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## Network Science: String Network. Activity guide for facilitators

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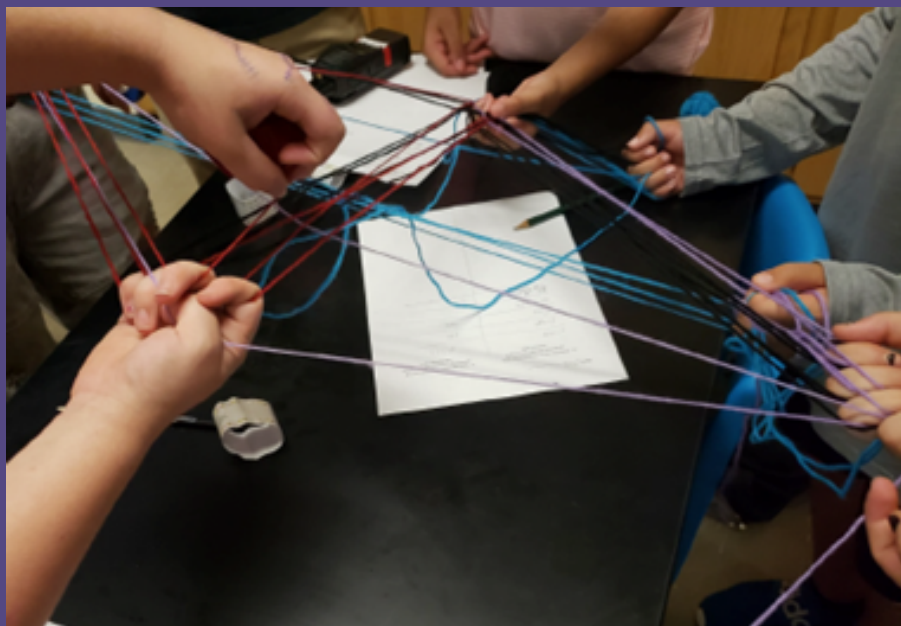
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# NETWORK SCIENCE

## String Network

Activity guide for facilitators



**WORLDS OF CONNECTIONS**  
SCIENCE EDUCATION PARTNERSHIP AWARD  
SUPPORTED BY THE NATIONAL INSTITUTES OF HEALTH

UNIVERSITY OF  
**Nebraska**  
Lincoln

# STRING NETWORK

## Next Generation Science Standards\*

**Crosscutting Concept 4. Systems and system models.** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

\*Next Generation Science Standards is a registered trademark of WestEd. Neither WestEd nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and do not endorse it.

## Objective

**Youth will understand and demonstrate** the importance of building and recognizing connections in a community. They will make a network model that reveals connections that may seem invisible until youth trace them. Youth will learn about the concept of 'six degrees of separation/small worlds' (i.e., how we may be connected to people far away through our friends' friends).

## Materials

### Per club

- Pre-made simple network picture (see **Demonstrations**, p. 10)
- Pre-made messy network picture (see **Demonstrations**, p. 11)
- Giant sticky note pad, whiteboard, or chalkboard

### Per youth

- **Interests Sheet** (p. 12)
- Writing utensil
- Coloring utensils

### Per group

- Balls of yarn/string/rope
- Painter's tape (optional)

## Anticipatory Set

Begin by leading an open discussion using the guiding questions below to spark youth curiosity and make them wonder about connections between people whom they might not already know.

- *How do you find people who share your interests?*
- *Do you like spending time with people who are more similar to or different from you?*



- *What is a system? Do the members of a club like ours form a system?*
- *What is a network? What are some examples of networks?*
  - Show the demonstration simple and messy networks as examples.

