

CLTK

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Preface

This guide was written as required reading for a humanities course on natural language processing (NLP) to offer more guidance and a lower point of entry than is given in CLTK's official [demo notebook](#), let alone in the [official documentation](#).

Lining Up Text

Having discontinued the corpus reader found in 0.1.x releases, CLTK 1.0 expects you to identify one or more documents directly on disk as input for processing. For the purposes of our course, a plaintext corpus of Old English homiletic prose is available in the repository under `echoe/`. As you won't know the contents of the corpus off by heart, you may want to inspect this directory with help from the `os` module:

```
>>> import os
>>> os.listdir('echoe/')
```

You can then open and read individual files as follows:

```
>>> v9file = open('echoe/394.11.txt')
>>> v9 = v9file.read()
>>> v9
'men ða leofestan ...'
```

Alternatively, you can use NLTK's corpus reader as explained in the [NLTK textbook](#):

```
>>> from nltk.corpus import PlaintextCorpusReader
>>> echoe = PlaintextCorpusReader('echoe', '.*')
```

You can then list available files as follows:

```
>>> echoe.fileids()
['018.40.txt', '018.42.txt', '021.27.txt', '021.28.txt', ...]
```

and access individual files as follows:

```
>>> v9 = echoe.raw('394.11.txt')
```

But an advantage of the corpus reader is that you can alternatively prepare the entire corpus for analysis (just be forewarned that the processing of a substantial corpus will take some time, and memory):

```
>>> corpus = echoe.raw()
```

If you want to analyze a different text or corpus that is not yet in plaintext, you will have to either parse or strip it first. For instance, you can parse HTML or XML using the BeautifulSoup module from the bs4 package as follows:

```
>>> from bs4 import BeautifulSoup
>>> raw = open('/home/username/somefile.html')
>>> soup = BeautifulSoup(raw, 'html.parser')
>>> text = soup.get_text()
```

Alternatively, you can clean up your corpus by other means before loading it in Python.

Default Pipeline Functionality

The functionality shown in the official [demo notebook](#) is available off the shelf, with the important caveat that the demo is centrally focused on Latin and Greek because these have the most comprehensive pipelines. The present section explains CLTK functionality available directly within Python at greater length, with a focus on Old English.

Old English

The only CLTK function we normally need to import is `cltk.NLP()`. We then tie this NLP to a process variable specifying the language with which we'll be working. In response, the interpreter outputs the full list of processes available for that language:

```
>>> from cltk import NLP
>>> pipeline = NLP(language='ang')
✱ CLTK version '1.0.24'.
Pipeline for language 'Old English (ca. 450-1100)' (ISO: 'ang'):
'MultilingualTokenizationProcess', 'OldEnglishLemmatizationProcess',
'OldEnglishEmbeddingsProcess', 'StopsProcess', 'OldEnglishNERProcess'.
```

For Old English, CLTK ships with a language-independent tokenizer and language-specific stopword and lemma lists. It draws on an external library (fastText) supposedly with Old English support for word embeddings. Although CLTK also claims to have a language-specific named-entity-recognition (NER) process, this process appears to be

essentially empty: unlike in the Latin model, the Old English directory structure lacks a list of proper names, and it employs a library (spaCy) that has no support for Old English. What we can expect CLTK to do off the shelf, then, is tokenize, lemmatize, and vector model, the last of these processes presumably on language-agnostic principles.

CLTK has been set up to run the pipeline with all these processes (the default) or a hand-culled selection of them, then inspect the results. Thus for instance:

```
>>> processed = pipeline.analyze(text=v9)
>>> processed.tokens[:12]
['men', 'ðā', 'leofestan', 'we', 'geleornodon', 'on',
'godcundum', 'gewritum', 'þæt', 'æghwylces', 'monnes',
'sawul']
>>> processed.lemmata[:12]
['mann', 'pa', 'leofestan', 'we', 'geleornodon', 'on',
'godcundum', 'gewrit', 'þæt', 'æghwylces', 'monnes',
'sawul']
```

Note that whenever it fails to identify a lemma, it returns the inflected form as found (leofestan, geleornodon, etc.)

