MJPhD

EFFECTIVE COMMUNICATION OF SCIENTIFIC DATA

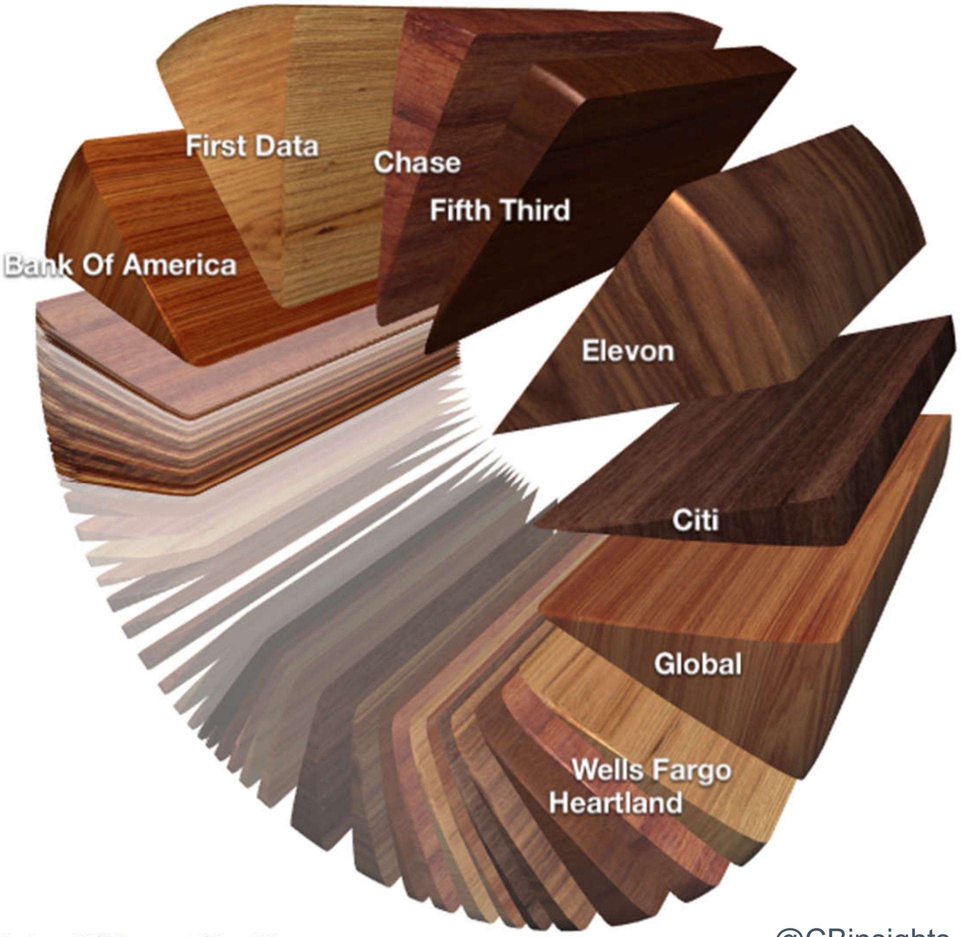
MARK JONES
CREATIVE DIRECTOR
MJPHD, LLC

16 September 2022

UofSC

Jump and
a net will
appear

The top 10 Payment Card Processors account for 57% of the total number of Merchant Outlets in 2010.



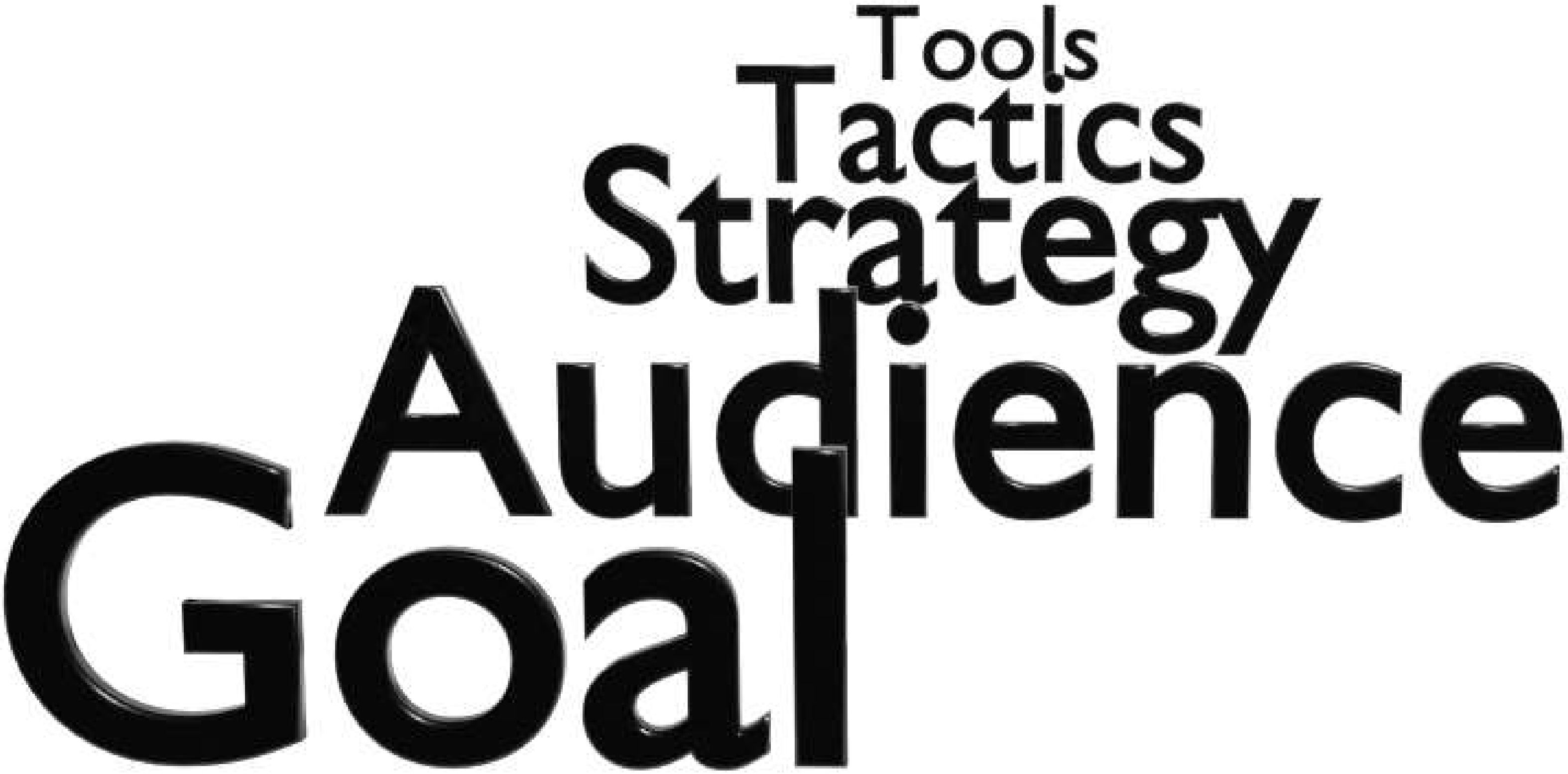
Distribution of the top 100 Payment Card Processors

