branches are named for the major-minor release, e.g., 0.4.x.)
- Versioning follows [Semantic Versioning](#).

- The code version is determined solely by the hg tags. This version appears in the package name (e.g., `hgvs-0.4.4-py2.py3-none-any.whl`) and in the version returned by `hgvs.__version__`. Updating to a specific version (e.g., `hg up -r 0.4.0`) will get you exactly that version.
- All significant development *must* have an associated issue in [hgvs issues](#); *create an issue if necessary*. Other changes *may* have an issue. Please develop using a bookmark or branch named for the issue, such as `44-normalization`.
- Pull requests should be narrowly focused around a bug or feature. Discrete commits with good log messages facilitate review. Consider collapsing/squashing commits with `hgvs rebase --collapse ...` to make the PR concise. Submit PRs against the default branch head (or close to it).
- Abide by current *code style*. Use `make reformat` to reformat all code with `yapf` prior to submitting a PR.
- Email the [hgvs-discuss](#) mailing list if you have questions.
- Test your code with `make test` before you submit a PR.
- Currently, only Python 2.7 is supported. Support for Python 3.5 is slated for the next release (#190).

A Quick Contribution Example

- Fork the project at <https://github.com/biocommons/hgvs/>

You will be able to make changes there and then submit your contributions for inclusion into the biocommons repo.

- Clone the project locally with

```
$ hg clone https://github.com/<your_username>/hgvs
```

- Create a virtualenv (recommended)

```
$ mkvirtualenv hgvs
```

There are other ways to make python virtual environment. How you do this isn't important, but using a virtual environment is good practice.

- Prepare your environment

```
$ make develop
```

The Makefile in hgvs wraps functionality in `setup.py`, and also provides many useful rules. See [make](#) for more information.

- Make a branch (for significant changes)

If you expect to change multiple files, please work in a branch. Please name the branch like `141-formatter-class`.

- Code, code, code!

You probably want to test code with:

```
$ make test
```

See [Local UTA](#) and [make](#) for tips on accelerating testing.

- Reformat code

This command will reformat the entire package in-place.:

```
$ make reformat
$ hg commit -m 'fixes #141: implements Formatter class'
```

Be sure to commit changes afterward!

- Commit and push:

```
$ make test
$ hg push
```

- Submit a pull request at the [hgvs package web site](#).

Using a local/alternative UTA instance

- Install UTA from a PostgreSQL as described at in the [UTA README](#).
- Specify an alternate UTA instance.

The easiest way to use a UTA instance other than the default is by setting `UTA_DB_URL`. The format is `postgresql://<user>:<pass>@<host>/<db>/<schema>`. For example:

```
postgresql://anonymous:anonymous@uta.biocommons.org/uta/uta_20140210
```

explicitly selects the public database, and

```
postgresql://localhost/uta/uta_20140210
```

selects a local instance. Developers can test connectivity like this:

```
$ UTA_DB_URL=postgresql://localhost/uta/uta_20140210 make test-quick
```

See `hgvs/dataproviders/uta.py` for current UTA database URLs.

Get Cozy with make

The `hgvs` package includes a GNU Makefile that aids nearly all developer tasks. It subsumes much of the functionality in `setup.py`. While using the Makefile isn't required to develop, it is the official way to invoke tools, tests, and other development features. Type `make` for `hgvs`-specific help.

Some of the key targets are:

develop Prepare the directory for local development.

install Install `hgvs` (as with `python setup.py install`).

test Run the default test suite (~4 minutes).

test-quick Run the quick test suite (~35s) of most functionality.

clean, cleaner, cleanest Remove extraneous files, leaving a directory in various states of tidiness.

docs Make the sphinx docs in `docs/build/html/`.

Code Style

The package coding style is based roughly on [PEP8](#), with the following changes:

```
column_limit = 120
spaces_before_comment = 4
split_before_named_assigns = True
```

These code conventions are uniformly enforced by `yapf`. The entire code base is periodically automatically reformatted for consistency.

Variables

The following code variable conventions are used for most of the `hgvs` code base. They should be considered aspirations rather than reality or policy. Understanding these conventions will help users and developers understand the code.

Note: A note on variable suffixes. If a particular variant type is expected, a suffix is often added to variable names. *e.g.*, `var_c` in a function argument list signifies that a `SequenceVariant` object with `type='c'` is expected.

hgvs* a string representing an HGVS variant name.

var* a `hgvs.variant.SequenceVariant` object

pos

posedit

hgvs_position

Release Process

`hgvs` uses a home-grown tool, `clogger`, to generate change logs. This section documents the process. (`Clogger` will be released at some point, but it is currently really only executable by Reece.)

`clogger`'s primary goal is to propose a preliminary changelog based on commit messages between specified release tags. That `.clog` file is a simple format like this:

```
clog format: 1; --outline--
* 0.4.1 (2015-09-14)
Changes since 0.4.0 (2015-09-09).
** Bug Fixes
*** fixes #274, #275: initialize normalizer with same alt_aln_method as
↳AssemblyMapper [43e174d6f8af]
*** fixes #276: raise error when user attempts to map to/from c. with non-coding
↳transcript [3f7b659f4f02]
```

`.clog` files should be edited for readability during the release process and committed to the repo (in `hgvs/doc/changelog/`).

A `Makefile` in the same directory generates an `.rst` file from the `.clog`. This file must also be committed to the repo. This file becomes the release changelog.

Finally, releases are bundled by major.minor versions in a file like `0.4.rst` (no patch level). That file must be edited to include the new release and committed to the repo.

Specific Example – 0.4.3 release

The 0.4.x branch has two recent changes for the 0.4.3 release. Here's how the release was prepared:

```
hg up 0.4.x
hg tag 0.4.3c1

cd doc/changelog
make 0.4.3c1.clog
mv 0.4.3c1.clog 0.4.3.clog
#edit 0.4.3.clog for readability
make 0.4.3.rst
#edit 0.4.rst to add 0.4.3 to index
```

cd ../.. (hgvs top-level), then hg status should now look like:

```
M doc/changelog/0.4.rst
A doc/changelog/0.4.3.clog
A doc/changelog/0.4.3.rst
```

Check your work. Type make docs, then view build/sphinx/html/changelog/0.4.3.html.

