## Al for Medicine Course 3 Week 1 lecture notebook

# **Using BioC format and the NegBio Library**

Welcome to this lecture notebook! You'll be exploring some of the uses of the NegBio library, a tool for biomedical text mining, which you will use in the graded assignment at the end of the week.

You'll be using the same dataset as in the assignment, so this is a good opportunity to become more familiar with it.

- This dataset consists of 1,000 X-ray reports that have been manually labeled by a board-certified radiologist.
- The reports indicate the presence or absence of several different pathologies.
- You'll also have access to the extracted "Report Impression" section of each report, which is the summary provided for each X-ray.

# **Import Pandas and Load Dataset**

# In [1]: import pandas as pd # Read the data from file df = pd.read\_csv("stanford\_report\_test.csv") # Check the num of rows, columns print(f"dataset has shape: {df.shape}") df.head()

dataset has shape: (1000, 18)

### Out[1]:

	SimpleTestReportID	Report Impression	No Finding	Enlarged Cardiomediastinum	Cardiomegaly	Lung Lesion
0	1.0	\n \n1.mild pulmonary edema, and cardiomegaly	NaN	NaN	1.0	NaN
1	2.0	\n \n1.unremarkable cardiomediastinal silhouet	NaN	0.0	NaN	NaN
2	3.0	\n1. lines and tubes are unchanged in position	NaN	NaN	NaN	NaN
3	4.0	\n1. postoperative portable film with a right	NaN	NaN	NaN	NaN
4	6.0	\n \n1.single frontal view of the chest demons	NaN	NaN	NaN	NaN

### ####################################

Report number: 1

- 1.mild pulmonary edema, and cardiomegaly. trace pleural fluid effusions.
- 2.low lung volumes with minimal basilar atelectasis.
- 3.no new focal consolidation.
- 4.interval placement of defibrillation pads.

#####################################

Report number: 2

- 1.unremarkable cardiomediastinal silhouette
- 2.diffuse reticular pattern, which can be seen with an atypical infection or chronic fibrotic change. no focal consolidation.
- 3.no pleural effusion or pneumothorax
- 4.mild degenerative changes in the lumbar spine and old right rib fractures.

Report number: 3

- 1. lines and tubes are unchanged in position.
- 2. increasing retrocardiac opacity and left midlung zone opacity.
- 3. there is a deep left costophrenic sulcus which is increased whe  $\ensuremath{\mathtt{n}}$

compared with prior films. no definite evidence of left pneumothorax. clinical correlation is recommended. if clinically indicated, consider film in expiration or decubitus views.

4. the icu team was informed of these results at 10 am on  $05\_02\_20$  05.

# Introducing BioC

Let's get started by looking at the BioC module. You'll be using BioC to convert your clinical data into a standard format that can be leveraged on more specialized libraries. This module is used for many other NLP tasks as well, such as serialization or deserialization of data. You can read more about it <a href="http://bioc.sourceforge.net/">http://bioc.sourceforge.net/</a>).

For your purposes, you're interested in the BioCCollection object, which represents a collection of documents for a project. The collection might be an entire corpus, or a partial one.

```
In [3]: import bioc

collection = bioc.BioCCollection()
    print(f"attributes with value: \n\n{collection.__dict__}\n")
    print(f"methods and attributes: \n\n{dir(collection)}\n")
    print(f"documents within collection: {collection.documents}")

attributes with value:

    {'encoding': 'utf-8', 'version': '1.0', 'standalone': True, 'sourc e': '', 'date': '2021-02-03', 'key': '', 'infons': {}, 'documents': []}

    methods and attributes:

    ['__class__', '__delattr__', '__dict__', '__dir__', '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__gt__', '__ha sh__', '_init__', '_init_subclass__', '_le__', '__lt__', '__mod ule__', '_ne__', '_new__', '_reduce__', '_reduce_ex__', '_rep r__', '__setattr__', '__sizeof__', '_str__', '__subclasshook__', '__weakref__', 'add_document', 'clear_infons', 'date', 'documents', 'encoding', 'infons', 'key', 'source', 'standalone', 'version']

documents within collection: []
```

# Preparing the Text for BioC

When working with collections, you're mostly interested in the documents attribute and the add document() method.

