# Network Analysis and the Classification of New Testament Manuscripts

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*”The Bible did not fall magically from the clouds. Man created it as a historical record of tumultuous times, and it has evolved through countless translations, additions, and revisions. History has never had a definitive version of the book.”*

Sir Leigh Teabing, Da Vinci Code

# Manuscript traditions of the New Testament

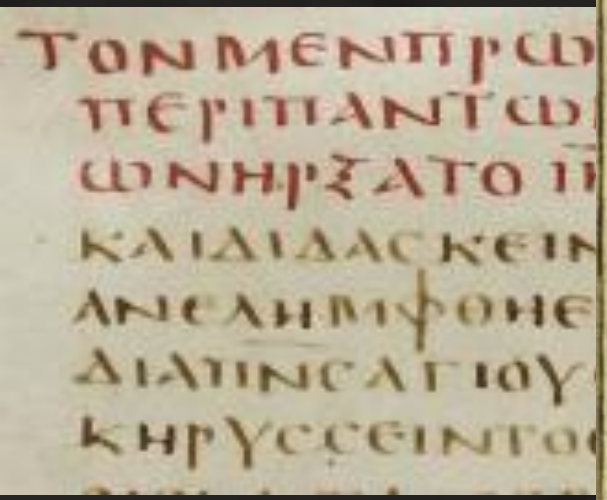
- New Testament was transmitted through the medium of manuscripts for over 1400 years
  - Manuscript = manus scriptus (“written by hand”)

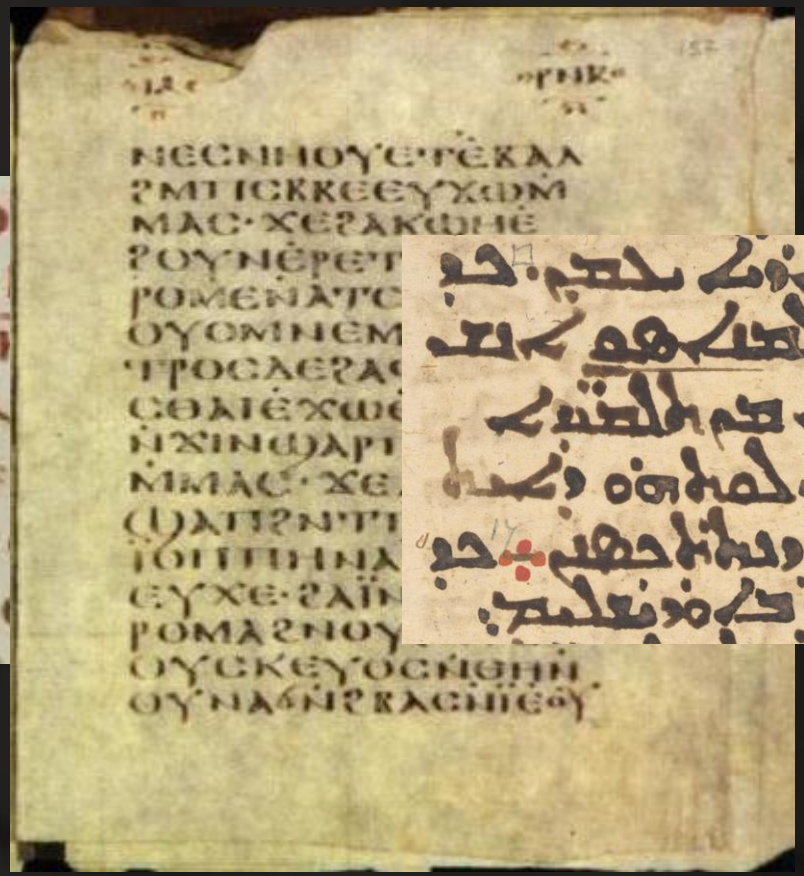
Source: British Library Catalogue of Illuminated Manuscripts. London, British Library MS Royal 14 E III, f. 6v. Northern France, 1st quarter of the 14th century
http://www.bl.uk/catalogues/illuminatedmanuscripts/ILLUMIN.ASP?Size=mid&IllID=43454

# Manuscript traditions of the New Testament

- New Testament was transmitted through the medium of manuscripts for over 1400 years
  - Manuscript = manus scriptus (“written by hand”)
- 27 different manuscript traditions
  - Each text circulated individually during the first Christian centuries
    - Every one of them has a unique history
    - Later assembled in collections of books
      - Gospels, Apostolos
  - Numerous translations
    - Greek, Latin, Coptic, Syriac…

# Manuscript traditions of the New Testament







# First Challenge

- The sizes of the manuscript traditions
  - Approximately 6000 Greek
  - 10 000 Latin
  - 1500 Armenian
  - 1000 Coptic New Testament manuscripts
- New manuscript discoveries are made each year