curated bad graphics

CB INSIGHTS

@CBinsights 28 Jun 2017

COMMUNICATION HIERARCHY

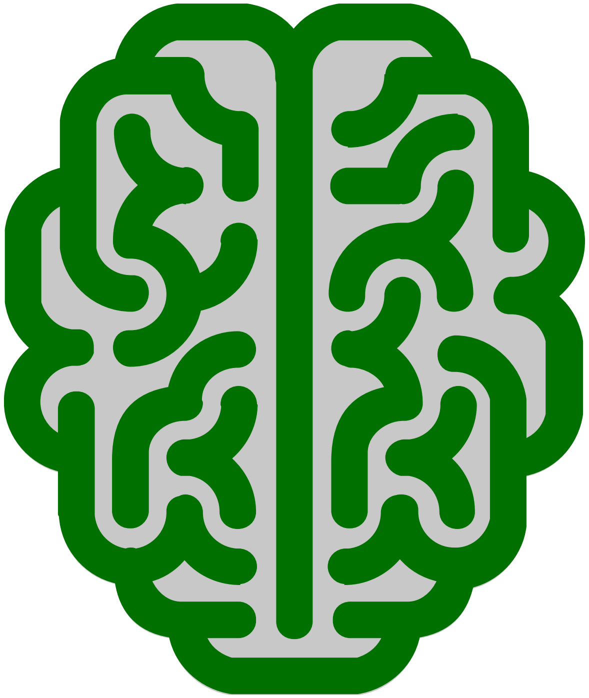

Tools
Tactics
Strategy
Audience
Goal

> Designing ~~a presentation~~ any communication without an audience in mind is like writing a love letter and addressing it ‘to whom it may concern’.