With Old English, there isn't much else you can do but lemmatize, but you can ask CLTK whether a given token is registered as a stopword, which may be of some limited use in further processing:

```
>>> processed.words[0].stop
False
>>> processed.words[1].stop
True
```

Another way of querying data is through the words accessor, which organizes what has been learned on a per-token basis. For Old English, this means you can access word form and inferred lemma from a single object.

```
>>> processed.words[0]
Word(index_char_start=0, index_char_stop=3, index_token=0,
index_sentence=None, string='men', pos=None, lemma='mann',
stem=None, scansion=None, xpos=None, upos=None,
dependency_relation=None, governor=None, features={},
category={}, stop=False, named_entity=False, syllables=None,
phonetic_transcription=None, definition=None)
>>> for token in processed.words[:3]:
...     print(token.string, 'is a form of', token.lemma)

men is a form of mann
ðā is a form of þa
leofestan is a form of leofestan
```

The final functionality available for Old English is word embeddings. This may not look like much when queried directly (try querying `processed.embeddings[0]`), but these “vectors” or lists of logarithms store valuable data on each form's relationships to other word forms in the corpus. This means that if we process a large enough corpus, we have access to a great deal of statistically inferred semantic information.

Middle English

Although CLTK claims a Middle English pipeline, it contains no more than a stopwords list, in addition to the universal tokenizer:

```
>>> pipeline = NLP(language='enm')
✂ CLTK version '1.0.24'.
Pipeline for language 'Middle English' (ISO: 'enm'):
'MiddleEnglishTokenizationProcess`, `StopsProcess`.
```

Latin

To demonstrate the capabilities of CLTK more fully, we will have to resort to Latin. That pipeline is demonstrated in the official [demonstration notebook](#), so there is no need to rehearse it here. For completeness' sake, here is the pipeline prompt for Latin:

```
>>> pipeline = NLP(language='lat')
✂ CLTK version '1.0.24'.
Pipeline for language 'Latin' (ISO: 'lat'):
'LatinNormalizeProcess`, `LatinStanzaProcess`,
'LatinEmbeddingsProcess`, `StopsProcess`,
'LatinNERProcess`, `LatinLexiconProcess`.
```

Additional Functionality

Detailed Output

As we saw above, the Old English lemmatizer as contained in the default pipeline returns either a headword or, if none is found, the input string. However, the underlying function has two options with which we may tweak this return: `best_guess=False`, which causes it to return all hits rather than just the one it considers the most likely, and `return_frequencies=True`, which returns the logarithm of the returned headword's relative frequency in the underlying word list. To access this information, we can call the function directly, bypassing the pipeline:

```
>>> from cltk.lemmatize.ang import OldEnglishDictionaryLemmatizer as lem
>>> lem.lemmatize_token('man')
'man'
>>> lem.lemmatize_token('man', return_frequencies=True, best_guess=False)
[('mann', -6.829400539827225), ('man', -4.832846657953158)]
```

In the above example, the form “man” may represent either the impersonal pronoun *man* “one,” identical in meaning and origin to German *man*, or it may be the noun *mann* “person; man,” similar in meaning to German *Mann*. If we run the lemmatizer with default options, all it returns is the likeliest headword, i.e. the pronoun. With the two custom options, it returns a list of tuples, each of which consists of a headword and the logarithm of its relative frequency in the word list. As these are all negative logarithms, whichever is closest to zero is evaluated as the likeliest headword, while absolute zero means only one match has been found. To evaluate a document as opposed to a single word form, you'll have to tokenize it first:

```
>>> tokens = 'MEN ða leofestan manað us and myngap þeos halige boc þæt we \
sien gemyndige ymb ure sawle þearfe'.lower().split()
```

```
>>> lem.lemmatize(tokens, return_frequencies=True, best_guess=False)
[(['mann', -6.829400539827225]), (['be', -3.109198614584248),
 ('da', -3.1405210857132895), (['pa', -2.344858341627749),
 ('se', -2.9011463394704973)], [], []), (['we', -5.037641070599171),
 ('us', -5.826098430963441)], (['and', -2.8869365088978443)], [], ... ]
```

Note that with these settings, an input with no hits returns an empty value (`[]`) with no frequency data.

