

# Scientific Text Mining and Knowledge Graphs

## Chapter 2

### Part 2: Knowledge Graph Learning

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[mjiang2@nd.edu](mailto:mjiang2@nd.edu)

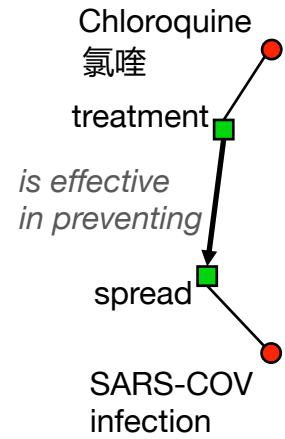
# Roadmap

- Scientific KGs of COVID-19 literature
- Learning scientific KG for literature search
- Learning scientific KG for text generation

# Roadmap

- **Scientific KGs of COVID-19 literature**
- Learning scientific KG for literature search
- Learning scientific KG for text generation

# Motivating Examples

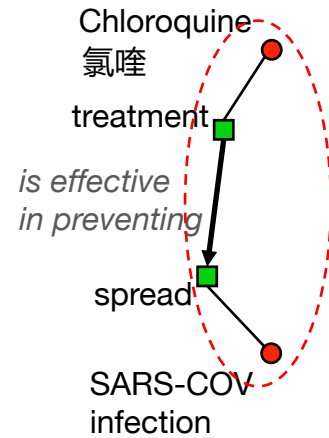


Vincent et al. 2005. Chloroquine is a potent inhibitor of SARS coronavirus infection and spread. *Virology Journal*.

● SARS-COV-2



# Motivating Examples (cont'd)



● SARS-COV-2

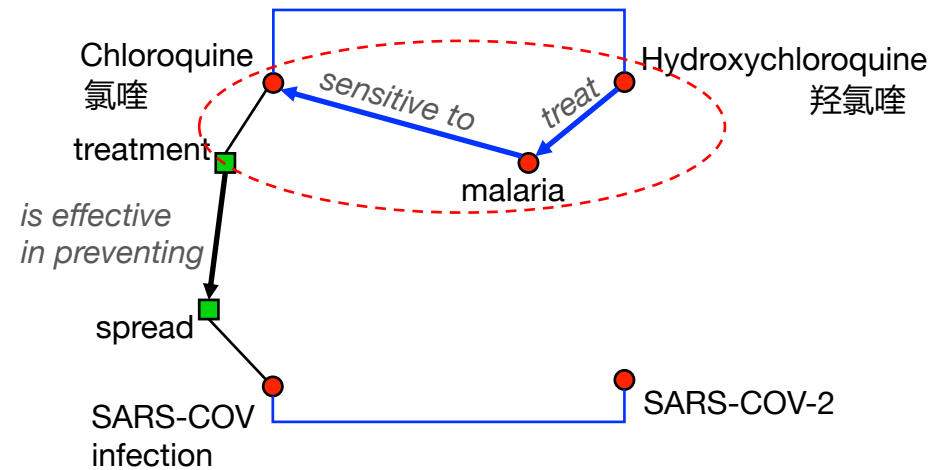
Vincent et al. 2005. Chloroquine is a potent inhibitor of SARS coronavirus infection and spread. *Virology Journal*.

“... The Chloroquine treatment is effective in preventing the spread of SARS-COV infection. ...”

↓ [1]

Quintuple: ( {Chloroquine ::: treatment},  
*is\_effective\_in\_preventing*,  
{SARS-COV\_infection ::: spread} )

# Motivating Examples (cont'd)



Vincent et al. 2005. Chloroquine is a potent inhibitor of SARS coronavirus infection and spread. Virology Journal.

[The Coronavirus Infectious Disease Ontology \(CIDO\)](#). The OBO Foundry, Ontobee, and NCBO.

“... Hydroxychloroquine is a medication used to treat malaria in areas where malaria remains sensitive to chloroquine. ...”

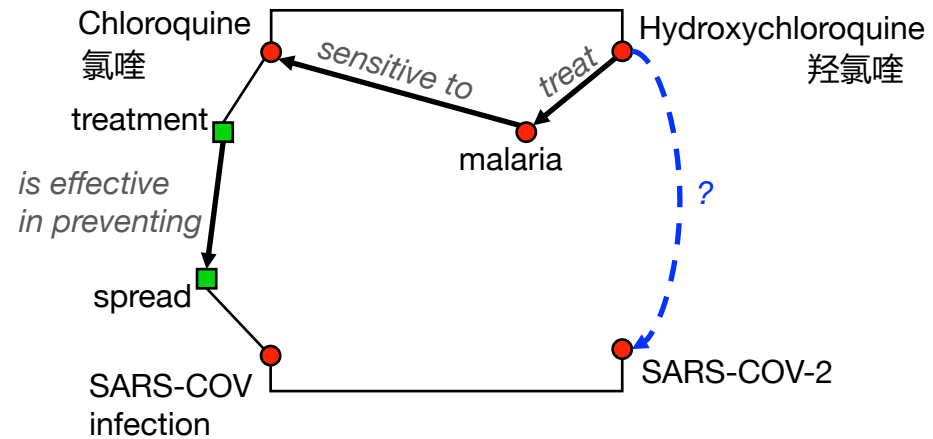
[Wiki]

↓ [1]

Tuples: (Hydroxychloroquine, *treat*, malaria)  
(malaria, *remains\_sensitive\_to*, chloroquine)

[1] Jiang et al. 2019. The Role of “Condition”: A Novel Scientific Knowledge Graph Representation and Construction Model. SIGKDD.

# Motivating Examples (cont'd)

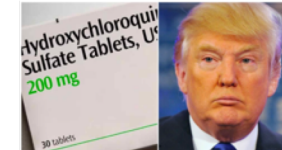


Vincent et al. 2005. Chloroquine is a potent inhibitor of SARS coronavirus infection and spread. Virology Journal.

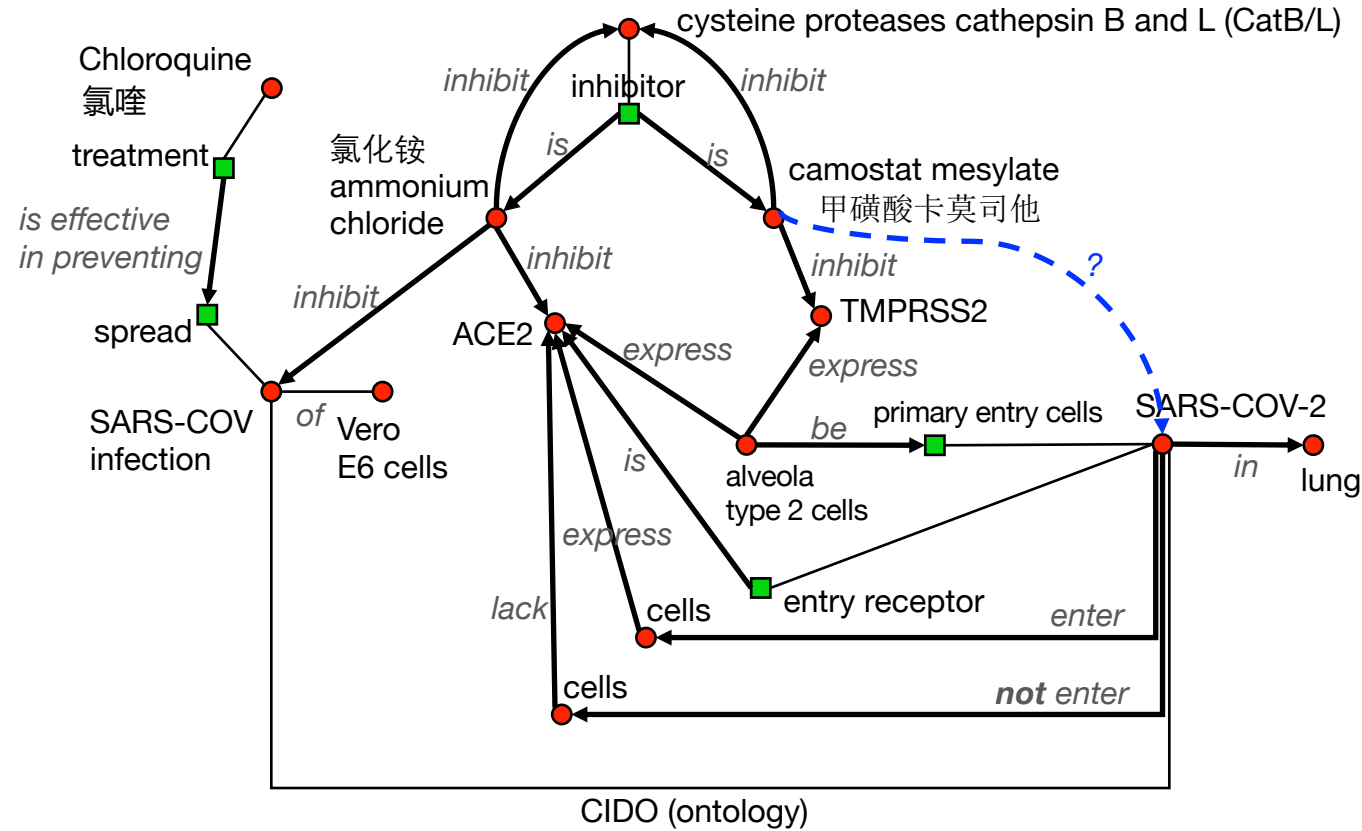
The Coronavirus Infectious Disease Ontology (CIDO). The OBO Foundry, Ontobee, and NCBO.

[FDA Warns Against Using Drugs Promoted By Trump After Reports Of 'Poisoning And Death'](#) [Forbes 04/24/2020]

<https://www.forbes.com/sites/carlieporterfield/2020/04/24/fda-warns-against-using-drugs-promoted-by-trump-after-reports-of-poisoning-and-death>



