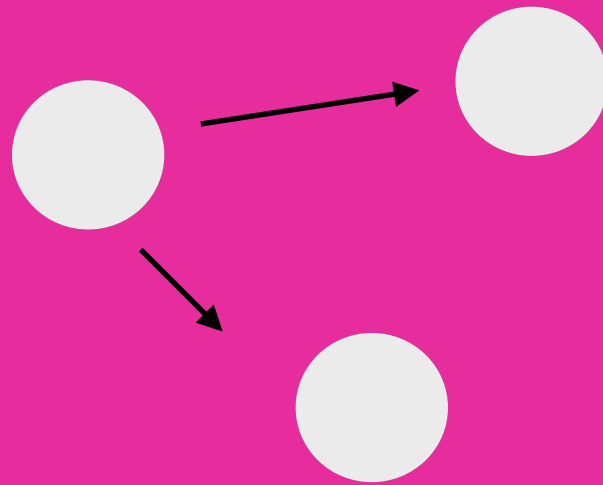
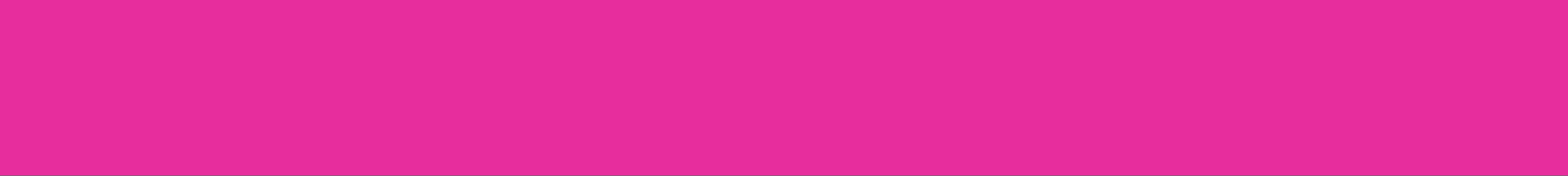


Mean Girls

*And*



*Graph Theory*



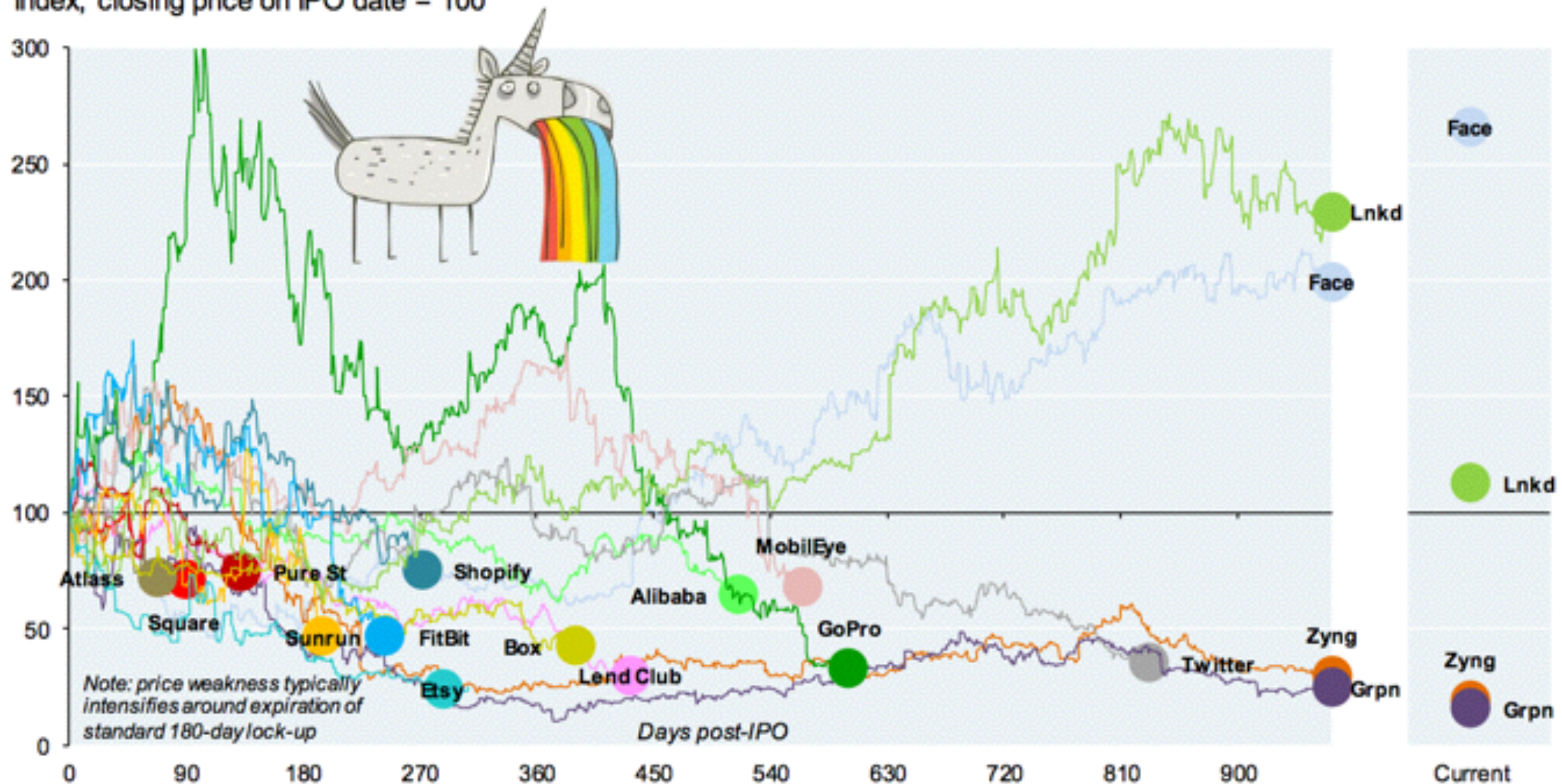
# What is Graph Theory:

What is Graph Theory:

