# Ecological data representation - moving beyond species occurrences (5 Credits – 2nd-3rd year bachelor students):

*Submodule 1: from species to communities*

*1) Collecting and processing species occurrence data*
*2) From occurrences to species ranges*
*3) From species to local communities*
*4) From species distribution to functional and environmental space*
*5) Light introduction to ecological niche modelling*

*Submodule 2: from communities to metacommunities*

*1) Representing metacommunities using presence/absence species/locality matrices*
*2) Finding patterns in metacommunity matrices*
*3) Light introduction to null model analysis*
*4) Species area curves and links to island theory of biogeography*
*5) Practical implications/relevance of the topic for conservation*

**Submodule 3: Ecological networks**

**1) Introduction to ecological networks**
2) Bipartite ecological networks (plant-pollinator, host-parasite…) vs food webs
3) Measuring structure in ecological networks
4) How/where to get species interaction data
5) Making network visualization meaningful

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

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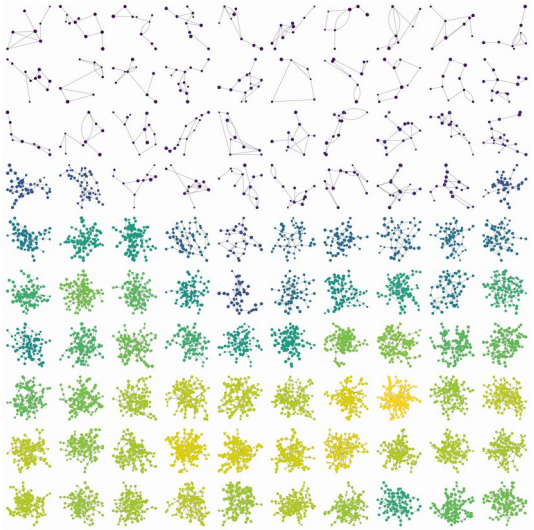
Research Centre for
Ecological Change

*Ecological Data Representation – SubModule 3*

# Introduction to Ecological Networks

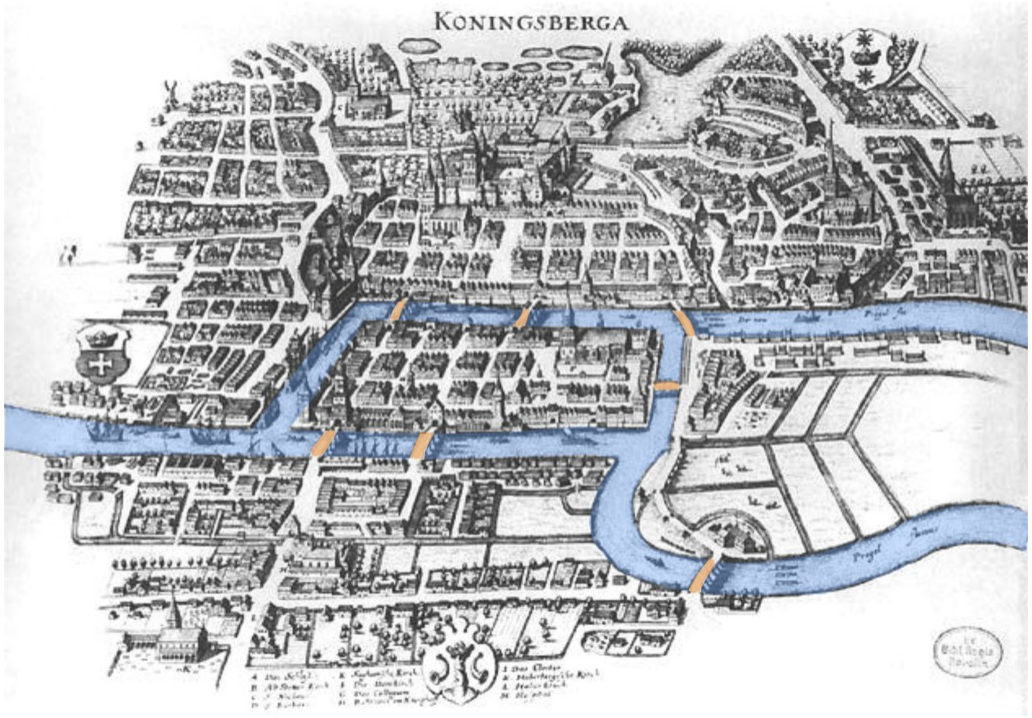
**Giovanni Strona**

*giovanni.strona@helsinki.fi*



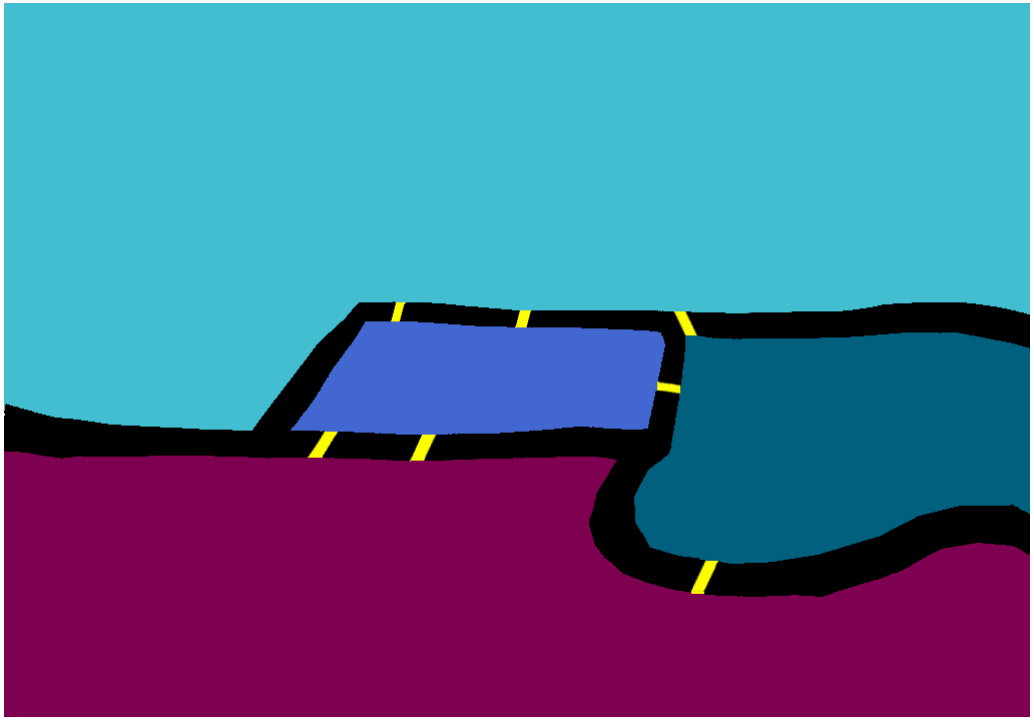
# Objectives

# The Seven Bridges of Königsberg




**Problem**: identify a path through the city that would cross each of the bridges once and only once.

# The Seven Bridges of Königsberg



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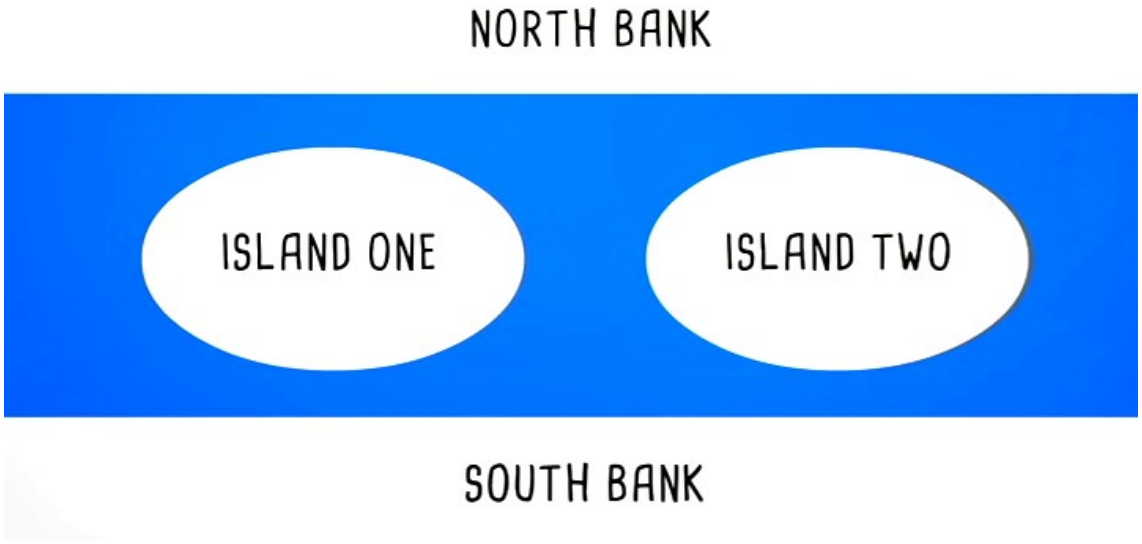
# Euler and the Seven Bridges of Königsberg




Euler, L., 1741. Solutio problematis ad geometriam situs pertinentis. Commentarii academiae scientiarum Petropolitanae, pp.128-140 (before publication, the solution was presented to the St. Petersburg Academy in 1735).