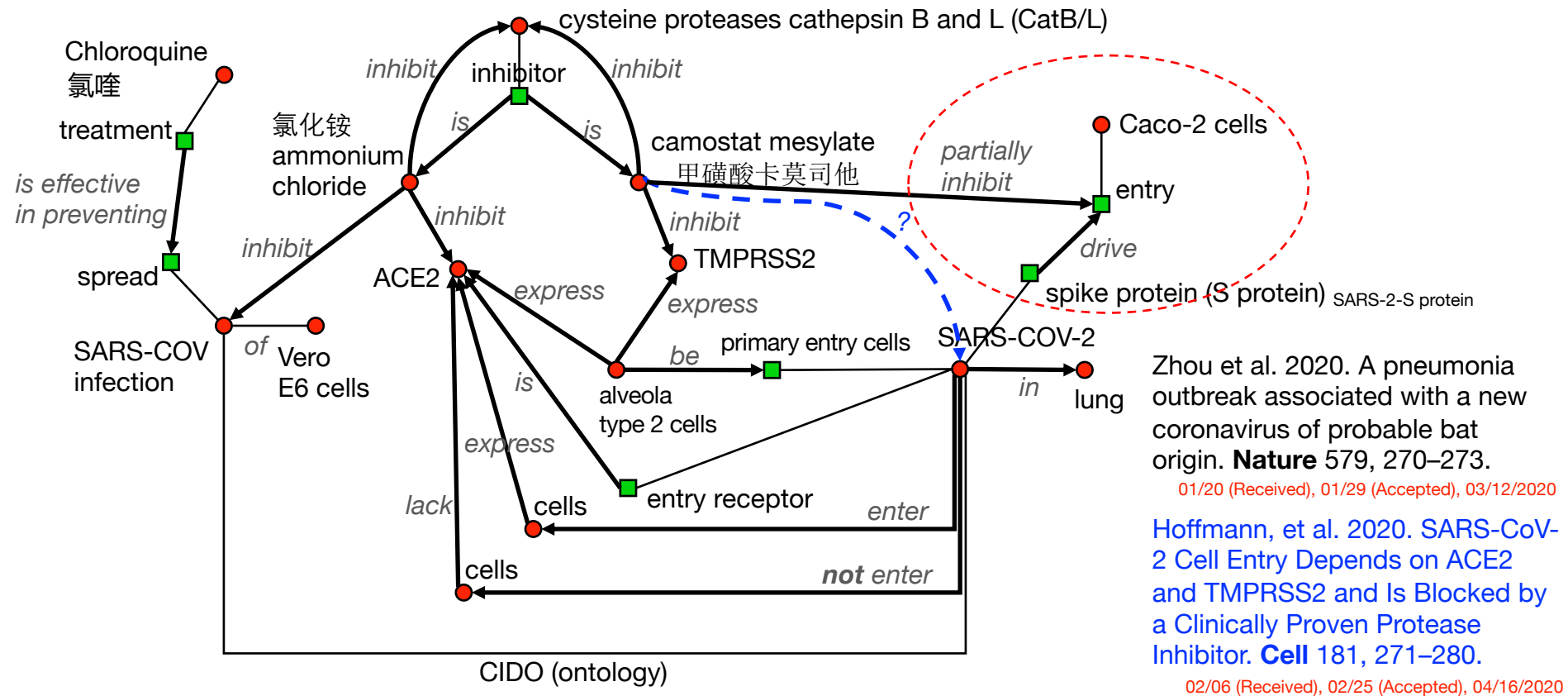
# Motivating Examples (cont'd)



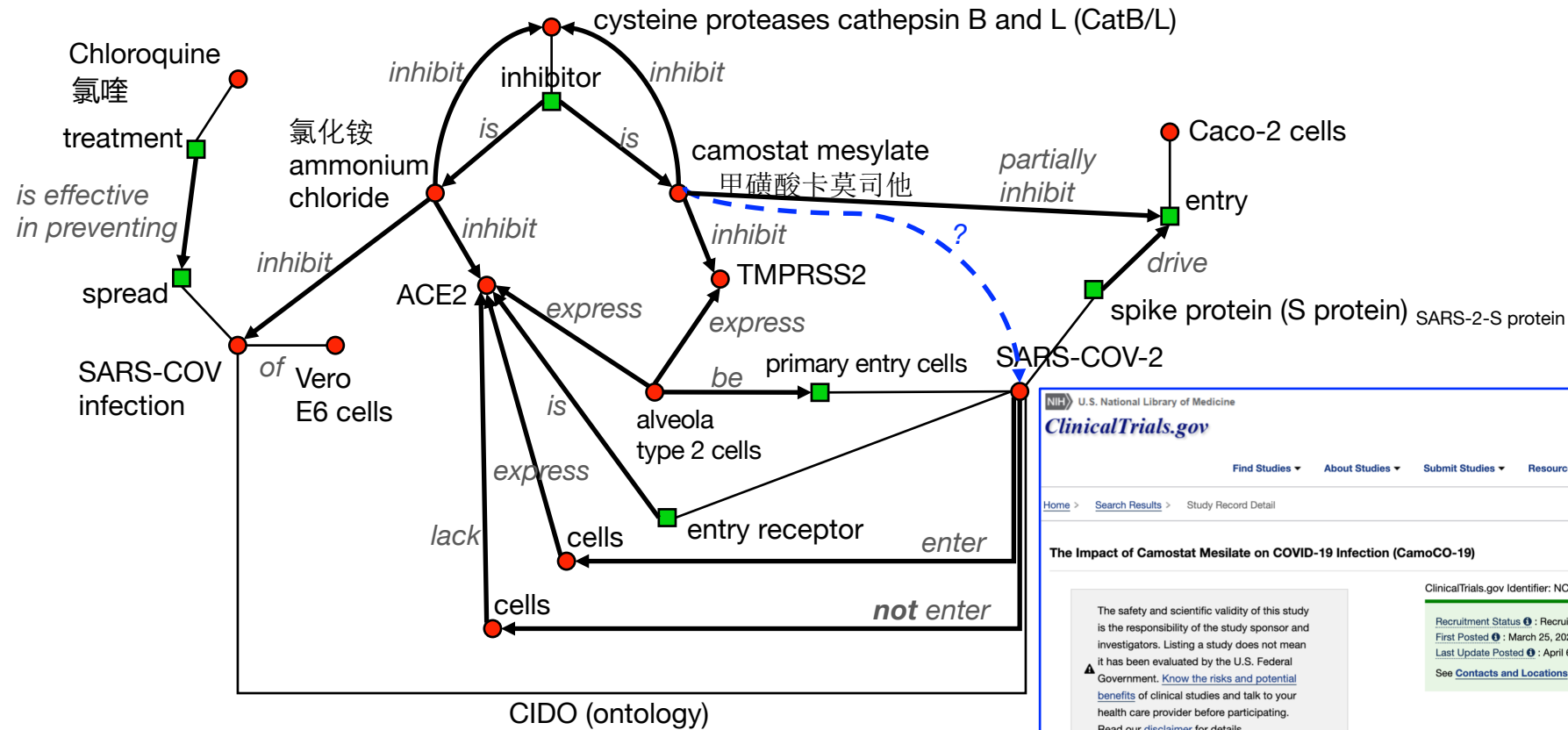
Zhou et al. 2020. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature* 579, 270–273.


01/20 (Received), 01/29 (Accepted), 03/12/2020

# Motivating Examples (cont'd)



# Motivating Examples (cont'd)




U.S. National Library of Medicine

[ClinicalTrials.gov](#)

[Find Studies](#)
[About Studies](#)
[Submit Studies](#)
[Resources](#)
[About Site](#)

[Home](#) > [Search Results](#) > Study Record Detail
 ☐ Save this study

### The Impact of Camostat Mesilate on COVID-19 Infection (CamoCO-19)

The safety and scientific validity of this study is the responsibility of the study sponsor and investigators. Listing a study does not mean it has been evaluated by the U.S. Federal Government. [Know the risks and potential benefits](#) of clinical studies and talk to your health care provider before participating. Read our [disclaimer](#) for details.

ClinicalTrials.gov Identifier: NCT04321096

[Recruitment Status](#) : Recruiting  
[First Posted](#) : March 25, 2020  
[Last Update Posted](#) : April 6, 2020  
[See Contacts and Locations](#)

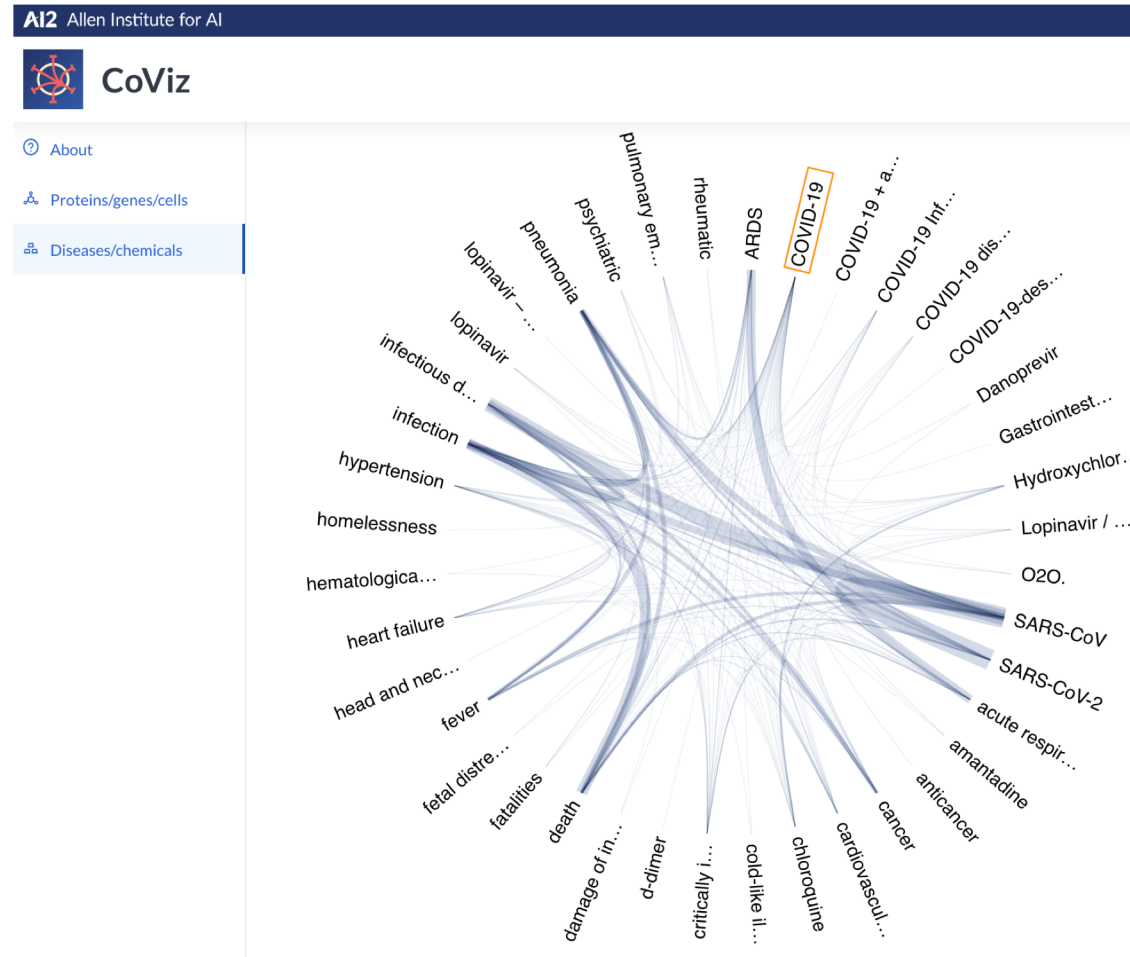
**Sponsor:**

University of Aarhus


**Information provided by (Responsible Party):**

University of Aarhus


# Knowledge Graph 1: CoViz by AI2



# Knowledge Graph 2: SPIKE-CORD



## AI2 Allen Institute for AI



## SPIKE-CORD: Extractive Search over CORD-19

Type

Query

S

<>v:virus \$infection \$causes a <>c:condition .

kv<v> (anything)

compound

word=infection

nsubj

word=causes

dobj

<c> (anything)

virus

infection

causes

condition

Chapter 25 Hematology and Immune-Related Disorders

Because

M. haemofelis infection

v

occasionally causes

thrombocytopenia

c

, PCR testing for hemoplasmosis is suggested .