The study of graphs

# Here is a graph!

**Many unicorns finding it hard to survive in the wilderness**  
Index, closing price on IPO date = 100



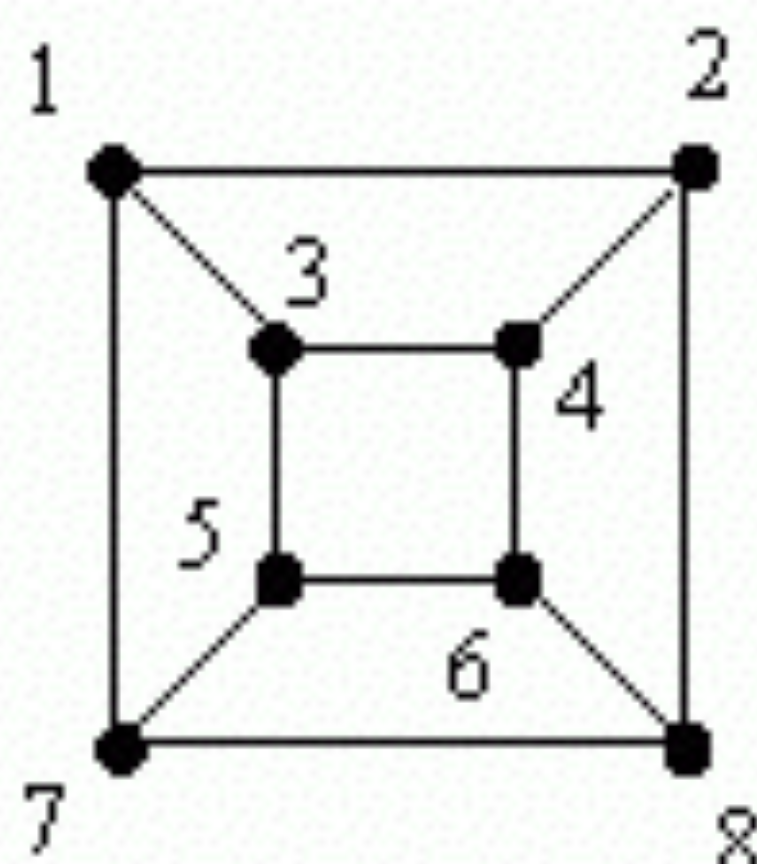
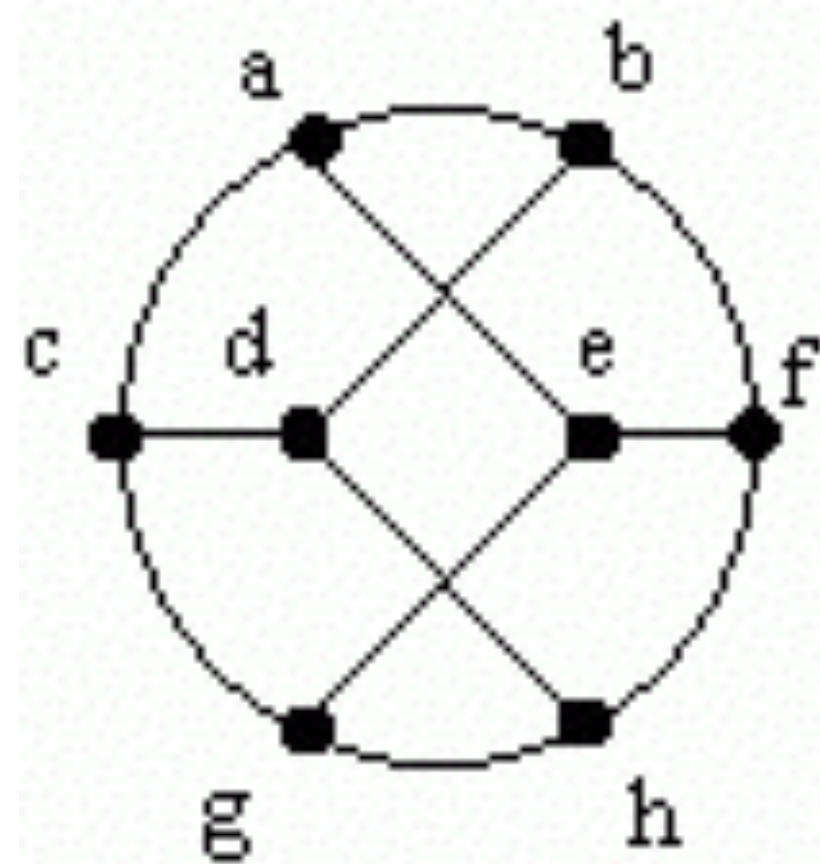
Source: Bloomberg, Techcrunch, JPMAM. February 16, 2016. "Current" shows most recent price index for companies public for more than 980 days.

No, not that kind of graph

No, not that kind of graph

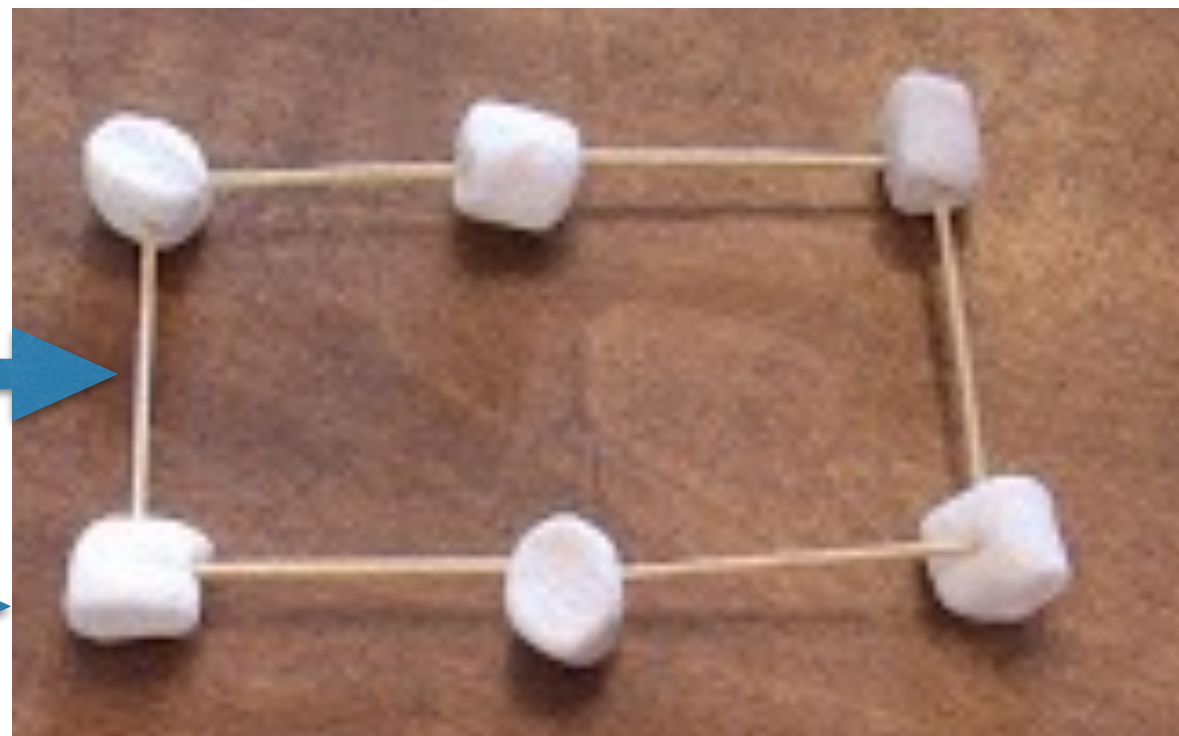
This kind of graph

A graph is an ordered pair  $G = (V, E)$  comprising a set  $V$  of vertices or nodes or points together with a set  $E$  of edges or arcs or lines, which are 2-element subsets of  $V$  (i.e. an edge is related with two vertices, and the relation is represented as an unordered pair of the vertices with respect to the particular edge).