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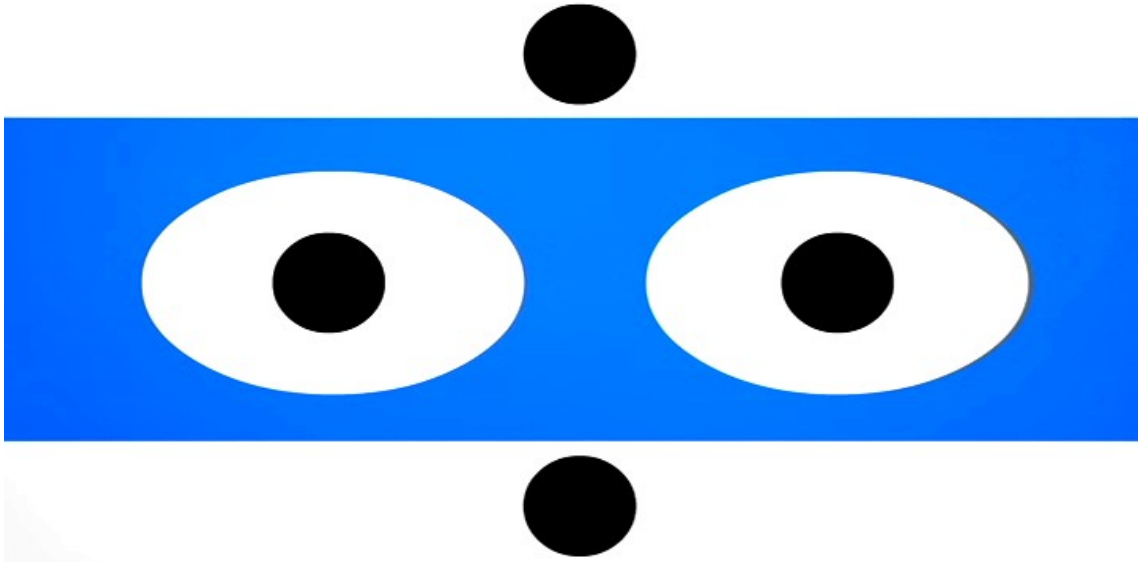

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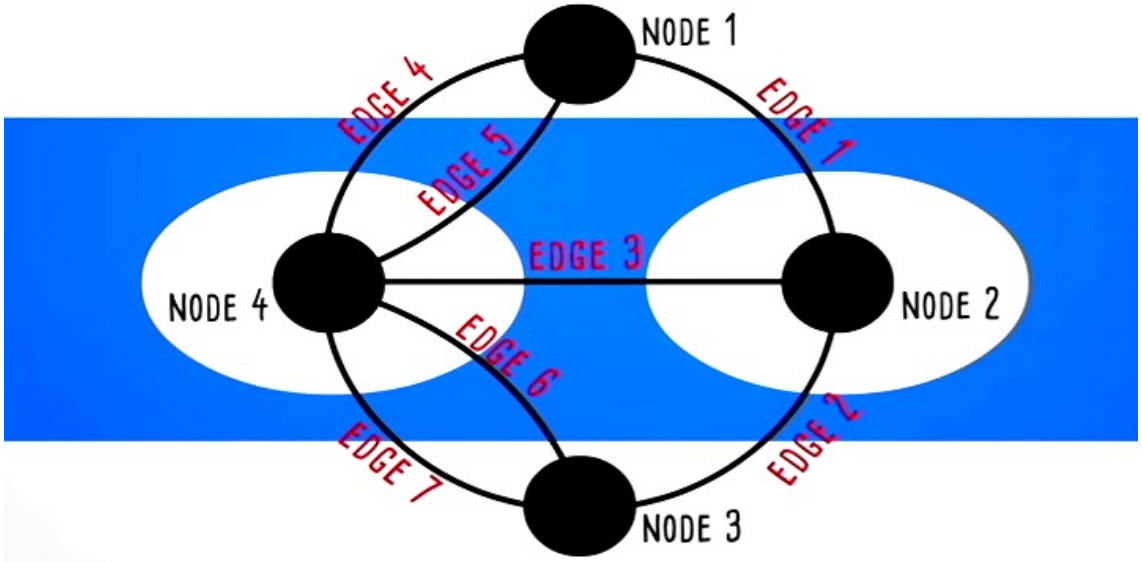


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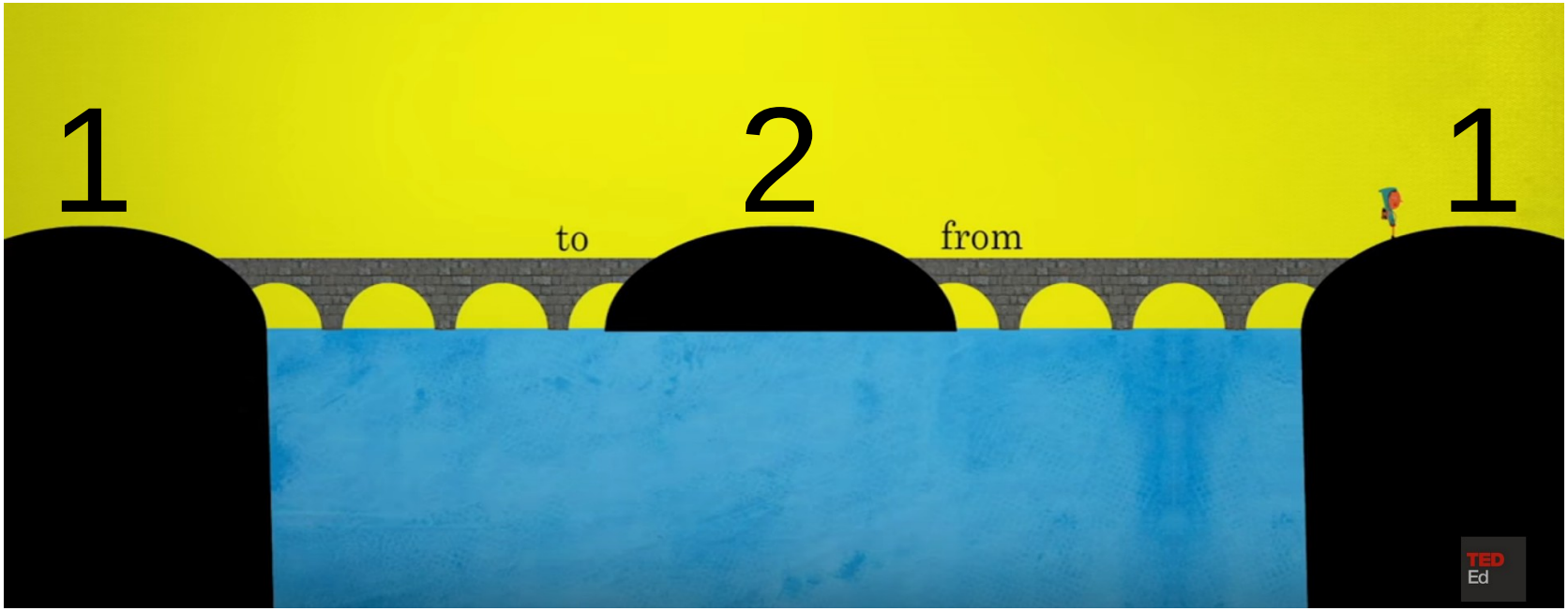


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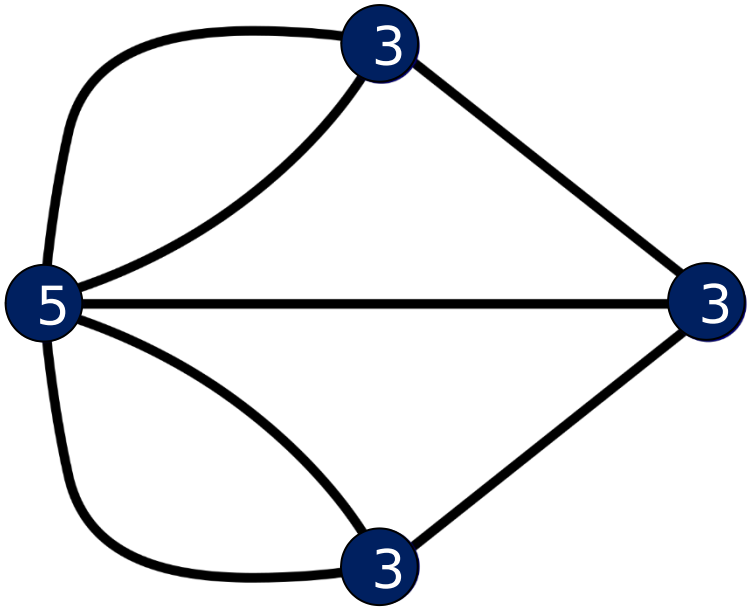
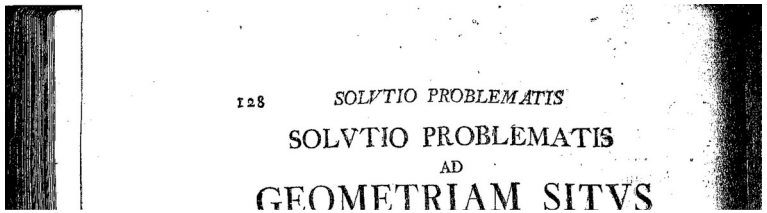



**Eulerian Path: visits every edge exactly once (allowing for revisiting vertices).**

**Condition for an "Eulerian Path":**
Exactly two nodes have an odd number of connections to other nodes in the graph. Path has to start from one of the two nodes with odd connections and end to the other one.