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[INTF] INSTITUT FÜR NEUTESTAMENTLICHE TEXTFORSCHUNG

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Indexed Biblical Content

Content Overview

Language

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Dated To 0 - 1799AD

Line Count 0 - ∞

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Page Height (mm) 0 - 500

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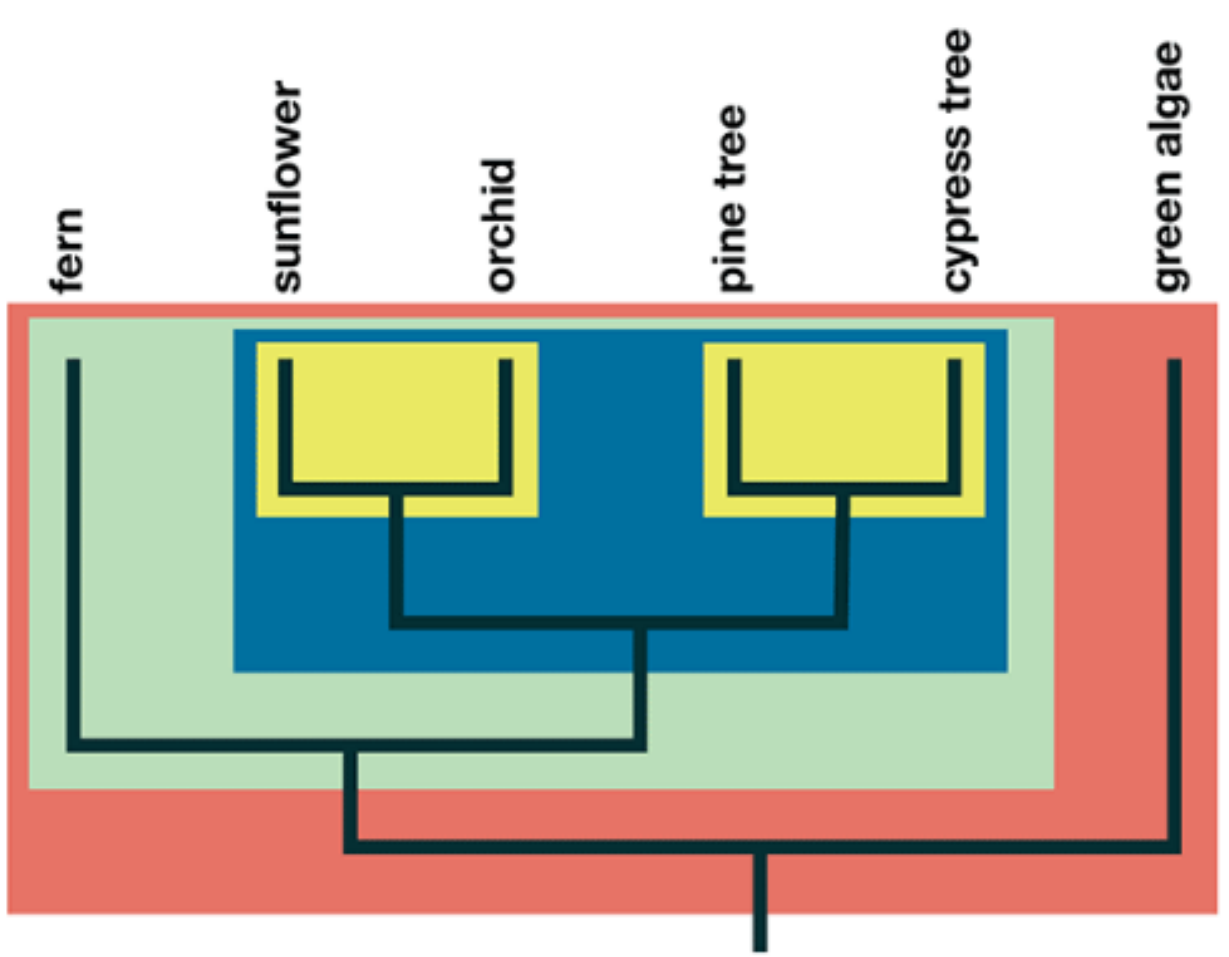
Has: Images Transcriptions

## Manuscript Details

## Bibliography

# First Challenge

- Hierarchical classification has been used to organize the data
  - Johan Bengel 1734 (Carl Linnaeus 1735)
    - Bengel classified manuscripts and Linnaeus natural world in a similar manner

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# First Challenge

- Considering all manuscript data is impossible when conventional computer-assisted techniques are used
  - Critics are forced to rely on samples
  - Preprocessing work takes too much time
    - Transcriptions
    - Collations
    - Establishing places of variation
    - Encoding variation places

# Transcribing process


the fox jumped over the hedge

# Collating manuscripts

| | |
|---|---|
| A | the fox jumped over the hedge |
| B | - |
| C | the cat jumped over the fence |
| D | a man saw that the fox jumped over the hedge |
| E | a man saw that the fox jumped over the fence |