## Procedure

### Set-up

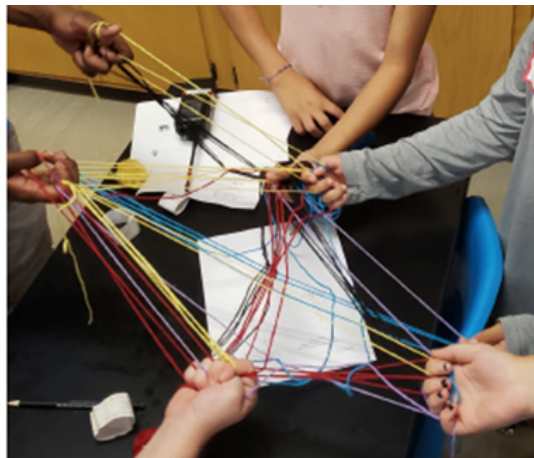
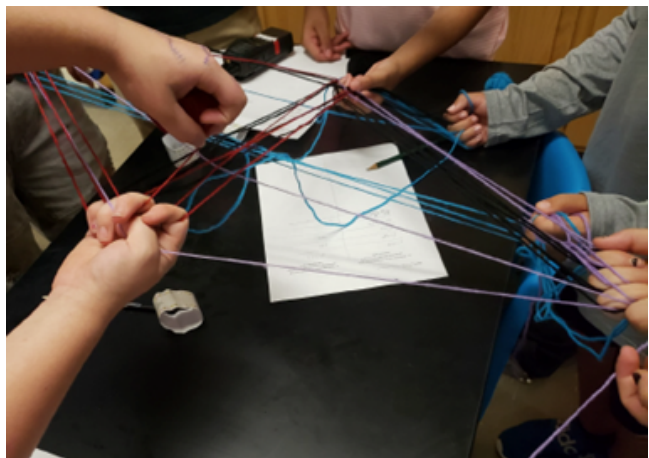
1. Set up tables for groups of 4-7.
2. Place several different colors of yarn at each table.
3. Place writing utensils and **Interest Sheets** (p. 12) for each youth at the tables.

### Activity 1 – Interests network

1. Introduce the activity by telling club members that they will discover shared interests and make networks based on those interests using the yarn.
2. Have youth fill out the **Interest Sheet**. Help youth who struggle with reading and/or writing. Be sure to allow youth some time to talk about their interests, listen to others, and experience feelings about what they share or not.
3. After talking to each other and discovering shared interests, each youth picks a color of yarn and holds onto one end. When they have something in common with another participant, they can hand them the other end of their yarn to form a connection. (See pictures below for examples.)

#### 4. Youth can decide...

- a. if they can both give each other yarn or just one of them passes their strand of yarn.
- b. what counts as a shared interest (e.g., someone who likes cats and someone who likes dogs both like animals.)
- c. if they want to hold the yarn or tape it down with painters' tape.