# Euler and the Seven Bridges of Königsberg



128 SOLVTIO PROBLEMATIS

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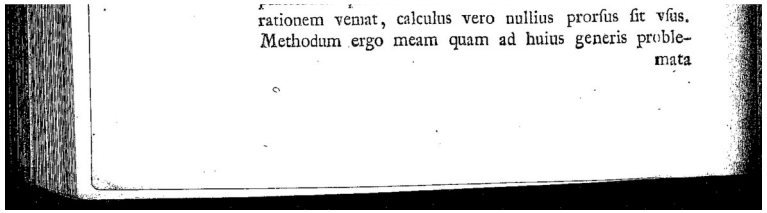
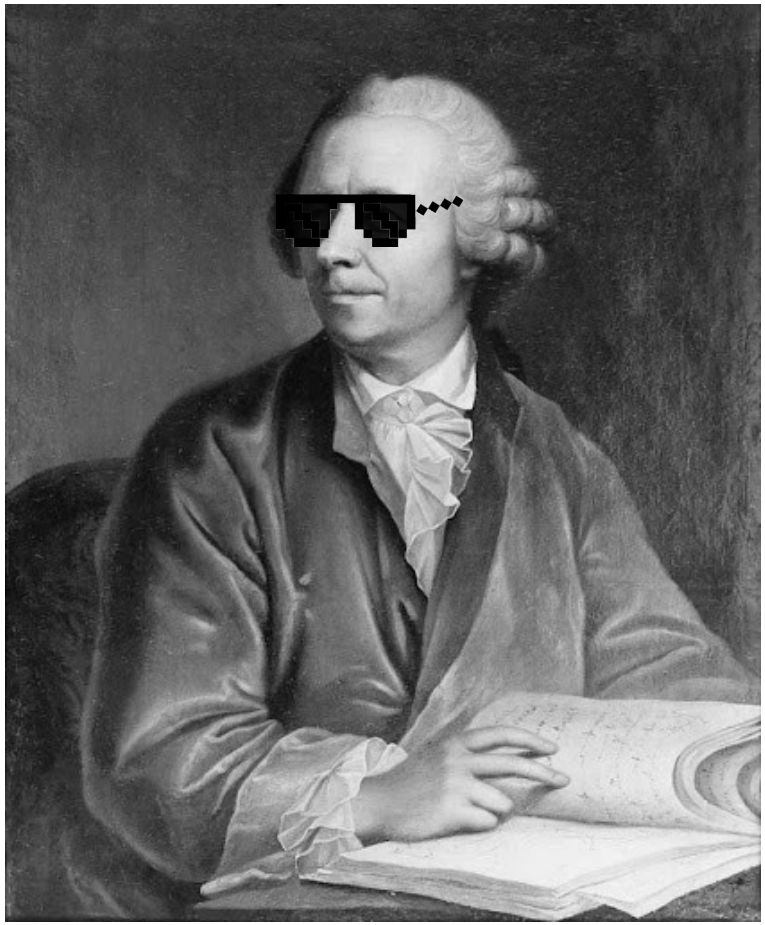
- First theorem of graph theory
- First true proof in network theory
- Intuition that key information in how nodes are connected and not their spatial position anticipated the development of topology



rationem venat, calculus vero nullius prorſus ſit vſus. Methodum ergo meam quam ad huius generis proble-
mata



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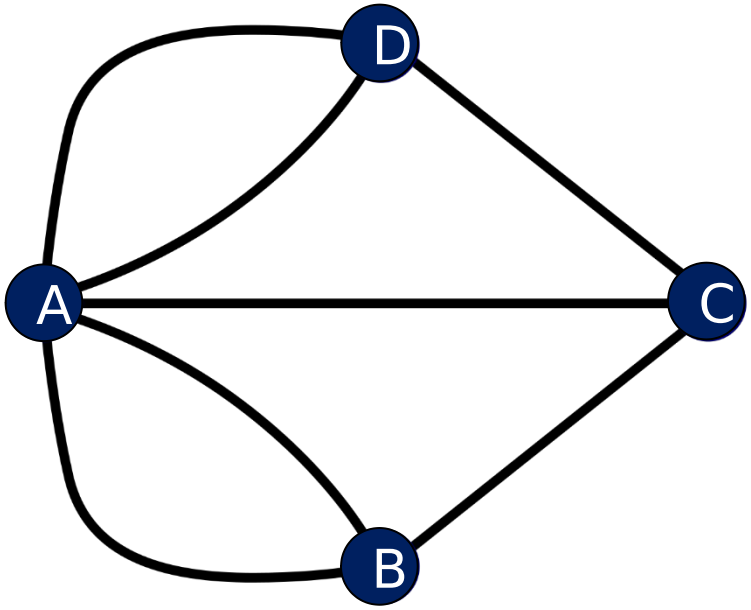


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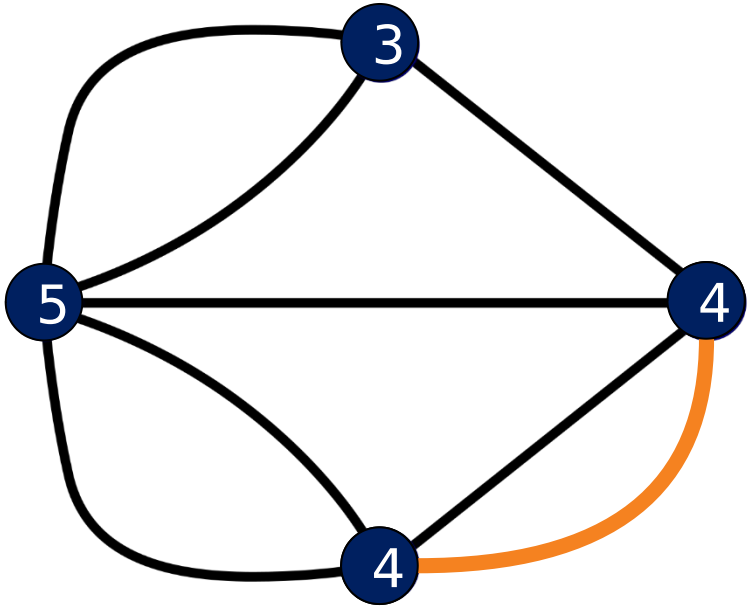


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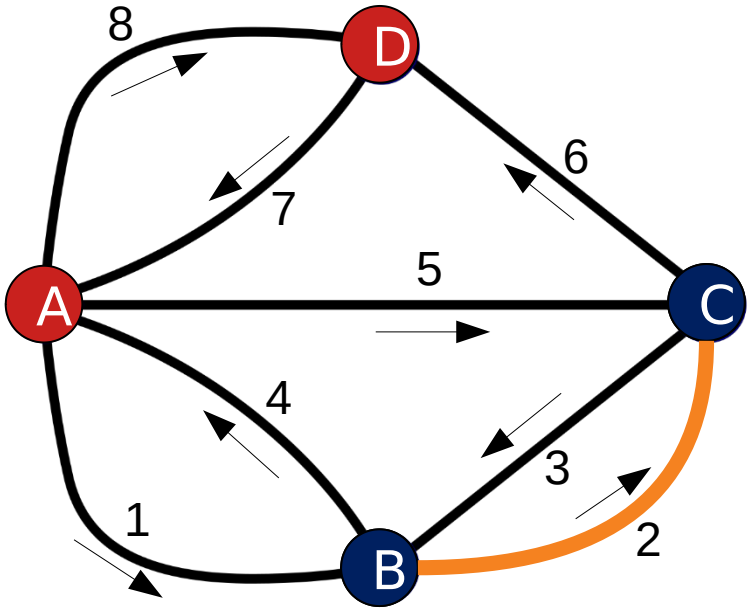


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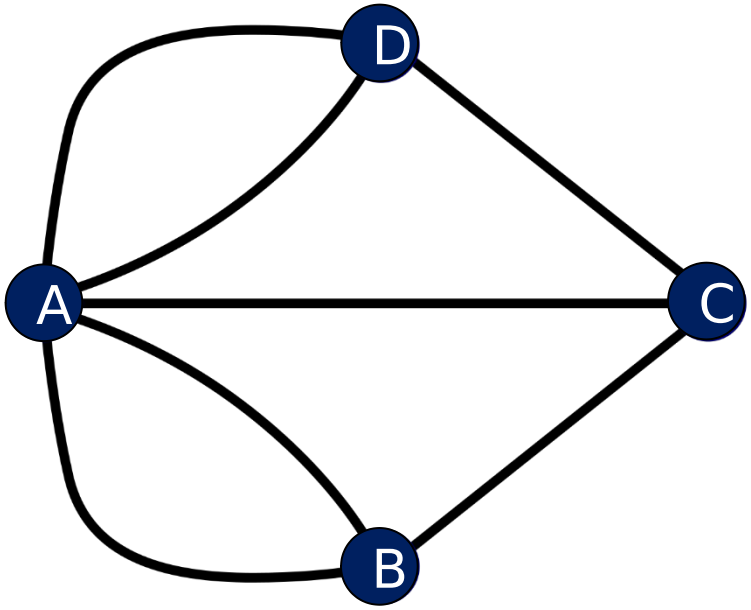
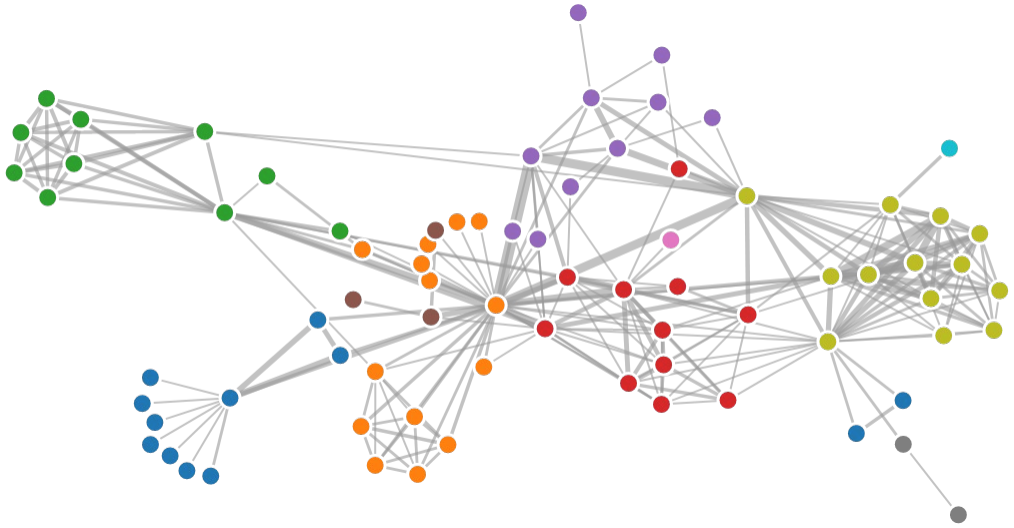