# Establishing variation places

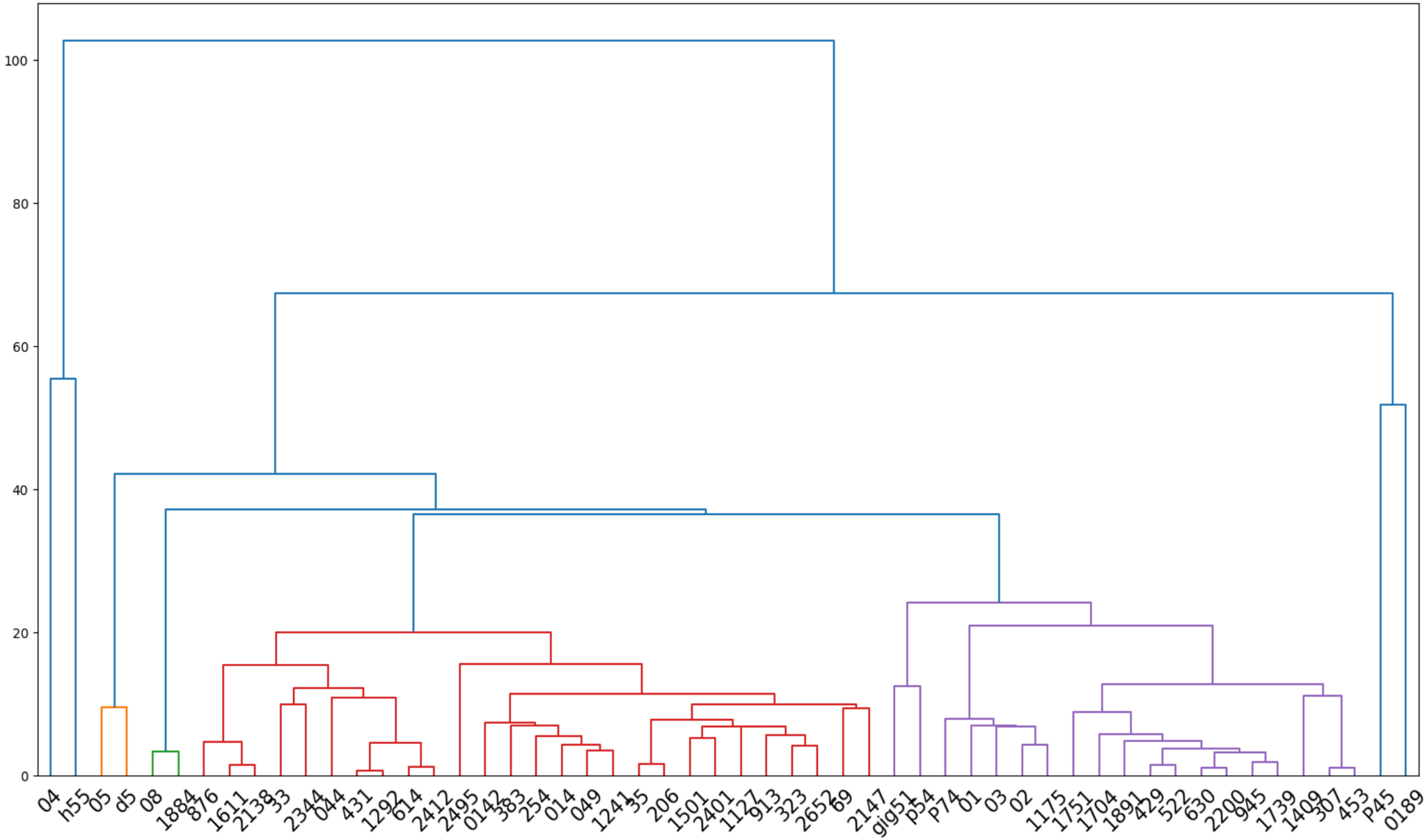
| | Solution 1 | | Solution 2 | | |
|---|---|---|---|---|---|
| A | – | the fox jumped over the hedge | – | the fox jumped | over the hedge |
| B | – | – | – | – | – |
| C | – | the cat jumped over the fence | – | the cat jumped | over the fence |
| D | a man saw that | the fox jumped over the hedge | a man saw that | the fox jumped | over the hedge |
| E | a man saw that | the fox jumped over the fence | a man saw that | the fox jumped | over the fence |

# Encoding variation places

| | Solution 1 | | Solution 2 | | |
|---|---|---|---|---|---|
| A | 0 | 1 | 0 | 0 | 0 |
| B | ? | ? | ? | ? | ? |
| C | 0 | 0 | 0 | 1 | 1 |
| D | 1 | 1 | 1 | 0 | 0 |
| E | 1 | 2 | 1 | 0 | 1 |