The BioC module gives you a standard format that allows you to apply other, more specialized libraries. Before seeing BioC in action, let's introduce NegBio, a tool that distinguishes negative or uncertain findings in radiology reports. It accomplishes this by using patterns on universal dependencies, instead of using rule-based methods. If you'd like to know more, check out the official github repo (<a href="https://github.com/ncbi-nlp/NegBio">https://github.com/ncbi-nlp/NegBio</a>), or the official documentation (<a href="https://negbio.readthedocs.io/en/latest/index.html">https://negbio.readthedocs.io/en/latest/index.html</a>).

You'll be using the NegBioSSplitter object to split your text into sentences. However, in order to do this, you'll first need to convert your text into a format that BioC supports. For this you'll use the text2bioc() function, which transforms the text into a BioC XML file. You can go even further and convert the text into documents with the text2document() function.

```
In [5]: collection.documents
```

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 $\label{local_bound_bou$ 

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 $\label{local_bound_bou$ 

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 $\label{linear_bished_$ 

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ations=[],],BioCSentence[offset=78,text='2. interval decre ... nno
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 $\label{linear_bished_$ 

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 $\label{local_bound_bou$ 

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BioCDocument[id=988,infons=[],passages=[BioCPassage[offset=0,text=' \n \nnormal heart ... ative changes.\n \n',infons=[],sentences =[BioCSentence[offset=0,text=' \n \nnormal heart size.',infons=[], annotations=[],relations=[],],BioCSentence[offset=24,text='interst itial prom ... \npulmonary edema.',infons=[],annotations=[],relations=[],],BioCSentence[offset=86,text='patchy consolidat ... on, or pneumonia.',infons=[],annotations=[],relations=[],],BioCSentence[offset=187,text='small bilateral \npleural effusions.',infons=[],an notations=[],relations=[],],BioCSentence[offset=224,text='no pneum othorax.',infons=[],annotations=[],relations=[],],BioCSentence[offset=315,text='left up per extrem ... el of the carina.',infons=[],annotations=[],relations=[],relations=[],relations=[],nonotations=[],relations=[],relations=[],nonotations=[],relations=[],nonotations=[],relations=[],nonotation

],relations=[],]],annotations=[],relations=[],],

BioCDocument[id=989,infons=[],passages=[BioCPassage[offset=0,text ='\n1. ap erect ches ... cortical defect.\n',infons=[],sentences=[ BioCSentence[offset=0,text='\n1. ap erect ches ... tinal silhouett e.',infons=[],annotations=[],relations=[],],BioCSentence[offset=82 ,text='the lungs appear clear.',infons=[],annotations=[],relations =[],],BioCSentence[offset=106,text='no rib\nfractures or pneumotho rax.',infons=[],annotations=[],relations=[],],BioCSentence[offset= 140, text='2. ap and lateral ... e\nshoulder joint.', infons=[], anno tations=[],relations=[],],BioCSentence[offset=281,text='there also appear ... n the lower neck.',infons=[],annotations=[],relations=[ ],],BioCSentence[offset=368,text='two paper clips p ... skin lacer ations.',infons=[],annotations=[],relations=[],],BioCSentence[offs et=453,text='no\nradiopaque foreign bodies.',infons=[],annotations =[],relations=[],],BioCSentence[offset=483,text='a lucent line pro ... r to the glenoid.',infons=[],annotations=[],relations=[],],Bio CSentence[offset=565,text='this can only be ... kely artifactual. ',infons=[],annotations=[],relations=[],],BioCSentence[offset=626, text='however, if there ... n may be helpful.',infons=[],annotatio ns=[],relations=[],],BioCSentence[offset=714,text='in\naddition, t her ... the lateral view.', infons=[], annotations=[], relations=[],] ,BioCSentence[offset=849,text='this could repres ... cortical def ect.',infons=[],annotations=[],relations=[],]],annotations=[],rela tions=[],]],annotations=[],relations=[],],

BioCDocument[id=990,infons=[],passages=[BioCPassage[offset=0,text='\n \n1.persistent p ... ed up stomach.\n \n',infons=[],sentences =[BioCSentence[offset=0,text='\n \n1.persistent pulmonary edema.', infons=[],annotations=[],relations=[],],BioCSentence[offset=35,tex t='2.unchanged right ... pleural effusion.',infons=[],annotations=[],relations=[],],BioCSentence[offset=83,text='3.right mid to lo ... rsus atelectasis.',infons=[],annotations=[],relations=[],],BioCSentence[offset=145,text='attention on follow-up chest x-ray.',inf ons=[],annotations=[],relations=[],],BioCSentence[offset=183,text='4.persistent cont ... ulled up stomach.',infons=[],annotations=[],relations=[],]],annotations=[],relations=[],]],annotations=[],relations=[],]],annotations=[],relations=[],]],