Ken Haemer
Presentation Research Manager,
AT&T

in HBR Guide to Persuasive Presentations

MIND READY

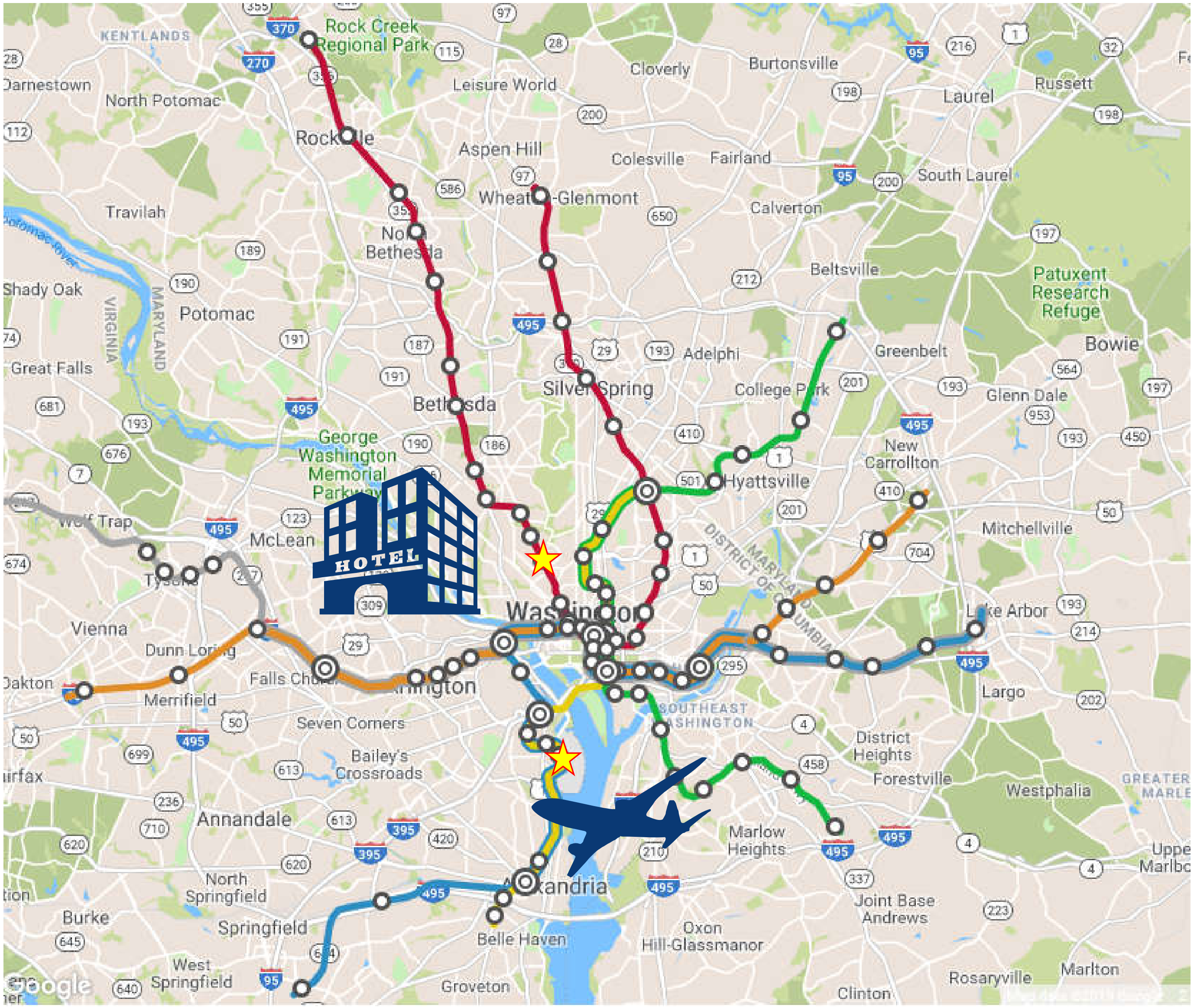