Now we're ready to finish up:

```
hg tag --remove 0.4.3c1
hg com -m 'added docs for 0.4.3 release'
hg tag 0.4.3
hg push
make upload # (builds distribution and uploads to pypi)
```

Change Log

1.0 Series

1.0.0 (2017-04-08)

Changes since 0.4.0 (2015-09-09).

This is a major release of the hgvs package that includes new features and behavior changes. Some client code may require minor modification. (Note: Previously, we had tentatively called this release 0.5.0. The magnitude of the changes and the desire to migrate to public API versioning led us release as 1.0.0.)

See *Installing hgvs* for installation instructions.

Major Features and Changes

This section highlights import behavior or interface changes relative to the 0.4.x series. Code modifications are likely for most of the features listed below.

EasyVariantMapper renamed to AssemblyMapper, now with GRCh38 and PAR support. EasyVariantMapper was renamed to AssemblyMapper to better reflect its role. AssemblyMapper defaults to GRCh38. Transcripts in pseudoautosomal regions have alignments to X and Y. Previously, EVM would refuse to guess which alignment to use and raise an exception. AssemblyMapper has a new argument, *in_par_assume*, which enables callers to prefer X or Y alignments.

VariantMapper validates variants before mapping. Several bug reports resulted from attempting to project invalid variants, such as variants with insertions between non-adjacent nucleotides. These generated exceptions or unexpected results. Intrinsic validation is now performed before mapping and normalization, and callers may wish to catch these.

Fully local installations – no network access required. *hgvs* requires access to transcripts and sequences for most operations. By default, *hgvs* will use public remote resources at runtime, which incurs significant latency and, in principle, presents a minor privacy concern. While UTA has always been available for local installation, the more significant delay was in sequence lookup. A new package, *SeqRepo*, provides a local sequence database that is synchronized with UTA. When used together, these packages completely obviate network connectivity and improve speed by approximately 50x.

hgvs transitions to public API versioning conventions. By transitioning from major version 0 (“initial development”) to 1 (“public API”), we are indicating that the API is expected to be stable. In practice, this change will mean that x.y.z versions will clearly distinguish bug fix releases (increment z), backward-compatible feature additions (increment y), and API incompatible changes (increment x). See [Semantic Versioning](#) for more information.

Changes in p. formatting to better conform to current varnomen recommendations. Inferred changes with unknown p. effects are now represented with *p.?* rather than *p.(?)* (#393). In addition, silent SNV mutations now include the amino acid, as in *NP_000050.2:p.Lys2597=* rather than *NP_000050.2:p.(=)* (#317). Both changes improve conformance with current [varnomen recommendations](#).

By default, do not show reference sequence in dels and dups. For example, *NM_000059.3:c.22_23delAAinsT* would be shown as *NM_000059.3:c.22_23delinsT*. Users may configure *max_ref_length* (default 0) order to change this behavior (#404).

BaseOffsetPosition datums now use enums, defined in hgvs.enums. For example, previous *hgvs.location.SEQ_START* must be replaced with *hgvs.enums.Datum.SEQ_START* (#396).

Unknown protein effect are now internally represented with ‘var.posedit=None’. This case is printed as *NP_01234.5:p.?* (#412).

Deprecations and Removals

- #349: drop support for dupN [0dbe440]
- #360: *HGVSValidationError* removed; used *HGVSInvalidVariantError* instead.

Bug Fixes

- #284: validation fails for g variants [512b882]
- #292: Fix bug in validator when validating m. variants and add tests [12d9b48]
- #308: validation across CDS start and CDS end boundaries [ac066ee], [8c8db03]
- #346: ensure that alignment starts at transcript position 0 [3af24b3], [9f29c87]
- #381: fix bug attempting to normalize p. variants; add issue test (test_issues.py) [834bed9]
- #393: fix inconsistent representation of unknown p. effect when inferred by c_to_p [3f1ac48]
- #409: Fix bug in normalizer when normalizing ident variant that is written as delins [94607ecc30da]
- #415: Limit assembly mapper to NC accessions [6056fd4414df]

New Features

- #105: configurable formatting [c8b9fd1]
- #249: Move intrinsic validation to models
- #253: Add p. validation support [3d3b9da], [ba943ae]
- #256: rename EasyVariantMapper to AssemblyMapper to better indicate functionality [d6697d6]
- #258, #330, #342: ensure that start and end datums are compatible [247d8bf]
- #260, #322: added tests to verify that exceptions are raised when mapping invalid variants [ac37ae0]
- #270: add is_intronic method to BaseOffsetPosition [4e40866]
- #282: preserve position in “identity” variants (e.g., norm(c.123A>A) => c.123= rather than c.=) [cc523ed]
- #295: raise exception when validating deletion length for intronic variants [4575ed8]
- #309: make errors more informative when coordinate is outside sequence bounds [d667d8b], [f4cd048]
- #314: support parsing identity variants [9116c72]
- #315: Validate accession type pairs [be90d50]
- #316: provide generalized transcript-to-genome projects to handle coding and non-coding transcripts transparently [26006c7]
- #317: Output silent p. variants according to HGVS recommendations [4babbb5]
- #319: added PosEdit.length_change() method [c191567], [c71a48b], [c70fded]
- #326: provide special handling for disambiguating alignments in pseudoautosomal regions [acc560e]
- #330: datum-matching [e05674b], [461ccd7]
- #336: add hgvs-shell as executable for exploration, debugging, bug submission [f6b6c3c]
- #356: add position comparison operators [4f7f7e4]
- #365: graded validation
- #366: move validation to variantmapper
- #372: rename hgvs/variant.py to hgvs/sequencevariant.py [2f69d65], [ad604fd]
- #379: move replace_reference to variantmapper (from evm) [c0f4be1]
- #386: reject discontinuous alignments [ea2527c]
- #391: Attempt reconnection if db connection is lost [2aef5fac3a61]
- #399: validators should raise only HGVSInvalidVariantError exceptions
- #404: Implement max_ref_length in formatter and don't show reference sequence by default