BioCDocument[id=992,infons=[],passages=[BioCPassage[offset=0,text=' \n \n1. there ha ... lower \nlobe. \n \n',infons=[],sentence s=[BioCSentence[offset=0,text=' \n \n1. there ha ... ar outflow tract.',infons=[],annotations=[],relations=[],],BioCSentence[offset=372,text='2. no pneumothor ... ed on \nthis film.',infons=[],an notations=[],relations=[],],BioCSentence[offset=455,text='3. interval elev ... ft hemidiaphragm.',infons=[],annotations=[],relation s=[],],BioCSentence[offset=506,text='interval \ndevelop ... left l ower \nlobe.',infons=[],annotations=[],relations=[],]],annotations=[],relations=[],]],annotations=[],relations=[],]

BioCDocument[id=993,infons=[],passages=[BioCPassage[offset=0,text
=' \n \n1.new right i ... ary arteries. \n \n',infons=[],sentences

=[BioCSentence[offset=0,text=' \n \n1.new right i ... elow \nthe c arina.',infons=[],annotations=[],relations=[],],BioCSentence[offset=88,text='no pneumothorax i ... s semierect film.',infons=[],annotations=[],relations=[],BioCSentence[offset=138,text='2.slightly improv ... ons or effusions.',infons=[],annotations=[],relations=[],],BioCSentence[offset=226,text='3.stable prominen ... lmonary ar teries.',infons=[],annotations=[],relations=[],],annotations=[],relations=[],],annotations=[],relations=[],],

BioCDocument[id=994,infons=[],passages=[BioCPassage[offset=0,text=' \n \n1.mild rightw ... cardiomegaly.\n \n',infons=[],sentences =[BioCSentence[offset=0,text=' \n \n1.mild rightw ... t \non 10\_29 \_2010.',infons=[],annotations=[],relations=[],],BioCSentence[offset=157,text='2.mild pulmonary edema.',infons=[],annotations=[],relations=[],],BioCSentence[offset=182,text='no focal consolidation.',infons=[],annotations=[],relations=[],],BioCSentence[offset=208,text='3.mild cardiomegaly.',infons=[],annotations=[],relations=[],]],annotations=[],relations=[],]]

BioCDocument[id=995,infons=[],passages=[BioCPassage[offset=0,text='\n \n1. unchanged ... al pneumothorax.\n',infons=[],sentences=[BioCSentence[offset=0,text='\n \n1. unchanged ... cal pneumothorax.',infons=[],annotations=[],relations=[],]],annotations=[],relations=[],],annotations=[],relations=[],]

BioCDocument[id=996,infons=[],passages=[BioCPassage[offset=0,text ='\n \n1.a single por ... , as before.\n \n',infons=[],sentence s=[BioCSentence[offset=0,text='\n \n1.a single por ... est was obt ained.',infons=[],annotations=[],relations=[],],BioCSentence[offse t=71,text='the cardiomediast ... in lung volumes.',infons=[],anno tations=[],relations=[],],BioCSentence[offset=188,text='there is \ nstable ... the aortic arch.',infons=[],annotations=[],relations =[],],BioCSentence[offset=238,text='2.a tunneled righ ... nged in position.',infons=[],annotations=[],relations=[],],BioCSentence[of fset=309,text='median sternotomy ... are again noted.',infons=[], annotations=[],relations=[],],BioCSentence[offset=402,text='3.inte rval increa ... ia or aspiration.',infons=[],annotations=[],relati ons=[],],BioCSentence[offset=519,text='recommend radiogr ... nsure resolution.',infons=[],annotations=[],relations=[],],BioCSentence[ offset=586,text='4.interval increa ... pleural effusion.',infons=[ ],annotations=[],relations=[],],BioCSentence[offset=656,text='5.no acute osseous abnormality.',infons=[],annotations=[],relations=[], ],BioCSentence[offset=689,text='clips project ove ... egion, as be fore.',infons=[],annotations=[],relations=[],]],annotations=[],rel ations=[],]],annotations=[],relations=[],],