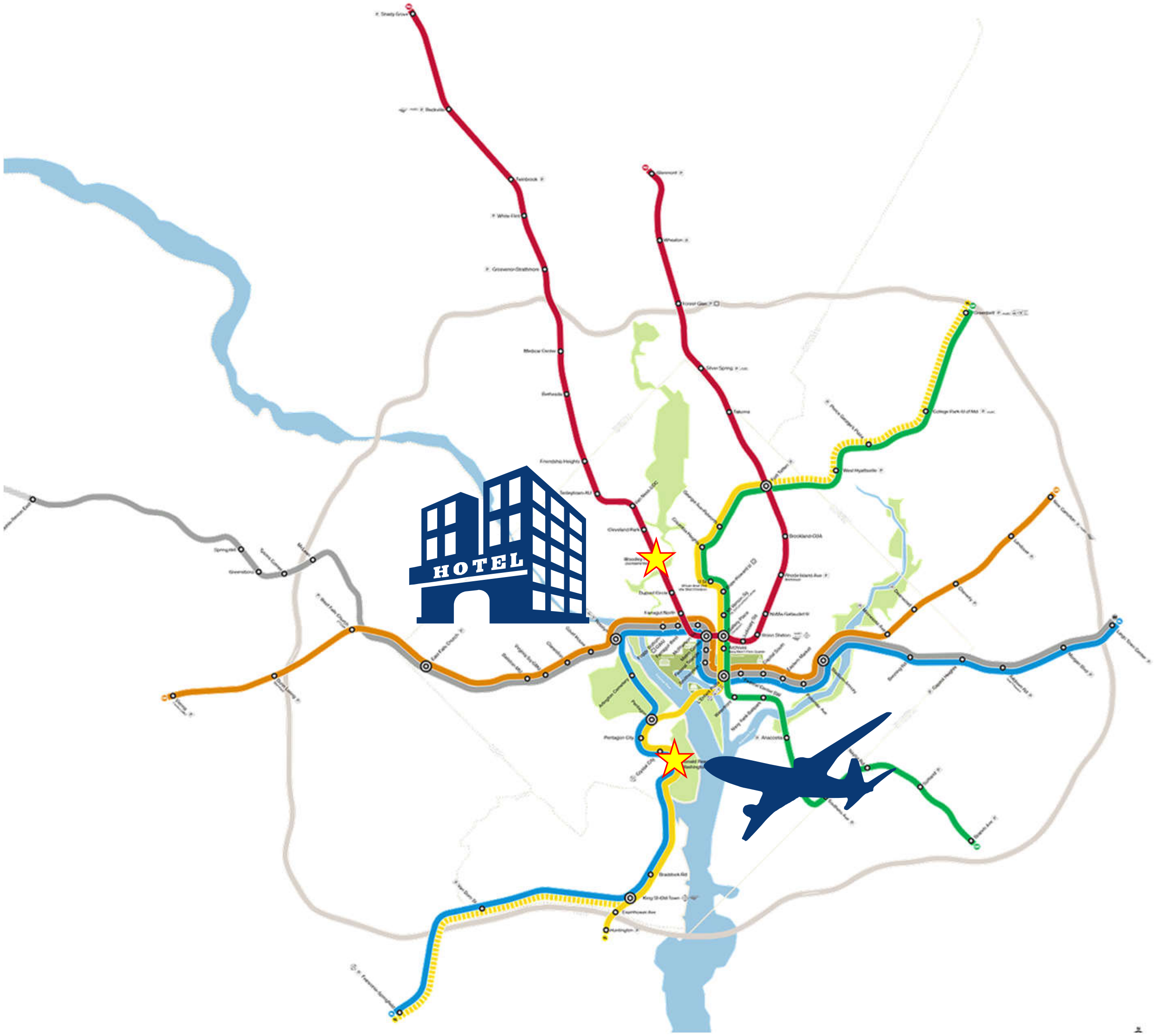
ready

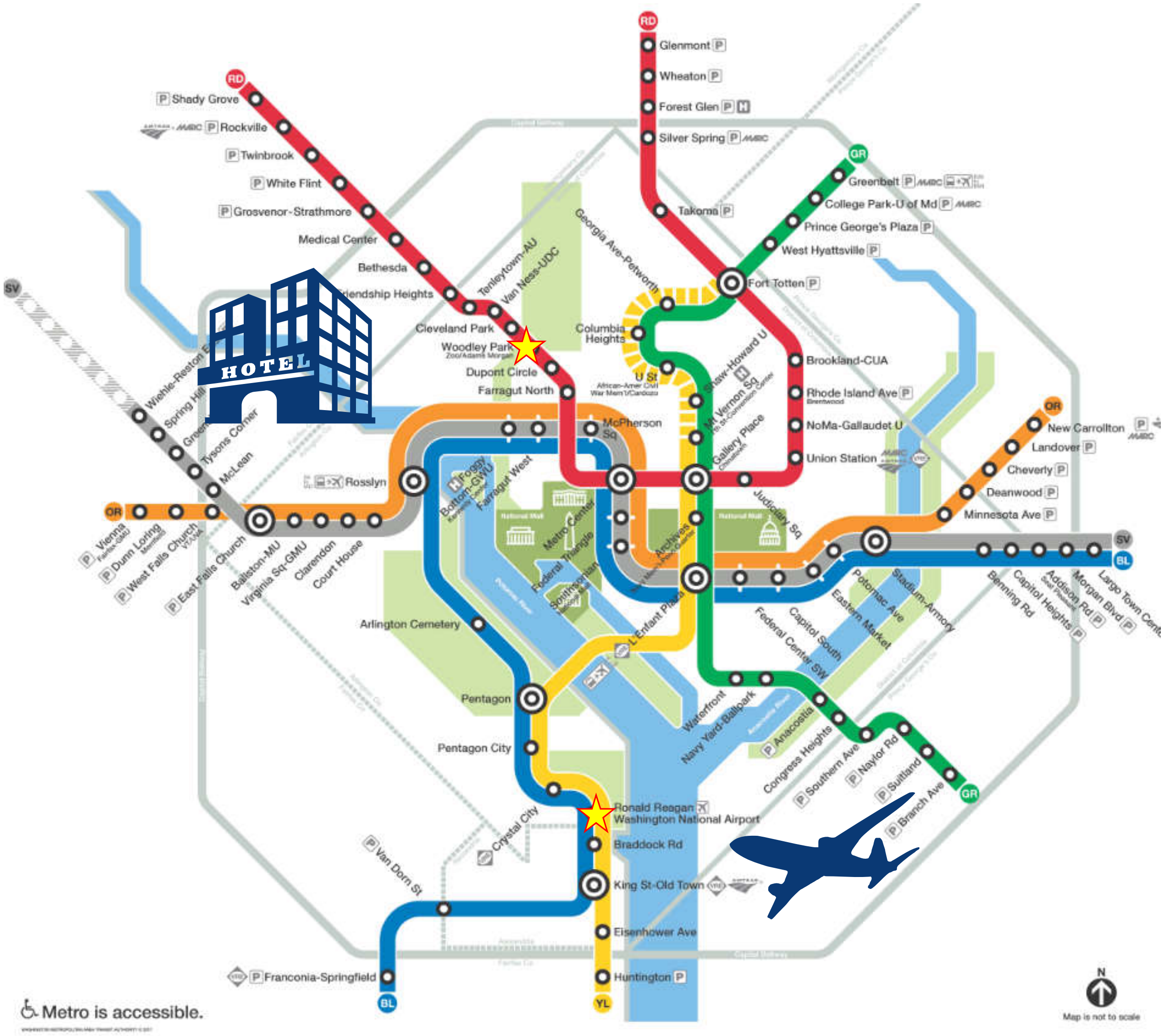
Washington, D.C.