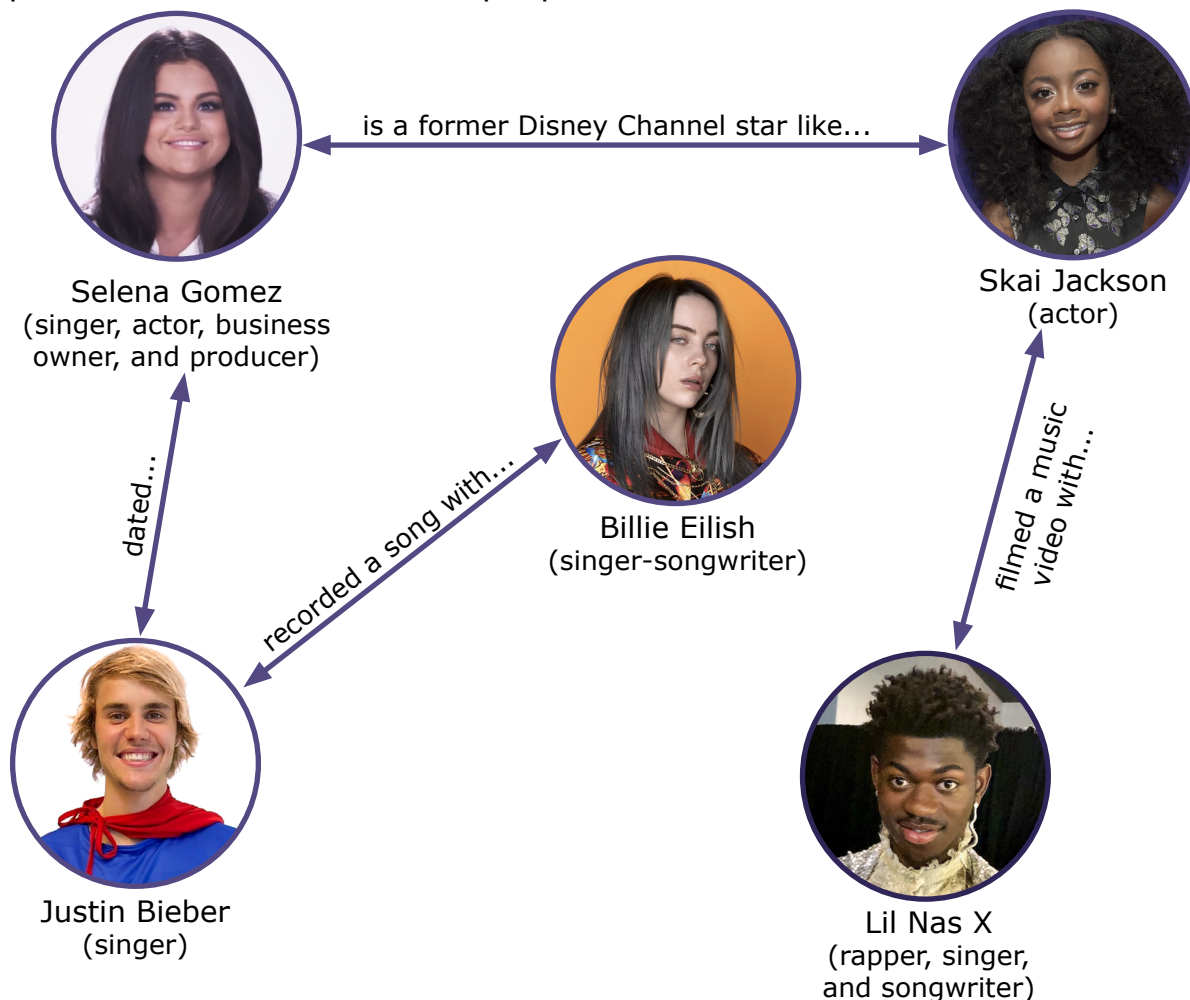


5. Pay attention to if any youth have no connections and try to help them find some, even if they are not on the **Interest Sheet**. For example, you can ask, *Can you think of other ways you might be connected?*
6. **Optional:** Once they finish the string network for their group, youth can try making connections to other groups, thus forming bridges between clusters.

## Activity 2 — Six degrees of separation (AKA the “Kevin Bacon game” or “small worlds” theory)

**Note:** This activity is better for youth grades 9+ who have knowledge of celebrity lives.

1. For this next activity, we are going to take a closer look at how many connections there really are between people.
2. Gather around the whiteboard (or chalkboard or giant sticky note pad). Assign groups as needed; each person/group gets their own color writing utensil.
3. Game rules:
  - a. Have the group decide on one real-life celebrity/public figure that everyone in the group knows and draw a circle (i.e., node) in the middle of the board with that person’s name next to it. Nodes in this game represent celebrities while the lines represent connections to other people.



- b. Then it is the first player's turn. If they know of a person who is connected to the chosen celebrity (e.g., they were in the same movie/they dated), they draw a line and a new node representing that new person and connection. The player should then write the name of that new person next to the new node as shown in the example
- c. Players will take turns adding nodes and making their own connections.
- d. People can make connections to anyone on their turn, but if they have no idea who to connect, they can pass.
- e. The game continues until time is up. Each connection equals one point. Players should add up how many lines in their color were in the network.