Other Changes

- #276: raise error when user attempts to map to/from c. with non-coding transcript [aaa0ff5]
- #363: update railroad diagram [3e23e10]

Internal and Developer Changes

- #236: migrate from built-in seqfetcher to bioutils seqfetcher [5e9a951]
- #237: Mock testing data; dropped unmaintained sqlite-based tests
- #287: ensure that modules are also getting doctested (continues #287) [3cbe93a]
- #347: Replace recordtype with attrs
- #395: get ThreadedConnectionPool sizes from config [a2a216c]
- #397: use hgvs.config for VariantMapper.__init__() [154cf5e]
- #400: make hdp cache mode (for testing) settable via HGVS_CACHE_MODE environment variable [09303c7]
- removed sqlite-based uta dataprovider; updated reqs in etc [e8c9d8d85d35]

0.4 Series

0.4.13 (2016-12-12)

Changes since 0.4.12 (2016-12-06).

Bug Fixes

- closes #390: fix missing HGVSError import in variantmapper [BROKEN: 9e3bee72a349]

0.4.12 (2016-12-06)

Changes since 0.4.11 (2016-09-15).

Bug Fixes

- #386: reject discontinuous alignments [BROKEN: 839a6fc36c7d]

Other Changes

- Minor typo corrections on quick_start.rst [BROKEN: 49bb4ac246f1] (PR #53 from kmcallenberg)

0.4.11 (2016-09-15)

Changes since 0.4.10 (2016-09-13).

Other Changes

- fixed #357: reenable parsing of sequence with inversion (backed out #340) [BROKEN: 881c58dda474]

0.4.10 (2016-08-16)

Changes since 0.4.9 (2016-08-01).

Bug Fixes

- fixes #336: add hgvs-shell as executable for exploration, debugging, bug submission [BROKEN: 8ae7f072abc1]
- fixes #346: pushed alignment validation into dataprovider get_tx_exons() to cover use in normalizer [BROKEN: 0bc61059562c]

Other Changes

- closes #352: use https for seqfetcher [BROKEN: ed0655b1bb2b]

0.4.9 (2016-08-01)

Changes since 0.4.8 (2016-07-19).

Special Attention

A small number of alignments provided by NCBI do not begin at the transcript start. These exist in UTA as-is and lead to incorrect mapping and validation. Issue #346 contains the list of 52 transcripts in 37 genes which exhibit this issue; please review prior results. **hgvs will now refuse to use such alignments.**

Bug Fixes

- #346 (partial fix): ensure that alignment starts at transcript position 0 [BROKEN: ab402bf020c6]
- fixes #338: check position range limit when normalizing [BROKEN: da5f1fbcf76d]
- fixes #285, #334, #335, #324, #340: inversions parsing, formatting, and normalization [BROKEN: 29a7b8634b01]
- fixes #340: do not accept sequence following inv [BROKEN: f76e1cb83422]

0.4.8 (2016-07-19)

Changes since 0.4.7 (2016-06-27).

Bug Fixes

- fixes #337: soft-pin bioutils >=0.1.0,<0.2.0 [BROKEN: 13620e943e0c]

0.4.7 (2016-01-23)

Changes since 0.4.6 (2016-06-27).

Bug Fixes

- fixes #310: Fix wrong start position when normalizing some variants [BROKEN: 734c08f18ea1]. Thanks to Meng Wang.

0.4.6 (2016-06-27)

Changes since 0.4.5 (2016-04-01).

Bug Fixes

- fixes #308: fix issues with validating across CDS start and CDS end boundaries [BROKEN: ce6995941984]

Other Changes

- closes #309: make errors more informative when coordinate is outside sequence bounds [BROKEN: e6e0decdad8e]
- closes #295: raise error when attempting to validate del length in intronic variants [BROKEN: 13674d3c6d14]

Internal and Developer Changes

- fix issues with release docs for 0.4.x layout [BROKEN: 52b2358fed02]

0.4.5 (2016-03-31)

Changes since 0.4.4 (2015-12-15).

Special Attention

- The `_execute()` method of the UTA data provider was removed.

As part of addressing bug #321, this *internal* method was removed. Deprecation notices will not be issued for internal methods. (By Python convention, tokens beginning with an underscore are considered private to the package or module.)

Bug Fixes

- fixes #321: use context manager to obtain and release cursors [BROKEN: 70c13e5a0643]

New Features

- closes #319: added `PosEdit.length_change()` method [BROKEN: fa5bb5fb9a50]

Other Changes

- closes #299: migrate 0.4.x branch docs to rtd theme [BROKEN: 3e016264457d]

0.4.4 (2015-12-15)

Changes since 0.4.3 (2015-12-06).

Bug Fixes

- fixes #282: preserve position in “identity” variants (e.g., norm(c.123A>A) => c.123= rather than c.=) [BROKEN: 5e6fd1524204]. (Reported by Stephan Pabinger.)
- fixes #294: extend variant type checks in validator [BROKEN: e28b5a525f6e]
- fixes #292: Fix bug in validator when validating m. variants and add tests [BROKEN: 64e31808a760]

Other Changes

- stopgap for #253: issue warning that p. validation is unsupported [BROKEN: a9bd9ab405bc] (Reported by Ram Srinivasan.)

0.4.3 (2015-12-04)

Changes since 0.4.2 (2015-09-30).

New Features

- closes #281: install hgvs-shell executable with package [BROKEN: bece4e961cd4]

Other Changes

- closes #289: work around pycharm bug PY-4213 [BROKEN: 19c0d4fefbfd]
- added 0.4.2 changelog (after the tagged commit :-()) [BROKEN: 4a596322bceb]

0.4.2 (2015-09-30)

Changes since 0.4.1 (2015-09-14).