Reagan National Airport

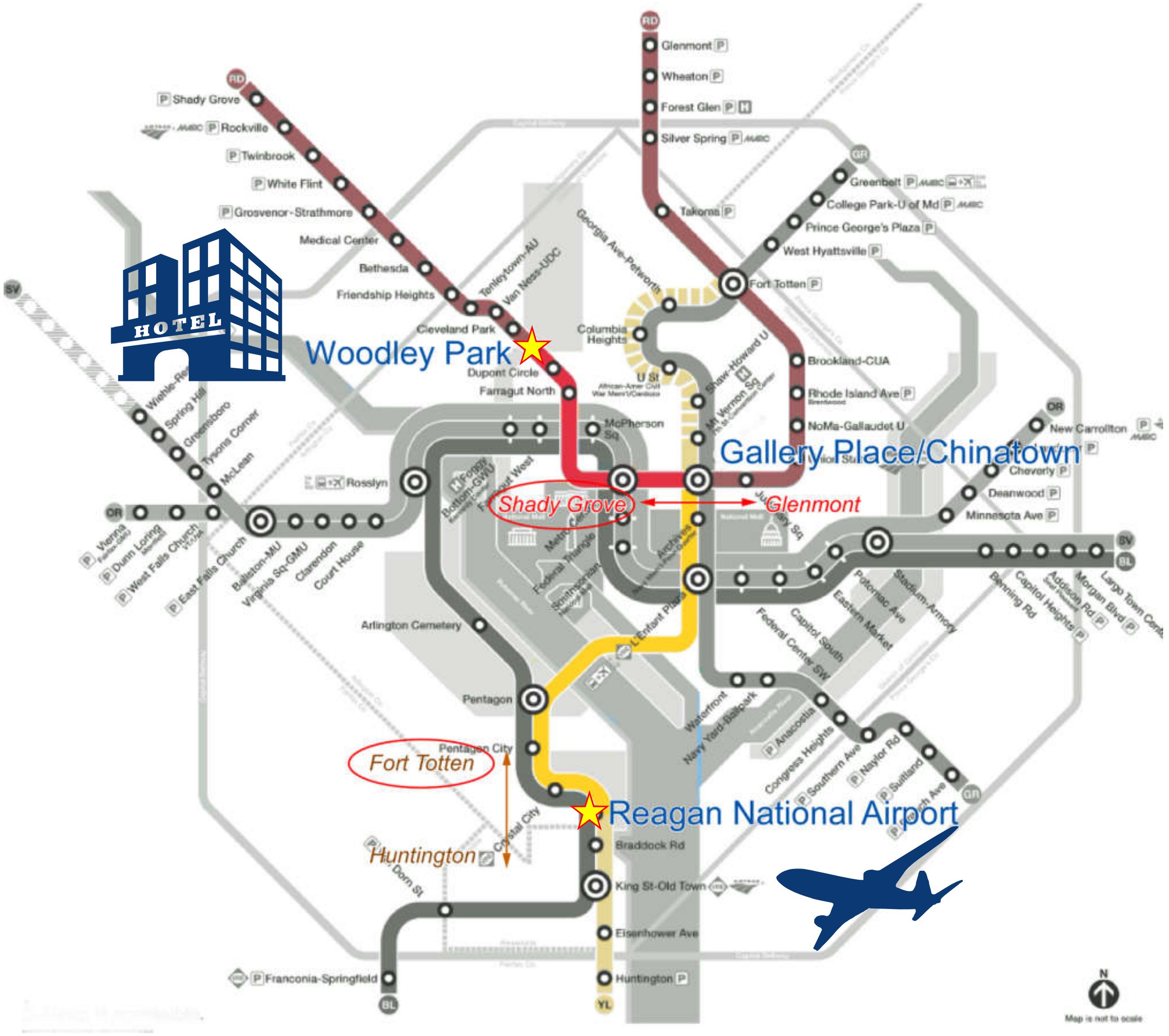
Marriott Woodley Park


KENTLANDS
Rock Creek Regional Park
Darnestown
North Potomac
Leisure World
Cloverly
Burtonsville
Laurel
Russett
Rockville
Aspen Hill
Colesville
Fairland
South Laurel
Travilah
Wheaton-Glenmont
Calverton
North Bethesda
Beltsville
Shady Oak
VIRGINIA
MARYLAND
Potomac
Patuxent Research Refuge
Bowie
Great Falls
Adelphi
Greenbelt
Silver Spring
College Park
Glenn Dale
Bethesda
George Washington Memorial Parkway
New Carrollton
Hyattsville
Wolf Trap
McLean
HOTEL
Mitchellville
Tysons
DISTRICT OF COLUMBIA
MARYLAND
Washington
Lake Arbor
Vienna
Dunn Loring
Oakton
Falls Church
Arlington
Largo
Merrifield
Seven Corners
SOUTHEAST WASHINGTON
District Heights
Bailey's Crossroads
Fairfax
Forestville
Westphalia
GREATER MARLB
Annandale
Marlow Heights
Upper Marlbo
North Springfield
Alexandria
Joint Base Andrews
Burke
Springfield
Belle Haven
Oxon Hill-Glassmanor
West Springfield
Rosaryville
Marlton
Groveton
Clinton
Google


HOTEL
Shady Grove
Rockville
Twinbrook
White Flint
Grosvenor-Strathmore
Medical Center
Bethesda
Friendship Heights
Tenleytown-AU
Van Ness-UDC
Cleveland Park
Woodley Park
Dupont Circle
Farragut North
Glenmont
Wheaton
Forest Glen
Silver Spring
Takoma
Fort Totten
West Hyattsville
College Park-U of Md
Greenbelt
Brookland-CUA
Rhode Island Ave
NoMa-Gallaudet U
Union Station
Georgia Ave-Petworth
Columbia Heights
U St
Federal Center SW
Pentagon
Pentagon City
Arlington Cemetery
Crystal City
Ronald Reagan Washington
Anacostia
Braddock Rd
King St-Old Town
Eisenhower Ave
Huntington
Branch Ave



RD
Glenmont
Wheaton
Forest Glen
Silver Spring
Takoma
Fort Totten
Brookland-CUA
Rhode Island Ave
NoMa-Gallaudet U
Union Station
Judiciary Sq
Gallery Place
Chinatown
Metro Center
Farragut North
Dupont Circle
Woodley Park
Zoo/Adams Morgan
Cleveland Park
Van Ness-UDC
Tenleytown-AU
Friendship Heights
Bethesda
Medical Center
Grosvenor-Strathmore
White Flint
Twinbrook
Rockville
Shady Grove
GR
Greenbelt
College Park-U of Md
Prince George's Plaza
West Hyattsville
Georgia Ave-Petworth
Columbia Heights
U St
African-Amer Civil War Mem'l/Cardozo
Shaw-Howard U
Mt Vernon Sq
7th St-Convention Center
Archives
Navy Memorial-Penn Quarter
L'Enfant Plaza
Waterfront
Navy Yard-Ballpark
Anacostia
Congress Heights
Southern Ave
Naylor Rd
Suitland
Branch Ave
OR
New Carrollton
Landover
Cheverly
Deanwood
Minnesota Ave
Vienna
Fairfax-GMU
Dunn Loring
Merrifield
West Falls Church
VT/UVA
East Falls Church
Ballston-MU
Virginia Sq-GMU
Clarendon
Court House
Rosslyn
Foggy Bottom-GWU
Farragut West
McPherson Sq
Federal Triangle
Smithsonian
Federal Center SW
Capitol South
Eastern Market
Potomac Ave
Stadium-Armory
Benning Rd
Capitol Heights
Addison Rd
Seat Pleasant
Morgan Blvd
Largo Town Center
SV
Wiehle-Reston East
Spring Hill
Greensboro
Tysons Corner
McLean
BL
Arlington Cemetery
Pentagon
Pentagon City
Crystal City
Ronald Reagan Washington National Airport
Braddock Rd
King St-Old Town
Van Dorn St
Franconia-Springfield
YL
Eisenhower Ave
Huntington
HOTEL
National Mall
Potomac River
Anacostia River
Capital Beltway
Metro is accessible.
N
Map is not to scale