## Differentiation/Extension

This activity can be conducted in a virtual (remote learning) setting:

1. Set up a video conferencing meeting that enables screen sharing.
2. Make a tally form using a shareable online spreadsheet (e.g., Google Sheets) that has a column for each interest. Ask people to put their name in the first column and to answer the questions going across in each column.
3. If you have time, draw the network together on a digital whiteboard (e.g., Jamboard) or in a slideshow presentation (e.g., Google Slides).
4. On the digital whiteboard or presentation slides, play the celebrity connections game together or in breakout rooms.

## Reflection Questions for Discussion/Debrief

Questions for a debrief discussion to connect the activity to network science and health.

### Activity 1

- *Were you surprised by the number of connections between you and other people? Why or why not?*
- *What other networks can you think of? (Examples: networks that show the spread of rumors, diseases, ideas, knowledge, information about opportunities [e.g., places to live, jobs, access to food, transportation])*
- *Would you rather have many or few connections to other people? Does the answer depend upon anything?*
- *When is it helpful to know about connections that are not at first obvious?*

### Activity 2

- *Did the network become denser over time (more connections)?*



- *Were some celebrities more connected than others? Why or why not?*
- *Could you connect the celebrity to people in your hometown?*
- *Have you ever asked a friend of a friend for help?*
- *Some researchers who study networks have found that over time our friends' friends' can influence our behavior even if we do not realize it. These connections can influence behaviors such as smoking, exercising, suicide, or drinking alcohol. Can you think of ways to use knowledge of social networks to help make communities healthier?*

## Career/Future Application

Youth who enjoyed this activity might find being a data sleuth, or **forensic accountant**, interesting. Forensic accountants track potentially fraudulent leads through financial data.

Additional career activities would include becoming a **sociologist** and learning about communities. Sociologists use network science to discover how the shapes of networks influence who survives disasters, who discovers opportunities such as job openings, and how diseases spread.

Youth who like bringing people together through shared interests may enjoy a job as a **broker** (e.g., real estate broker, franchise broker, vehicle trader, or stock broker).

Other careers include **epidemiologist** (studying how diseases spread), **intelligence analyst** (using network analyses to study collusion), and **marketing specialist** (using social influence to get people interested in a new product).

## Background

**Note:** Some online resources have incorrect information about six degrees of separation.

### So what?

We are more connected to one another than we often realize.

When we simply look at other people or only know them superficially, we do not always realize how much we have in common. By learning about others and creating a string network of connections, youth can see the webs that connect us that are often invisible otherwise.

For the second activity about six degrees of separation, we are trying to demonstrate how a world with over 7 billion people can actually become “small” by mapping links between people (i.e., “small world phenomenon”).

### Resources for deeper exploration

Watch a video (about 9 minutes) that summarizes the science of six degrees of separation.



SCIENCE OF SIX DEGREES

Even though there are more people in the world than when the original research occurred in the 1960s, recent research suggests that we now have more like 4-5 degrees of separation. Read the article to learn more.



NETWORK SCIENCE

For a more detailed and mathematical exploration, read Section 3.8 on small worlds and six degrees of separation from the book *Network Science* by Albert-László Barabási. According to the book, even though the internet is vast, any two randomly selected webpages are separated by, on average, 19 degrees of separation.



SEPARATING YOU AND ME? 4.74 DEGREES

## Vocabulary

**Note:** The vocabulary terms are helpful for the activity facilitator to learn the scientific language used in the activity and within the network science community. You can decide if you want to emphasize vocabulary or not.

### Network

1) A set of relationships; 2) can be visualized as models to show how things are connected; 3) when mapped, reveal hidden information.

### Network model

A representation of a real-world network.