BioCDocument[id=997,infons=[],passages=[BioCPassage[offset=0,text
='\n1. status post p ... al pneumothorax.\n',infons=[],sentences=[
BioCSentence[offset=0,text='\n1. status post p ... ual pneumothora
x.',infons=[],annotations=[],relations=[],]],annotations=[],relations=[],]

BioCDocument[id=998,infons=[],passages=[BioCPassage[offset=0,text='\n1. pulmonary ede ... ally\n indicated.\n',infons=[],sentences=[BioCSentence[offset=0,text='\n1. pulmonary ede ... leural effusions.',infons=[],annotations=[],relations=[],],BioCSentence[offset=59,text='2. cardiomegaly.',infons=[],annotations=[],relations=[],],BioCSentence[offset=76,text='3. left retrocard ... or consolidations=[],

```
n.',infons=[],annotations=[],relations=[],],BioCSentence[offset=12
7,text='a pa and\n lateral ... cally\n indicated.',infons=[],annot
ations=[],relations=[],]],annotations=[],relations=[],]],annotations=[],relations=[],]
```

BioCDocument[id=999,infons=[],passages=[BioCPassage[offset=0,text
='\n \n1.stable posit ... ace disease.\n \n \n',infons=[],sentence
s=[BioCSentence[offset=0,text='\n \n1.stable posit ... venous cat
heter.',infons=[],annotations=[],relations=[],],BioCSentence[offse
t=64,text='2.improvement in lung volumes.',infons=[],annotations=[
],relations=[],],BioCSentence[offset=96,text='mild worsening of ..
. ir space disease.',infons=[],annotations=[],relations=[],]],annotations=[],relations=[],]]

## **Interpreting the Documents**

Now your BioC collection has been filled with documents, but the output is very hard to read. Let's break it down a little more.

```
In [6]: len(collection.documents)
Out[6]: 1000
```

Looks like you have a document for each report impression. But what's stored inside each document? Let's check the first one.

```
In [7]: collection.documents[0]
Out[7]: BioCDocument[id=0,infons=[],passages=[BioCPassage[offset=0,text='\n \nl.mild pulmona ... lation pads. \n \n',infons=[],sentences=[B ioCSentence[offset=0,text='\n \nl.mild pulmona ... and cardiomegal y.',infons=[],annotations=[],relations=[],],BioCSentence[offset=46 ,text='trace pleural fluid \neffusions.',infons=[],annotations=[], relations=[],],BioCSentence[offset=80,text='2.low lung volume ... ilar atelectasis.',infons=[],annotations=[],relations=[],],BioCSentence[offset=135,text='3.no new focal consolidation.',infons=[],an notations=[],relations=[],],BioCSentence[offset=168,text='4.interv al placem ... ibrillation pads.',infons=[],annotations=[],relations=[],relations=[],]],annotations=[],relations=[],relations=[],relations=[],]
```

Each document has an attribute called "passages" in which the sentences are stored. Notice that passages is a list, but for this case it will only have one element:

```
In [8]: collection.documents[0].passages[0].sentences

Out[8]: [BioCSentence[offset=0,text='\n \n1.mild pulmona ... and cardiomeg aly.',infons=[],annotations=[],relations=[],],
        BioCSentence[offset=46,text='trace pleural fluid \neffusions.',in fons=[],annotations=[],relations=[],],
        BioCSentence[offset=80,text='2.low lung volume ... ilar atelectas is.',infons=[],annotations=[],relations=[],],
        BioCSentence[offset=135,text='3.no new focal consolidation.',infons=[],annotations=[],relations=[],],
        BioCSentence[offset=168,text='4.interval placem ... ibrillation p ads.',infons=[],annotations=[],relations=[],]]
```

Each sentence stores information about the text, offset, relations and annotations. Let's check the sentences saved in the first document of our collection:

```
In [9]: for i,s in enumerate(collection.documents[0].passages[0].sentences)
         print(f"sentence number {i + 1}: {s.text}\n")
         print("################"")
      sentence number 1:
      1.mild pulmonary edema, and cardiomegaly.
      sentence number 2: trace pleural fluid
      effusions.
      sentence number 3: 2.low lung volumes with minimal basilar atelect
      asis.
      sentence number 4: 3.no new focal consolidation.
      sentence number 5: 4.interval placement of defibrillation pads.
      ######################################
```