**Eulerian circuit or Eulerian cycle: Eulerian trail that starts and ends on the same nodes.**

**Condition for "Eulerian Cycle":**
All of nodes have an even number (>0) of connections to other nodes in the graph.

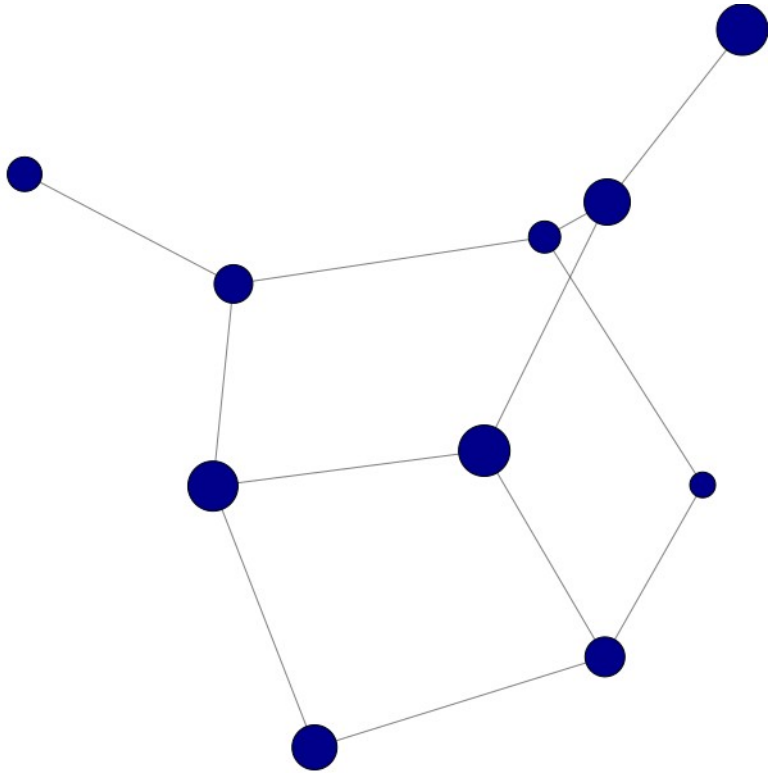


https://d3gt.com/unit.html?degree-of-vertex

# Basic Definitions

nodes/vertices

edges/links

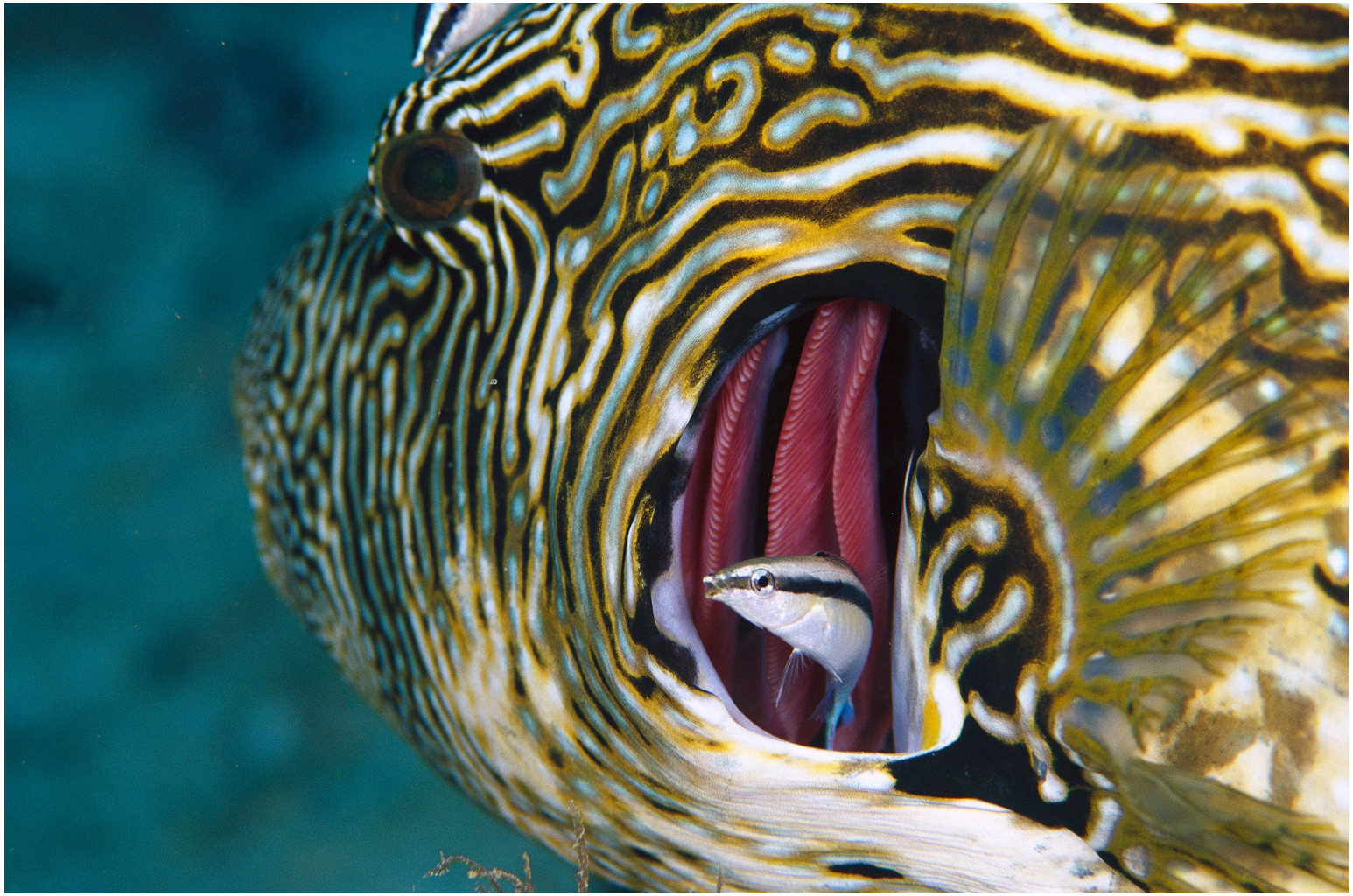


| Network | Nodes | Edges |
|---|---|---|
| Internet | Routers | Internet connections |
| WWW | Webpages | Hyperlinks |
| Social networks | Individuals | Social relations |
| Airport network | Airports | Direct flights |
| Protein interaction networks | Proteins | Binding interactions |
| Citation networks | Publications | Citations |
| Collaboration networks | Scientists | Coauthorship |
| Power grids | Power plants | Cables |