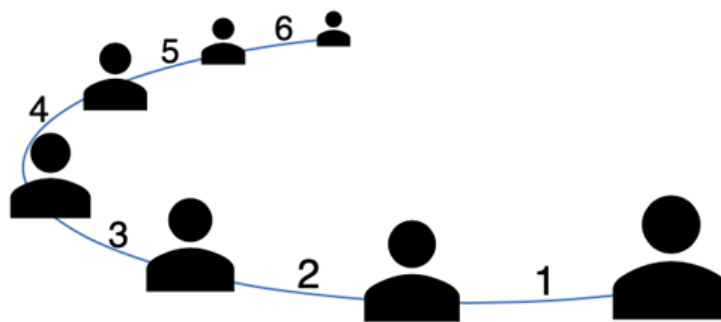


## System

"A system is a group of interacting, interrelated, and interdependent components that form a complex and unified whole" (Benson and Jost 2019). "Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems Models are limited in that they only represent certain aspects of the system under study" (NGSS Lead States 2013).

## Six degrees of separation/small world theory

A network science idea that if we randomly select any two people in the world, on average they could connect to one another through a maximum of only six people. Even though there are billions of people in the world, measuring network connections helps us see we really live in a "small world." In other words, if you don't know someone directly, you know someone who knows someone who knows someone, and therefore, on average, any two randomly selected people are connected by just six steps (i.e., degrees of separation).



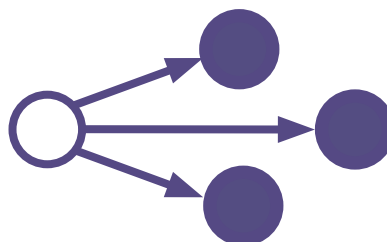
## Vertex (vertices)

Also called a node, usually drawn as a circle; can represent different things in a network (e.g., people, animals, cells in the body, organizations, etc.). For example, vertices or nodes in our immediate family can include siblings, guardians, and even pets.



## Degree

The number of lines a vertex has connected to it. The leftmost vertex pictured below has a degree of three:



## References

### Next Generation Science Standards crosscutting concepts

NGSS Lead States. (2013). APPENDIX G: Crosscutting concepts in the Next Generation Science Standards. In *Next Generation Science Standards: For States, By States*. Washington, DC: National Academies Press.

### Vocabulary terms were adapted from the following book

Nooy, W. D., A. Mrvar, & V. Batagelj. (2005). *Exploratory Social Network Analysis with Pajek*. Cambridge: Cambridge University Press.

### Our definition of "system" is from

Benson, T., and T. Jost. (2019). Introduction to systems thinking for early childhood. Waters Center for Systems Thinking CEELo Leadership Academy, Washington D.C., July 3—Aug 1, 2019. [http://ceelo.org/wp-content/uploads/2019/08/CEELO\\_2019Cohort5Workbook.pdf](http://ceelo.org/wp-content/uploads/2019/08/CEELO_2019Cohort5Workbook.pdf)

### Pre-made messy network

Goh, K.-i., M.E. Cusick, D. Valle, B. Childs, M. Vidal, and A.-L. Barabási. 2007. The human disease network. *PNAS*. 104:21:8685-8690. <https://www.pnas.org/content/pnas/104/21/8685.full.pdf>

### The following source contains information on Stanley Milgram's small-world study

Travers, Jeffrey & Stanley Milgram. (1977). An experimental study of the small world problem. In *Social Networks: A Developing Paradigm*, ed. Samuel Leinhardt, 179-97. Cambridge, MA: Academic Press. <https://doi.org/10.1016/B978-0-12-442450-0.50018-3>

Markoff, John & Somini Sengupta. (2011). Separating you and me? 4.74 degrees. *The New York Times*. <https://www.nytimes.com/2011/11/22/technology/between-you-and-me-4-74-degrees.html>

### Resources for deeper exploration

Barabási, Albert-László. (2015). Small worlds. In *Network Science* [Online], Section 3.8. Cambridge, UK: Cambridge University Press. <http://networksciencebook.org/chapter/3#small-worlds>