## Cleaning up with the clean() function

Notice how the first report impression, which had two sentences, was split successfully. However, the newlines have not been trimmed. The clean() function from the previous lecture notebook will come in handy here. Let's bring it back out of the toolbox and apply it in this notebook!

```
In [10]: import re
    def clean(sentence):
        lower_sentence = sentence.lower()
        corrected_sentence = re.sub('and/or', 'or', lower_sentence)
        corrected_sentence = re.sub('(?<=[a-zA-Z])/(?=[a-zA-Z])', 'or
', corrected_sentence)
        clean_sentence = corrected_sentence.replace("..", ".")
        punctuation_spacer = str.maketrans({key: f"{key} " for key in "
        .,"})
        clean_sentence = clean_sentence.translate(punctuation_spacer)
        clean_sentence = ' '.join(clean_sentence.split())
        return clean_sentence</pre>
```

#### **Exercise**

Now that you've spent some time exploring how the NegBio library works, let's try it out on your data.

You'll determine whether a given report impression can tell you if a patient has an existing condition, while taking into account whether there was negation or uncertainty in the findings. For this task, you'll use these predetermined categories:

# **Import NegBio Dependencies**

Next you'll import everything you need for this task. Don't be alarmed by the declared paths below the imports! They're just mapping the path to various files that NegBio relies on.

```
In [12]: from pathlib2 import Path
         from negbio.main chexpert import pipeline
         from negbio.pipeline.parse import NegBioParser
         from negbio.chexpert.stages.load import NegBioLoader
         from negbio.chexpert.stages.extract import NegBioExtractor
         from negbio.chexpert.stages.classify import ModifiedDetector
         from negbio.chexpert.stages.aggregate import NegBioAggregator
         from negbio.pipeline.ptb2ud import NegBioPtb2DepConverter, Lemmatiz
         er
         PARSING MODEL DIR = "~/.local/share/bllipparser/GENIA+PubMed"
         CHEXPERT PATH = "NegBio/negbio/chexpert/"
         MENTION PATH =f"{CHEXPERT PATH}phrases/mention"
         UNMENTION PATH = f"{CHEXPERT PATH}phrases/"
         NEG PATH = f'{CHEXPERT PATH}patterns/negation.txt'
         PRE_NEG_PATH = f'{CHEXPERT_PATH}patterns/pre_negation_uncertainty.t
         xt'
         POST NEG PATH = f'{CHEXPERT PATH}patterns/post negation uncertainty
         .txt'
```