Annexin A2 on lung epithelial cell surface is recognized by severe acute respiratory syndrome-associated coronavirus

Severe acute respiratory syndrome-associated coronavirus ( SARS-CoV ) Annexin A2 Autoantigen Anti-spike domain 2 ( S2 )

a c t Severe acute respiratory syndrome-associated coronavirus ( SARS-CoV ) infection

v

causes

lung failure

c

characterized

22412

31726

# NER

COVID-19  
AMINO\_ACID  
ANATOMICAL\_SYSTEM  
CANCER  
CELLULAR\_COMPONENT  
CELL\_LINE  
CELL\_TYPE  
CHEBI  
CHEMICAL  
CL  
COVID-19  
DEVELOPING\_ANATOMICAL\_STRUCTURE  
DISEASE  
DNA  
ENTITY  
GENE\_OR\_GENE\_PRODUCT  
GGP  
GO  
IMMATERIAL\_ANATOMICAL\_ENTITY  
MULTI-TISSUE\_STRUCTURE  
ORGAN  
ORGANISM  
ORGANISM\_SUBDIVISION  
ORGANISM\_SUBSTANCE  
PATHOLOGICAL\_FORMATION  
PROTEIN  
RNA  
SIMPLE\_CHEMICAL  
SO  
TAXON  
TISSUE

## Relation

- \$causes
- \$treats
- \$uses

based on **SciSpacy**: SpaCy models for biomedical text processing

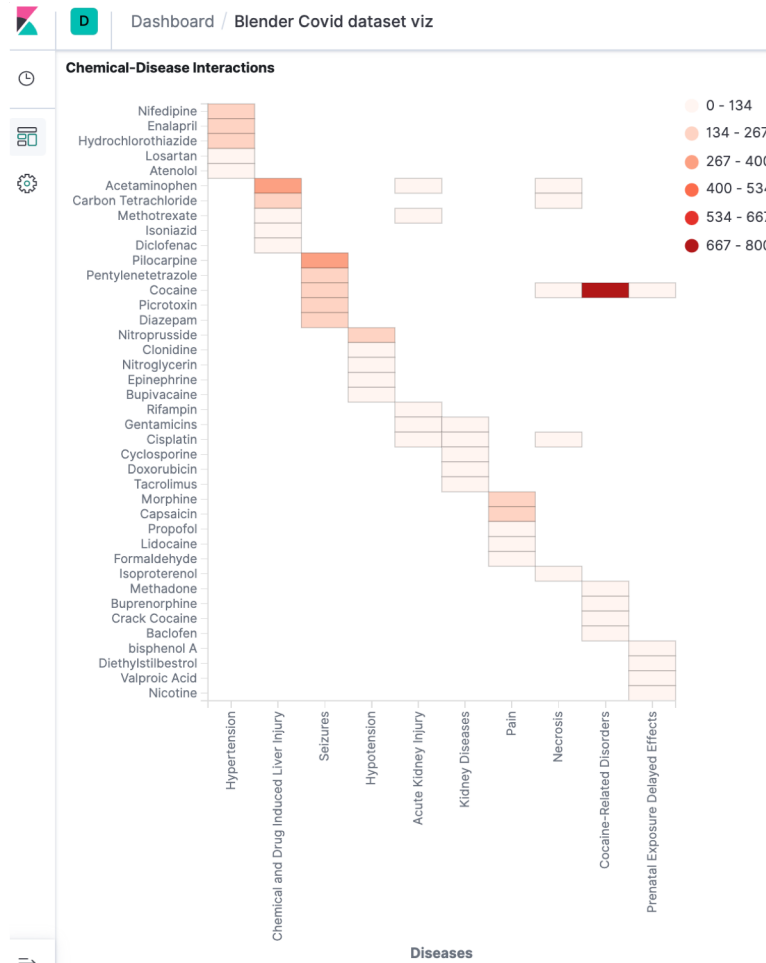
<https://allenai.github.io/scispaCy/>

<https://spike.covid-19.apps.allenai.org/search/covid19>

<https://spike.covid-19.apps.allenai.org/md/covid-usage-examples>



# Knowledge Graph 3: Blender Covid + SemViz@Brendeis



Chemical Word Cloud

Cyclosporine sodium arsenite  
Ethynyl Estradiol Dexamethasone  
pirinixic acid Estradiol Aflatoxin B1  
Cisplatin Benzo(a)pyrene  
**bisphenol A**  
**Valproic Acid**  
Resveratrol dorsomorphin Ethanol  
Acetaminophen Doxorubicin  
Lipopolysaccharides



Chemicals - Count

<http://blender.cs.illinois.edu/covid19/?fbclid=IwAR2z0BcjDWScjuilCaWQD-YrdZvtIGGQh3LNjvDi4JzzwU6G1K9HD4owYWE>

<https://www.semviz.org/>

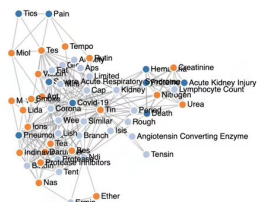
# Knowledge Graph 4: Weill Cornell

## COVID-19 Literature Search Engine

Query

Popular question...

SubmitReset



Relevant Articles

**Abstract:** Background: Computed tomography (CT) is the preferred imaging method for di...  
**Authors:** Jun Chen; Li...  
2020-02-26

**A serological assay to detect SARS-CoV-2 seroconversion in humans**  
**Abstract:** Introduction: SARS-CoV-2 (severe acute respiratory disease coronavirus 2), whic...  
**Authors:** Fatima Ama...  
2020-03-18

**A mathematical model for the spatiotemporal epidemic spreading of COVID19**  
**Abstract:** An outbreak of a novel coronavirus, named SARS-CoV-2, that provokes the COV...  
**Authors:** Alex Arenas;...  
2020-03-23

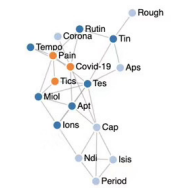
**ACE-2 Expression in the Small Airway Epithelia of Smokers and COPD Patients: Implications for COVID-19**  
**Abstract:** Introduction: Coronavirus disease 2019 (COVID-19) is a respiratory infection cau...  
**Authors:** Janice M Le...  
2020-03-23

**The Effectiveness of Social Distancing in Mitigating COVID-19 Spread: a modeli**  
**Abstract:** Background The novel coronavirus COVID19 has been classified by the World H...  
**Authors:** George J Mil...  
2020-03-23

Copyright © Wang's Lab at Weill Cornell Medicine. Developer: Sendong Zhao, Yu Hou and Fei Wang

## COVID-19 Literature Search Engine

Pointed  
Lethal



### A mathematical model for the spatiotemporal epidemic spreading of COVID19

2020-03-23

Alex Arenas; Wesley Cota; Jesus Gomez-Gardenes; Sergio Gómez; Clara Granell; Joan T. Matamalas; David Soriano-Panos; Benjamin Steinegger

**Abstract:** An outbreak of a novel coronavirus, named SARS-CoV-2, that provokes the COVID-19 disease, was first reported in Hubei, mainland China on 31 December 2019. As of 20 March 2020, cases have been reported in 166 countries/regions, including cases of human-to-human transmission around the world. The proportions of this epidemics is probably one of the largest challenges faced by our interconnected modern societies. According to the current epidemiological reports, the large basic reproduction number,  $R_0 \sim 2.3$ , number of secondary cases produced by an infected individual in a population of susceptible individuals, as well as an asymptomatic period (up to 14 days) in which infectious individuals are undetectable without further analysis, pave the way for a major crisis of the national health capacity systems. Recent scientific reports have pointed out that the detected cases of COVID19 at young ages is strikingly short and that lethality is concentrated at large ages. Here we adapt a Microscopic Markov Chain Approach (MMCA) metapopulation mobility model to capture the spread of COVID-19. We propose a model that stratifies the population by ages, and account for the different incidences of the disease at each strata. The model is used to predict the incidence of the epidemics in a spatial population through time, permitting investigation of control measures. The model is applied to the current epidemic in Spain, using the estimates of the epidemiological parameters and the mobility and demographic census data of the national institute of statistics (INE). The results indicate that the peak of incidence will happen in the first half of April 2020 in absence of mobility restrictions. These results can be refined with improved estimates of epidemiological parameters, and can be adapted to precise mobility restrictions at the level of municipalities. The current estimates largely compromises the Spanish health capacity system, in particular that for intensive care units, from the end of March. However, the model allows for the scrutiny of containment measures that can be used for health authorities to forecast with accuracy their impact in prevalence of COVID-19. Here we show by testing different epidemic containment scenarios that we urge to enforce total lockdown to avoid a massive collapse of the Spanish national health system.

# Recommended Principles

- **P1: Relation-schema free:** Open-domain IE with domain-specific pre-training?
- **P2: Attribute-aware:** Quintuple: ({Esubj::<sub>A</sub>subj}, R, {Eobj::<sub>A</sub>obj})
  - Entities and noun phrases (attributes, etc.) and verbal phrases (relation), etc.
- **P3: Multi-tuple:** One sentence can make multiple associated tuples
- **P4: Graph-oriented:** Discovering knowledge by link/path prediction

*“We showed that extracellular acidic pH reduces the activity of TRPV5/V6 channels, whereas alkaline pH increases the activity of TRPV5/V6 channels in Jurkat T cells.”*

Fact tuple 1: (extracellular acidic pH, reduces, {TRPV5/V6 channels: activity})

Fact tuple 2: (alkaline pH, increases, {TRPV5/V6 channels: activity})

Condition tuple: (TRPV5/V6 channels, in, Jurkat T cells)

# Roadmap

- Scientific KGs of COVID-19 literature
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# Three-Layered Scientific KG

**stmt6:** *We showed that extracellular acidic pH reduces the activity of TRPV5/V6 channels, whereas alkaline pH increases the activity of TRPV5/V6 channels in Jurkat T cells.*

**fact 1:** ( extracellular\_acidic\_pH, reduces, {TRPV5/V6\_channels: activity} )

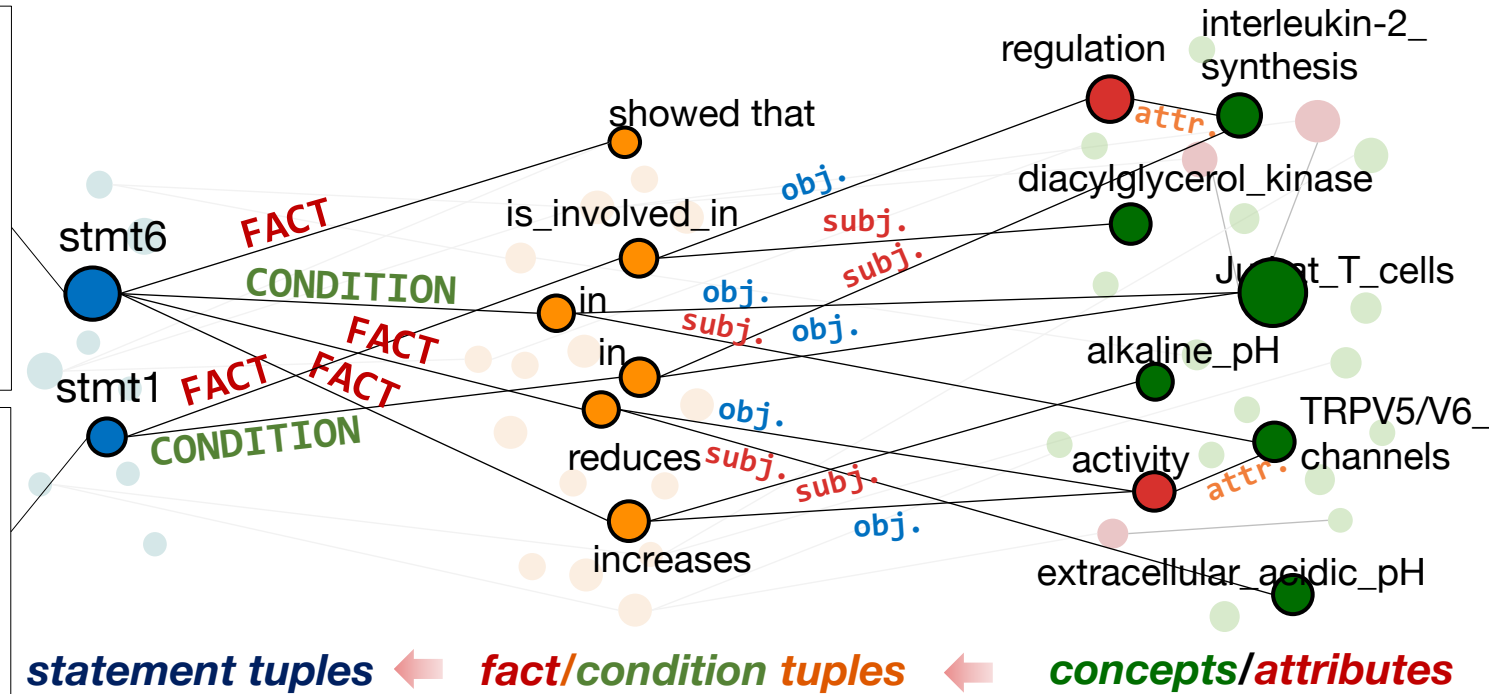
**fact 2:** (alkaline\_pH, increases, {TRPV5/V6\_channels: activity})