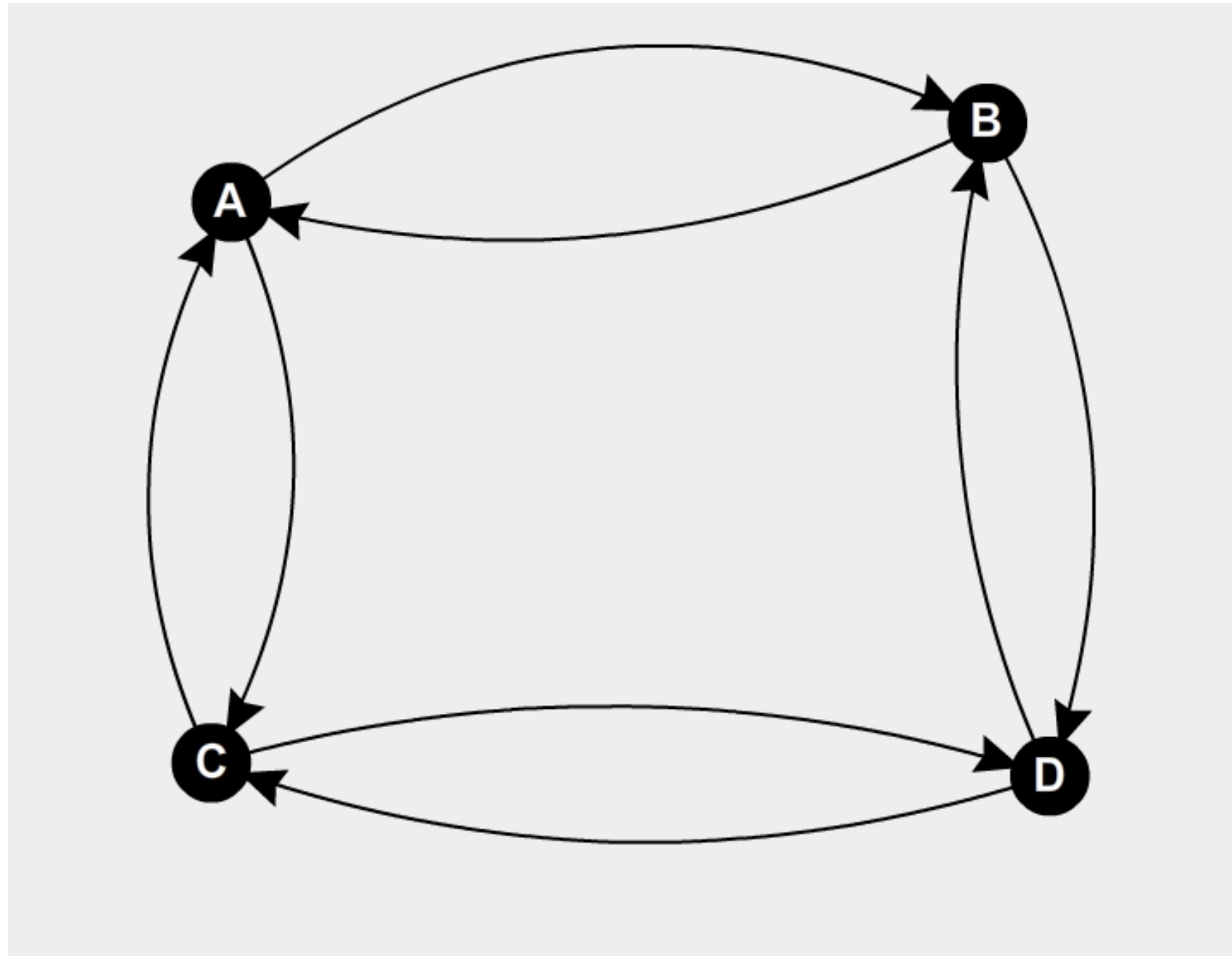
$G =$

$E$   
 $V$

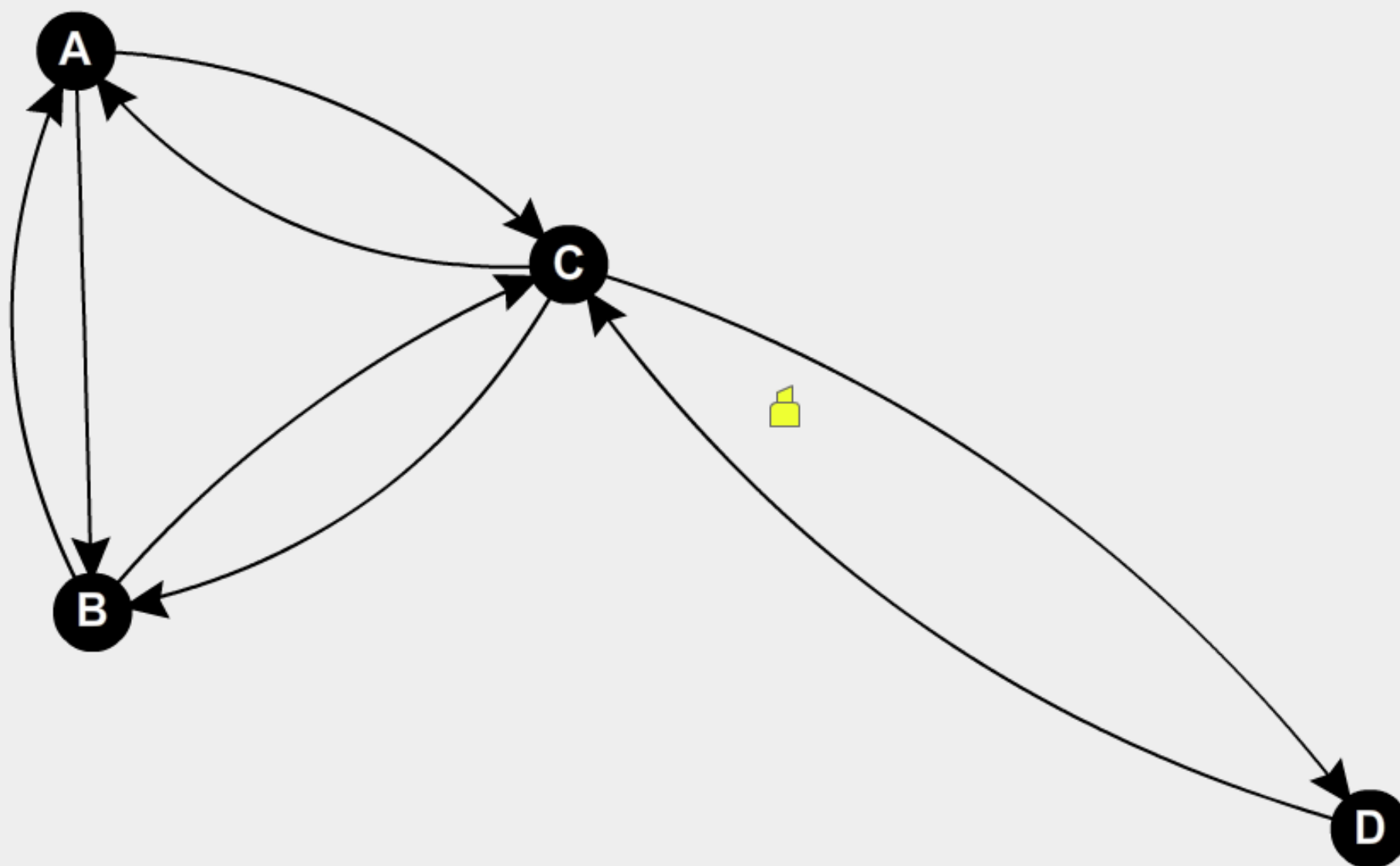












Why do we care?