The encoding of information within these files is beyond the scope of this notebook, but if you're really curious about the contents you could do something like this to see more:

```
!cat $NEG PATH
```

```
In [13]: !cat $NEG PATH
         # No definite XXX
         ({} > {} {lemma:/definite/}) > {dependency:/neg/} {}
         # No obvious XXX
         (\{\} > \{\} \{lemma:/obvious/\}) > \{dependency:/neg/\} \{\}
         {} > {dependency:/amod|nsubj/} {lemma:/normal|unremarkable/}
         {} < {dependency:/amod|nsubj/} {lemma:/normal|unremarkable/}
         (\{\} > \{\}) < \{dependency:/nsubj|dobj/\} \{lemma:/unremarkable|norm\}
         {} < {} ({} > {dependency:/amod/} {lemma:/normal|unremarkable/})
         {} < {} ({} < {dependency:/nsubj/} {lemma:/normal|unremarkable/})
         {} < {dependency:/conj:no/} {}
         \{\} < \{\} (\{\} < \{dependency:/conj:or/\} (\{\} > \{\} \{lemma:/no/\})\}
         {} < {dependency:/nsubj/} ({lemma:/limit.*/} > {} {lemma:/upper/}
         & > {dependency:/nmod:of/} {lemma:/normal/} & > {dependency:/case/
         } {lemma:/at|within/})
         {} < {} ({dependency:/exclude/} < {} ({} > {} {lemma:/no/}))
         ({lemma:/silhouette/} > {} {}) < {dependency:/dobj|nsubj/} {lemma:
         /obscure/}
```

```
({} > {dependency:/amod/} {lemma:/normal|unremarkable/}) < {depend</pre>
ency:/dobj|nsubj/} {lemma:/demonstrate.*|show|present|display/}
{} < {dependency:/nmod:of/} ( {lemma:/appearance/} > {dependency:/
amod/} {lemma:/normal/} & < {dependency:/dobj/} {lemma:/demonstrat</pre>
e.*|show|present|display/})
{} < {dependency:/amod/} ({} < {dependency:/dep|nsubj/} {lemma:/no
rmal | unremarkable / } )
{} < {dependency:/amod/} ({} > {dependency:/neg/} {lemma:/no/})
{} < {dependency:/amod/}({lemma:/finding.*/} < {dependency:/dobj/}
({lemma:/acute/} > {dependency:/nsubj/} {lemma:/no/}))
{} < {dependency:/amod/} ({lemma:/structure.*/} < {dependency:/dep
| nsubj/} ({lemma:/appear/} > {dependency:/xcomp/} {lemma:/normal|u
nremarkable/}))
{} < {dependency:/compound/} ({} > {dependency:/neg/} {})
{} < {dependency:/nsubj/} {lemma:/absent/}</pre>
{} < {dependency:/amod/} ({} < {dependency:/nmod:of/} ({lemma:/evi
dence/} > {dependency:/case/} {lemma:/without/}))
{} < {dependency:/amod/} ({} < {dependency:/nmod:of/} ({lemma:/evi
dence/} > {dependency:/neg/} {}))
# XXX within normal limits
{} < {} ({} < {} ({lemma:/show|demonstrate|present/} > {dependency
:/nmod:within/} ({lemma:/limit.*/} > {} {lemma:/normal/})))
({} > {} ) > {dependency:/nmod:within/} {lemma:/limit.*/}
{} < {dependency:/nsubj/} ({lemma:/limit.*/} > {} {lemma:/upper/}
& > {dependency:/nmod:of/} {lemma:/normal/} & > {dependency:/case/
} {lemma:/at|within/})
\{\} < \{\} (\{\} < \{dependency:/nsubj/\} (\{lemma:/limit.*/\} > \{\} \{lemma:/limit.*/\} > \{\} \}
/upper/} & > {dependency:/nmod:of/} {lemma:/normal/} & > {dependen
cy:/case/} {lemma:/at|within/}))
\{\} < \{\} (\{\} < \{dependency:/nsubj/\} (\{lemma:/limit.*/\} > \{dependency:/nsubj/\} (\{lemma:/limit.*/) > \{dependency:/n
y:/amod/} {lemma:/normal/} & > {dependency:/case/} {lemma:/at|with
in/}))
({lemma:/vascularity/} > {dependency:/amod/} {lemma:/pulmonary/})
> {dependency:/amod/} {lemma:/normal/}
\{\} < \{dependency:/dobj|nsubj/\} (\{\} > \{dependency:/nmod:within/\} 
lemma:/limit.*/} > {} {lemma:/normal/}))
{} > {dependency:/nmod:within/} ({lemma:/limit.*/} > {dependency:/
amod/} {lemma:/normal/})
{} > {} ({lemma:/limit/} > {} {lemma:/normal/})
# XXX is/appears/are/appear/remain/remains (now, otherwise) normal
/unremarkable
{} < {} ({lemma:/appear|remain/} > {} {lemma:/normal|unremarkable/
})
# XXX is/appears/are/appear/remain/remains (now, otherwise) within
normal limits
\{\} > \{\} (\{lemma:/remain|appear/\} > \{\} (\{lemma:/limit/\} > \{\} \{lemma:/limit/\} > \{\} \})
:/normal/}))
```

```