# Ecological Networks

plant-pollinator networks

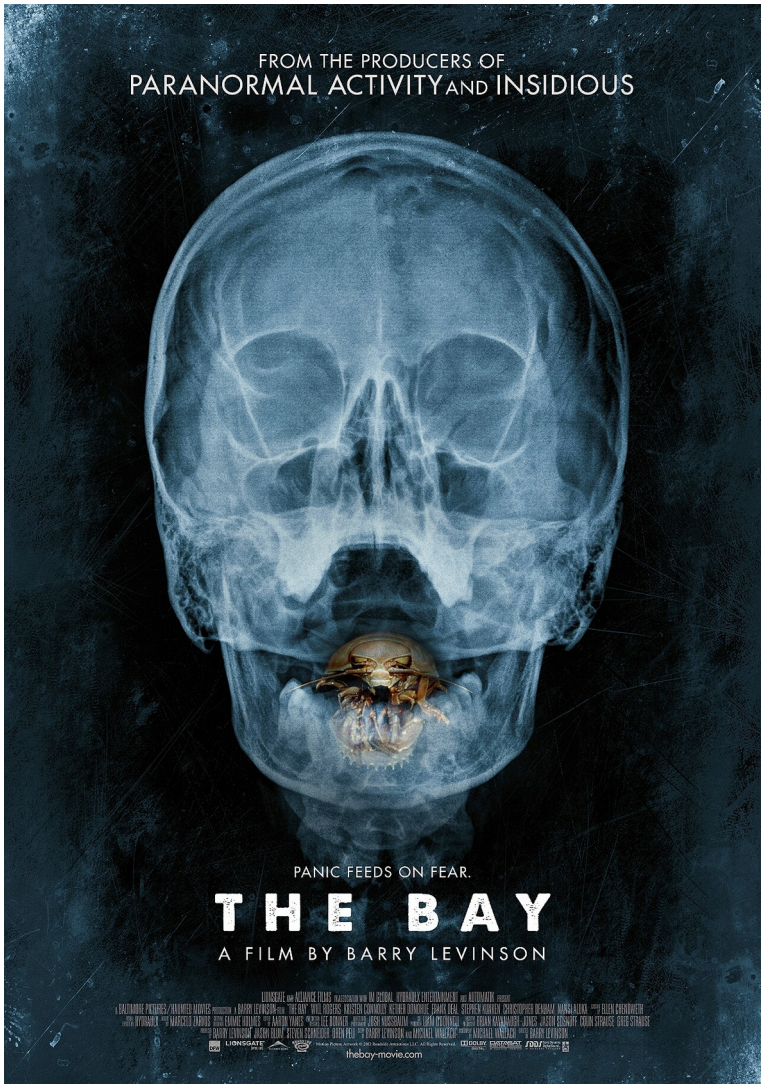
# seed-disperser networks



**cleaning-symbiosis networks**

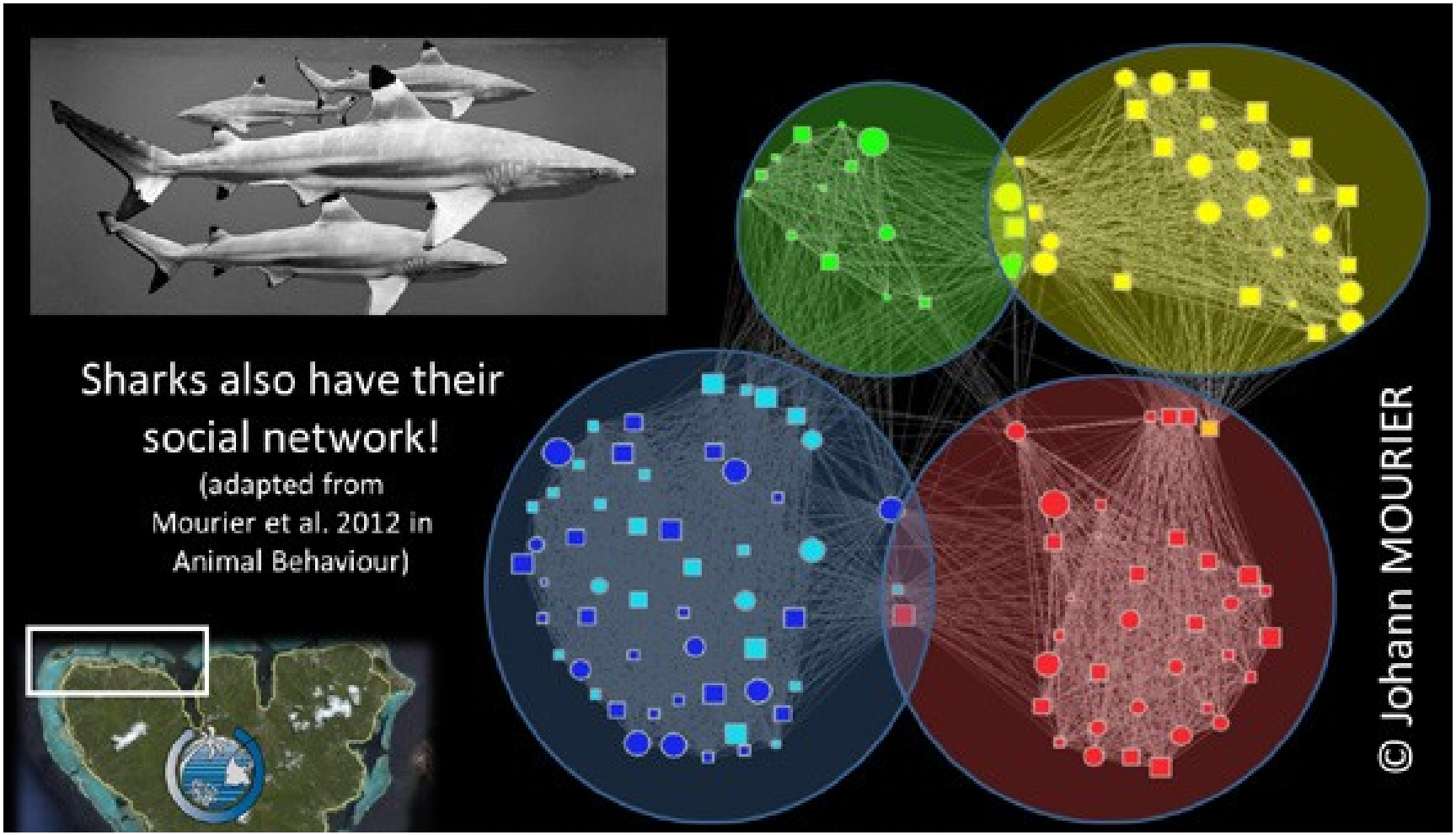
# dung beetle-mammal networks


# host-parasite networks




# host-parasite networks

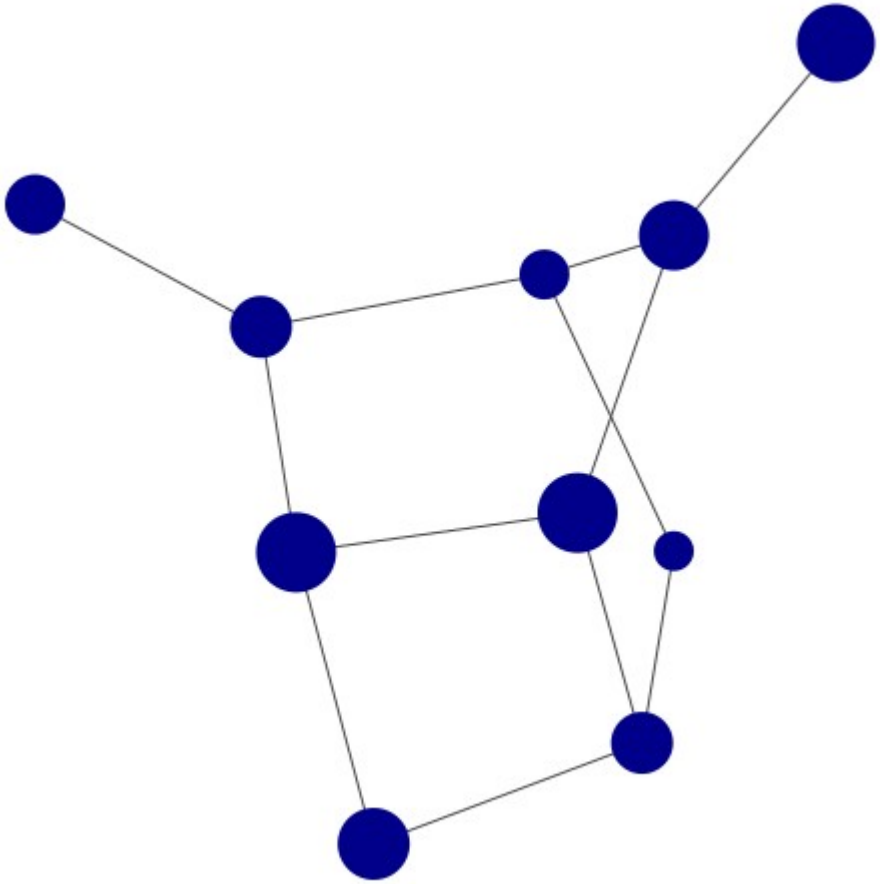
# trophic networks (food-webs)