# Second challenge

- Recombination
  - Scribes used more than one exemplar
  - Recombination mixes manuscript relations
- New Testament manuscripts are heavily recombined
  - Conventional hierarchical classifications becomes very difficult
  - Mixture blurs the boundaries of textual groups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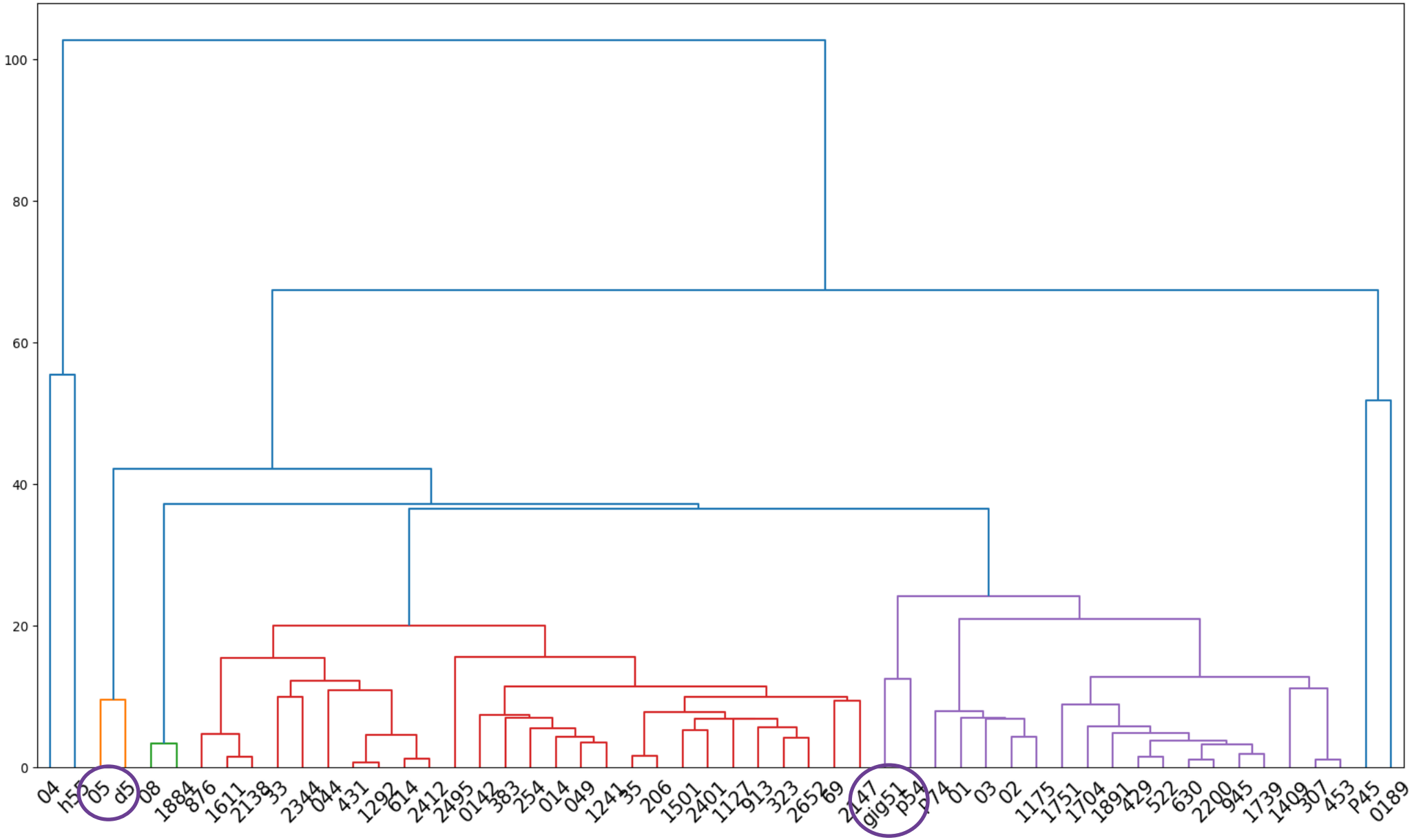
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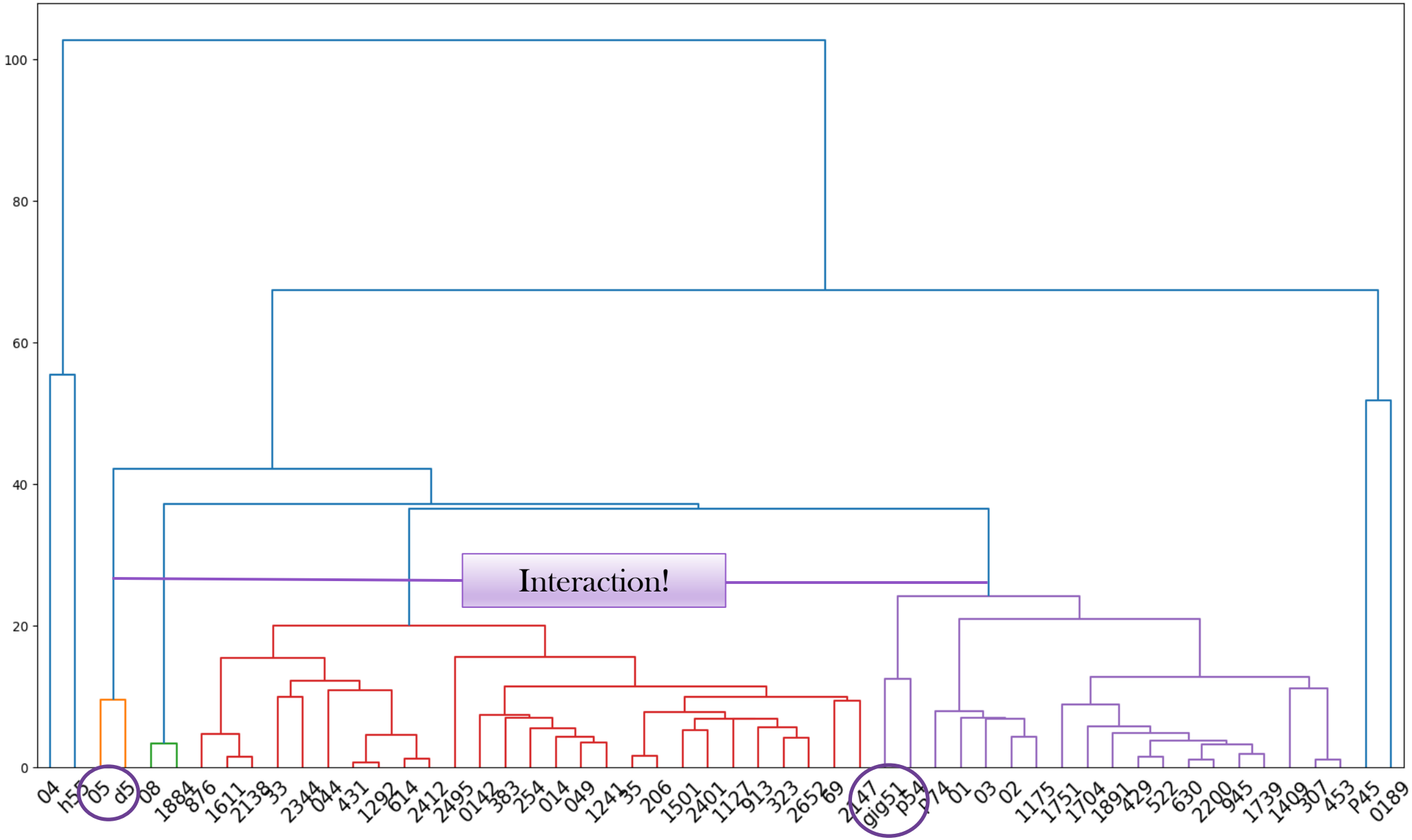
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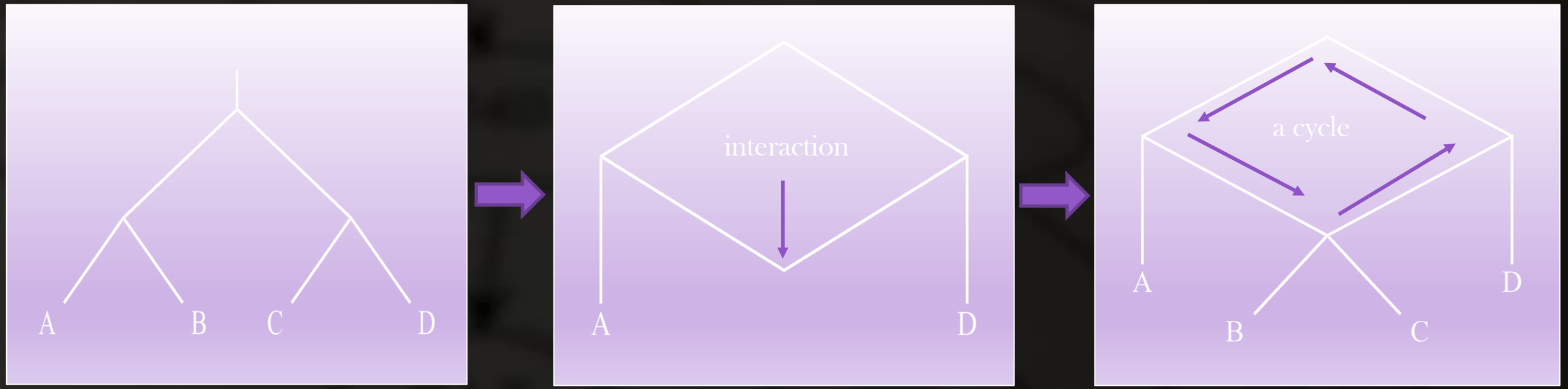
# From trees to networks