# rather than XXX
{} <{dependency:/conj:negcc/} {}</pre>
{} <{dependency:/nmod:without/} {}
{} <{dependency:/nmod:without|nmod:of/} {lemma:/clear|clearing/}=k
ey
{} <{dependency:/nmod:out/} {lemma:/rule/}=key
# removal of XXX
{} <{dependency:/nmod:of/} {lemma:/history|free|disappearance|reso
lution|drainage|resolution|removal/}
{} <{dependency:/nmod:for/} {lemma:/negative/}</pre>
# exclude XXX
{} <{} {lemma:/exclude/}</pre>
{} <{dependency:/advmod|dep|conj:or/} {lemma:/no/}
# XXX has resolved
{} <{dependency:/nsubj/} ({lemma:/resolve/}=key >{dependency:/aux/
} {})
# there is no XXX
{} <{dependency:/nsubj/} ({lemma:/be/} >{} {lemma:/no/})
# without evidence|finding of|for XXX
{} <{dependency:/nmod:of|nmod:for/} ({lemma:/evidence|finding/} <{
dependency:/nmod:without/} {})
# without development of XXX
{} < {dependency:/nmod:of/} ({lemma:/development/} > {} {lemma:/wi
thout/})
# No development of XXX
{} < {dependency:/nmod:of/} ({lemma:/development/} > {} {lemma:/no
/})
# no evidence of for XXX
{} <{dependency:/nmod:of|nmod:for/} ({lemma:/evidence/} >{dependen
cy:/neg/} {})
# without evidence | finding of | for XXX
{} <{dependency:/nmod:of|nmod:for/} ({lemma:/evidence|finding/} >{
} {lemma:/without/})
# no focus of XXX
{} <{dependency:/nmod:of/} ({lemma:/focus/} >{dependency:/neg/} {}
{} <{dependency:/nmod:of/} ({lemma:/focus/} >{} {lemma:/no/})
# no moderate to XXX
```

```
{} <{dependency:/nmod:to/} ({lemma:/moderate/} >{dependency:/neg/}
# no evidence of developing XXX
{} <{} ({lemma:/developing/} <{} ({lemma:/evidence/} <{dependency:
/nmod:without/} {}))
{} <{} ({lemma:/developing/} <{} ({lemma:/evidence/} >{} {lemma:/n
0/}))
# no focal XXX
{} <{dependency:/dobj/} ({} >{dependency:/nsubj/} {lemma:/no/})
# XXX is previously demonstrated/visualized
{} <{dependency:/dobj|nsubjpass/} ({lemma:/demonstrate|visualize/}
>{} {lemma:/previously/})
# there is no NN to suggest/explain XXX
\{\} < \{\} (\{lemma:/suggest|explain|diagnose/\} < \{\} (\{tag:/V.*/\} > \{\}\})
({tag:/N.*/} > {} {lemma:/no/}))
# no NN to suggest/explain XXX
\{\} < \{\} (\{lemma:/suggest|explain|diagnose/\} < \{\} (\{tag:/N.*/\} > \{\}\})
{lemma:/no/}))
# no area of XXX
{} < {dependency:/nmod:of/} ({lemma:/area/} > {dependency:/compoun
d/} {lemma:/no/})
# XXX is not enlarged
{} < {dependency:/nsubjpass/} ({lemma:/enlarge/} > {dependency:/ne
g/ {})
# without development of XXX
{} < {dependency:/nmod:of/} ({lemma:/development/} > {dependency:/
case/} {lemma:/without/})
# XXX removed
{} < {} {lemma:/remove/}
{} > {} {lemma:/remove/}
# XXX is no longer seen
\{\} < \{dependency:/nsubjpass/\} (\{lemma:/see/\} > \{\} (\{\} > \{dependency:/nsubjpass/\} \})
y:/neg/} {lemma:/no/}))
{} < {dependency:/nsubjpass/} ({lemma:/see/} > {} {lemma:/no/})
# without evidence seen for XXX
\{\} < \{\} (\{lemma:/see/\} > \{\} (\{lemma:/evidence/\} > \{\} \{lemma:/see/\} > \{\} \}
ma:/without/})))
\{\} < \{\} (\{lemma:/see/\} > \{\} (\{lemma:/evidence/\} > \{\} \{lemma:/withoutheapthalemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainlemainl
ut/}))
# normal/unremarkable appearance of XXX
{} < {} ({lemma:/appearance/} > {} {lemma:/normal|unremarkable/})
```

```
# normal/unremarkable XXX | XXX is/appears normal/unremarkable
# make more general
{} > {} {lemma:/normal|unremarkable/}
{} < {} {lemma:/normal|unremarkable/}</pre>
# XXX has/have cleared
# cleared XXX
{} < {} {lemma:/clear/}</pre>
{} > {} {lemma:/clear/}
# no obvious associated XXX
\{\} < \{\} (\{lemma:/associate.*/\} > \{\} (\{lemma:/obvious/\} > \{dependen \})
cy:/neg/} {}))
\{\} > \{dependency:/neg/\} \{\} \& > \{\} \{lemma:/obvious/\} \& > \{\} \{lemma:
/associate.*/}
# XXX with interval resolution
{} > {} ({lemma:/resolution/} > {} {lemma:/interval/})
# no XXX / general negative case
{} >{dependency:/neg/} {}
{} >{} {lemma:/no/}
{} >{dependency:/case/} {lemma:/without/}
```