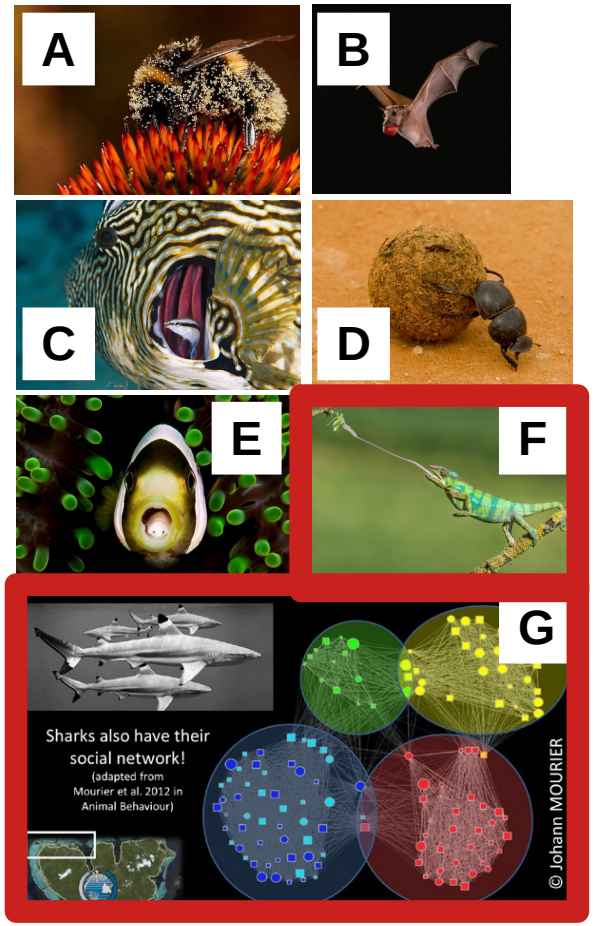



# animal social networks

# Network Classes

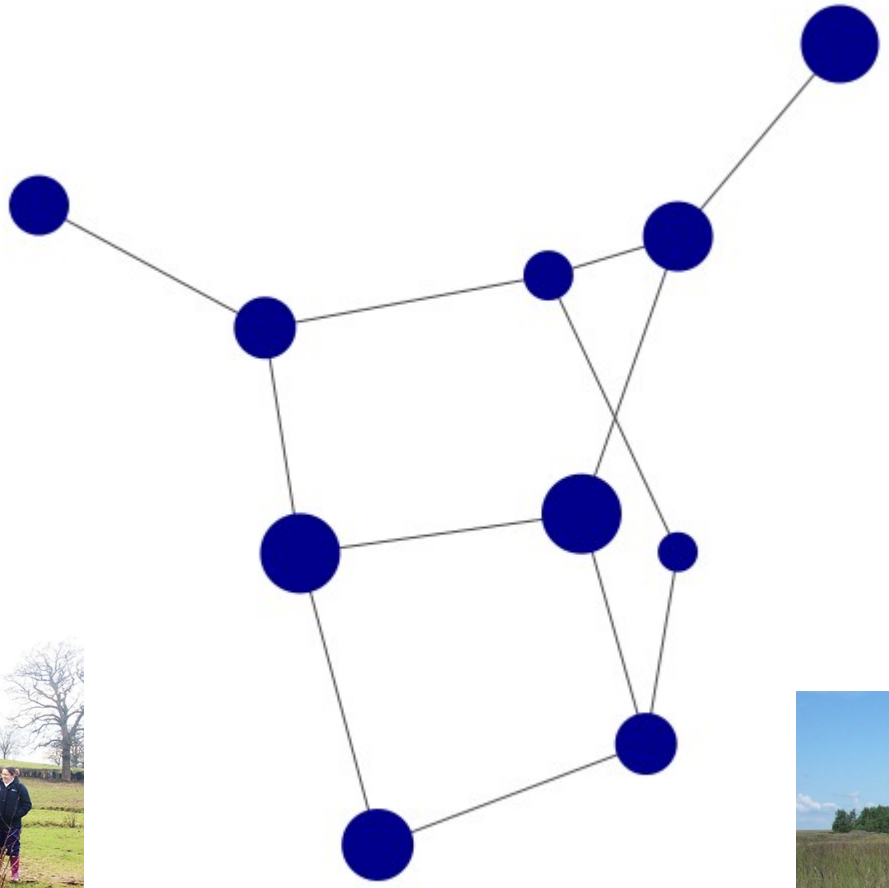
## Undirected vs. Directed





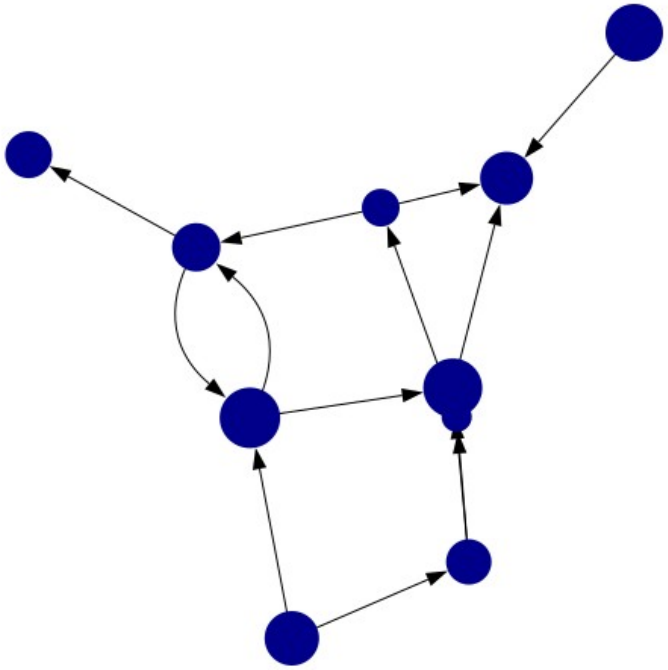
# Network Classes

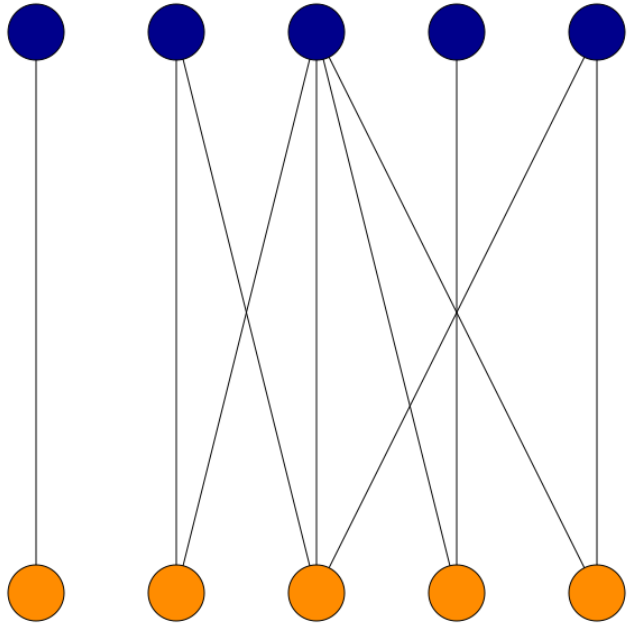
## Unweighted vs. Weighted

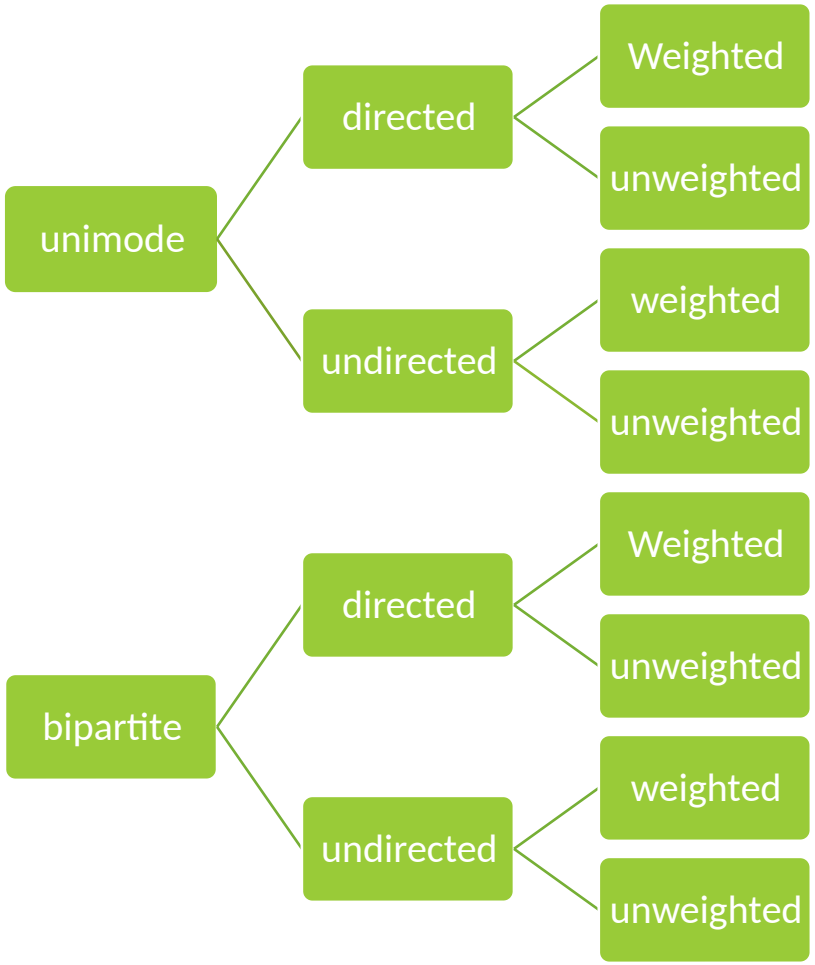


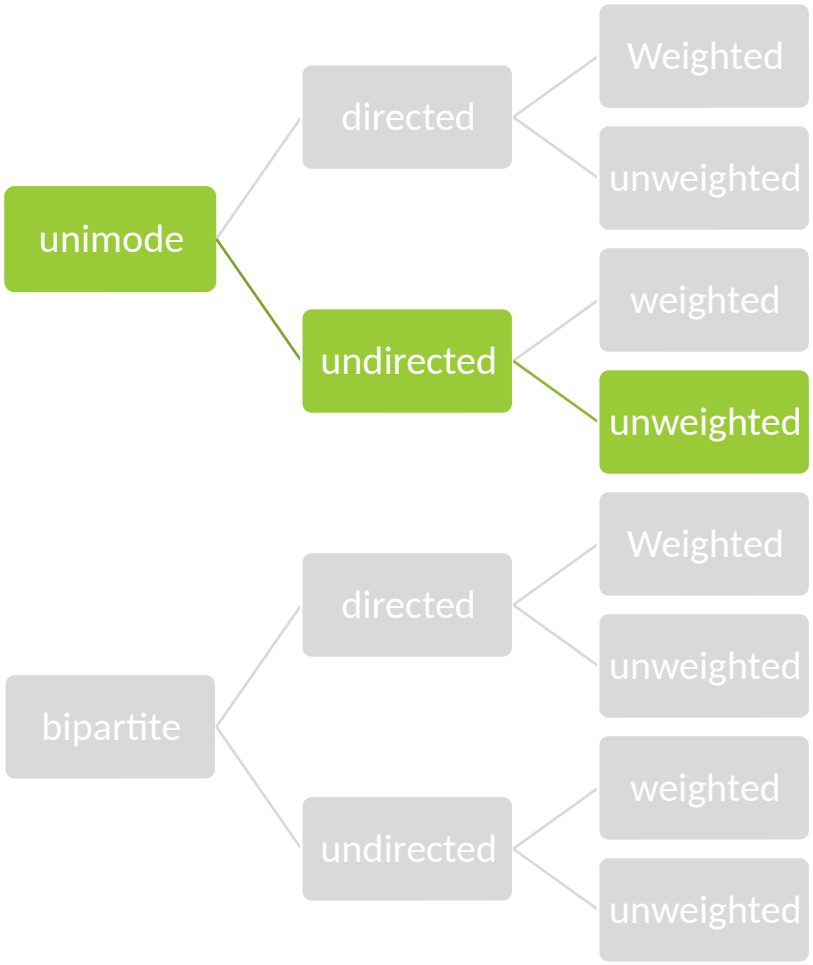
# Network Classes

## Unimode vs. Bipartite






unimode
directed
Weighted
unweighted
undirected
weighted
unweighted
bipartite
directed
Weighted
unweighted
undirected
weighted
unweighted