**condition 1:** ( TRPV5/V6\_channels, in, Jurkat\_T\_cells )

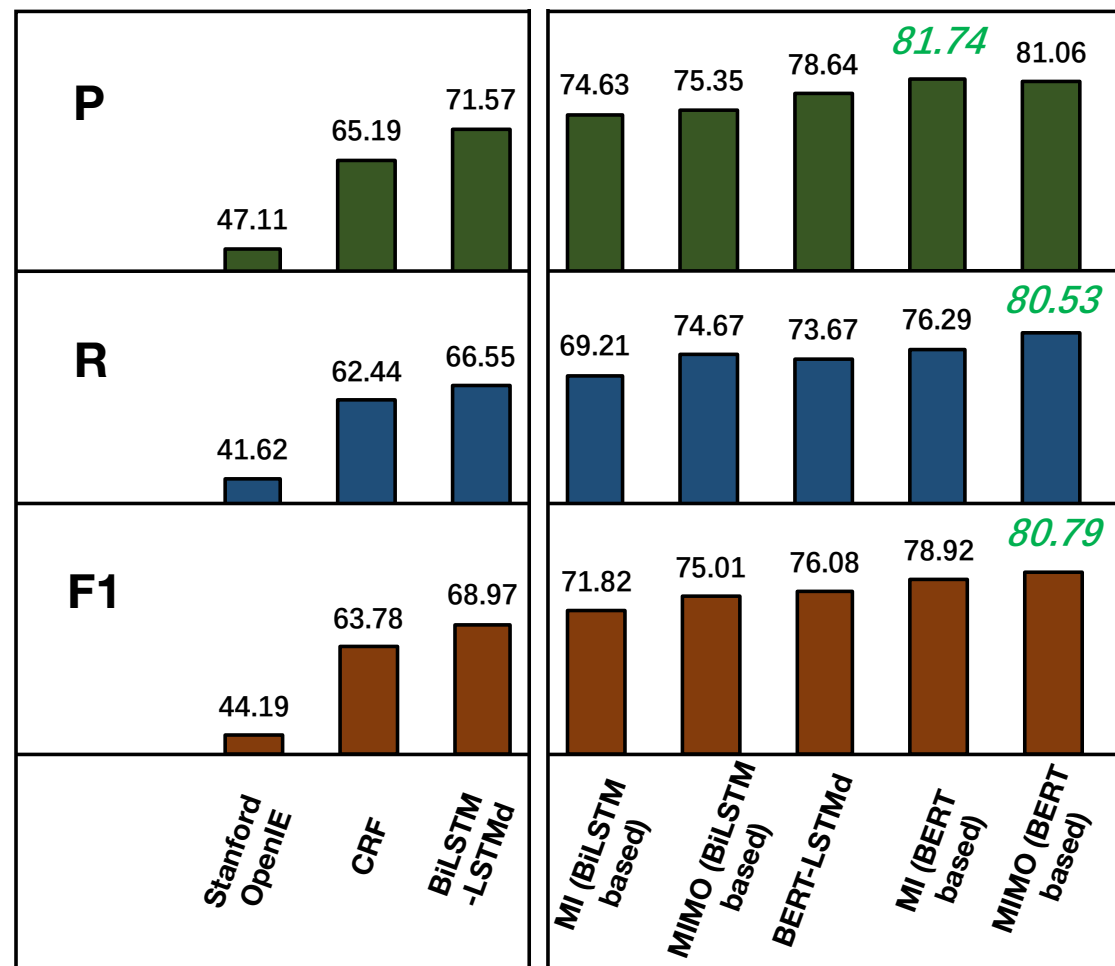
**stmt1:** *A diacylglycerol kinase is involved in the regulation of interleukin-2 synthesis in Jurkat T cells.*

**fact 1:** ( diacylglycerol\_kinase, is\_involved\_in, {interleukin-2\_synthesis: regulation} )

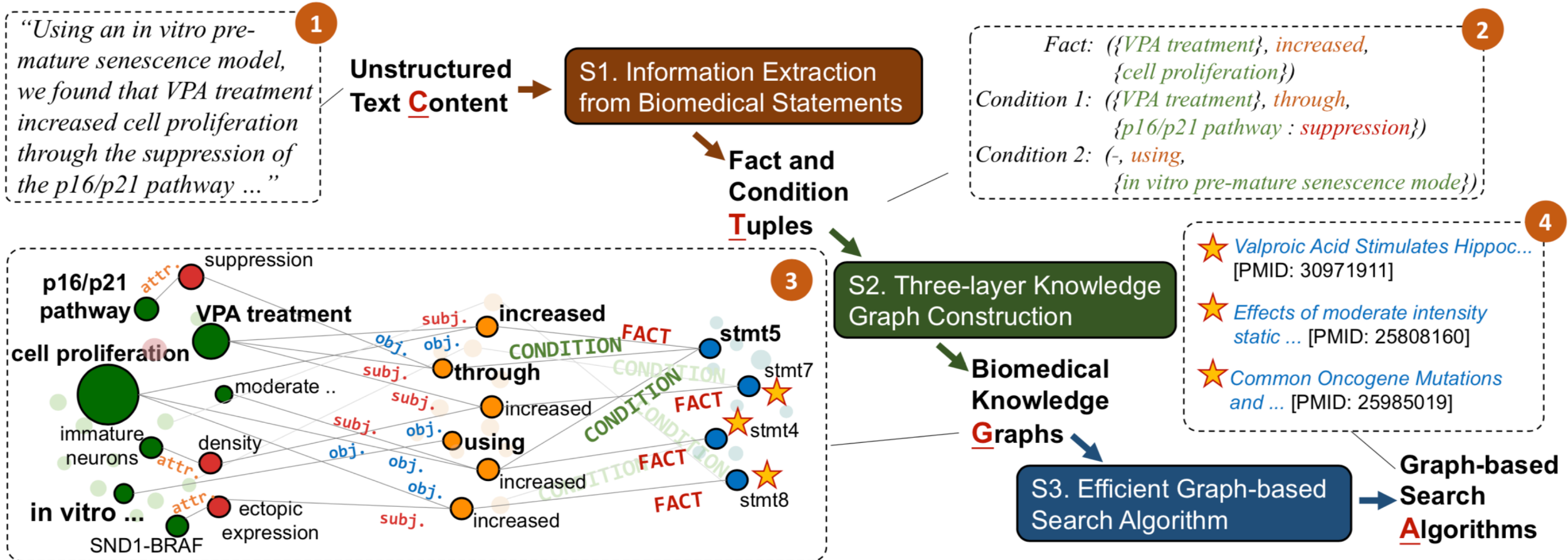
**condition 1:** ( interleukin-2\_synthesis, in, Jurkat\_T\_cells )



# MIMO: An Information Extraction Model



# Novel Framework: CTGA



- Search and knowledge discovery
- Prediction and inference

- Hypothesis generation
- Hypothesis validation



# A Demonstration System

http://www.biokgs.com

## CTGA v1.0: Graph-based Biomedical Literature Search

Using an in vitro pre-mature senescence model, we found that VPA treatment increased cell proliferation through the suppression of the p16/p21 pathway.

Search

**Example**  
**Statement:** *Smoking increases the risk of lung cancer.*  
*green:* concepts    *orange:* relations    *red:* attributes

| subject                                  | relation | object | subject                                  | relation | object   | subject                                      | relation | object   |
|--|----------|--------|--|----------|----------|--|----------|----------|
| <input checked="" type="checkbox"/> same | same     | same   | <input checked="" type="checkbox"/> same | same     | -        | <input checked="" type="checkbox"/> -        | same     | same     |
| <input checked="" type="checkbox"/> same | -        | same   | <input checked="" type="checkbox"/> same | relevant | -        | <input checked="" type="checkbox"/> relevant | relevant | -        |
| <input checked="" type="checkbox"/> -    | relevant | same   | <input checked="" type="checkbox"/> -    | relevant | relevant | <input checked="" type="checkbox"/> -        | relevant | relevant |

Cancel All

Histone deacetylase inhibitor valproic acid promotes the induction of pluripotency in mouse fibroblasts by suppressing reprogramming-induced senescence stress. **SciKG**

**Comparison**  
<https://www.ncbi.nlm.nih.gov/pubmed/?term=26112217> [Show Original Tuples](#)  
■ (vpa treatment, increased, cell proliferation)

Valproic Acid Stimulates Hippocampal Neurogenesis via Activating the Wnt/β-Catenin Signaling Pathway in the APP/PS1/Nestin-GFP Triple Transgenic Mouse Model of Alzheimer's Disease. **SciKG** **Comparison**

<https://www.ncbi.nlm.nih.gov/pubmed/?term=30971911> [Show Original Tuples](#)  
■ (vpa treatment, promoted, cell proliferation)

Effects of moderate intensity static magnetic fields on human bone marrow-derived mesenchymal stem cells. **SciKG** **Comparison**

<https://www.ncbi.nlm.nih.gov/pubmed/?term=25808160> [Show Original Tuples](#)  
■ (moderate intensity smfs, increased, cell proliferation)

Estradiol and GPER Activation Differentially Affect Cell Proliferation but Not GPER Expression in the Hippocampus of Adult Female Rats. **SciKG** **Comparison**

<https://www.ncbi.nlm.nih.gov/pubmed/?term=26075609> [Show Original Tuples](#)  
● ({gper: activation}, decreased, cell proliferation)

**Statement Tagging**  
**Stmt 1:** *Using an in vitro pre-mature senescence model, we found that VPA treatment increased cell proliferation through the suppression of the p16/p21 pathway.*

**Selected Facts from Input Text**  
**Fact 1:** (vpa treatment, increased, cell proliferation)  
[Condition](#)

**Concept Mapping**  
**cell proliferation**  
**mapping:** GO\_0008283 | NCIT\_C18081 | OMIT\_0024131  
**hypernyms:** biological\_process | cell function | cell growth processes | cell process | cellular function | cellular process | single organism process | single-organism process  
**relevant concepts:** cell aggregation | cell killing | ...

1

2

3



# Case Study

## Query

VPA treatment increased cell proliferation.