Additional Processing Functions

CLTK offers a few language processing functions additional to those integrated into the pipeline. For Old English, we have access to a syllabifier, an IPA transcription utility, and a transliterator of Old English runes. These may be used as follows:

```
>>> from cltk.phonology.ang.transcription import Transcriber
>>> Transcriber.transcribe('habbað æfre ānræðne gēlēafan')
'hab:að æ:fre a:nræ:dne jelæ:avan'
>>> from cltk.phonology.ang.phonology import OldEnglishSyllabifier
>>> syll = OldEnglishSyllabifier()
>>> syll('monan')
['mo', 'nan']
>>> from cltk.phonology.ang.transliteration import Transliterate
>>> Transliterate.transliterate('𐝀𐝃𐝆𐝇𐝈𐝉𐝊 𐝋𐝌 𐝍𐝎𐝏𐝐𐝑𐝒𐝓𐝔𐝕𐝖𐝗𐝘𐝙𐝚𐝛𐝜𐝝𐝞𐝟𐝠𐝡𐝢𐝣𐝤𐝥𐝦𐝧𐝨𐝩𐝪𐝫𐝬𐝭𐝮𐝯𐝰𐝱𐝲𐝳𐝴𐝵𐝶𐝷𐝸𐝹𐝺𐝻𐝼𐝽𐝾𐝿𐞀𐞁𐞂𐞃𐞄𐞅𐞆𐞇𐞈𐞉𐞊𐞋𐞌𐞍𐞎𐞏𐞐𐞑𐞒𐞓𐞔𐞕𐞖𐞗𐞘𐞙𐞚𐞛𐞜𐞝𐞞𐞟𐞠𐞡𐞢𐞣𐞤𐞥𐞦𐞧𐞨𐞩𐞪𐞫𐞬𐞭𐞮𐞯𐞰𐞱𐞲𐞳𐞴𐞵𐞶𐞷𐞸𐞹𐞺𐞻𐞼𐞽𐞾𐞿𐟀𐟁𐟂𐟃𐟄𐟅𐟆𐟇𐟈𐟉𐟊𐟋𐟌𐟍𐟎𐟏𐟐𐟑𐟒𐟓𐟔𐟕𐟖𐟗𐟘𐟙𐟚𐟛𐟜𐟝𐟞𐟟𐟠𐟡𐟢𐟣𐟤𐟥𐟦𐟧𐟨𐟩𐟪𐟫𐟬𐟭𐟮𐟯𐟰𐟱𐟲𐟳𐟴𐟵𐟶𐟷𐟸𐟹𐟺𐟻𐟼𐟽𐟾𐟿𐠀𐠁𐠂𐠃𐠄𐠅𐠆𐠇𐠈𐠉𐠊𐠋𐠌𐠍𐠎𐠏𐠐𐠑𐠒𐠓𐠔𐠕𐠖𐠗𐠘𐠙𐠚𐠛𐠜𐠝𐠞𐠟𐠠𐠡𐠢𐠣𐠤𐠥𐠦𐠧𐠨𐠩𐠪𐠫𐠬𐠭𐠮𐠯𐠰𐠱𐠲𐠳𐠴𐠵𐠶𐠷𐠸𐠹𐠺𐠻𐠼𐠽𐠾𐠿𐡀𐡁𐡂𐡃𐡄𐡅𐡆𐡇𐡈𐡉𐡊𐡋𐡌𐡍𐡎𐡏𐡐𐡑𐡒𐡓𐡔𐡕𐡖𐡗𐡘𐡙𐡚𐡛𐡜𐡝𐡞𐡟𐡠𐡡𐡢𐡣𐡤𐡥𐡦𐡧𐡨𐡩𐡪𐡫𐡬𐡭𐡮𐡯𐡰𐡱𐡲𐡳𐡴𐡵𐡶𐡷𐡸𐡹𐡺𐡻𐡼𐡽𐡾𐡿𐢀𐢁𐢂𐢃𐢄𐢅𐢆𐢇𐢈𐢉𐢊𐢋𐢌𐢍𐢎𐢏𐢐𐢑𐢒𐢓𐢔𐢕𐢖𐢗𐢘𐢙𐢚𐢛𐢜𐢝𐢞𐢟𐢠𐢡𐢢𐢣𐢤𐢥𐢦𐢧𐢨𐢩𐢪𐢫𐢬𐢭𐢮𐢯𐢰𐢱𐢲𐢳𐢴𐢵𐢶𐢷𐢸𐢹𐢺𐢻𐢼𐢽𐢾𐢿𐣀𐣁𐣂𐣃𐣄𐣅𐣆𐣇𐣈𐣉𐣊𐣋𐣌𐣍𐣎𐣏𐣐𐣑𐣒𐣓𐣔𐣕𐣖𐣗𐣘𐣙𐣚𐣛𐣜𐣝𐣞𐣟𐣠𐣡𐣢𐣣𐣤𐣥𐣦𐣧𐣨𐣩𐣪𐣫𐣬𐣭𐣮𐣯𐣰𐣱𐣲𐣳𐣴