unimode
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bipartite
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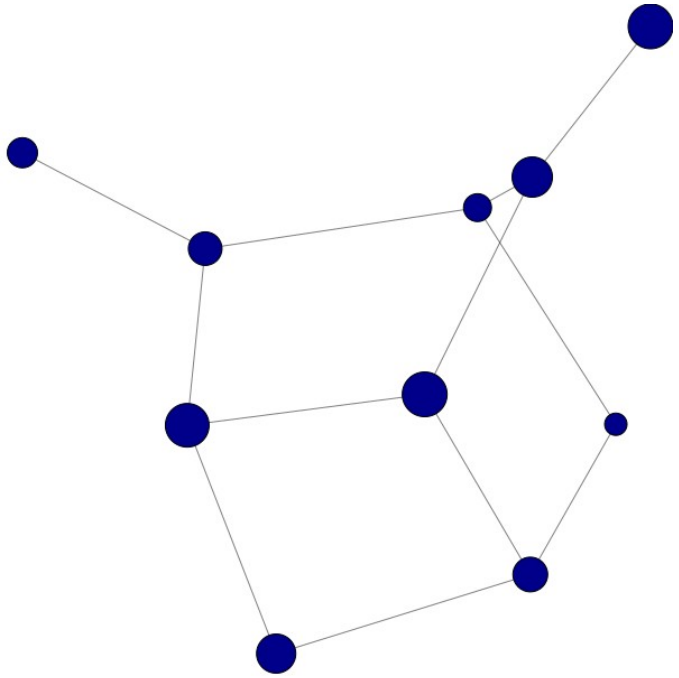

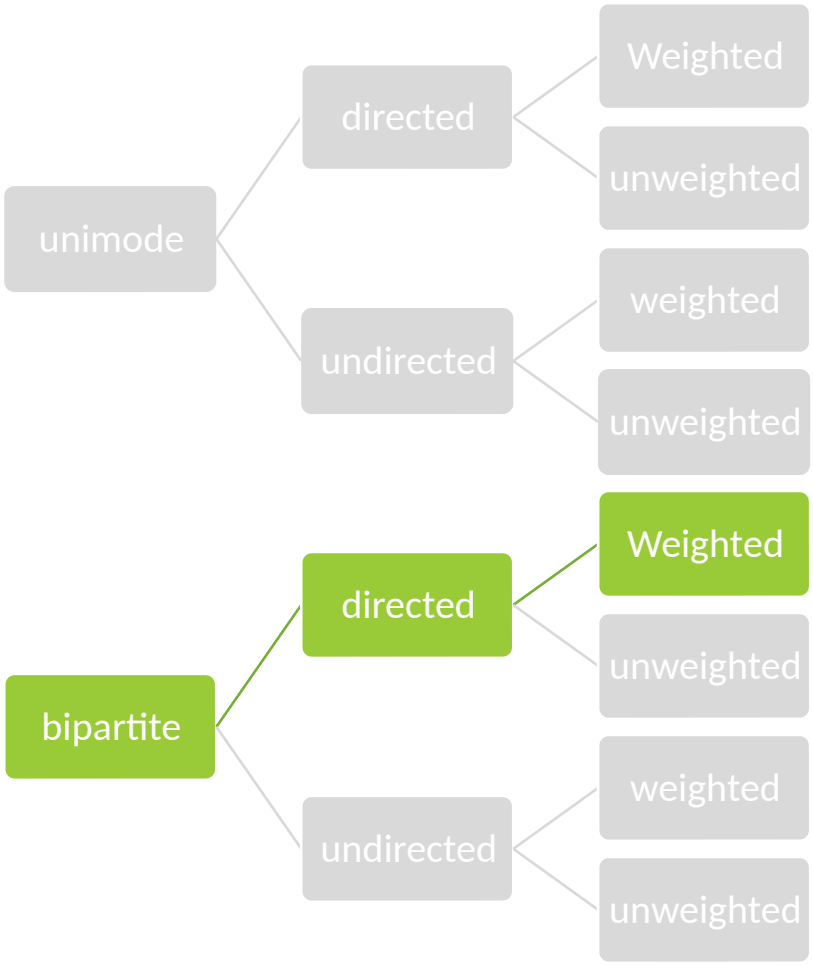
unimode
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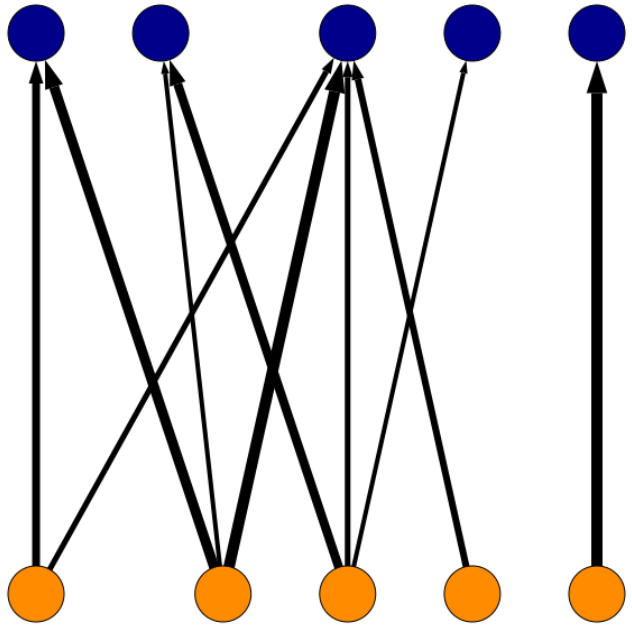
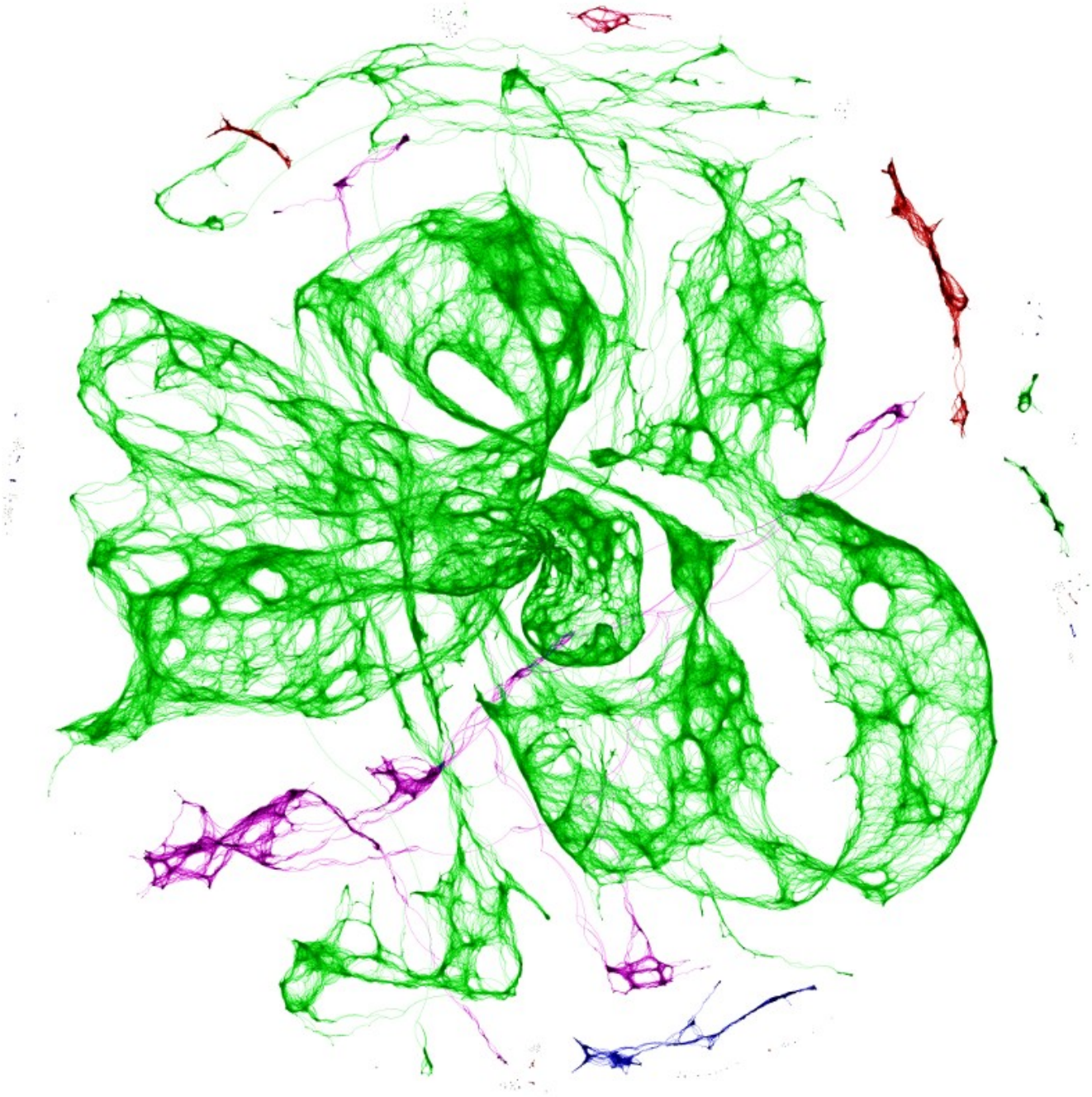
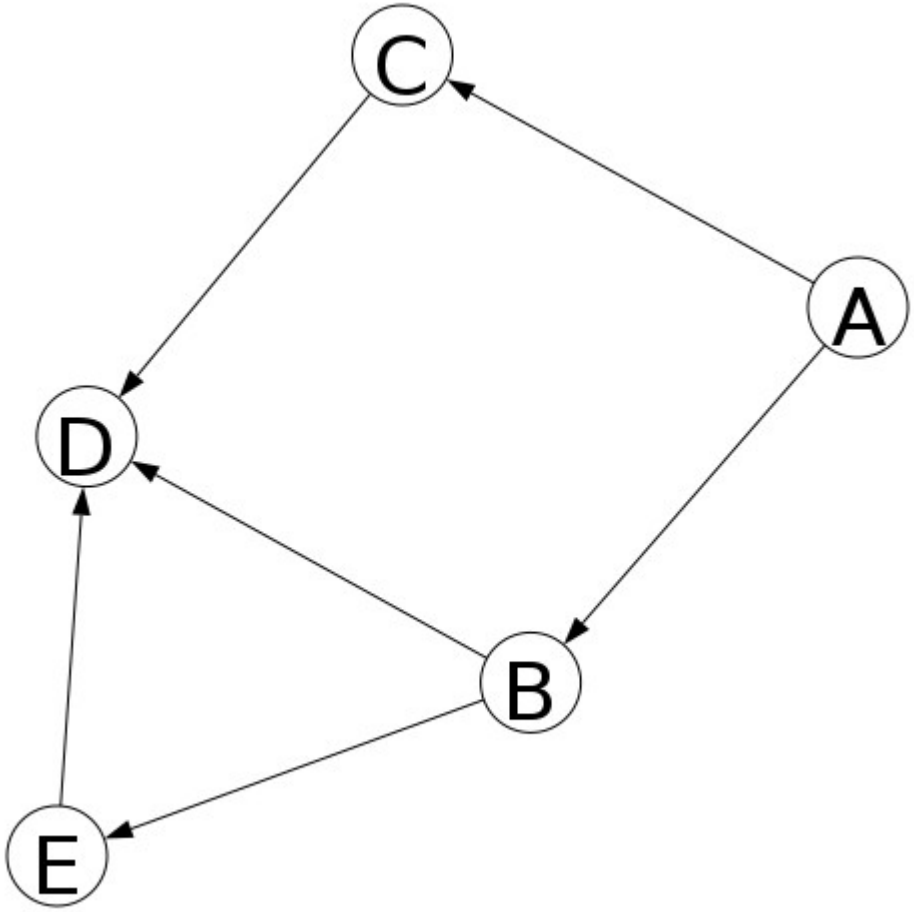