## CTGA

1. Using an in vitro pre-mature senescence model , we found that **VPA treatment increased cell proliferation** and inhibited apoptosis through the suppression of the p16/p21 pathway.  
(Knowledge: {**VPA treatment**, **increase**, **cell proliferation**}, {**VPA treatment**, **inhibit**, **apoptosis**})
2. **VPA treatment** promoted **cell proliferation** and **increased** the density of immature neurons in the dentate gyrus (DG) of the hippocampus of 3xTgAD mice.  
(Knowledge: {**VPA treatment**, **promote**, **cell proliferation**}, {**VPA treatment**, **increase**, **density of immature neurons**})
3. **VPA treatment increased** cathepsin B levels and activities in primary CLL **cells**.  
(Knowledge: {**VPA treatment**, **increase**, **cathepsin B level**})
4. Moderate intensity SMFs **increased cell proliferation**, ALP activity, and calcium release.  
(Knowledge: {**Moderate intensity SMF**, **increase**, **cell proliferation**})
5. Ectopic expression of SND1-BRAF in H1299 **cells increased** phosphorylation levels of MEK/ERK , **cell proliferation** , and spheroid formation  
(Knowledge: {**Ectopic expression of SND1-BRAF**, **increase**, **cell proliferation**})

## PubMed

1. These results suggest that **VPA increased** type-1 stem **cells** in relation to the activation of SCF-KIT signaling and suppression of BTG2-mediated antiproliferative effect on stem **cells**.
2. Prostate cancer **cells** , sensitive and resistant to temsirolimus , were exposed to **VPA** , and tumor **cell** growth behavior compared.
3. **VPA treatment** promoted **cell proliferation** and **increased** the density of immature neurons in the dentate gyrus (DG) of the hippocampus of 3xTgAD mice.
4. **Cell proliferation** had **increased** to control levels at 30 and 45 d, demonstrating that memory recovery occurs over a period of six weeks after discontinuing **VPA treatment**.
5. To compare the protective effects of suberoylanilide hydroxamic acid (SAHA) and **valproic acid (VPA)** on human lens epithelial **cells** (HLECs) following ultraviolet-B exposure. 21

# Results

| Search Engines          | BLEU-1       | BLEU-2       | BLEU-3       | BLEU-4       | ROUGE-L      | SkipThought  | Aver.Embedding | Top@5      | Top@1      | MRR         |
|-------------------------|--------------|--------------|--------------|--------------|--------------|--------------|----------------|------------|------------|-------------|
| <b>PubMed-FullText</b>  | 17.22        | 7.01         | 4.43         | 3.37         | 16.34        | 75.56        | 68.54          | 88%        | 77%        | 81.5        |
| <b>CTGA-FullText</b>    | <b>17.61</b> | <b>7.73</b>  | <b>5.07</b>  | <b>3.90</b>  | <b>17.03</b> | <b>75.91</b> | <b>68.77</b>   | <b>93%</b> | <b>92%</b> | <b>92.3</b> |
| <i>Improvement</i>      | 2.3%↑        | 10.3%↑       | 14.4%↑       | 15.7%↑       | 4.2%↑        | 0.5%↑        | 0.3%↑          | 5.7%↑      | 19.5%↑     | 13.3%↑      |
| <b>PubMed-BestMatch</b> | 28.84        | 21.46        | 18.42        | 16.71        | 34.91        | 80.31        | 81.92          | -          | -          | -           |
| <b>CTGA-BestMatch</b>   | <b>32.60</b> | <b>24.67</b> | <b>21.06</b> | <b>18.84</b> | <b>38.26</b> | <b>81.77</b> | <b>82.80</b>   | -          | -          | -           |
| <i>Improvement</i>      | 13.0%↑       | 15.0%↑       | 14.3%↑       | 12.7%↑       | 9.6%↑        | 1.8%↑        | 1.1%↑          | -          | -          | -           |

| Search Engines | Rate@1      | Rate@3      | Rate@5      | Preference% | Kendall-Tau  | SF-Dist     | RBO          | DCG          | NDCG         |
|----------------|-------------|-------------|-------------|-------------|--------------|-------------|--------------|--------------|--------------|
| <b>PubMed</b>  | 4.60        | 3.43        | 2.92        | 34%         | 68.95        | 10.14       | 87.18        | 9.61         | 96.63        |
| <b>CTGA</b>    | <b>4.83</b> | <b>3.69</b> | <b>3.31</b> | <b>66%</b>  | <b>76.15</b> | <b>8.34</b> | <b>89.31</b> | <b>10.60</b> | <b>99.25</b> |

# Roadmap

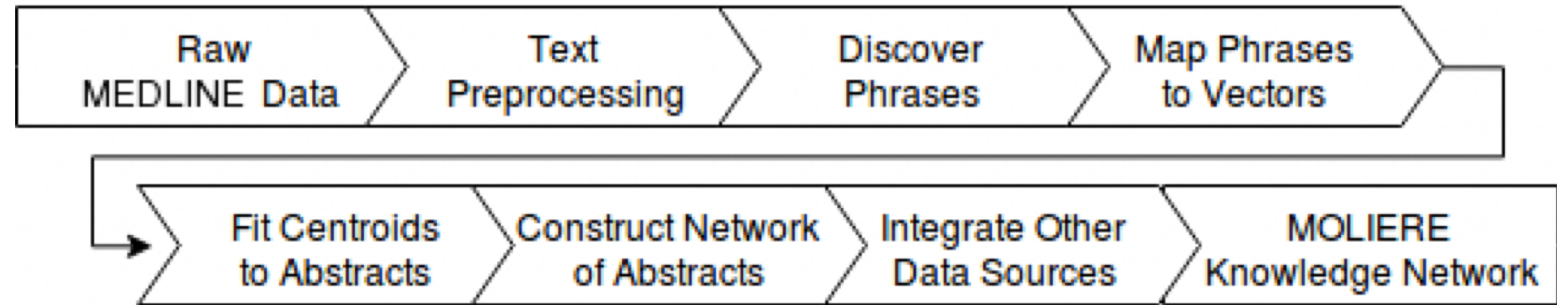
- Scientific KGs of COVID-19 literature
- Learning scientific KG for literature search
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# Three Interesting Works

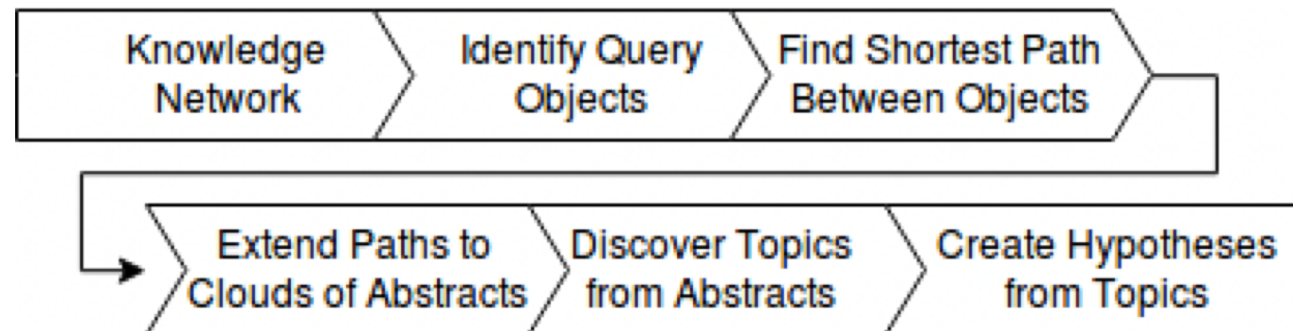
- MOLIERE: Automatic Biomedical Hypothesis Generation System (KDD'17)
- PaperRobot: Incremental Draft Generation of Scientific Ideas (ACL'19)
- Text Generation from Knowledge Graphs with Graph Transformers (NAACL'19)

# MOLIERE: Automatic Biomedical Hypothesis Generation System (KDD'17)

Network construction:



Query processing:

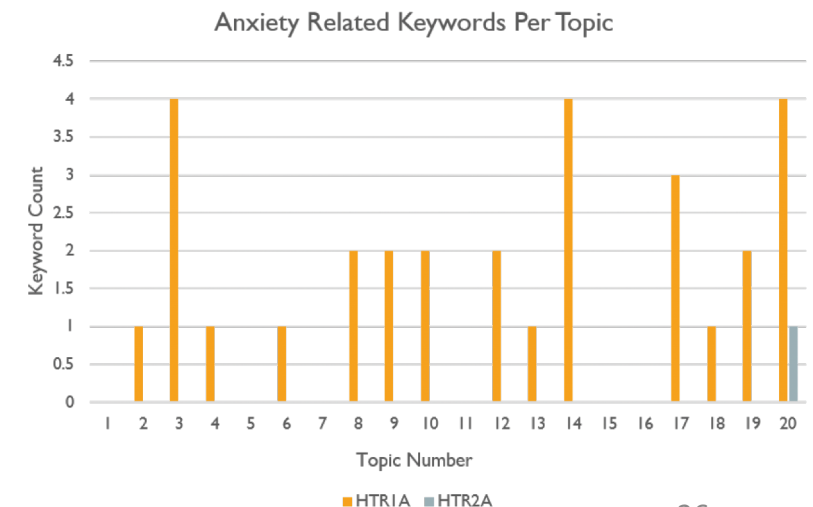
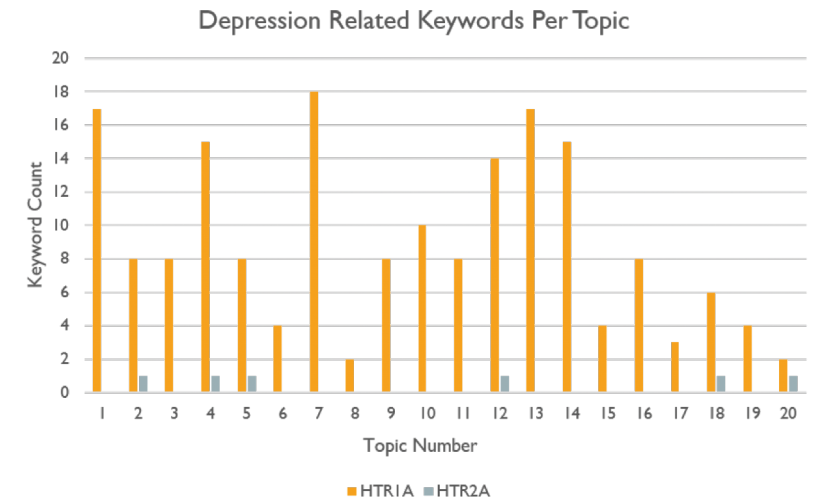


# Results

As a result of running two queries, Venlafaxine to HTR1A, and Venlafaxine to HTR2A, we can corroborate the findings of Wang et al. in [49]. We find that neither pair of keywords is directly connected or connected through a single abstract. Nevertheless, **phrases such as “long term antidepressant treatment,” “action antidepressants,” and “antidepressant drugs” are all prominent keywords in the HTR1A query.** Meanwhile, the string “depress” only occurs four times in unrelated phrases with the HTR2A results. The distribution of depression related keywords from both queries can be seen in figure 5.