Bug Fixes

- fixes #284: validation fails for g variants [BROKEN: 9732eaf5be1c]

0.4.1 (2015-09-14)

Changes since 0.4.0 (2015-09-09).

Bug Fixes

- fixes #274, #275: initialize normalizer with same alt_aln_method as EasyVariantMapper [BROKEN: 43e174d6f8af]
- fixes #276: raise error when user attempts to map to/from c. with non-coding transcript [BROKEN: 3f7b659f4f02]

0.4.0 (2015-09-09)

Changes since 0.3.7 (2015-06-23). See issues at [milestone 0.4.0](#).

Special Attention

- #227: x_to_r and r_to_x methods were renamed to x_to_n and n_to_x as part of support for non-coding transcripts.
- #231: The UTA data provider will use a recently updated database by default (uta_20150827). Clients with custom configurations should use postgresql://anonymous:anonymous@uta.biocommons.org/uta/uta_20150827. (Note the change of hostname, username, and password as well; see Deprecations.)
- #238: Most methods now raise HGVSDataNotAvailableError when expected data is not available. Previously, None was returned for some methods.
- #244: Removed cache_transcripts argument from VariantMapper. This argument was deprecated in 0.3.0 and is now obsolete. Dataproviders are now expected to cache data.
- #246: Remove hgvsX_to_hgvsY methods. These methods were deprecated in 0.3.0 and are now obsolete.
- #247: Dup and Repeat “seq” instance variable renamed to “ref” for consistency.
- EasyVariantMapper, Normalizer, and Validator now fetch sequence data at runtime, which may raise performance and privacy concerns. Users may wish to read [Privacy Issues](#) in the documentation.

Deprecations

- UTA: UTA now uses anonymous:anonymous as the username:password. uta_public:uta_public will be obsolete shortly.

Bug Fixes

- #248: Don't raise validation exception when del sequence is empty [BROKEN: b6c07d329d36]

New Features

- #44: Added variant normalization and use during mapping. Thanks to Meng Wang and Kevin Jacobs for contributions. (pull request #17)
- #168: EasyVariantMapper supports replacing the reference sequence during mapping and enabled by default.
- #227: Implement initial support for non-coding transcripts.
- #230: Allow full IUPAC for NA and AA, with tests. Previously, the grammar admitted only ACGTU.

- #233: Added `get_similar_transcripts()` to data UTA provider to expose UTA's `tx_similarity` view.
- #234, #241: Preferentially use transcript-protein accession associations from RefSeq when mapping c. to p. variants. Previously, when multiple protein accessions were associated with a single distinct sequence, the p. accession was arbitrary.
- #236, #240: Added `seqfetcher.SeqFetcher` to fetch sequences from NCBI & Ensembl
- #250: Implemented configuration module; `hgvs.global_config` is initialized once and available globally
- #251: Parens now optional around p. edits; default is enabled per HGVS spec (`hgvs.global_config.mapping.inferred_p_is_uncertain`)
- #255: variants normalized by EasyVariantMapper by default [BROKEN: 1b85d4deabc3]
- #261: Replace reference default from config (`hgvs.global_config.mapping.replace_reference`)
- UTA is now available as a docker image for local installation. See [Local Installation of UTA](#).

Other Changes

- #213: Clarify warning message when validating intronic variants.
- #254: Support inversion, conversion, and nadupn variants
- Added `misc/experimental/tx-seq-discrepancies` to identify genomic locations of reference-transcript discrepancies
- Added variant context method to `evm` (temporary location, but useful for debugging)
- `HGVSError` now subclasses `HGVSParseError` (not `Exception`) [BROKEN: ff6cd4dc51dc]
- Lots of documentation updates.
- Raise `HGVSParseError` (instead of `ometa.runtime.ParseError`) when parsing fails [BROKEN: efa93fe29d15]
- The UTA data provider now checks for the requested schema on connection and provides more informative errors on failure.
- `hdp.data_version` returns schema name for UTA since that that is the conventional use.
- Use `autocommit` to prevent transaction overhead and locks [BROKEN: 65d69e41716e]

Internal and Developer Changes

- #263: Trying out a new tag-based changelog mechanism for 0.4.0 and 0.4 series.
- All code will be mercifully reformmated with `yapf` occasionally using `.style.yapf`
- Build and upload wheel packages (in addition to existing eggs and tarballs)
- Docs significantly overhauled and moved to readthedocs.org with automatic webhook-based building
- Enable users to set `application_name` when connecting [BROKEN: 835ac7771909]
- `_UTA_URL_KEY` (dev use only) will switch URLs to any in `hgvs/_data/defaults.ini`
- on import of `hgvs`, emit logging info line w/version [BROKEN: aa97f2c1cdc8]
- sped up most tests by using `setUpClass()` rather than `setUp()` [BROKEN: a6d227f6a3e0]

This is the monolithic changelog for the 0.0, 0.1, 0.2, and 0.3 series of hgvs releases. Beginning with 0.4, changes will be recorded in release-specific files; see [Change Log](#).

0.3 Series

0.3.7 (2015-06-23)

Client Changes

- #233: Expose UTA's notions of transcript similarity via the UTA data provider. See `get_similar_transcripts()`.
- #236: Added `seqfetcher.SeqFetcher` to fetch sequences from NCBI & Ensembl
- #199: Improved installation documentation re: PostgreSQL dependency
- #232: Migrated to major.minor versions for schemas and schema provider-client compatibility; "compatible" := (provided x == required x) ^ (provided y >= required y)
- `misc/experimental/vcf-add-hgvs`: optionally generate coding variants
- numerous doc updates

Internal and Developer Changes

- add missing requests library to `setup.py` (only affected developers)
- updated `bioutils` version in `setup.py`

0.3.6 (2015-06-02)

- #228: `IndexError` when schema name is empty
- #228: updated CHANGELOG
- `hgvs/edit.py`: doc string indentation fix

0.3.5 (2015-05-19)