# Preprocessing the manuscript data for the network analysis

- Data mining techniques
  - The k-shingling algorithm
    - Texts are broken into smaller pieces (tokenization)
    - results to distance values
  - Every manuscript is compared with one another
  - A distance matrix

# Preprocessing the manuscript data for the network analysis

- Data mining techniques
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*Table 4. A distance matrix*

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **A** | 0 | 5 | 7 | 2 | 9 | 3 |
| **B** | 5 | 0 | 4 | 11 | 14 | 2 |
| **C** | 7 | 4 | 0 | 7 | 11 | 10 |
| **D** | 2 | 11 | 7 | 0 | 15 | 6 |
| **E** | 9 | 14 | 11 | 15 | 0 | 19 |
| **F** | 3 | 2 | 10 | 6 | 19 | 0 |

# K-Shingling

a man saw that the fox jumped over the fence

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| a man | man saw | saw that | that the | the fox | fox jumped | jumped over | over the | the fence |
| that the | fox jumped | the fence | a man | jumped over | over the | the fox | saw that | man saw |

# K-Shingling

a man saw that the fox jumped over the fence

a man saw that the fox jumped over the hedge

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| fox jumped | man saw | jumped over | that the | saw that | the fox | a man | over the | the fence |
| that the | fox jumped | the hedge | a man | jumped over | over the | the fox | saw that | man saw |

# Calculating similarities

| *Set1* | fox jumped | man saw | jumped over | that the | saw that | the fox | a man | over the | the fence |
|---|---|---|---|---|---|---|---|---|---|

| *Set2* | that the | fox jumped | the hedge | a man | jumped over | over the | the fox | saw that | man saw |
|---|---|---|---|---|---|---|---|---|---|

| Word bigram | *Set 1* | *Set 2* |
|---|---|---|
| fox jumped | 1 | 1 |
| man saw | 1 | 1 |
| jumped over | 1 | 1 |
| that the | 1 | 1 |
| saw that | 1 | 1 |
| the fox | 1 | 1 |
| a man | 1 | 1 |
| over the | 1 | 1 |
| the hedge | 0 | 1 |
| the fence | 1 | 0 |

Intersection = 8

Union = 10

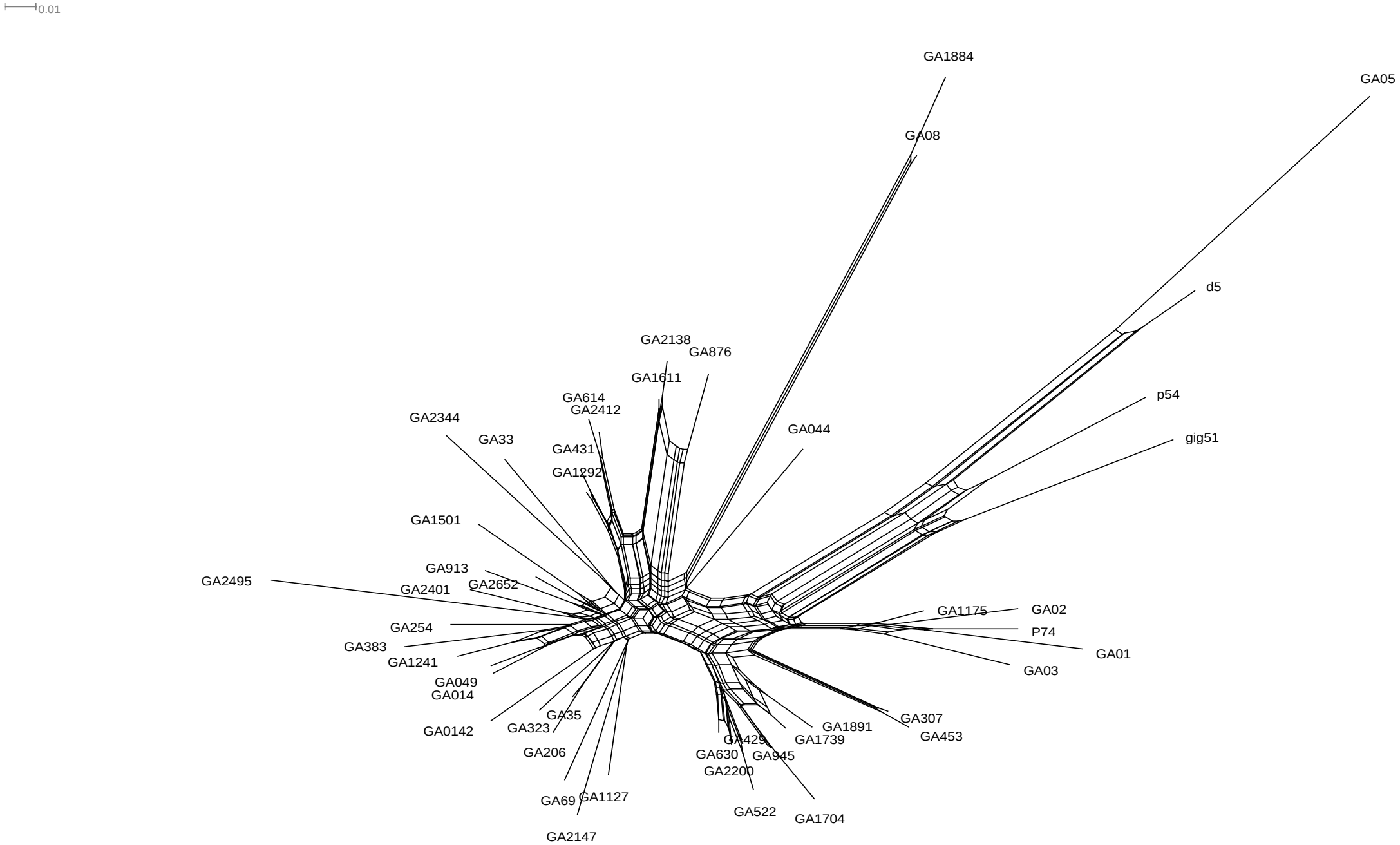
Sørensen-Dice Coefficient (SDC)