𐣵𐣶𐣷𐣸𐣹𐣺𐣻𐣼𐣽𐣾𐣿𐤀𐤁𐤂𐤃𐤄𐤅𐤆𐤇𐤈𐤉𐤊𐤋𐤌𐤍𐤎𐤏𐤐𐤑𐤒𐤓𐤔𐤕𐤖𐤗𐤘𐤙𐤚𐤛𐤜𐤝𐤞𐤟𐤠𐤡𐤢𐤣𐤤𐤥𐤦𐤧𐤨𐤩𐤪𐤫𐤬𐤭𐤮𐤯𐤰𐤱𐤲𐤳𐤴𐤵𐤶𐤷𐤸𐤹𐤺𐤻𐤼𐤽𐤾𐤿𐥀𐥁𐥂𐥃𐥄𐥅𐥆𐥇𐥈𐥉𐥊𐥋𐥌𐥍𐥎𐥏𐥐𐥑𐥒𐥓𐥔𐥕𐥖𐥗𐥘𐥙𐥚𐥛𐥜𐥝𐥞𐥟𐥠𐥡𐥢𐥣𐥤𐥥𐥦𐥧𐥨𐥩𐥪𐥫𐥬𐥭𐥮𐥯𐥰𐥱𐥲𐥳𐥴𐥵𐥶𐥷𐥸𐥹𐥺𐥻𐥼𐥽𐥾𐥿𐦀𐦁𐦂𐦃𐦄𐦅𐦆𐦇𐦈𐦉𐦊𐦋𐦌𐦍𐦎𐦏𐦐𐦑𐦒𐦓𐦔𐦕𐦖𐦗𐦘𐦙𐦚𐦛𐦜𐦝𐦞𐦟𐦠𐦡𐦢𐦣𐦤𐦥𐦦𐦧𐦨𐦩𐦪𐦫𐦬𐦭𐦮𐦯𐦰𐦱𐦲𐦳𐦴𐦵𐦶𐦷𐦸𐦹𐦺𐦻𐦼𐦽𐦾𐦿𐧀𐧁𐧂𐧃𐧄𐧅𐧆𐧇𐧈𐧉𐧊𐧋𐧌𐧍𐧎𐧏𐧐𐧑𐧒𐧓𐧔𐧕𐧖𐧗𐧘𐧙𐧚𐧛𐧜𐧝𐧞𐧟𐧠𐧡𐧢𐧣𐧤𐧥𐧦𐧧𐧨𐧩𐧪𐧫𐧬𐧭𐧮𐧯𐧰𐧱𐧲𐧳𐧴𐧵𐧶𐧷𐧸𐧹𐧺𐧻𐧼𐧽𐧾𐧿𐨀𐨁𐨂𐨃𐨄𐨅𐨆𐨇𐨈𐨉𐨊𐨋𐨌𐨍𐨎𐨏𐨐𐨑𐨒𐨓𐨔𐨕𐨖𐨗𐨘𐨙𐨚𐨛𐨜𐨝𐨞𐨟𐨠𐨡𐨢𐨣𐨤𐨥𐨦𐨧𐨨𐨩𐨪𐨫𐨬𐨭𐨮𐨯𐨰𐨱𐨲𐨳𐨴𐨵𐨶𐨷𐨹𐨺𐨸𐨻𐨼𐨽𐨾𐨿𐩀𐩁𐩂𐩃𐩄𐩅𐩆𐩇𐩈𐩉𐩊𐩋𐩌𐩍𐩎𐩏𐩐𐩑𐩒𐩓𐩔𐩕𐩖𐩗𐩘𐩙𐩚𐩛𐩜𐩝𐩞𐩟𐩠𐩡𐩢𐩣𐩤𐩥𐩦𐩧𐩨𐩩𐩪𐩫𐩬𐩭𐩮𐩯𐩰𐩱𐩲𐩳𐩴𐩵𐩶𐩷𐩸𐩹𐩺𐩻𐩼𐩽𐩾𐩿𐪀𐪁𐪂𐪃𐪄𐪅𐪆𐪇𐪈𐪉𐪊𐪋𐪌𐪍𐪎𐪏𐪐𐪑𐪒𐪓𐪔𐪕𐪖𐪗𐪘𐪙𐪚𐪛𐪜𐪝𐪞𐪟𐪠𐪡𐪢𐪣𐪤𐪥𐪦𐪧𐪨𐪩𐪪𐪫𐪬𐪭𐪮𐪯𐪰𐪱𐪲𐪳𐪴𐪵𐪶𐪷𐪸𐪹𐪺𐪻𐪼𐪽𐪾𐪿𐫀𐫁𐫂𐫃𐫄𐫅𐫆𐫇𐫈𐫉𐫊𐫋𐫌𐫍𐫎𐫏𐫐𐫑𐫒𐫓𐫔𐫕𐫖𐫗𐫘𐫙𐫚𐫛𐫜𐫝𐫞𐫟𐫠𐫡𐫢𐫣𐫤𐫦𐫥𐫧𐫨𐫩𐫪𐫫𐫬𐫭𐫮𐫯𐫰𐫱𐫲𐫳𐫴𐫵𐫶𐫷𐫸𐫹𐫺𐫻𐫼𐫽𐫾𐫿𐬀𐬁𐬂𐬃𐬄𐬅𐬆𐬇𐬈𐬉𐬊𐬋𐬌𐬍𐬎𐬏𐬐𐬑𐬒𐬓𐬔𐬕𐬖𐬗𐬘𐬙
```