To see who is popular



Famous: everyone knows you

Ignorantly Famous: everyone knows you, BUT  
you don't know everyone



Famous: there is a directed edge that can be traced from every node to the target node, AND the target node has a directed edge connecting to every other node in the graph

Ignorantly Famous: there is a directed edge that can be traced from every node to the target node

Gretchen

Karen

Regina George

Katie





Football dude

Gretchen

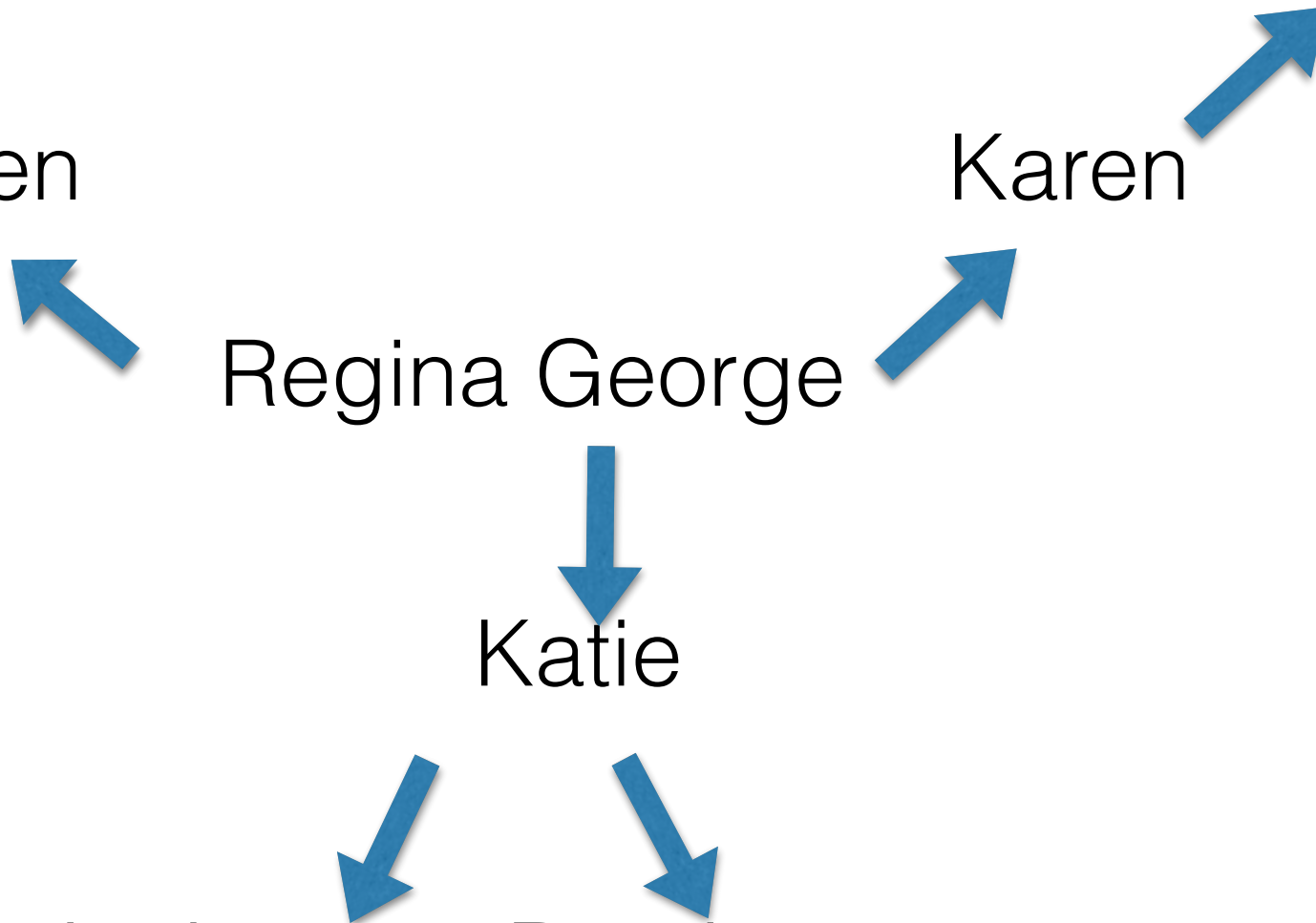
Karen

Regina George

Katie

Janice

Damien



Football dude

Gretchen

Karen

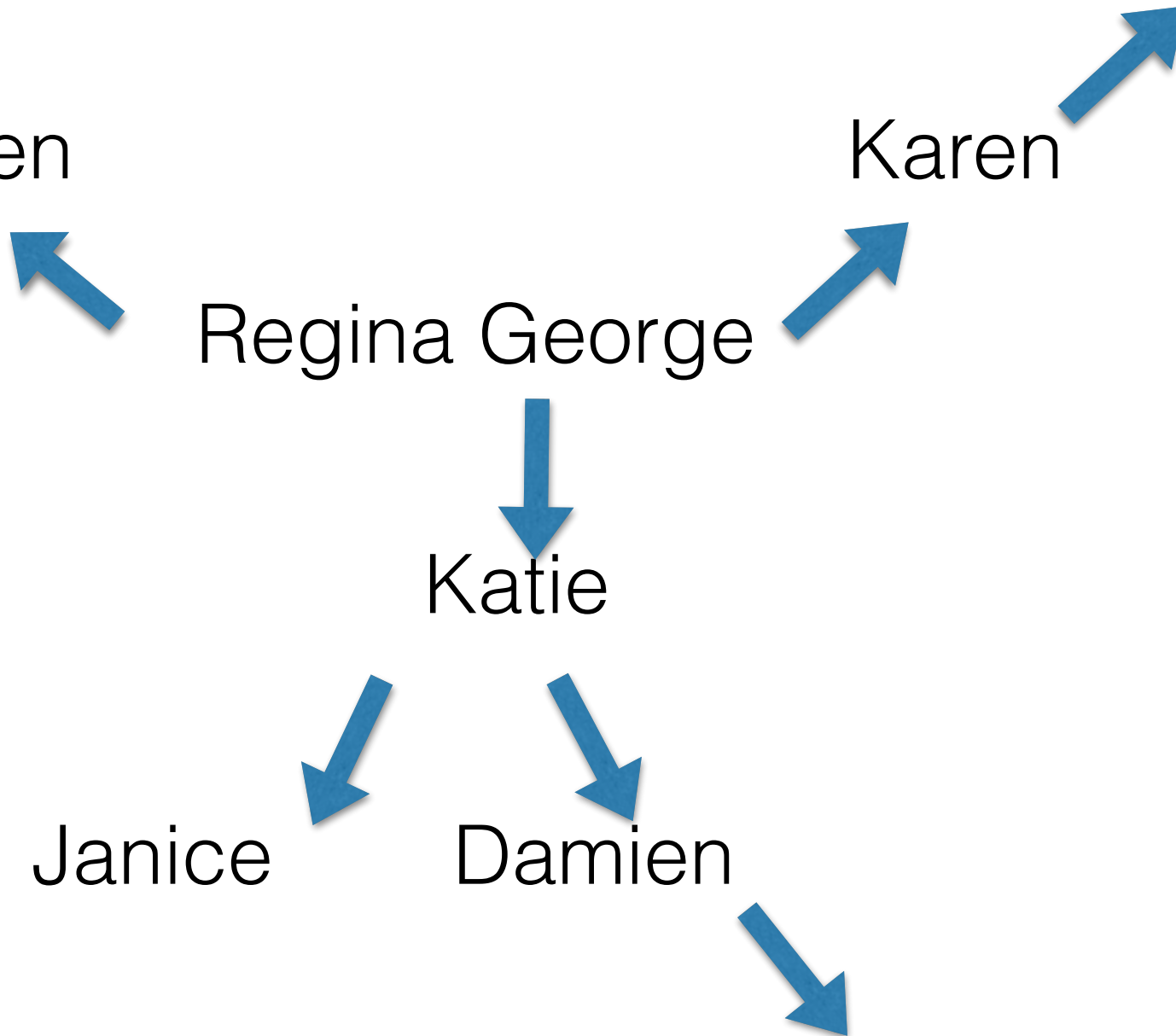
Regina George

Katie

Janice

Damien

Math guy



Football dude

Gretchen

Karen

Regina George

Katie

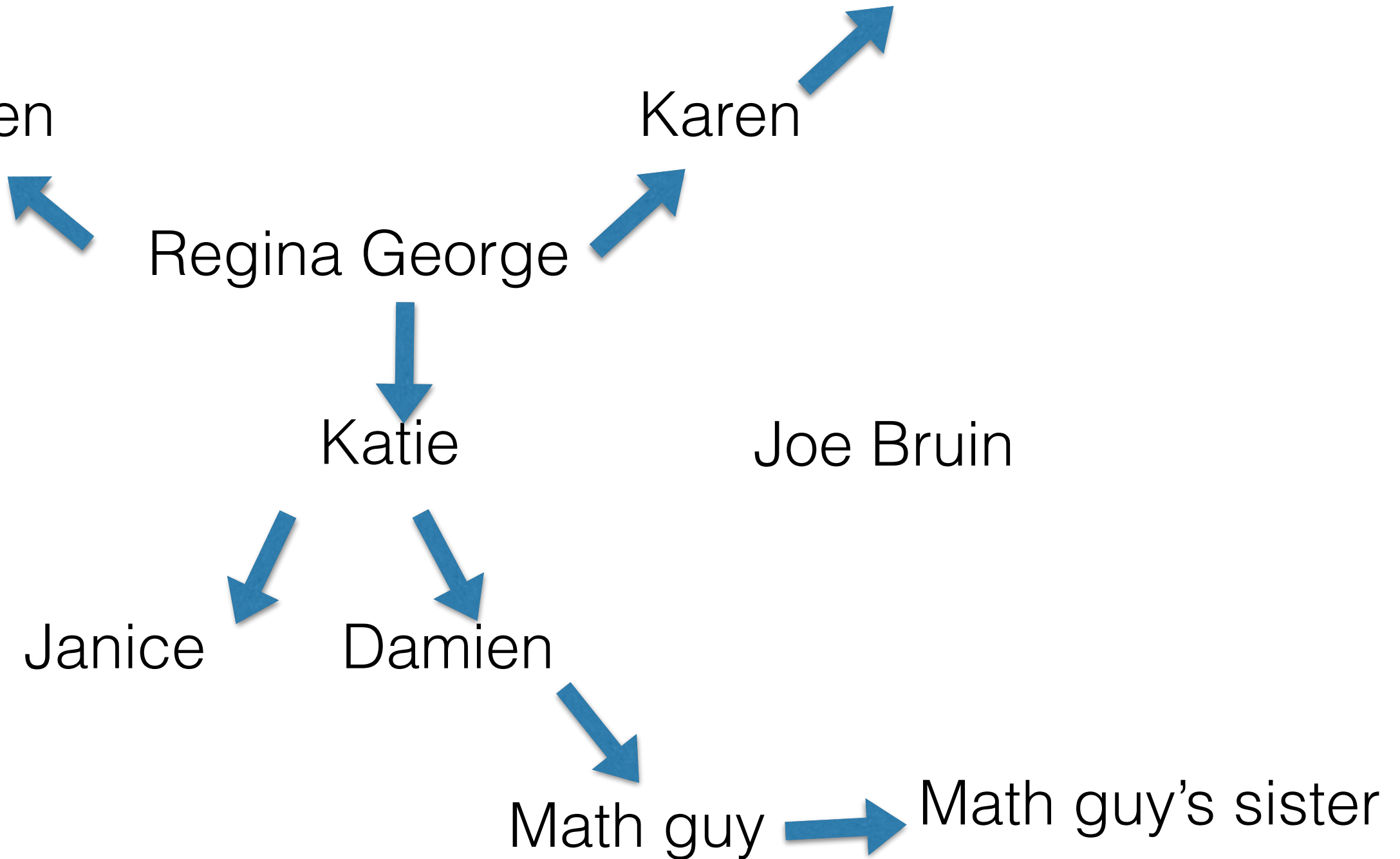
Joe Bruin

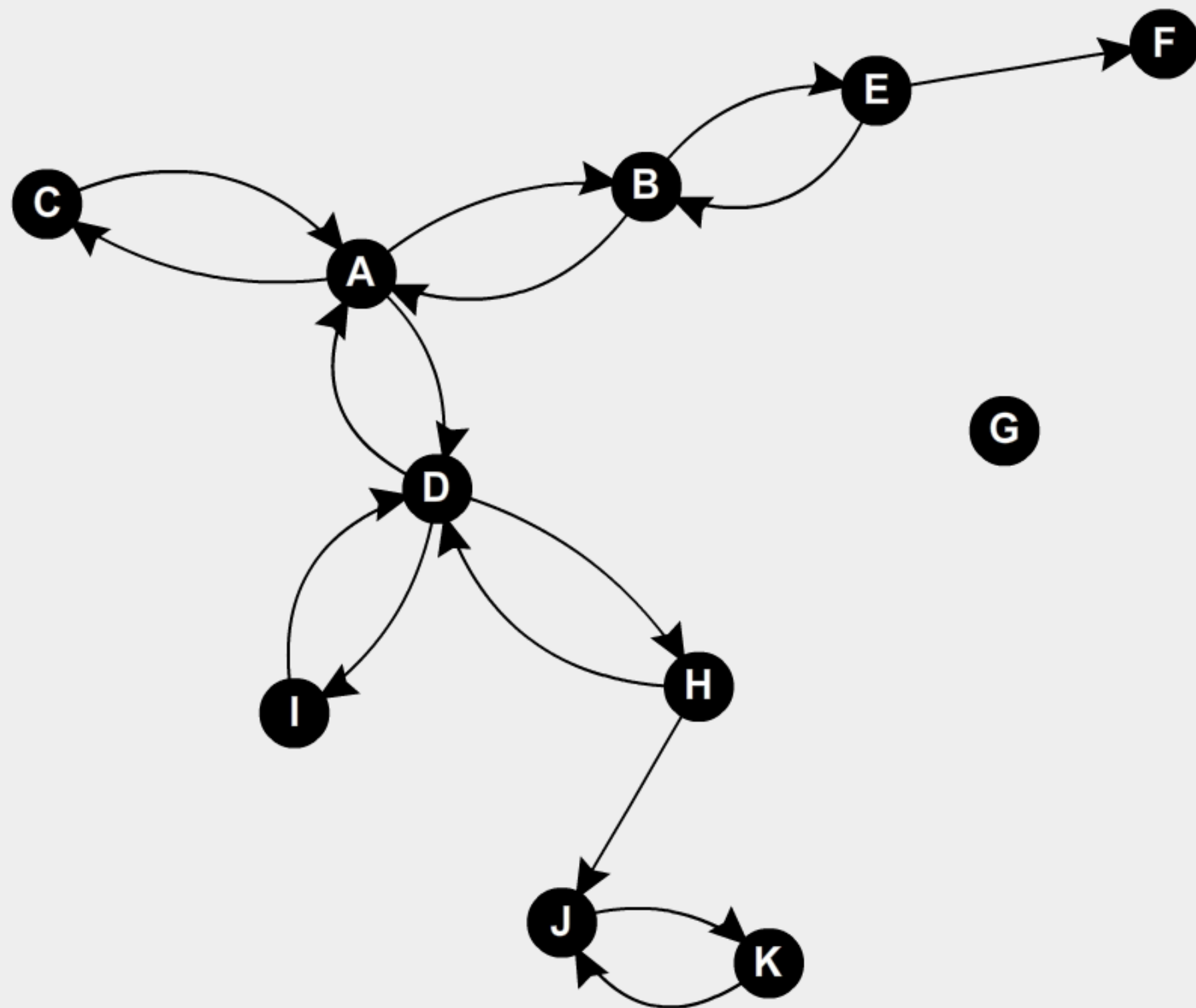
Janice

Damien

Math guy

Math guy's sister





Regina-George Number: the shortest path  