- #219: remove validation requirement that `ref != alt`
- #220: Do not modify cached results when building CIGAR (pkaleta)
- #226: support schema names in db urls; standardized `search_path` handling; merge connection pool and single-threaded client classes
- added AUTHORS

0.3.4 (unreleased)

0.3.3 (2014-08-28)

- #194: fix bug when reverse complementing nucleotides parsed from unicode
- #197: use utf-8 coding, unicode, and all py3k `__future__` features in all source
- #198: documentation improvements
- #202: implement mutalyzer comparisons
- #203: return `HGVSParseError` instead of `ometa.runtime.ParseError` for parsing errors

- #205: fix “base” bias for the exact middle of an odd-length intron
- #206: make `get_tx_for_region` return only transcripts with alignment data
- added flake8 configuration
- added regression test framework (`tests/data/gcp/regression.tsv`)

0.3.2 (2014-07-12)

- #194: fix bug when reverse complementing nucleotides parsed from unicode

0.3.1 (2014-07-12)

- #193: fix lookup table for NC_000014.8 (was .10)
- #192: deprecated `VariantMapper` `cache_transcripts` param and replaced with always-on lru cache in uta data provider

0.3.0 (2014-06-19)

- #103: significantly updated documentation
- #162: provide simplified mapping interface, `EasyVariantMapper`
- #171: integrate the data provider interface into hgvs, obsoleting `bdi`. See `hgvs.dataproviders.*`
- #177: rename mapping functions to `x_to_y` (dropping “hgvs” prefix)
- #180: made `set_uncertain` an internal method (`_set_uncertain`)
- #181: renamed `hgvs.hgvsmapper.HGVSMapper` to `hgvs.variantmapper.VariantMapper`
- #184: rename `HGVSPosition.seqref` to `ac`
- #185: enable validator to use HDPI to fetch sequence data; `mfd` now required only for genomic sequences
- Makefile: print machine info during testing to calibrate/debug timing probs
- moved `hgvs/data` to `hgvs/_data` to emphasize it is internal and avoid tab completion on it
- remove unused args from `VariantMapper.c_to_p()`
- replace `u1/uta1` references with `hdp`; update docs
- replaced `bdi` with `hdp` when referencing the data provider; tests pass
- `setup.py`: removed nose-timer (appeared to cause problems with pip install)
- standardize exception names with “HGVS” prefix
- updated examples/manuscript-example; other minor changes

0.2 Series

0.2.2 (2014-06-12)

- #103: significantly updated documentation
- #142: added BIC test cases

- #167: disable the any_variant rule because it is confusing
- #179: added quick and extra tags to tests; updated Makefile to support make test, test-quick, test-extra; removed test_hgvs_parser_real (but kept gcp version)
- added support for testing models (“models” attr and test-models)

0.2.1 (2014-06-11)

- #157: don't reverse complement numeric “sequences” (as in del26)
- #159: Update comment in tests/data/ADRA2B-dbSNP.tsv
- #161: transform examples to sphinx doc (+upload)
- #167: disable the any_variant rule because it is confusing
- #175: added type to NADupN and Copy edit classes
- Added Important Notes section in README.rst
- Makefile: “test” target should depend on “setup” after all
- added example for stringification to README.rst
- added examples/Manuscript Example.ipynb
- added installation status (from hgvs-integration-test at travis-ci) and build status (from drone.io)
- hgvsmapper: use deepcopy when converting edits
- removed unused sphinx_pypi_upload.py
- updated examples to use uta1

0.2.0 (2014-03-09)

- updated README.rst example to use uta1; added .rst files to nosetest testing
- added ci-test-ve; switched to hgtools 5.0 use_vcs_version in setup.py
- take 1 on reconciling test differences between internal jenkins and drone.io
- removed accidental tag (!); added sphinxcontrib-fulltoc to setup.py

0.1 Series

0.1.11 (2014-03-05)

- removed accidental tag (!); added sphinxcontrib-fulltoc to setup.py
- updated package metadata; removed requirements.txt; tests pass

0.1.9 (2014-03-05)

- #40: added additional tests
- #114: add test that checks that all rules have been tested - and add tests for rules that were missed!
- #135: add more tests; fixed and enabled tests previously commented out

- #147: update tests to use updated sqlite test DB
- Added U14680.1 (BIC tx) to grammar test
- ExtrinsicValidator should not guess about bdi and mfdb sources; instead require caller to specify
- Fixed an un-handled case for parsing AA frameshifts - short form, e.g. "Ala97fs" (no alt AA). Added tests.
- Makefile, setup.py, setup.cfg sync with sibling projects
- Merged hgvs_using_uta1 into default
- Merged in extrinsic_validation (pull request #5)
- Remove redundant test
- added Validator class that wraps intrinsic and extrinsic validation
- added bdi accession testing
- added codeship status badge to README.rst, for testing
- added creating-a-variant example
- added sbin/get-dbsnp-tests-for-gene
- added tests from dbSNP for 6 new gene; fixed probs with uncertainty and Terd+ in existing tests
- bug fixes for uta1 integration; all tests pass except for sqlite db test
- checking cigar ref tgt orientation
- cigar intron count fix
- cut DNAH11 tests to representative set (apx 80% cut)
- finished integrating uta1 into hgvs and started updating tests
- fixed DNAH11-dbSNP tests
- fixed bug when falling off transcripts
- hgvsmapper is updated with uta1 requirements. testing modifications using hgvs-shell
- removed accession test from extrinsic validator (sequence lookup covers accession lookup)
- removed codeship badge
- renamed ~Validation to ~Validator to keep with class-as-actor naming scheme
- starting external validation with bdi
- testing
- trivial change to tickle codeship build
- updated edit type and tests to include identity for sub e.g., T>T
- updated external validation using bdi; added identity edit type for sub T>T; added HGVSValidationException class; added sample tests for mfdb
- updated package metadata; removed requirements.txt; tests pass
- upped bdi min version to >=0.1.0 (interface1)
- use pip installation status as build status since that's what users will experience
- working through updating TM and IM. HM g_to_c appears to work

0.1.8 (2014-01-22)