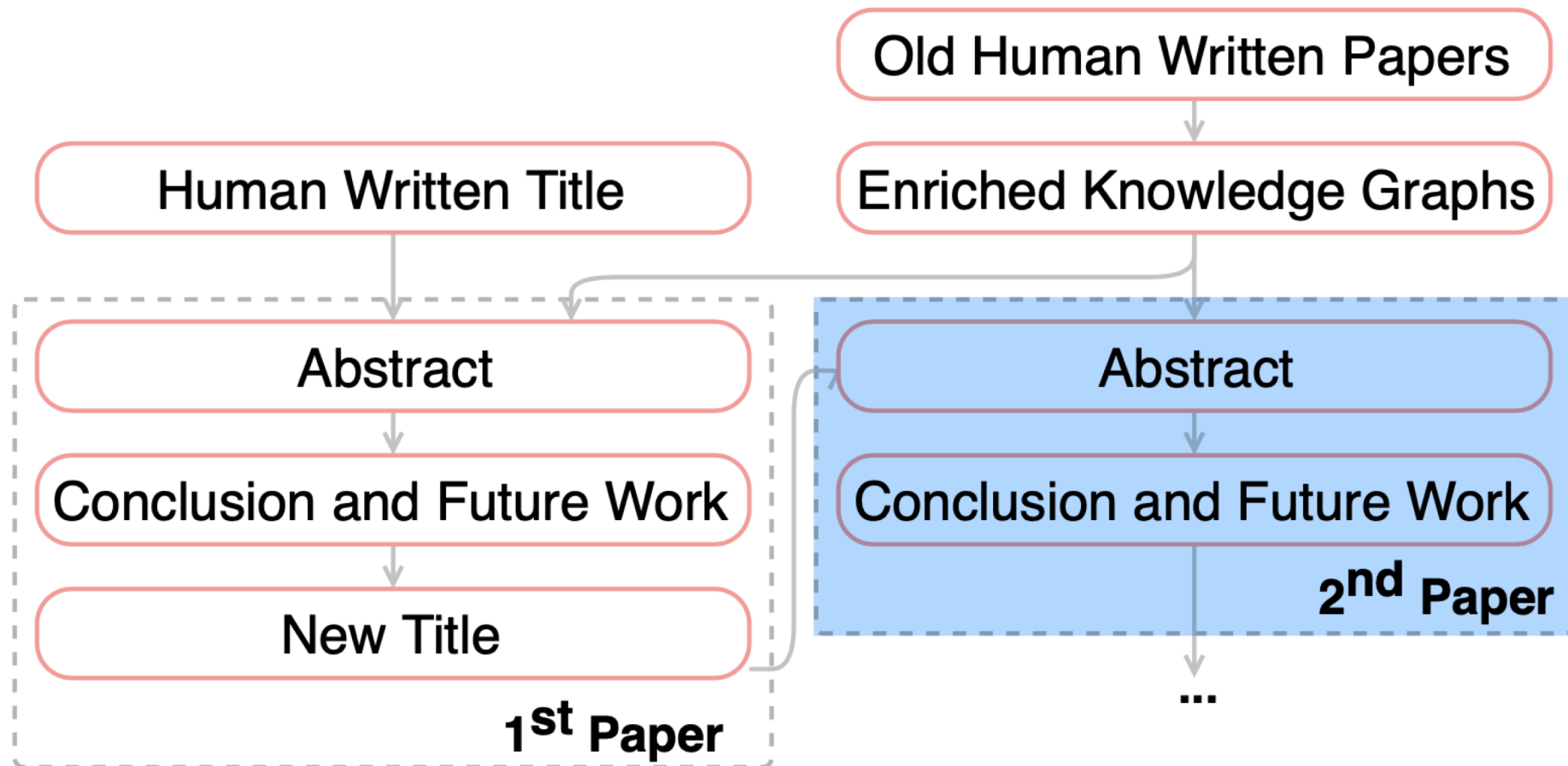
Similarly, our results for **HTR1A contain a single topic holding the phrases “anxiogenic,” “anxiety disorders,” “depression anxiety disorders,” and “anxiolytic response.”** In contrast, our HTR2A results do not contain any phrases related to anxiety. The distribution of anxiety related keywords from both queries can be seen in figure 6.

Our findings agree with those of Wang et al. which were that **a small association score of 0.34 between Venlafaxine and HTR1A** indicates a connection which is likely **related to depressive disorder and anxiety.** The association score between Venlafaxine and HTR2A, in contrast, is a much higher 4.0. This indicates that the connection between these two keywords is much weaker.

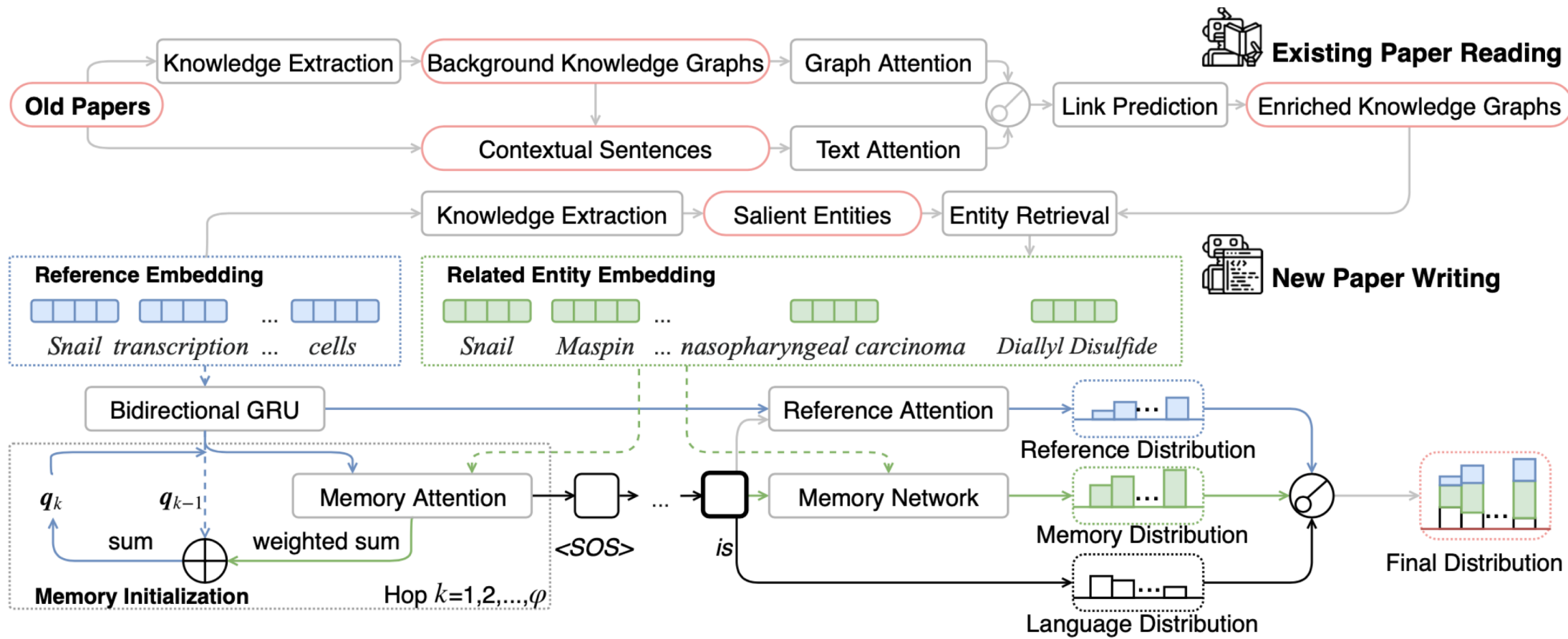


# PaperRobot: Incremental Draft Generation of Scientific Ideas (ACL'19)

- Incremental writing

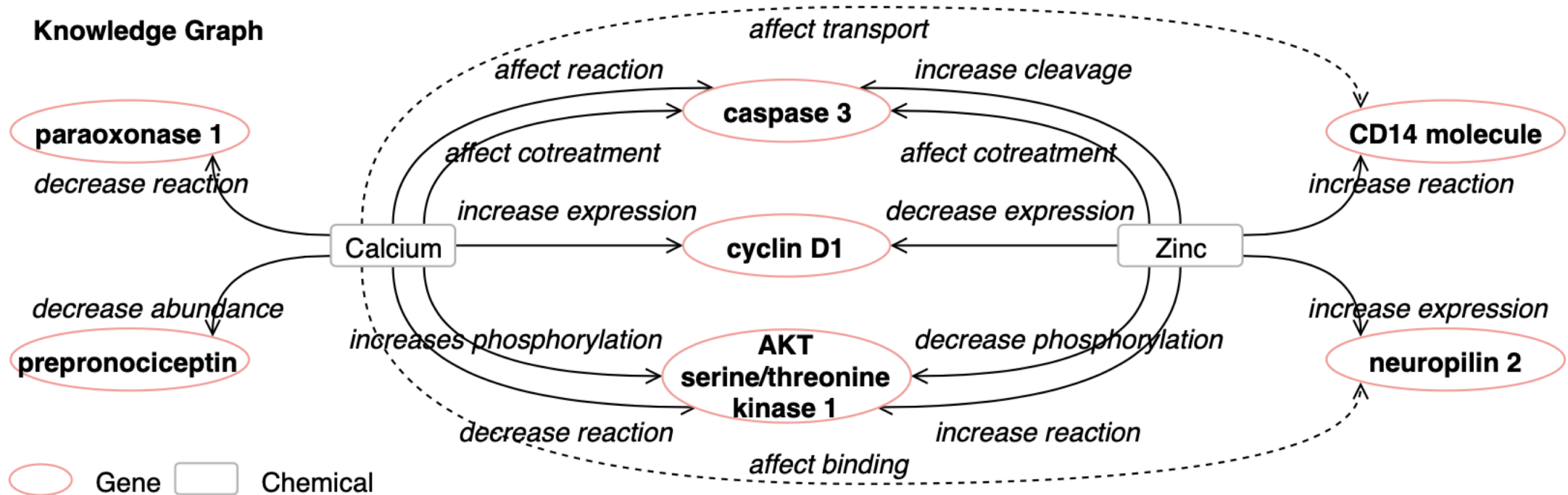


# Architecture Overview





# Biomedical Knowledge Extraction and Link Prediction



**Contextual Sentence:** So,  $\text{Ca}^{2+}$  possibly **promoted** **caspases** activation upstream of **cytochrome c** release, but inactivated **caspase** activity by calpain and/or fast depletion of ATP; whereas  $\text{Zn}^{2+}$  blocked the **activation of procaspase-3** with no visible change in the level of **cytochrome c**, and the block possibly resulted from its direct inhibition on **caspase-3** enzyme.