$$\frac{2\,x\,intersection}{sum\ of\ the\ number\ of\ elements\ in\ each\ set}$$

= 16 / 18 = 0.888 = 88 %

# Preprocessing the manuscript data for network analysis

- The k-shingling algorithms can process hundreds of manuscripts in matter of minutes
- Distance values are used to construct a network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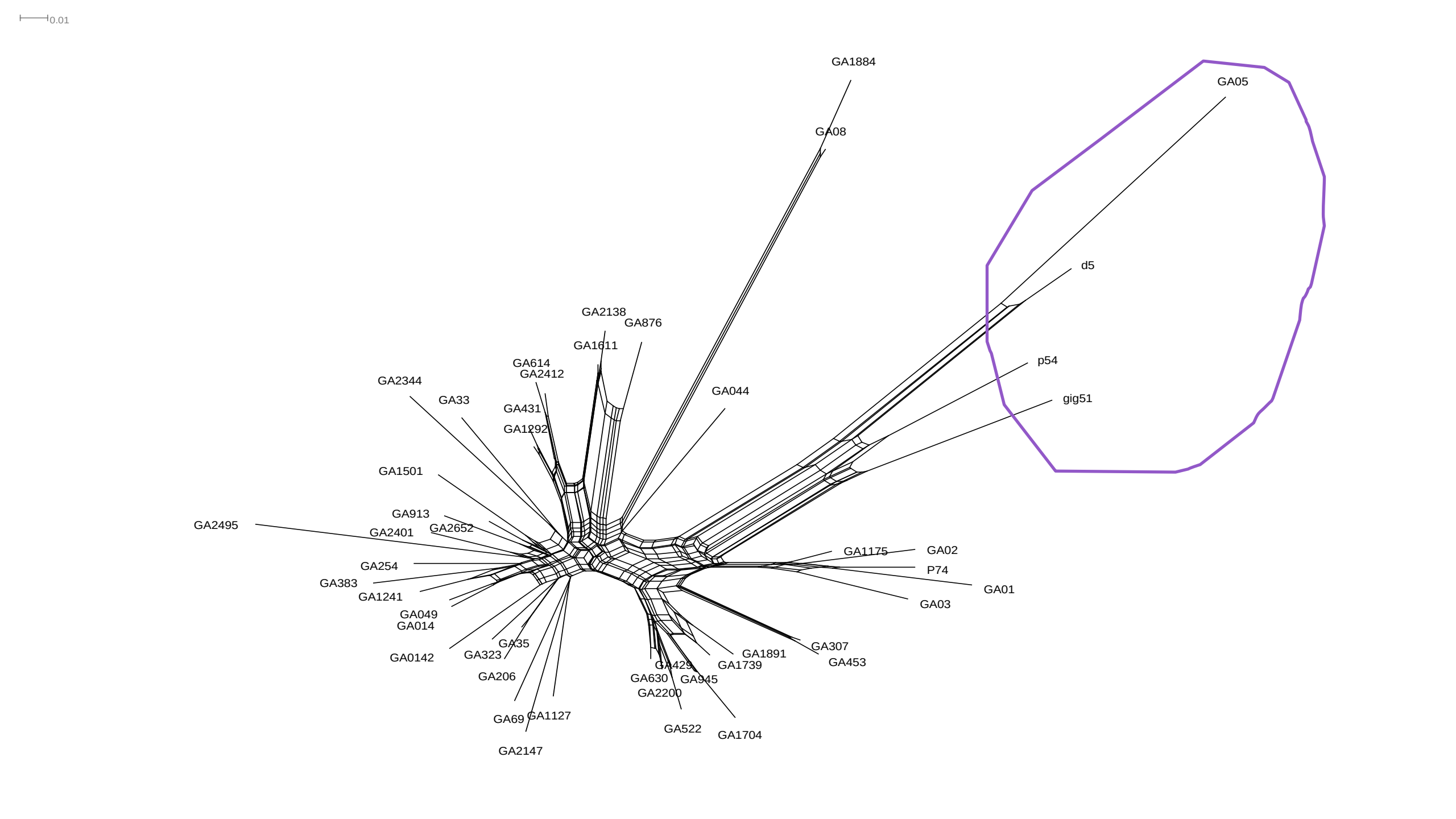