- updated README.rst example for bdi connect()

0.1.7 (2014-01-22)

- #106, #108: parse uncertain hgvsp/hgvsr; converter produces uncertain hgvsp.
- #110, #111: handle cases of entire gene deletion (p.0?) and stop codon in frame (p.?). Updated tests.
- #65, #89: can now parse Met1? and ext*N; removed extra fs parsing from delins.
- #65: cleanup; AASub can go back to being a subclass of AARefAlt
- #65: def_p_pos needs to accept term13 as well as aa13 for ext; tests updated.
- #65: fixed an ordering bug; added tests.
- #65: fs/ext are now their own pro_edit types; they correspond to their own class objects. 5' extensions and 3' extensions can be parsed. Tests updated.
- #65: should be stringifying * as Ter; fixed code in 2 lines & tests in many.
- #65: tighten ext rules; require a number for new start positions.
- #90: added dup in hgvsmapper; allowed rev complement util to handle None (was triggering exceptions); added tests for dup.
- #91: add extension support for parsing copyN and DupN
- #91: make adding default totally extendable by allowing additional imports for the base grammar (default empty list)
- #91: simplest implementation of parsing copyN, dupN - added directly to grammar (no extension)
- #99: fix aa13t parsing
- #99: fix aa13t parsing, take 2; tests pass (including G* test)
- #99: re-enable tests related to this issue.
- Fixed a bug where del5insT was getting stringified as "5>T"
- added datum to range checking
- added datum to range checking
- added edit type as a property to the edit object; updated tests; added examples to hgvs-shell
- added edit type as a property to the edit object; updated tests; added examples to hgvs-shell
- close anonymous branch
- closed experimental dev branch
- closed hgvsvalidator feature branch on wrong default branch (grafted to default)
- doc updates and Makefile fix after fouled merge
- fixed minor doc typos
- hgvs_to_hgvsp - ac defaults to None; seems better than forcing the user to pass 'None' as a param if they want the protein accession looked up.
- iv grammar branch
- make doc is broken & not used; removing it from make ci-test for now.

- merged in validator (pull request #4)
- minor change to rebase
- removed links section from README
- renamed hgvsvalidator to validator and corresponding test; corrected start-end check added tests
- revised intrinsic validator and tests; deleted requests from setup.py
- updated README.rst example for bdi connect()
- updated docs to point back to pythonhosted
- updated installation.rst
- updated ipython notebook examples
- updated railroad building
- updated railroad in docs
- updated the fragile railroad building again

0.1.6 (2014-01-11)

- updated docs to point back to pythonhosted
- added setuptools to requirements.txt
- updated requirements.txt
- fixed bug in setup.py re: classifiers

0.1.5 (2014-01-11)

- fixed bug in setup.py re: classifiers

0.1.4 (2014-01-11)

- #97: a bagillion doc updates; branch closed

0.1.3 (2014-01-11)

- #60: 1st stab at grammar tests from the bottom-up (through locations/definite positions). (See header in test_hgvs_grammar_full.py for details.) Also added a few error checking tests.
- #60: drop None from SequenceVariant (use case - only parsing an edit); grammar update for offset
- #60: implement cleanup; distributed remaining items to separate issues.
- #73: migrate hgvs to bdi-based protein accession lookup
- #90: fixed typo for delins and ins for parsing hgvsp
- #92: add a subclass of AARefAlt (AASub) which overrides `__str__` to get the representation right; grammar update
- #92: fix error in NARefAlt
- #93: added *variant* liftover for HGVS projector, with tests

- #93: implemented HGVS projector for interval liftover
- #96: cleanup and test update
- #96: deleting tests/data
- #96: fix file
- #96: name cleanup
- #96: removed nightly test target
- #96: short set of real data for gcp parsing
- #97: a bagillion doc updates; branch closed
- #97: major doc restructuring, cleanup, additions
- A few more basic tests
- Add parser test which just tries to parse all the cvids (g, c and p) - currently skips unsupported forms. Also tweaked the r variants in the all cvid file (T should be U).
- Add some basic intervalmapper tests based on the coverage results
- Fill in more protein edit tests
- Fixed a bug breaking n_edit and m_edit; updated tests.
- Make documentation more Sphinx-friendly
- More grammar tests; simplified dup check for hgvs to p conversion
- Tweak HGVS_p expected so an edit creating a stop codon is represented by Ter instead of * (to match hgvs string code)
- add alternative UTA_DB_URL options to Makefile; cleanup eggs in cleanest (not cleaner) and bdist et al. in cleaner (not cleanest)
- added .travis.yml
- added a projector example
- added classifiers and keywords to setup.py
- added license to docs
- added railroad diagram to docs
- additional grammar tests - HGVS edits are failing commented out for now
- bug fix: make test was running nightly tests
- build reST doc for railroad grammar
- code cleanup
- commenting out test until I am in a place where I can run it
- doc updates
- eliminated most sphinx warnings
- lots of doc restructuring and consolidation
- minor cleanup
- more grammar tests
- removed reST examples

- sync default into branch
- sync default into dev
- updated README with pypi info
- updated installation
- updated misc/hgvs-shell for new bdi.uta0.connect()
- updated railroad diagram to include version number
- updated sphinx doc/source/conf.py
- yet more doc changes

0.1.2 (2014-01-05)

- #85: adapted hgvs to bdi with runtime-selectable UTA connections
- updated README with pypi info
- doc updates
- now depend on uta and bdi from PyPI (not dependency_links); sync'd Makefile and setup.py with uta; updated test and docs targets

0.1.1 (2014-01-03)