# Results

|                            |  |   |   |
|----------------------------|--|---|---|
| Title                      | <b>Snail</b> transcription factor negatively regulates <b>maspin</b> tumor suppressor in human prostate cancer cells   |   |   |
| Entities                   | Related: <b>nasopharyngeal carcinoma</b> ; diallyl disulfide   |   |   |
| Output                     | <b>Human (Neal et al., 2012)</b>   | <b>System</b>   | <b>Post-edited by Human</b>   |
| Abstract                   | Background: <b>Maspin</b> , a putative <b>tumor suppressor</b> that is down-regulated in breast and <b>prostate cancer</b> , has been associated with decreased cell motility. <b>Snail</b> transcription factor is a zinc finger protein that is increased in breast cancer and is associated with increased tumor motility and invasion by induction of epithelial-mesenchymal transition (EMT). We investigated the molecular mechanisms by which <b>Snail</b> increases <b>tumor</b> motility and invasion utilizing <b>prostate cancer</b> cells. Methods: Expression levels were analyzed by <b>RT-PCR</b> and <b>western blot</b> analyses. Cell motility and invasion assays were performed, while <b>Snail</b> regulation and binding to <b>maspin</b> promoter was analyzed by luciferase reporter and chromatin immunoprecipitation (ChIP) assays. Results: <b>Snail</b> protein expression was higher in different <b>prostate cancer</b> cells lines as compared to normal prostate epithelial cells. | Background: <b>Snail</b> is a multifunctional protein that plays an important role in the pathogenesis of <b>prostate cancer</b> . <i>However</i> , it has been shown <i>to be</i> associated with poor prognosis. The purpose of this study <i>was</i> to investigate the effect of <i>negatively</i> on the expression of <b>maspin</b> in <b>human nasopharyngeal carcinoma</b> cell lines. Methods: <i>Quantitative real-time PCR</i> and western blot analysis were used to determine <i>whether the demethylating agent was investigated by quantitative RT-PCR (qRT-PCR) and Western blotting</i> . Results showed that the binding protein plays a significant role in the regulation of <b>tumor</b> growth and progression. | Background: <b>Snail</b> is a multifunctional protein that plays an important role in the pathogenesis of <b>prostate cancer</b> . It has been shown associated with poor prognosis. The purpose of this study is to investigate the negative effect of on the expression of <b>Maspin</b> in <b>human nasopharyngeal carcinoma</b> cell lines. Methods: Quantitative <b>RT-PCR (qRT-PCR)</b> and <b>western blot analyses</b> were used to determine <i>correlation of the two proteins expressions</i> . Results showed that the binding protein plays a significant role in the regulation of <b>tumor</b> growth and progression. |
| Conclusion and Future work | Collectively, our results indicate for the first time that <b>Snail</b> can negatively regulate <b>maspin</b> through direct promoter repression resulting in increased migration and invasion in prostate <b>cancer</b> cells. This study reveals a novel mechanism of how <b>Snail</b> may function and show the importance of therapeutic targeting of <b>Snail</b> signaling in future.  | In summary, our study demonstrates that <b>Snail</b> negatively <i>inhibited</i> the expression of <b>Maspin</b> in <b>human nasopharyngeal carcinoma</b> cell lines <i>and in vitro</i> . Our results indicate that <i>the combination of the demethylating agent</i> might be a potential therapeutic target for the treatment of <b>prostate cancer</b> .  | In summary, our study <i>in vitro</i> demonstrates that <b>Snail</b> negatively <i>inhibits</i> the expression of <b>Maspin</b> in <b>human nasopharyngeal carcinoma</b> cell lines. Our results <i>further</i> indicate that <b>Maspin</b> might be a potential therapeutic target for the treatment of <b>prostate cancer</b> .   |
| New Title                  | Role of <b>maspin</b> in cancer (Berardi et al., 2013)   | The role of <b>nasopharyngeal carcinoma</b> in the rat model of <b>prostate cancer</b> cells  | The role of <b>Maspin</b> in the rat model of <b>nasopharyngeal carcinoma</b> cells   |

# Results (cont'd)

| Model                                | Title-to-Abstract |             | Abstract-to-Conclusion and Future Work |             | Conclusion and Future Work-to-Title |            |
|--------------------------------------|-------------------|-------------|--|-------------|-------------------------------------|------------|
|                                      | Perplexity        | METEOR      | Perplexity                             | METEOR      | Perplexity                          | METEOR     |
| Seq2seq (Bahdanau et al., 2015)      | 19.6              | 9.1         | 44.4                                   | 8.6         | 49.7                                | 6.0        |
| Editing Network (Wang et al., 2018b) | 18.8              | 9.2         | 30.5                                   | 8.7         | 55.7                                | 5.5        |
| Pointer Network (See et al., 2017)   | 146.7             | 8.5         | 74.0                                   | 8.1         | 47.1                                | 6.6        |
| Our Approach (-Repetition Removal)   | 13.4              | 12.4        | 24.9                                   | <b>12.3</b> | 31.8                                | 7.4        |
| Our Approach                         | <b>11.5</b>       | <b>13.0</b> | <b>18.3</b>                            | 11.2        | <b>14.8</b>                         | <b>8.9</b> |

| Task       | Input                             |           | Output                     | Domain Expert | Non-expert |
|------------|-----------------------------------|-----------|----------------------------|---------------|------------|
| End-to-End | Human Title                       | Different | Abstract (1st)             | 10            | <b>30</b>  |
|            |                                   | Same      |                            | <b>30</b>     | 16         |
|            | System Abstract                   | Different | Conclusion and Future work | <b>12</b>     | 0          |
|            |                                   | Same      |                            | 8             | 8          |
|            | System Conclusion and Future work | Different | Title                      | <b>12</b>     | 2          |
|            |                                   | Same      |                            | 12            | <b>25</b>  |
|            | System Title                      | Different | Abstract (2nd)             | <b>14</b>     | 4          |
| Diagnostic | Human Abstract                    | Different | Conclusion and Future work | 12            | <b>14</b>  |
|            |                                   | Same      |                            | <b>24</b>     | 20         |
|            | Human Conclusion and Future work  | Different | Title                      | 8             | <b>12</b>  |
|            |                                   | Same      |                            | 2             | <b>10</b>  |



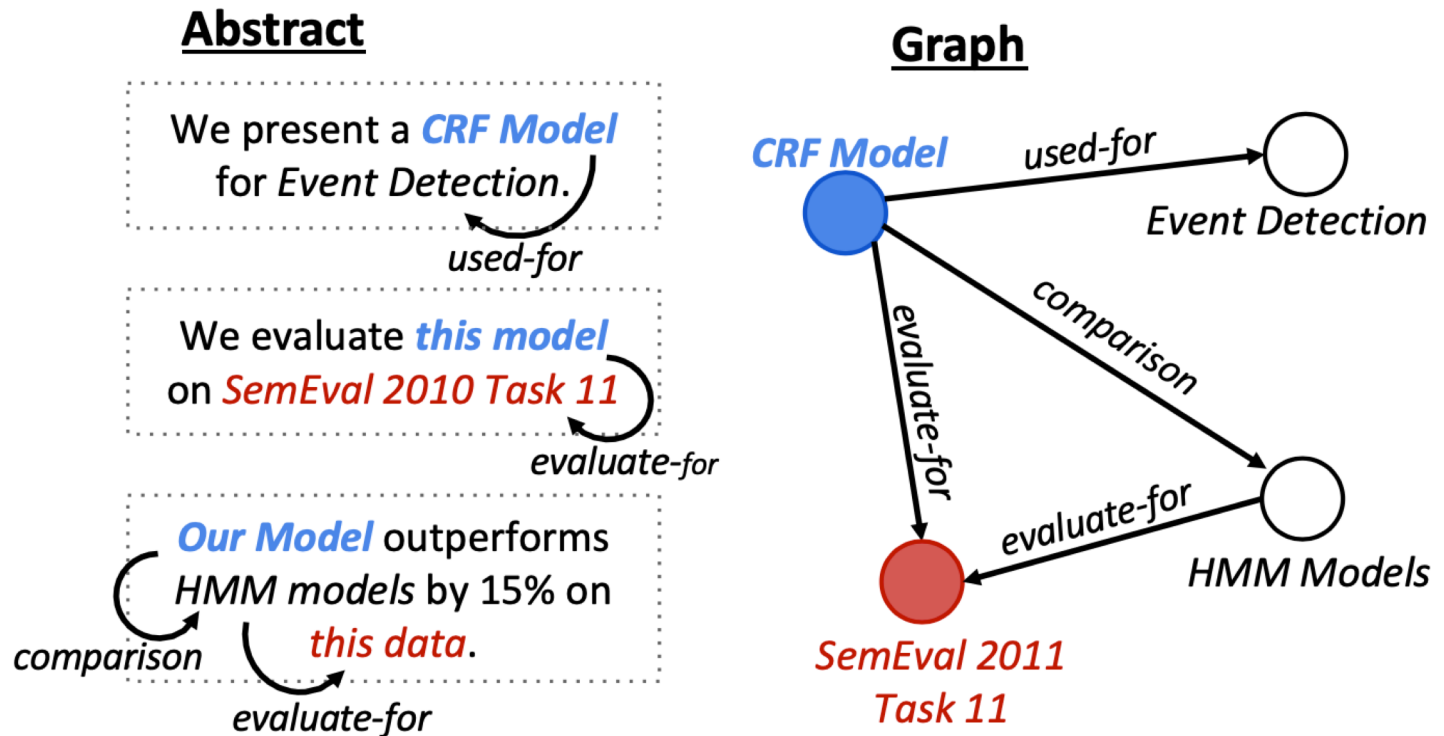
# Results (cont'd)

| Output                     | Without Memory Networks  | Without Link Prediction   | Without Repetition Removal   |
|----------------------------|--|---|--|
| Abstract                   | Background: <b>Snail</b> has been reported to exhibit a variety of biological functions. In this study, we investigated the effect of negatively on <b>maspin</b> demethylation in <b>human prostate cancer</b> cells. Methods: Quantitative real-time PCR and western blot analysis were used to investigate the effects of the demethylating agent on the expression of the protein kinase (TF) gene promoter. Results: The results showed that the presence of a single dose of 50 $\mu M$ in a dose-dependent manner, whereas the level of the BMP imipramine was significantly higher than that of the control group. | Background: <b>Snail</b> has been shown to be associated with poor prognosis. In this study, we investigated the effect of negatively on the expression of <b>maspin</b> in <b>human prostate cancer</b> cells. Methods: Cells were treated with a single dose of radiotherapy for 24 h, and was used to investigate the significance of a quantitative factor for the treatment of the disease. Results: The remaining controls showed a significant increase in the G2/M phase of the <b>tumor suppressor protein</b> ( $p < 0.05$ ). | Background: <b>Snail</b> is a major health problem in human malignancies. However, the role of <b>Snail</b> on the expression of <b>maspin</b> in <b>human prostate cancer</b> cells is not well understood. The aim of this study was to investigate the effect of <b>Snail</b> on the expression of <b>maspin</b> in <b>human prostate cancer</b> cells. Methods: The expression of the expression of <b>Snail</b> and <b>maspin</b> was investigated using quantitative RT-PCR and western blot analysis. Results: The remaining overall survival (OS) and overall survival (OS) were analyzed. |
| Conclusion and Future work | In summary, our study demonstrated that negatively inhibited the expression of the BMP imipramine in <b>human prostate cancer</b> cells. Our findings suggest that the inhibition of <b>maspin</b> may be a promising therapeutic strategy for the treatment.  | In summary, our results demonstrate that negatively inhibited the expression of <b>maspin</b> in <b>human prostate cancer</b> cells. Our findings suggest that the combination of radiotherapy may be a potential therapeutic target for the treatment of disease.  | In summary, our results demonstrate that <b>snail</b> inhibited the expression of <b>maspin</b> in <b>human prostatic</b> cells. The expression of <b>snail</b> in PC-3 cells by <b>snail</b> , and the expression of <b>maspin</b> was observed in the presence of the expression of <b>maspin</b> .  |
| New Title                  | Protective effects of homolog on <b>human breast cancer</b> cells by inhibiting the Endoplasmic Reticulum Stress   | The role of <b>prostate cancer</b> in <b>human breast cancer</b> cells  | The role of <b>maspin</b> and <b>maspin</b> in human <b>breast cancer</b> cells  |