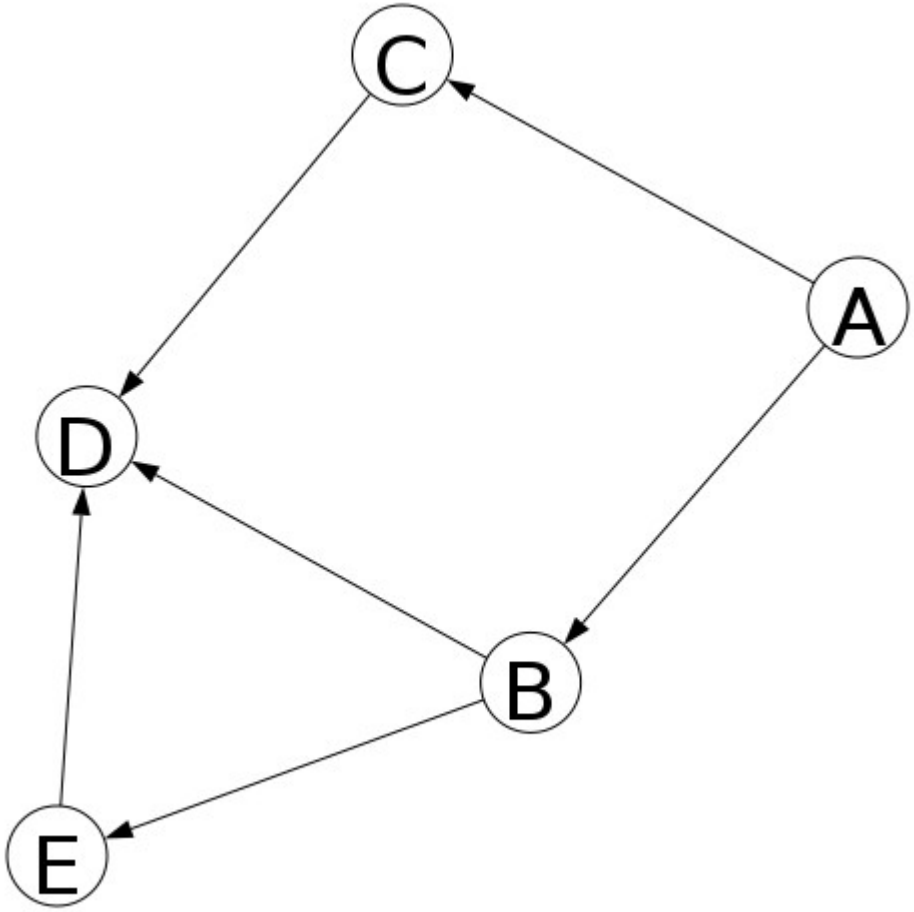
# Network Representation - Edgelist



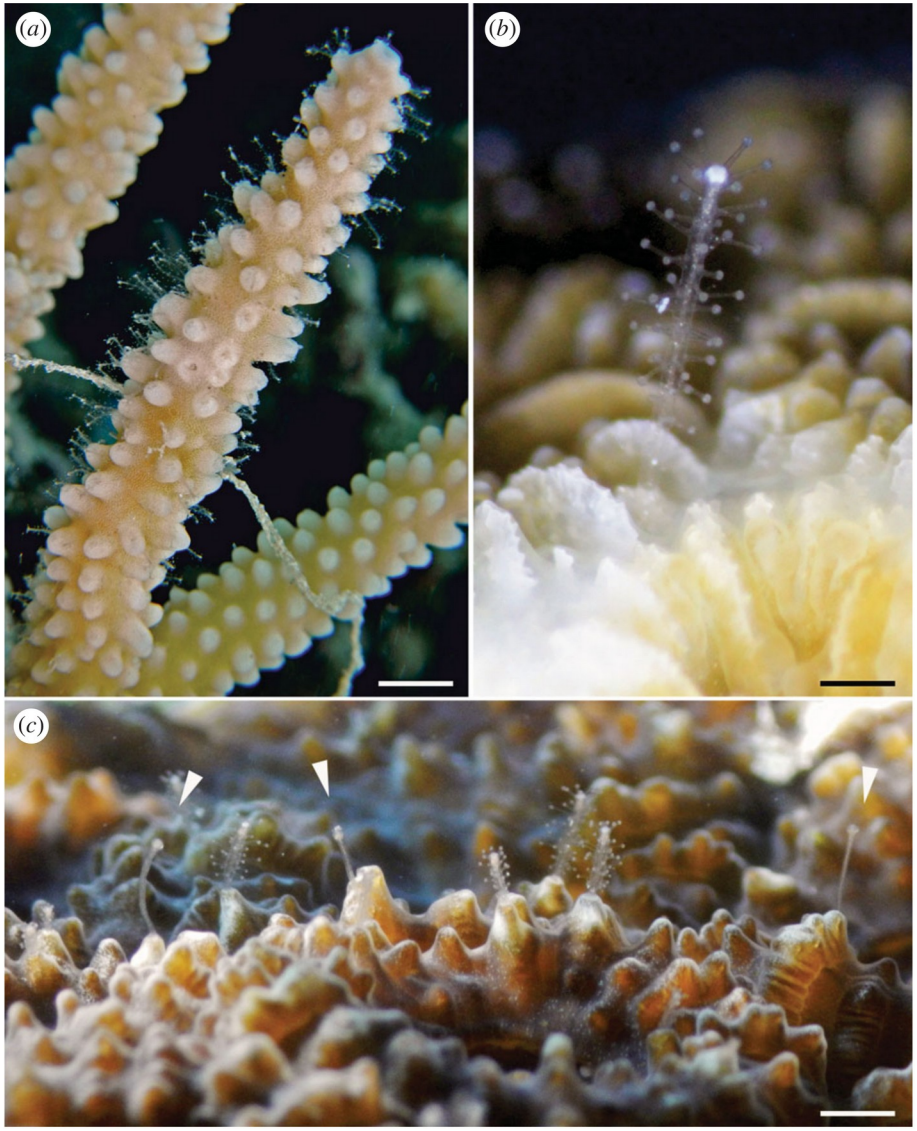

(A, B)
(A, C)
(B, D)
(B, E)
(C, D)
(E, D)

# Network Representation –Matrix

## Unimode Networks




| | A | B | C | D | E |
|---|---|---|---|---|---|
| **A** | 0 | 1 | 1 | 0 | 0 |
| **B** | 0 | 0 | 0 | 1 | 1 |
| **C** | 0 | 0 | 0 | 1 | 0 |
| **D** | 0 | 0 | 0 | 0 | 0 |
| **E** | 0 | 0 | 0 | 1 | 0 |




**Assignement**:

- Think at/look for some unusual/ poorly investigated class of ecological interactions that might be represented in form of a network
- Identify which kind of network (directed/undirected, weighted unweighted, bipartite/unimode) would be more suitable to represent the selected interaction.
- If possible/not too time consuming, try to arrange some of the interactions in either an edgelist or a matrix (or both).

Montano S, ..., **Strona G** (2017) Corals hosting symbiotic hydrozoans are less susceptible to predation and disease. Proceedings of the Royal Society B: Biological Sciences. 284(1869):20172405.

**Slides, additional material, suggested reading:**
https://github.com/giovannistrona/Ecological-Data-Representation

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