Veritasium. (2015, August 25). *The science of six degrees of separation* [Video]. YouTube. <https://www.youtube.com/watch?v=TcxZSmzPw8k>

Wheaton, Kristan J. & Melonie K. Richey. (2014). The potential of social network analysis in intelligence. *E-International Relations*. <https://www.e-ir.info/2014/01/09/the-potential-of-social-network-analysis-in-intelligence/>

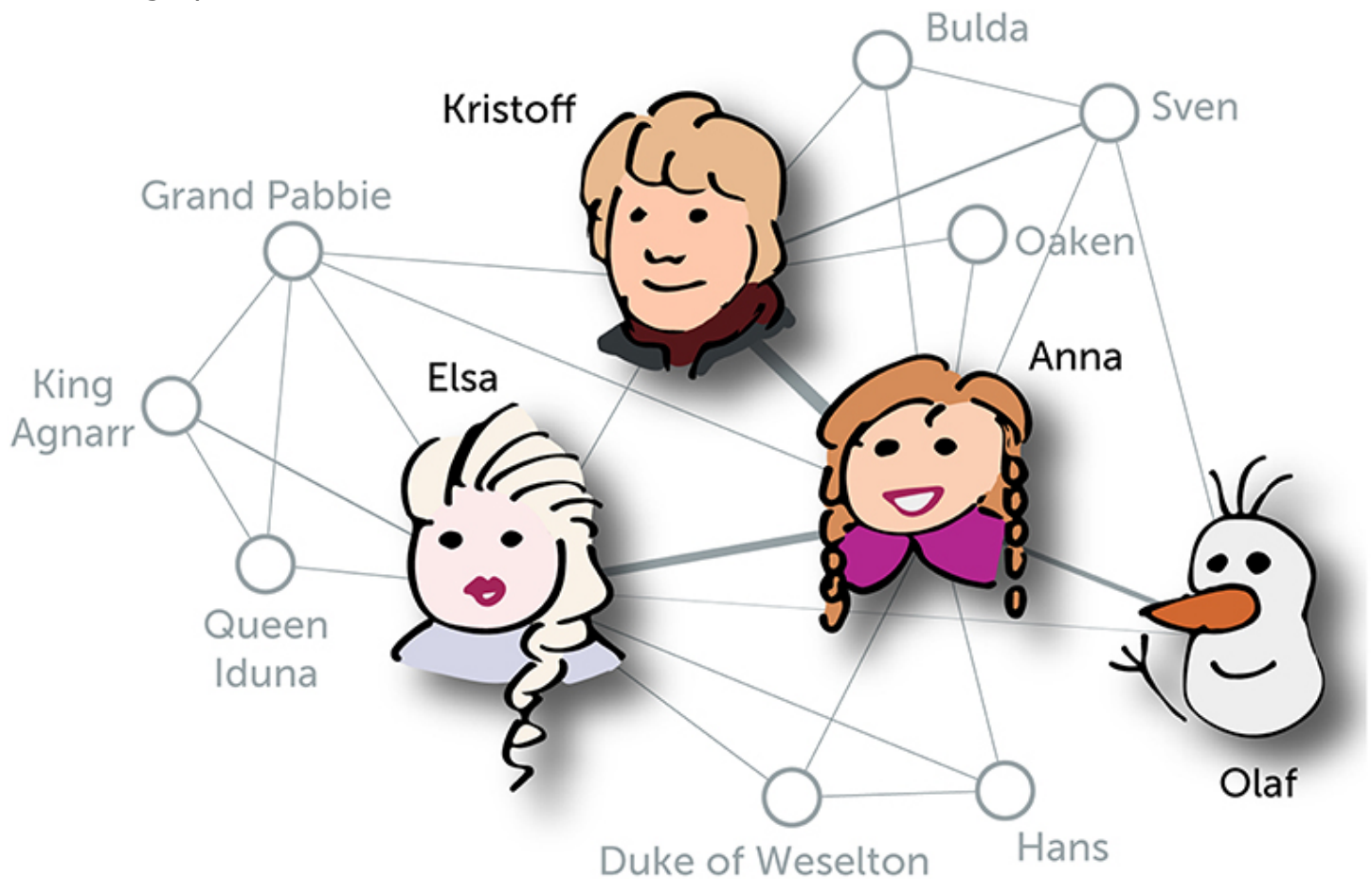
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## Demonstrations