HOTEL
Woodley Park
Gallery Place/Chinatown
Shady Grove
Glenmont
Fort Totten
Huntington
Reagan National Airport
RD
Glenmont
Wheaton
Forest Glen
Silver Spring
Takoma
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Brookland-CUA
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GR
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College Park-U of Md
Prince George's Plaza
West Hyattsville
Georgia Ave-Petworth
Columbia Heights
U St
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Mt Vernon Sq
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Dupont Circle
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McPherson Sq
Metro Center
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Smithsonian
Archives
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L'Enfant Plaza
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Farragut West
Rosslyn
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Ballston-MU
Virginia Sq-GMU
Clarendon
Court House
Arlington Cemetery
Pentagon
Pentagon City
Crystal City
Braddock Rd
King St-Old Town
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BL
Waterfront
Navy Yard-Ballpark
Anacostia
Congress Heights
Southern Ave
Naylor Rd
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Minnesota Ave
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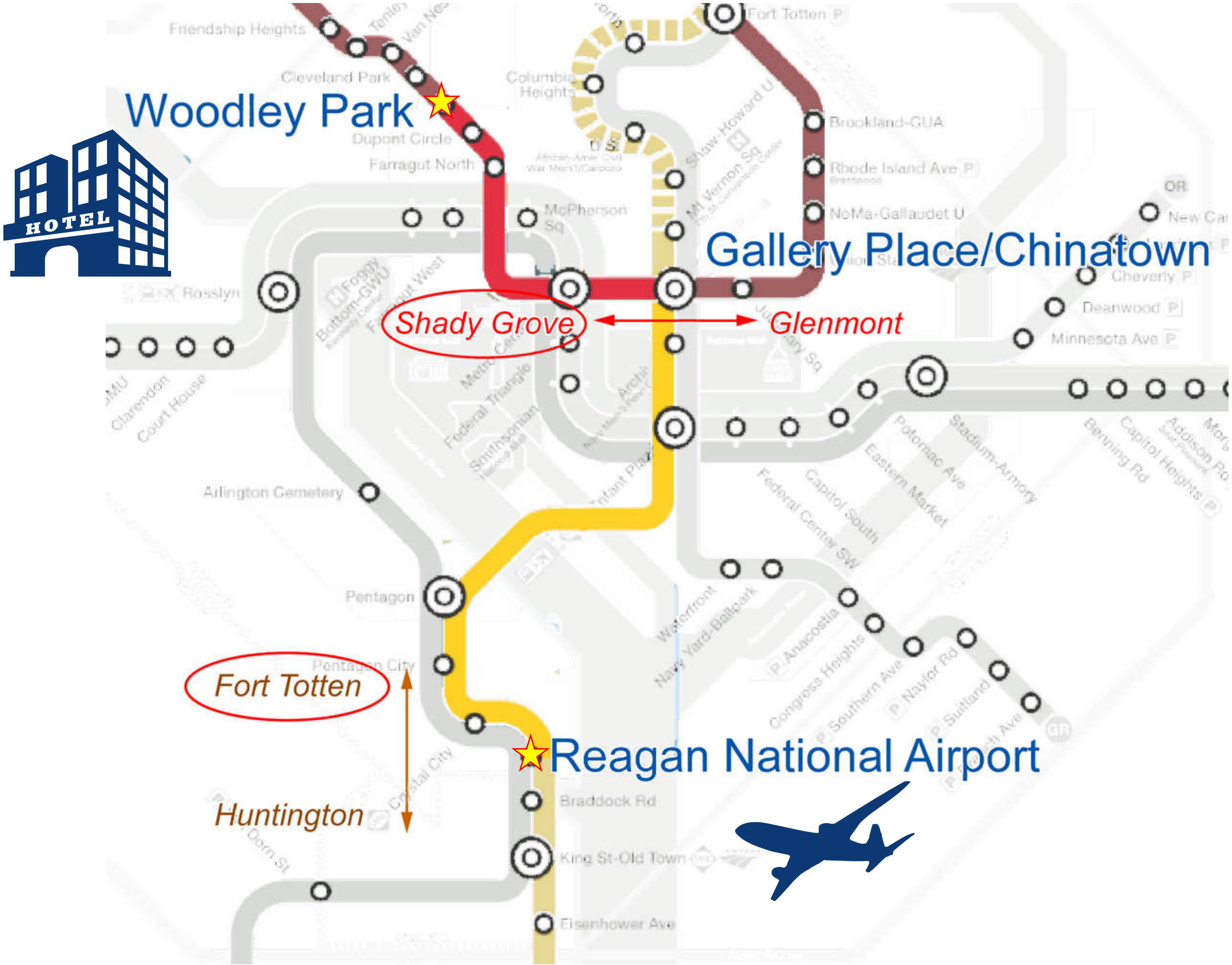
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Fort Totten
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Reagan National Airport
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Dupont Circle
Farragut North
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Rosslyn
Arlington Cemetery
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Pentagon City
Crystal City
Braddock Rd
King St-Old Town
Eisenhower Ave
Cheverly
Deanwood
Minnesota Ave
Waterfront
Navy Yard-Ballpark
Anacostia
Congress Heights
Southern Ave
Naylor Rd
Suitland

SIMPLICITY

> Everything should be made as simple as possible, but not simpler.
>
> Albert Einstein

Woodley Park
Gallery Place/Chinatown
Shady Grove
Glenmont
Fort Totten
Huntington
Reagan National Airport