- #64: handle the following: (1) indel crosses stop codon; (2) indel crosses start codon; need to retest on full suite
- #64: update 4 tests to reflect p.Met1? behavior for deletions crossing from 5' utr to cds:
- #83: cleanup fs* cases where mutalyzer assigns fs*N where N = end of transcript instead of an actual stop codon (expected result is now fs*?)
- #83: comment out tests that need review/cleanup (and added comment); fixed tests where expected result was incorrect (still need to check tests w/ no expected result)
- #83: fill in intronic variants with expected hgvsp results (p.?) per curators
- #84: ext with no stop codons are represented as ext*? - updated tests accordingly
- #84: fix expected result
- Turn off dbg
- Turn off more dbg
- added *lots* of documentation
- added Apache license and code boilerplate to all source files and scripts
- doc updates
- fix coverage by calling tests via python setup.py nosetest; fix test name
- logo: rotated, moved to subdir, created favicon
- made png and ico logos transparent
- moved sphinx sources to doc/source and updated configs
- now depend on uta and bdi from PyPI (not dependency_links); sync'd Makefile and setup.py with uta; updated test and docs targets

- removed test-setup-coverage from Makefile dependencies (put in setup.py instead)
- s/locusdevelopment/invitae/
- updated doc static images
- updated hgvs-logo.png per Makefile
- updated setup.py “license” attribute
- vastly improved sphinx documentation. More to do

0.1.0 (2013-12-30)

- #52: generate syntax/railroad diagrams (in misc/railroad/)
- #56: updated tests; fixed fs*N (only one still broken)
- #62: synchronized setup files among UTA program components
- #66: added support for p.0, p.=, p.?, p.(=), p.(?), with tests
- #66: updated grammar for p.0, p.=, p.?, p.(=), p.(?) to reject invalid p.(0), etc.
- #72: update hgvs to use bdi (no direct connections to uta anymore)
- Close branch jenkins.
- Convert test input and consumer to use 4-column format
- Fix extension for frameshift case; update test to get around dupN (trim the N)
- Fix tag
- Last cleanup before merge
- README.rst: fixed preformatted text (that wasn't)
- Refactored cp tests to work from a common base which more closely resembles the gcp test. All-CVID test input file is in 4-column format (lots of missing data, though)
- Revamp of c to p based on tests results; checkpoint. Sanity & EH tests all run.
- Update makefile to include a mechanism for generating code coverage during tests
- Updated Makefile test task to skip tests prefixed with test_nightly; added task to run all; enabled all cvid test to check this
- add missing files to package_data
- added Apache license and code boilerplate to all source files and scripts
- added architecture & dependency info to README.rst
- added comments to failed and broken tests
- added examples directory
- added sbin/test-runner (see script header for example)
- added setuptools>2.0 to setup.py (testing); updated README.rst
- close branch
- corrected minor README typo
- fix test
- fixed bug in reported AA edit for extensions

- fixed bug introduced in 63e0baf7c986; removed unnecessary and obsolete `edti.interface` import in `tests/framework/mock_input_source.py`
- fixed bug that caused protein accession to be not looked up when not specified
- fixed bug with unqualified class names in `hgvs.pymeta`
- `hgpsc` to `hgvsp` bug fixes/updates: changed `del/dups` to represent the c-terminal end; variants in `utr`, `intron` & `1st AA` are treated as `p.?` (subject to review). Cleaned up test data. Tweaked `seguid` data so the tests pick up the correct NP in a case where there's more than one match - mainly just to get the tests to pass.
- `hgpsc` to `p` takes an accession
- make the nightly start from `make cleanest` (tougher)
- merge into default
- more README and `setup.py` updates
- move `edti` bits to `bdi`
- moved `misc/hgvs-shell` to `sbin`
- `setup.py`: testing yet another `dependency_links` format
- updated README.rst
- updated `bdi` and tests to use external UTA instance
- updated examples dir
- updated logo and README

0.0 Series

0.0.9 (2013-12-16)

- added comments to failed and broken tests
- renamed grammars to `.pymeta`
- consolidated `g-c-p` testing into a single test file; commented out putatively broken tests; DNAH11 works!
- add forgotten `sbin/fastaseguid` for `commit -2` (0d29d0ea2d42)
- fixed minor grammar bugs re: AA term and frameshift
- added accession lookup for all of RefSeq protein
- got 'make jenkins' target working
- harmonized with UTA Makefile and `setup.py` to try to get tests working
- added `biopython` to `setup.py`
- fixed `pro_eq` grammar bug mentioned in [#42](#)
- Updated DNAH11 and NEFL tests. They run, so I'll mark as complete, but there are errors associated with the proteins
- `hgpsc_to_hgvsp`: Fixed a `delins` bug
- `hgpsc_to_hgvsp`: Fixed bug in insertion indexing; improved exception handling
- added `misc/hgvs-shell` to simplify manual testing
- `hgvs` tests for DNAH11 and NEFL -> note protein not currently working just change if statement

- initial checkin for jenkins branch; want to test this in the build context
- Close branch c_to_p
- Merged in c_to_p (pull request #3)
- Incorporate AASpecial; tests pass.
- merge from default
- merged default into c_to_p
- added AASpecial to handle p.=, p.?, p.0 (and parenthesized versions)
- fixed setup.py issue that caused omission of hgvs.utils on install
- Forgot to add a test file to mercurial
- Merged from default; fixed a test.
- Make test file name more consistent
- SIMplified comparison in the event of a simple substitution; updated tests so the failed tests are commented out.
- Reformatted Emily's test data to make it more consumer-friendly; continuous test tweaking - latest checkpoint.
- Another couple of fixes based on EH tests; checking in working version of the tests.
- updated hgvsmapper with all g<->r<->c transformations
- remove explicit class references from makeGrammar invocation, require fully-qualified class name in hgvs.ometa
- close uncertainty branch
- added chr_to_NC in utils, added c_to_g in hgvsmapper
- Name cleanup for tests
- Tests now play nicely with both real data and the mock data.
- Add call to get_tx_seq()
- Missed a rename in the tests.
- Rename test classes to be a bit more consistent with their use.
- Inserted hgpsc_to_hgvsp into hgvsmapper.
- merge from default
- align with developer.rst conventions on naming hgvs variants vs. strings
- Fix tests to run in makefile context; some more documentation
- revamped hgvs_c_to_p so its interface matches hgvsmapper; should make incorporation a simple matter of copying the hgpsc_to_hgvsp method in. Updated tests accordingly. Moved tests to top-level.
- Merge from default
- Re-arranging code for utils/staging for hgvs mapper.
- Purged debug code
- Ack - last checkin broke the tests; fixed accession setup
- format cleanup
- Incorporate stopgap for protein accession; refactor so interface consumes data in the current UTA format; refactor tests to mimic UTA input; getting actual seq is still a placeholder.