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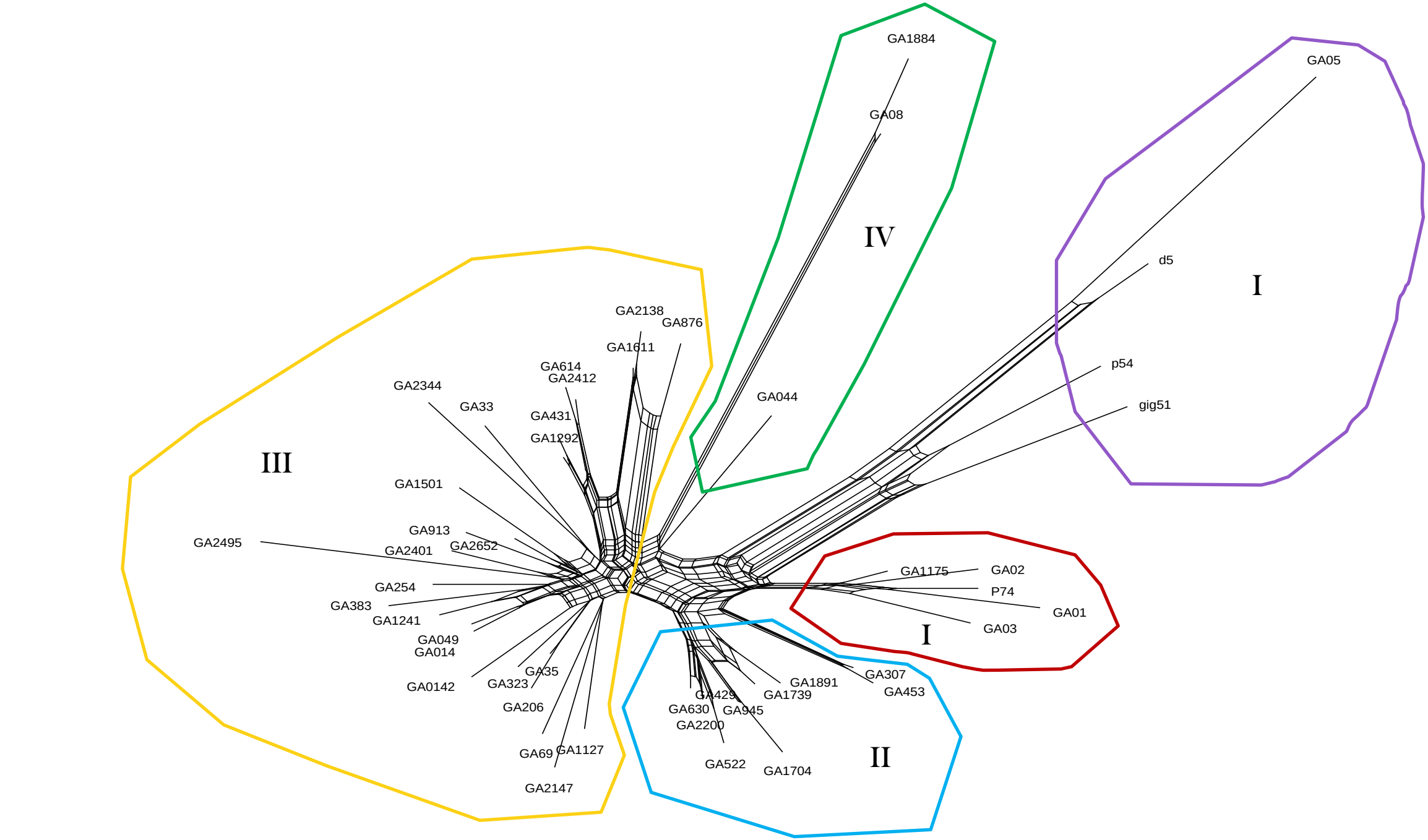
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# The future is in algorithms

- A Program called Relate was written to conduct the analysis
  - https://github.com/PasHyde/relate
- The possibilities of the network analysis are substantial
- The described method allows one to consider all manuscript evidence