Please be advised that these utilities are not to be taken as authoritative for the purposes they were designed to serve. Also please note that the syllabifier only takes a single word at a time as input.

Corpus Downloader

CLTK has a function `FetchCorpus()` that links to repositories for a range of premodern corpora. For Old English, it offers the complete Old English poetic corpus, which it downloads in HTML format, then converts to JSON so it may be accessed in Python (though it fails to strip out `` tags meant to indicate emendations in the print edition). The other Old English “corpus” on offer is in fact CLTK’s Old English model, which allows us to explore the package’s processing strategies in isolation from the general pipeline; but that model is downloaded the first time we run the NLP on an Old English text, so there is no need to download it separately. More substantial corpora are available for Latin and Greek.

A full list of all linked corpora may be obtained by issuing

```
>>> import cltk
>>> cltk.data.fetch.LANGUAGE CORPORA.values()
```

or, to sort them by language:

```
>>> cltk.data.fetch.LANGUAGE CORPORA.items()
```

Both these lists are rather hard to read, however. It may help to print the values one per line, like so:

```
>>> print(*cltk.data.fetch.LANGUAGE_CORPORA.values(), sep="\n")
```

or you can narrow down by language. To this end, you’ll need the relevant language code. These are contained in `cltk.languages.glottolog.LANGUAGES`, though to print them in an acceptably clean list would require a few lines of code. Instead, it may help to know that the languages codes used follow the ISO 639-3 standard, with values like the following:

Table 1: Selection of medieval northern European language codes in the ISO 639-3 standard

Code	Language
ang	Old English
enm	Middle English
gmh	Middle High German
goh	Old High German
grc	Acient Greek
lat	Latin
non	Old Norse
osx	Old Saxon/Old Low German

Alternatively, you may search CLTK’s index of languages using part of a language’s Modern English name as a keyword string:

```
>>> cltk.languages.utils.find_iso_name('english')
['enm', 'ang']
>>> cltk.languages.utils.get_lang('ang')
Language(name='Old English (ca. 450-1100)', glottolog_id='olde1238',
latitude=51.06, longitude=-1.31, dates=[], family_id='indo1319',
parent_id='ang11265', level='language', iso_639_3_code='ang', type='h')
```

Returning to our list of corpora, we can now limit it to languages we’re interested in:

```
>>> from cltk.data.fetch import FetchCorpus
>>> FetchCorpus('ang').list_corpora
['old_english_text_sacred_texts', 'ang_models_cltk']
```

As note above, there are in fact only two exclusively Old English corpora available, one of which is the Anglo-Saxon Poetic Records (here called “Sacred Texts” because that is the title of the somewhat suspect website now hosting this HTML corpus), the other is CLTK’s own model tree for Old English. But what this return doesn’t tell you is that CLTK is also aware of multilingual corpora, one of which includes several Old English prose texts. Use the “language code” multilingual to discover these:

```
>>> FetchCorpus('multilingual').list_corpora
['multilingual_treebank_proiel', 'multilingual_treebank_iswoc',
'multilingual_treebank_torot']
```

The ISWOC treebank is the corpus we want; it contains a modest subset of the *Dictionary of Old English* Corpus (DOEC). We may download corpora as follows:

```
>>> FetchCorpus('multilingual').import_corpus('multilingual_treebank_iswoc')
>>> for i in FetchCorpus('ang').list_corpora:
...     FetchCorpus('ang').import_corpus(i)
```

The latter command tells `FetchCorpus()` to download each of its Old English corpora in turn. Please note that if you run the same `for-loop` code for a language like Latin, which has a larger set of corpora linked in CLTK, you may hit an error because one of the repositories is no longer available at the listed URL. If this is the case, you can try downloading the corpora one by one to see which one failed.

You will find your downloaded corpora in your `~/cltk_data/` folder, in subfolders named for their language keys. Whereas CLTK 0.1.x **supplied** a corpus reader, this feature seems to have been abandoned with release 1.0. This is unfortunate inasmuch as it results in a lack of continuity between the experience of downloading and accessing a corpus; the latter will have to make reference to the location of the downloaded files on disk. You can, however, point NLTK's general-purpose corpus reader (not its YCOE reader) to that location and use some of the functionality of NLTK. For instructions, see the NLTK textbook under **§2.1.9 Loading Your Own Corpus**.