- merging default into c_to_p
- added location uncertainty (parsing, representation, formatting, testing)
- added multifastadb code and tests
- [mq]: hgvsmapper-work
- imported patch hgvs-utils-dir
- added multifastadb tool and tests
- added Rudy's AA p.= rule
- [mq]: grammar-relo
- added hgvs.stopgap
- Close branch transcriptmapper
- Merged in transcriptmapper (pull request #2)
- added TODO for tracking, prior to merging pull request
- Basic handling of variants in non-coding regions; will return p.= in all cases; this does not handle the case where a 5'utr variant results in the creation of an upstream Met.
- merged with default, TM bug fixes and more tests
- cleanup names (or at least make them a little more descriptive)
- added tm.cds_start_i in place of hard coding cds
- refactoring
- Roll back exon-specific changes and assume input is entire transcript concatenated together; retain the transcript data as recordtype
- fix test for AA in 2nd exon
- Convert transcript data object to recordtype; add tests for multi-exon (in progress)
- more tests
- additional TM fixes and more tests with multiple exons and strands
- Account for transcripts w/ more than 1 exon (test input assumed one)
- added some 1-exon tests
- Incorporate aa util and extend interval class (for test data); convert code to produce SequenceVariant objects for hgvs c to p. Also hacked in a way to handle p.= into the grammar (should be reviewed before merge).
- bug fixes
- Merged default into c_to_p
- added enum to transcriptmapper tests
- Last cleanup before merging default into here
- all input/output is hgvs-based. updated tests accordingly
- Close branch protein-variants
- Merged in protein-variants (pull request #1)
- hgvs.edit: fixed and improved fs handling, and added mediocre tests
- hgvs.utils: added Xaa=X, Ter=*, Sec=U for aa1-to-aa3 & aa3-to-aa1 translation

- code cleaning
- finished tests for transcriptmapper
- finished all the g,r,c conversions adding more tests
- More cleanup; simplify variant inserter code
- updated transcriptmapper to support g->r, r->g, r->c and appropriate tests
- minor cleanup
- variant insert tests
- merged edti-uta0 branch
- closing branch prior to merge
- edti: added `__metaclass__` to `edti.interface`; added `fetch_gene_info` to `uta0`
- `hgvs.edti`: EDTI base interface and UTA0 implementation milestone
- `hgvs.parser`: add function attributes for every rule to enable, e.g., `Parser.parse_c_interval(...)`
- implemented `p.` parsing and formatting, with tests
- `hgvs.utils`: handle case when `aa` string is `None`
- `hgvs.utils`: added `aa_to_aa{1,3}` functions to coerce to 1- or 3-letter amino acids
- `hgvs.utils`: added protein 1-letter and 3-letter conversion
- Checkpoint for new branch (`hgvs c` to `p`)
- branched `transcriptmapper`
- improved parsing of `hgvs_position` rules (i.e., without edits) to handle `g,m,n,r,c,p` types distinctly
- added `{gmn,c,r,p}_edit` rule to parse variants without accessions (e.g., `c.76A>T`)
- renamed `DelIns` class to `RefAlt`
- renamed `Variant` to `SequenceVariant`, and instance variant `seqref` to `ac`
- closed abandoned protein-support branch
- updated parser tests to include aspirational and “reject” tests
- `[mq]`: import-location-changes
- `[mq]`: import
- `hgvs.location`: renamed location classes; added `BaseOffset` position for `r.` and `c.`; removed predicate methods (`is_exonic`, etc);
- incomplete, buggy milestone
- `setup.py`: use full path for `doc/description.rst`
- updated `CDSPosition` to include `datum` and added tests
- use `get_distribution()` rather than `require()` to fetch version
- Fix for pathing to `grammar.txt` from within `hgvs.parser.Parser`
- modified `setup.py` to `zip_safe` `false`
- TODO edited online with Bitbucket
- Making `setup.py` file pathing absolute

- Fix for setup.py
- updated Makefile and setup.py
- revert directory to current after upload
- fixed bug in HGVSPosition.__str__ and added HGVSPosition test

0.0.7 (2013-10-11)

- fixed bug in HGVSPosition.__str__ and added HGVSPosition test
- collapsed grammar cases for c_pos; fixed variant test case typo

0.0.6 (2013-10-11)

- collapsed grammar cases for c_pos; fixed variant test case typo
- updated docs; fixed typo in variant

0.0.5 (2013-10-11)

- updated docs; fixed typo in variant
- added HGVSPosition (aka HGVS Lite)

0.0.4 (2013-10-11)

- added HGVSPosition (aka HGVS Lite)
- “simple” (single site) variants now pass tests
- update hgvs.__init__ and sphinx to use version from hgtools

0.0.3 (2013-10-10)

- update hgvs.__init__ and sphinx to use version from hgtools
- removed home-grown hg versioning in favor of hgtools
- removed virtualenv support and cleaned up Makefile
- milestone sync; c, gmn, and r types mostly work; some tests broken
- updated variant and added test
- updated grammar (more to do) and tests
- added hgvs.posedit and tests
- updated hgvs.edit
- removed CDSInterval (will use Interval for all intervals)
- fixed typo
- update hgvs.location and tests
- minor setup.py changes

0.0.2 (2013-09-20)

- minor setup.py changes
- grammar simplification; added Laros grammar, examples, comments
- Reverted Lawrence's changes to edit.py (after discussing with him).
- Adding some convenience properties to be used in Geneticus.
- updated grammar; added README.rst
- added missing deps to setup.py; switched to plain ole distutils
- added developer notes, logo, sphinx config

0.0.1 (2014-08-01)

- initial commit

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```

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