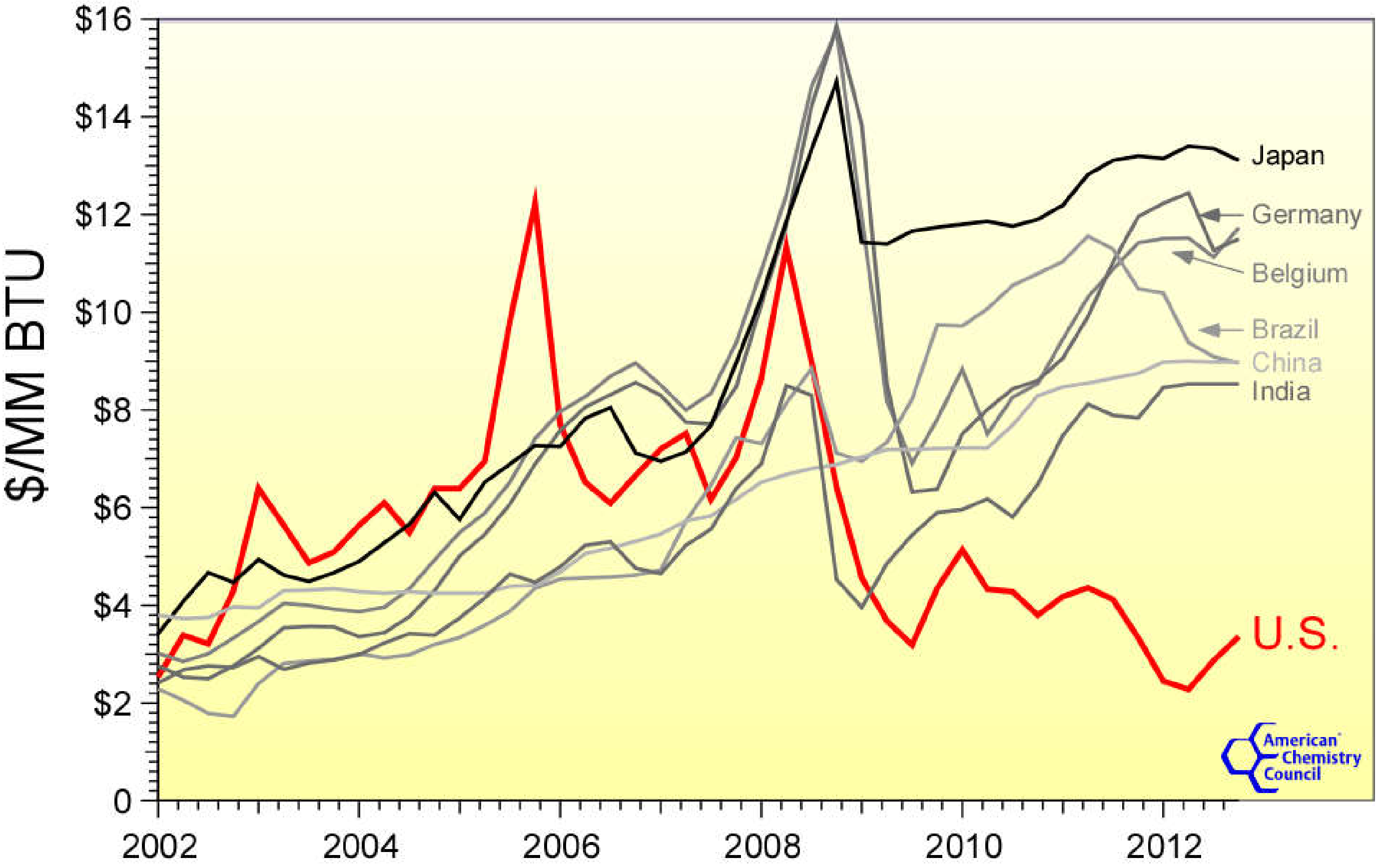
FIVE PRINCIPLES OF DATA PRESENTATION

- Tell the truth
- Get to the point
- Pick the right tool
- Highlight what is important
- Keep it ~~simple~~ **appropriate**

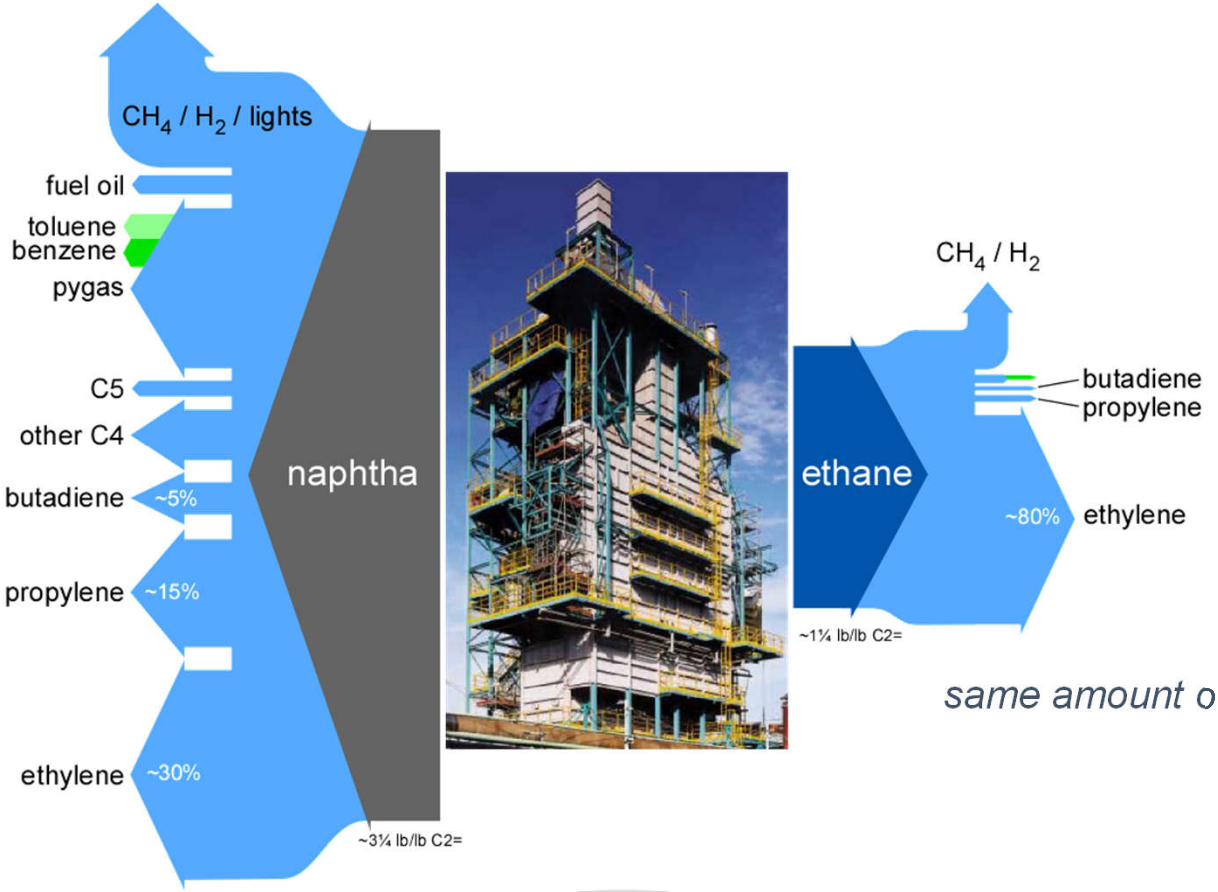
Everything should be made as simple as possible, but not simpler.