### Pre-made simple network

Network graph of the main characters in *Frozen*



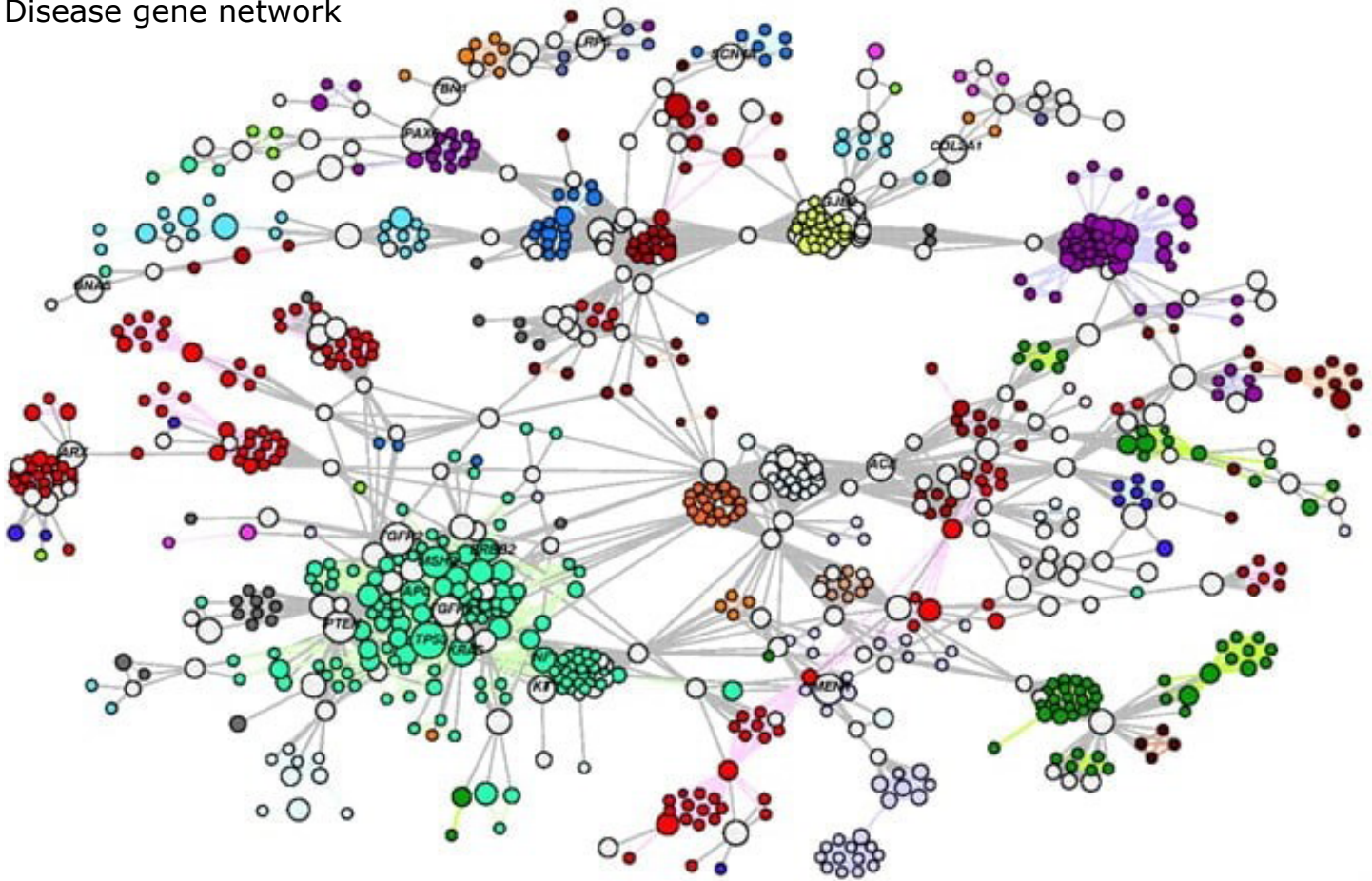
The **nodes** of this network represent the people who are a part of the network such as Anna, Elsa, Kristoff, Olaf, Hans. The **edges** or **links** are the lines that connect the main characters together if they talk to each other. The more that they say to each other, the thicker the line between the two characters.