Running this process for the entire dataset is very slow (~1.5 hr on a fast laptop!) so let's slice it to showcase how NegBio works. Let's start with 50 random observations.

```
In [14]: sampled_df = df.sample(50)
```

Also, let's recreate the code from the beginning of the notebook as a function, including the clean() function as well.

```
In [15]: def get_bioc_collection(df):
    collection = bioc.BioCCollection()
    splitter = NegBioSSplitter()
    for i, report in enumerate(df["Report Impression"]):
        document = text2bioc.text2document(str(i), clean(report))
        document = splitter.split_doc(document)
        collection.add_document(document)
    return collection
```

Here, you'll repeat your process from earlier by converting the report impression strings into a BioC XML format which NegBio can read.

```
In [16]: collection = get_bioc_collection(sampled_df)
```

Now let's instantiate NegBio 's lemmatizer.

The process of lemmatization refers to returning the dictionary form of a word (or lemma) by removing inflectional endings. It's very cool and you can read more about it <a href="https://nlp.stanford.edu/IR-book/html/htmledition/stemming-and-lemmatization-1.html">https://nlp.stanford.edu/IR-book/html/htmledition/stemming-and-lemmatization-1.html</a>).

```
In [17]: lemmatizer = Lemmatizer()
```

Next you'll instantiate NegBio 's converter to convert from parse tree to universal dependencies. This is done using the Stanford converter, which you can find more information about <a href="https://github.com/dmcc/PyStanfordDependencies">https://github.com/dmcc/PyStanfordDependencies</a>).

The parse tree used here is the <u>Penn Treebank (https://catalog.ldc.upenn.edu/docs/LDC95T7/cl93.html)</u>. In general terms, a treebank is an annotated text corpus that includes analysis beyond part-of-speech tagging. They've become very valuable resources to NLP research in recent years.

Universal dependencies, or UD, provide a powerful framework for annotating grammar across different languages. Read more about them <a href="https://universaldependencies.org/">https://universaldependencies.org/</a>).

```
In [18]: ptb2dep = NegBioPtb2DepConverter(lemmatizer, universal=True)
```

You've already seen the splitter in action before, so you can skip it.

```
In [19]: ssplitter = NegBioSSplitter(newline=True)
```

Now you'll instantiate the parser and the loader.

Under the hood, you're using the <u>BLIPP reranking parser (https://github.com/BLLIP/bllip-parser)</u>, which is a statistical natural language parser.

The loader, as you might imagine, loads the reports into memory.

Over all of this, the <u>chexpert-labeler (https://github.com/stanfordmlgroup/chexpert-labeler)</u> is used. This labeler extracts observations from radiology reports specifically, and can provide a vocabulary appropriate to the clinical context.

```
In [20]: parser = NegBioParser(model_dir=PARSING_MODEL_DIR)
    loader = NegBioLoader()
```

The extractor is what extracts the observations from the report impressions.

```
In [21]: extractor = NegBioExtractor(Path(MENTION_PATH), Path(UNMENTION_PATH
))
```

The negator will determine whether negation or uncertainty exists in the context of the observations provided by the extractor.

```
In [22]: neg_detector = ModifiedDetector(PRE_NEG_PATH, NEG_PATH, POST_NEG_PA
TH)
```

The aggregator then aggregates these observations if they belong to the same category.

```
In [23]: aggregator = NegBioAggregator(CATEGORIES)
```

## Putting it all together

Finally, you'll put everything together using the pipeline function, which takes as arguments all of the objects you've instantiated so far. Then you'll get a nice, clean DataFrame with your result:

In [26]: negbio\_pred.head()

Out[26]:

	Edema	Lung Lesion	Pleural Effusion	Pneumothorax	Pneumonia	Consolidation	Airspace Opacity	Atelectas
0	True	True	True	True	False	False	False	Fal
1	False	False	False	False	True	False	False	Fal:
2	False	False	False	False	True	True	False	Fal
3	False	False	False	True	False	False	True	Fal
4	False	False	False	False	False	True	False	Fal

Now you can check every entry in the report impressions for the presence of a condition, while knowing that negation has been taken into account. Really cool!

Congratulations on finishing this notebook!!! This was a very high-level explanation of everything that NegBio does and as you may have noticed, this library leverages many other great tools and libraries. Hopefully, it was a good introduction to how it works. Nice work, keep it up!