to the target node

The smaller your Regina-George Number, the  
more popular you are



Regina George = 0

Gretchen/Katie/Karen = 1

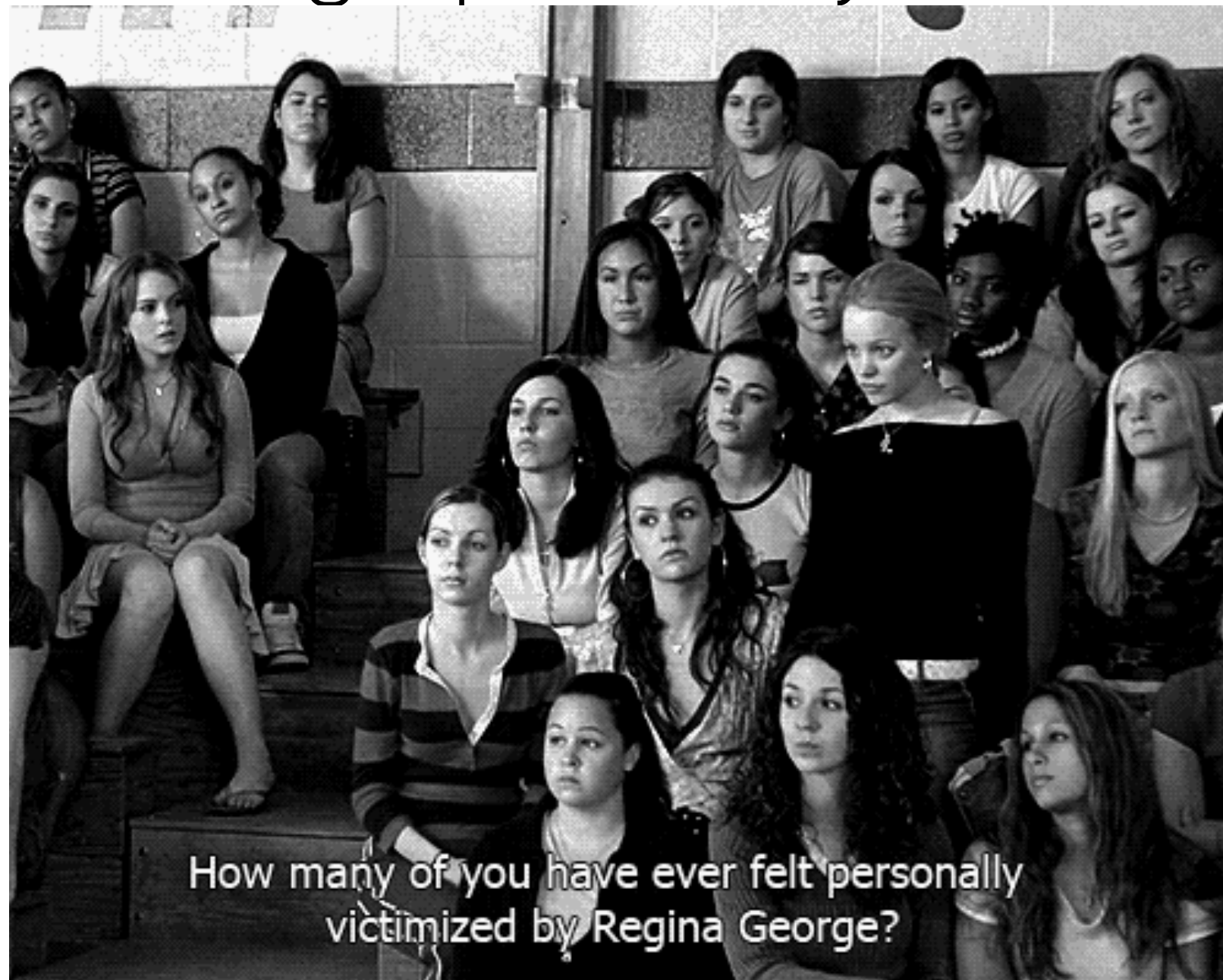
Football guy/Janice/Damien = 2

Math guy = 3

Math guy's sister = 4

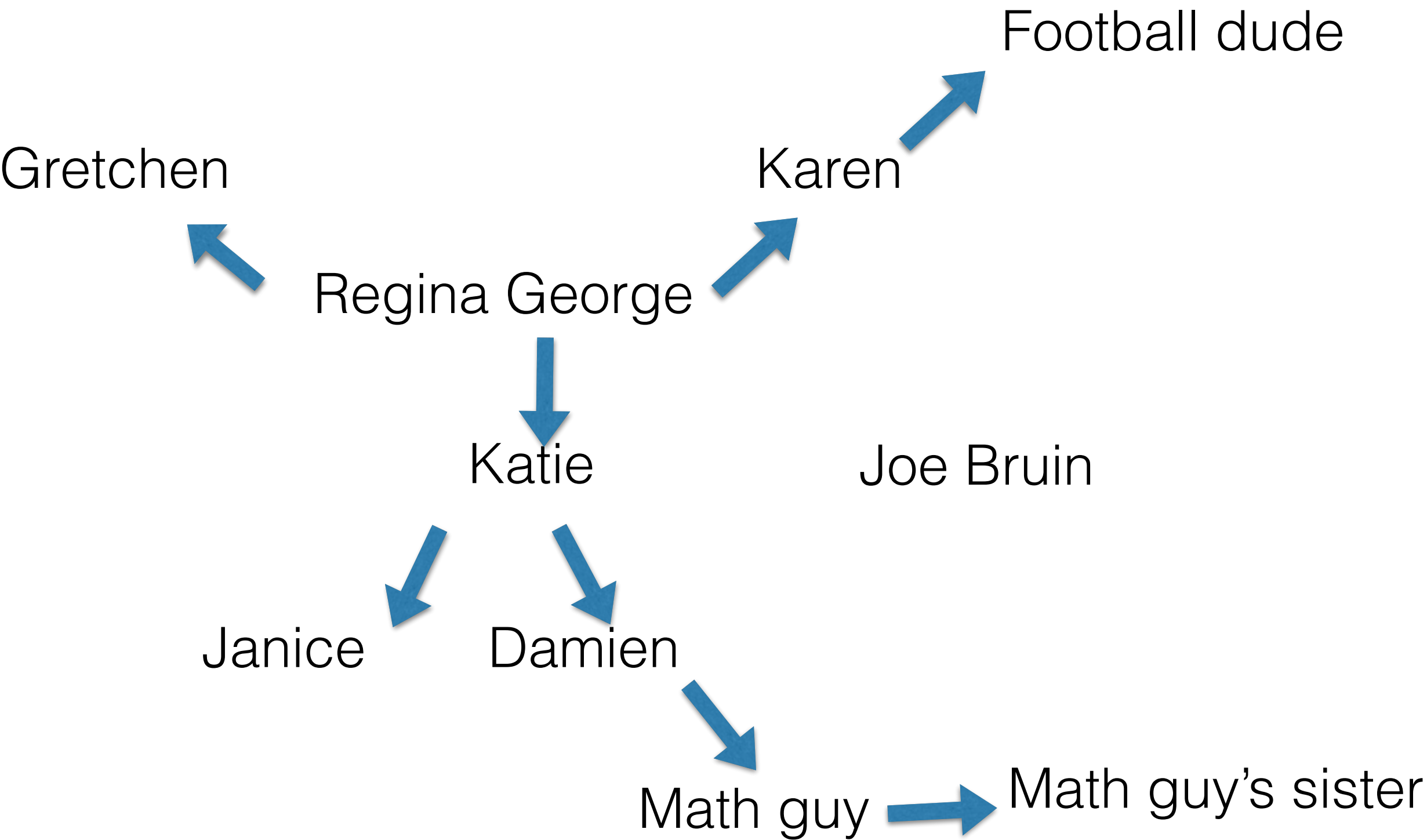
Joe Bruin = infinity

# How Rumors Spread, demonstrated through graph theory



How many of you have ever felt personally  
victimized by Regina George?