**Source:** Holme P, Porter M and Sayama H (2019). Who Is the Most Important Character in Frozen? What Networks Can Tell Us About the World. *Front. Young Minds*. 7:99. doi: 10.3389/frym.2019.00099. <https://kids.frontiersin.org/article/10.3389/frym.2019.00099> .



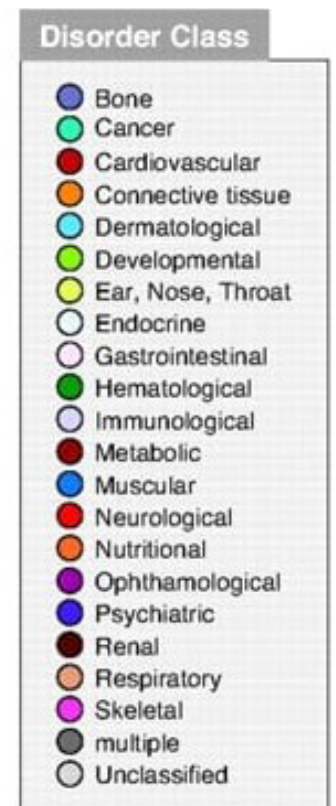
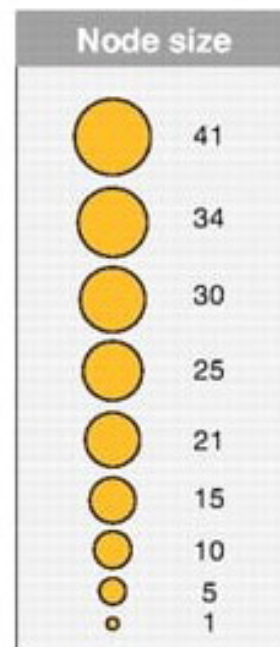
## Pre-made messy network

Disease gene network



In the disease gene network, each **node** represents a gene, with two genes connected if they are both involved in the same disorder. The size of each node represents the number of disorders in which the gene is involved. These graphs illustrate the common genetic origin of many diseases.

**Source:** Goh, Kwang-il, Michael E. Cusick, David Valle, Barton Childs, Marc Vidal, and Albert-Laszlo Barabasi. 2007. The human disease network. *PNAS*. 104:21:8685-8690. <https://www.pnas.org/content/pnas/104/21/8685.full.pdf>



# Interests Sheet

Name: \_\_\_\_\_

Answer the questions below. Write as many answers as you can.

## Who am I?

(**Examples:** student, sibling, scientist, curious, funny)

- 1.
- 2.
- 3.
- 4.
- 5.



## What are my favorite places?

(**Examples:** parks, stores, restaurants, cities, states)

- 1.
- 2.
- 3.
- 4.
- 5.



## What are my favorite foods?

(**Examples:** pizza, cookies, spinach, apples)

- 1.
- 2.
- 3.
- 4.
- 5.



## What are my favorite hobbies or games?

(**Examples:** reading, sports, video games)

- 1.
- 2.
- 3.
- 4.
- 5.