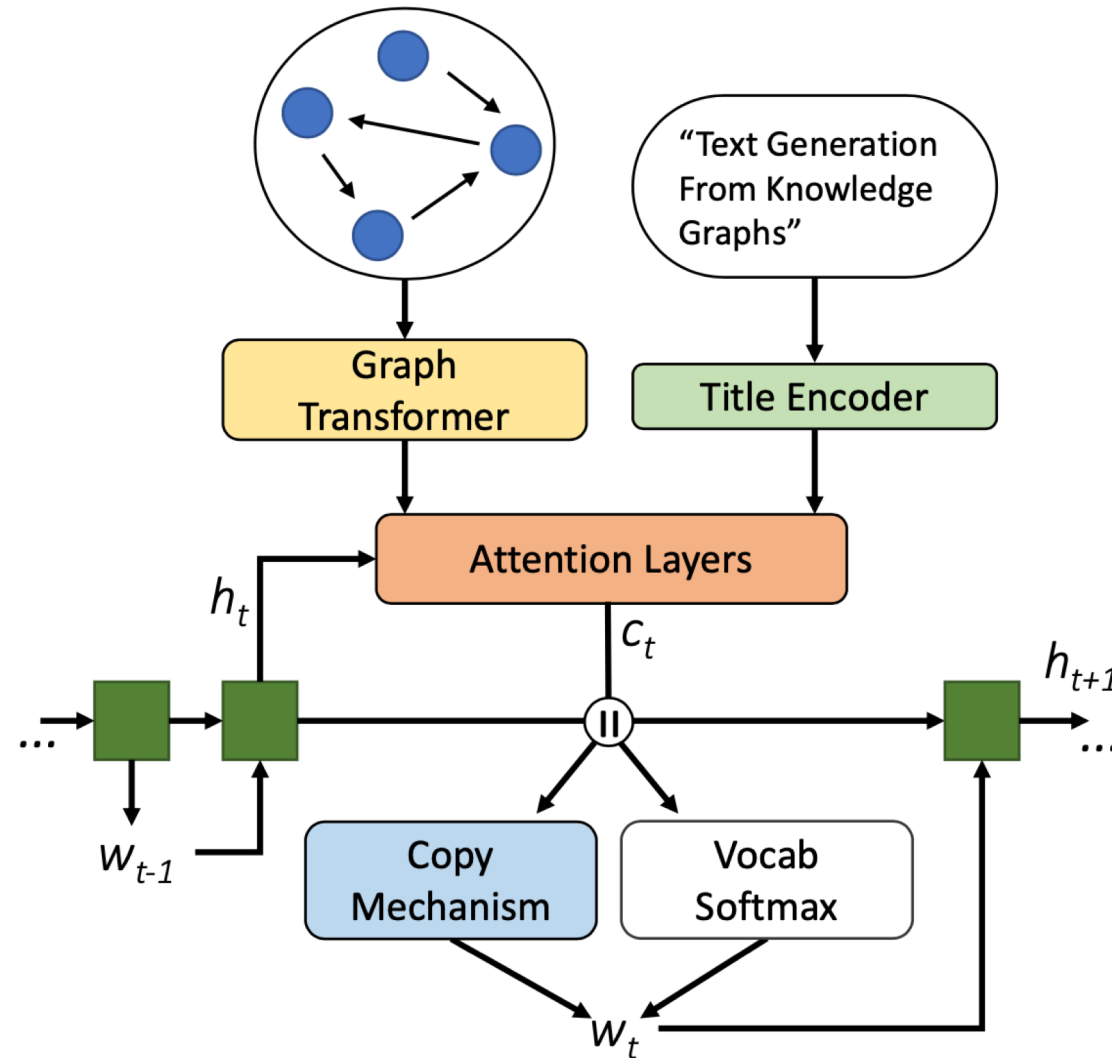
# Text Generation from Knowledge Graphs with Graph Transformers (NAACL'19)

- Text-to-graph extraction
- Graph-to-text generation

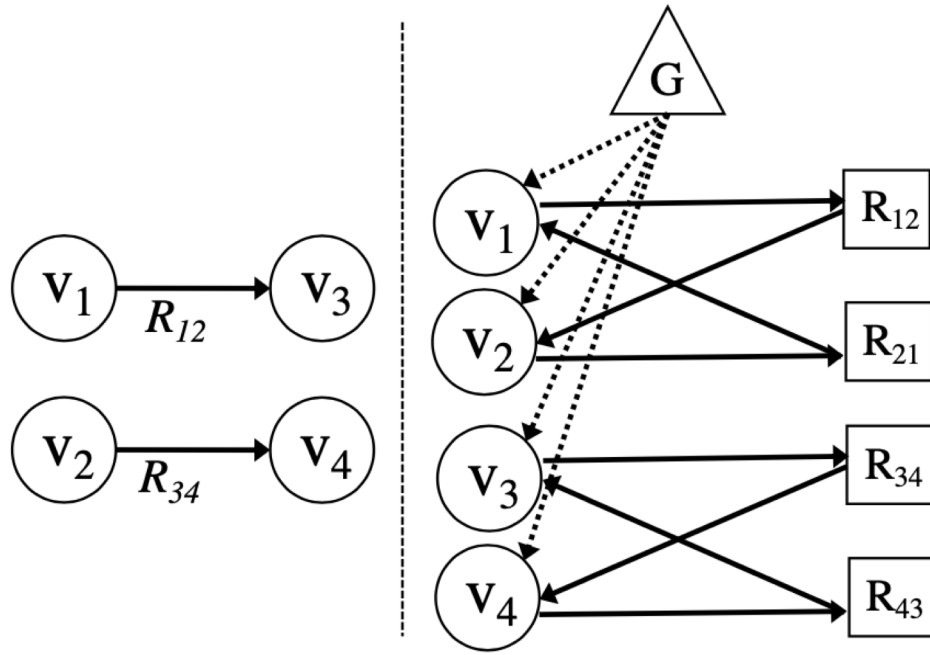
**Title:** Event Detection with Conditional Random Fields



# Graph Writer Model

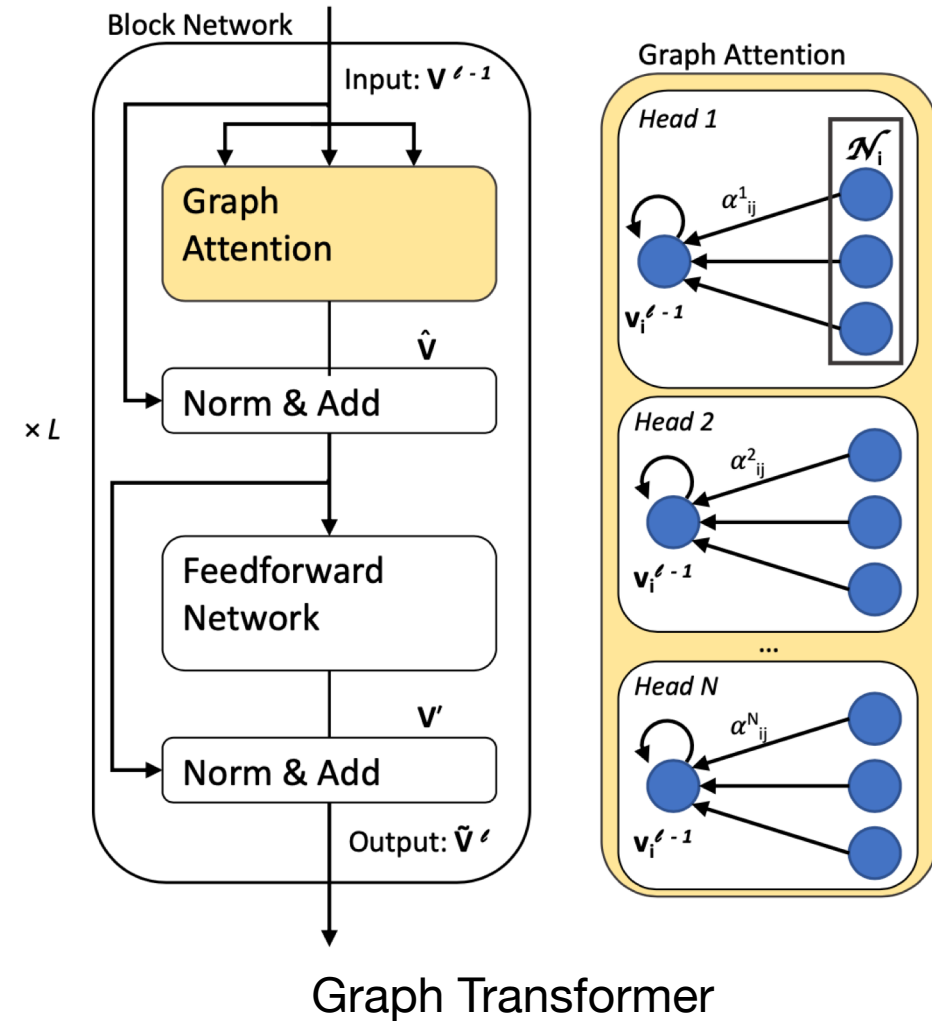


# Graph Attention and Graph Transformer



Converting disconnected labeled graph to connected unlabeled graph for use in attention-based encoder.

$v_i$  refer to vertices,  $R_{ij}$  to relations, and  $G$  is a global context node.



# Results

|              |  |
|--------------|--|
| Title        | Block and Group Regularized Sparse Modeling for Dictionary Learning  |
| Knowledge    | (dictionary learning, CONJUNCTION, sparse coding) ; (optimization problems, USED-FOR, dictionary learning) ; (optimization problems, USED-FOR, sparse coding)...   |
| GraphWriter  | Sparse representations have recently been shown to be effective in many optimization problems. However, existing dictionary learning methods are limited in the number of dictionary blocks, which can be expensive to obtain. In this paper, we propose a novel approach to dictionary learning based on sparse coding ...  |
| GAT          | In this paper, we consider the problem of dictionary learning in well-known datasets. In particular, we consider the problem of dictionary learning, where the goal is to find a set of dictionary blocks that maximize the likelihood of a given set of dictionary blocks ...   |
| EntityWriter | We propose a novel dictionary learning framework for reconstructed block/group sparse coding schemes. The dictionary learning framework is based on the descent, which is a block structure of the group structure ...   |
| Rewriter     | This paper presents a new approach to the k-means of the algorithm. The proposed approach is based on the basis of the stationarity algorithm. The algorithm is based on the fact that the number of bits is a constant of the base of the base of the input ...   |
| Gold         | This paper proposes a dictionary learning framework that combines the proposed block/group (BGSC) or reconstructed block/group (R-BGSC) sparse coding schemes with the novel Intra-block Coherence Suppression Dictionary Learning algorithm. An important and distinguishing feature of the proposed framework is that all dictionary blocks are trained simultaneously ... |



# Results (cont'd)

|              |   |
|--------------|---|
| Title        | Image Interpolation with Directionlets  |
| Knowledge    | (directionally adaptive image interpolation USED-FOR edge information) ; (numeric and visual quality, HYPONYM-OF, directionally adaptive image interpolation) ; (directionlets, EVALUATE-FOR, multiple-direction wavelet transform) ...   |
| GraphWriter  | In this paper, we propose a novel directionally adaptive image interpolation based on the multiple-direction wavelet transform, called directionlets, which can be used as a directionlets to improve the numeric and visual quality of the directionally adaptive image interpolation ...  |
| GAT          | In this paper, we propose a novel directionally adaptive image interpolation, called directionally adaptive image interpolation, for directionally adaptive image interpolation , which is based on the multiple-direction wavelet transform ...  |
| EntityWriter | We present a novel directionally adaptive image interpolation for numeric and visual quality. The wavelet transform is based on the wavelet transform between the low-resolution image and the interpolated image. The high-resolution image is represented by a wavelet transform ...  |
| Rewriter     | We present a new method for finding topic-specific data sets. The key technical contributions of our approach is to be a function of the terrestrial distributed memory. The key idea is to be a function of the page that seeks to be ranked the buckets of the data. The basic idea is a new tool for the embedded space ...                  |
| <i>Gold</i>  | We present a novel directionally adaptive image interpolation based on a multiple-direction wavelet transform, called directionlets. The directionally adaptive image interpolation uses directionlets to efficiently capture directional features and to extract edge information along different directions from the low-resolution image ... |