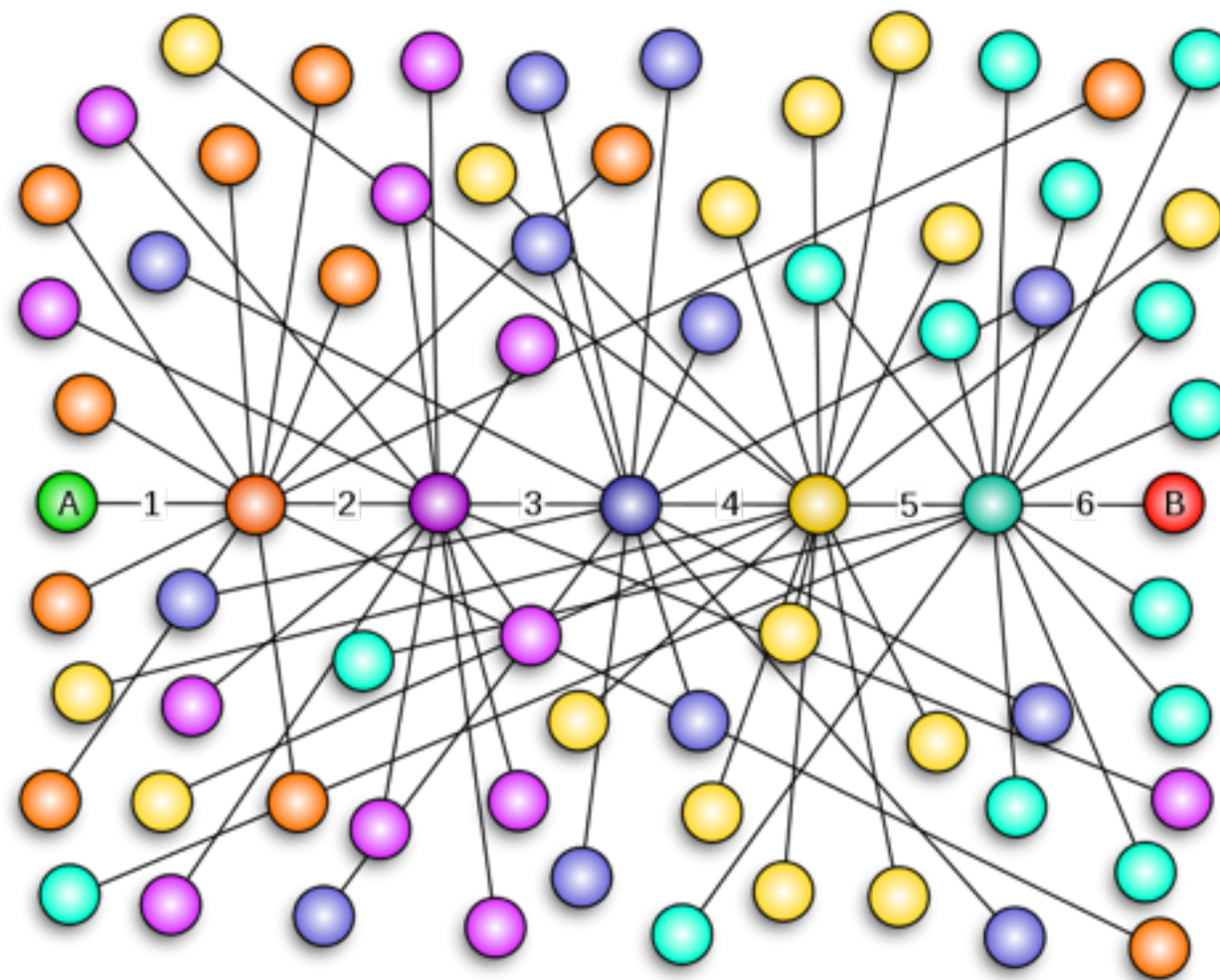


# Social Network Analysis

- Epidemiology - human contact and the spread of disease
- Google Page rank algorithm
  - importance of a site is measured by the number of connected sites
- National Security; counter-intelligence, and law enforcement

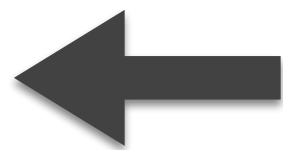
# Six Degrees of Separation

Six degrees of separation is the theory that everyone and everything is six or fewer steps away, so that a chain of "a friend of a friend" statements can be made to connect any two people in a maximum of six steps



# Small-world Experiment

Stanley Milgram and other researchers examining the average path length for social networks of people in the United States. The small-world phenomenon is when two people in a network are likely to be connected through short intermediate acquaintances. The research suggested that human society is a small-world-type network characterized by short path-lengths.



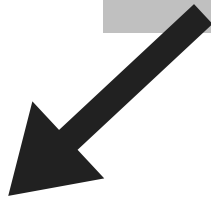
Small- world

# Small-world Experiment

Send packages to  
the Midwest from  
Boston



People receive  
packages and then  
send to a person who  
they think might know  
the sender



If a person knows the  
sender, they send it  
directly to them



The average path a  
package took was  
through ~5.5  
recipients

# Small-world Experiment



People receive packages and then send to a person who they think might know the sender

If a person knows the sender, they send it directly to them

The average path a package took was through ~5.5 recipients

# Small-world Experiment



If a person knows the sender, they send it directly to them

The average path a package took was through  $\sim 5.5$  recipients

# Small-world Experiment



The average path a package took was through  $\sim 5.5$  recipients

# Small-world Experiment





# Small-world Experiment



# More Numbers!

- Erdos Numbers

- number of links needed to connect the author of a paper with Paul Erdos, a well-established mathematician who published quite frequently. An author's Erdos number is 1 if he has co-authored a paper with Erdos, 2 if he has co-authored a paper with someone who has co-authored a paper with Erdos, etc.

- Kevin Bacon Numbers

- number of links needed to connect actors/actresses who have acted in a movie with Kevin Bacon

- <http://www.sixdegrees.org/>

- connects celebrities with social causes and charities

- It's social networking for social good.

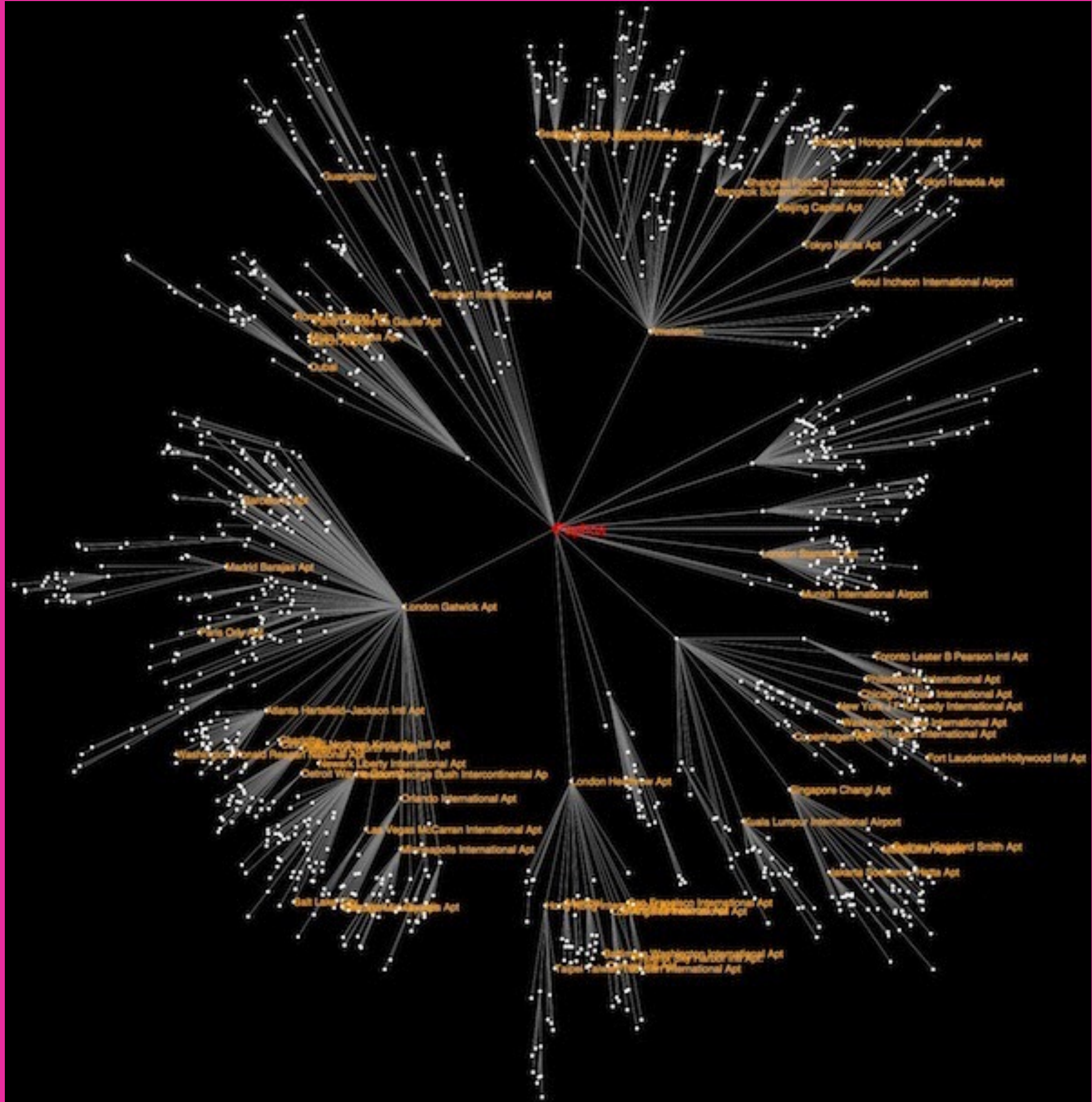
What if I am in college and  
do not care about trivial high  
school popularity?

What if I am in college and  
do not care about trivial high  
school popularity?

What if we were instead modeling highly  
infectious diseases?

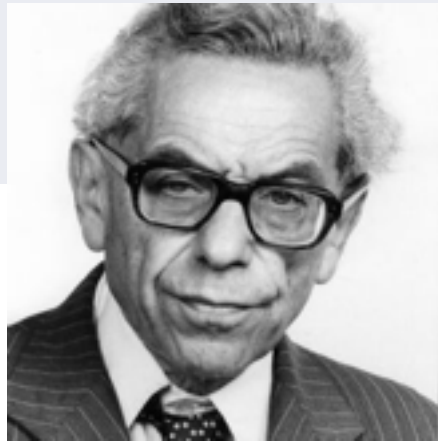






**mathbook**





Paul Erdős is writing ANOTHER paper that's soon to be published

Wall

Info

Photos

Boxes

**Basic Information**

Sex: Male  
Birthday: March 26, 1913  
Hometown: Budapest, Austria-Hungary

[View photos of Georg \(5\)](#)[Send Georg a message](#)[Poke message](#)**Information****Networks:**

Budapest

**Birthday:**

March 26th, 1913

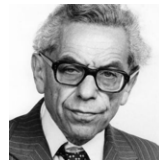
**Hometown:**

Budapest, Austria-Hungary

Write something...

The Television is something the Russians invented to destroy American Education

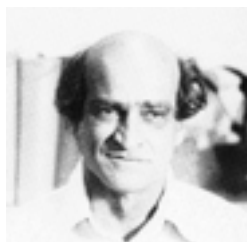
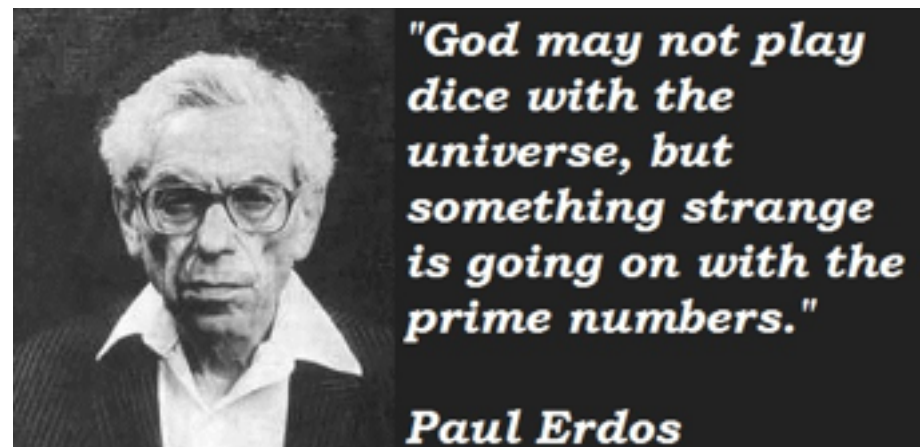
Share



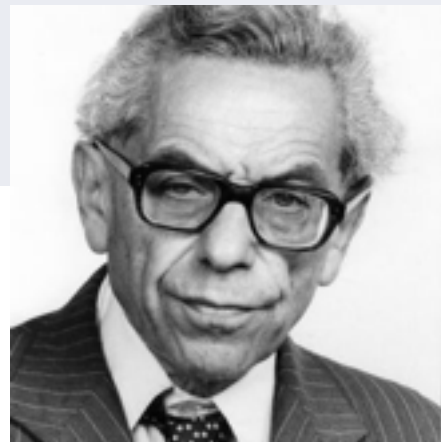
wrote around 1,525 mathematical articles in his lifetime



published *On a new method in elementary number theory which leads to an elementary proof of the prime number theorem*

[Joseph Kruskal](#)[Ernst G. Straus](#)





Paul Erdős is writing ANOTHER paper that's soon to be published

[Wall](#)[Info](#)[Photos](#)[Boxes](#)[View photos of Paul \(5\)](#)[Send Paul a message](#)[Poke message](#)

### Information

#### Networks:

Budapest

#### Birthday:

March 26th, 1913

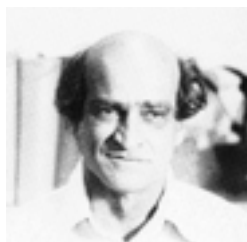
#### Hometown:

Budapest, Austria-Hungary

### Friends (500)



[Joseph Kruskal](#)



[Ernst G. Straus](#)



Tutoring Terrance Tao, seems like he has a lot of potential!