Nancy Duarte in Slideology

WORLD NATURAL GAS PRICES

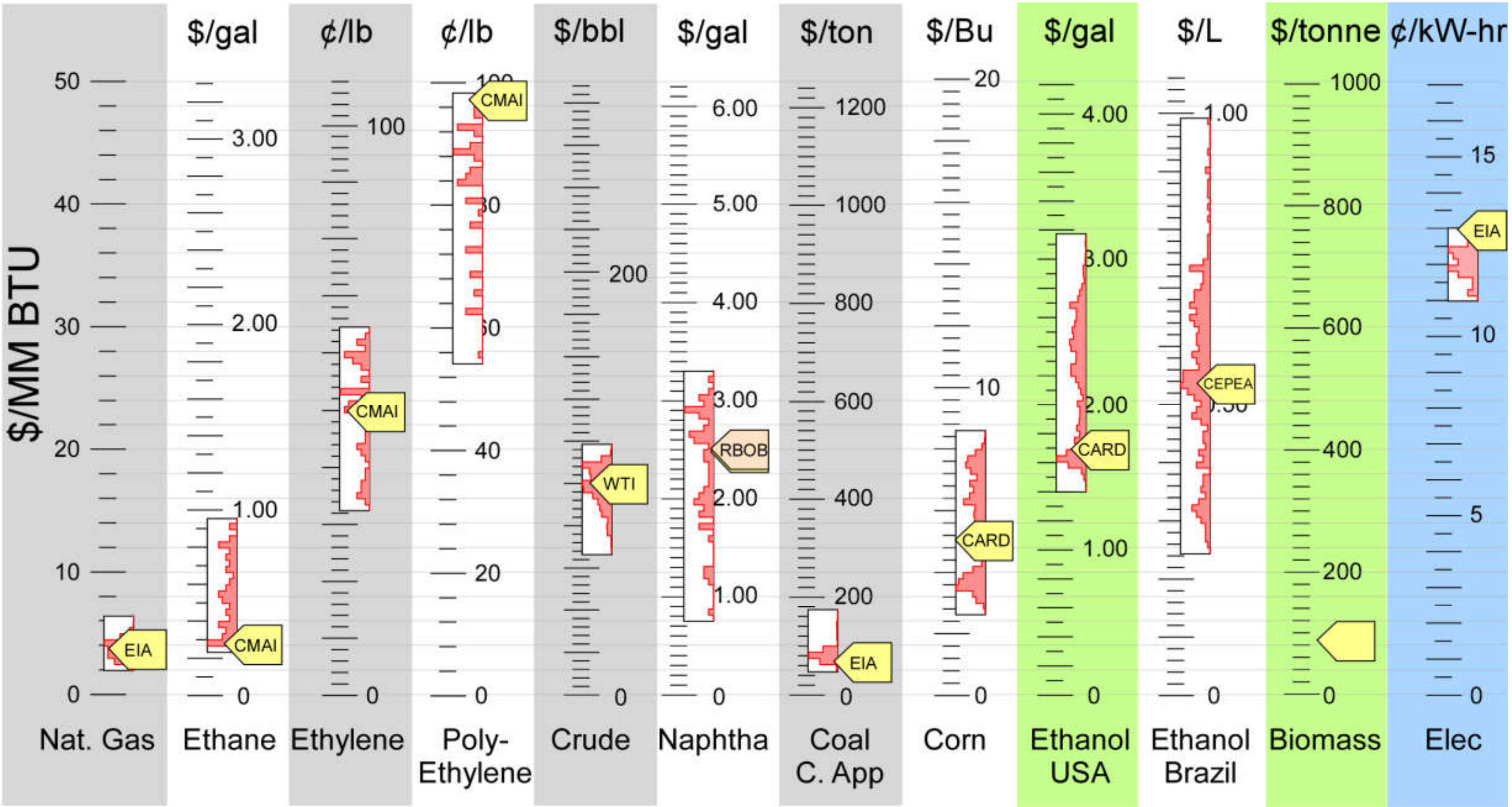


NAPHTHA VS ETHANE CRACKING COMPARISON

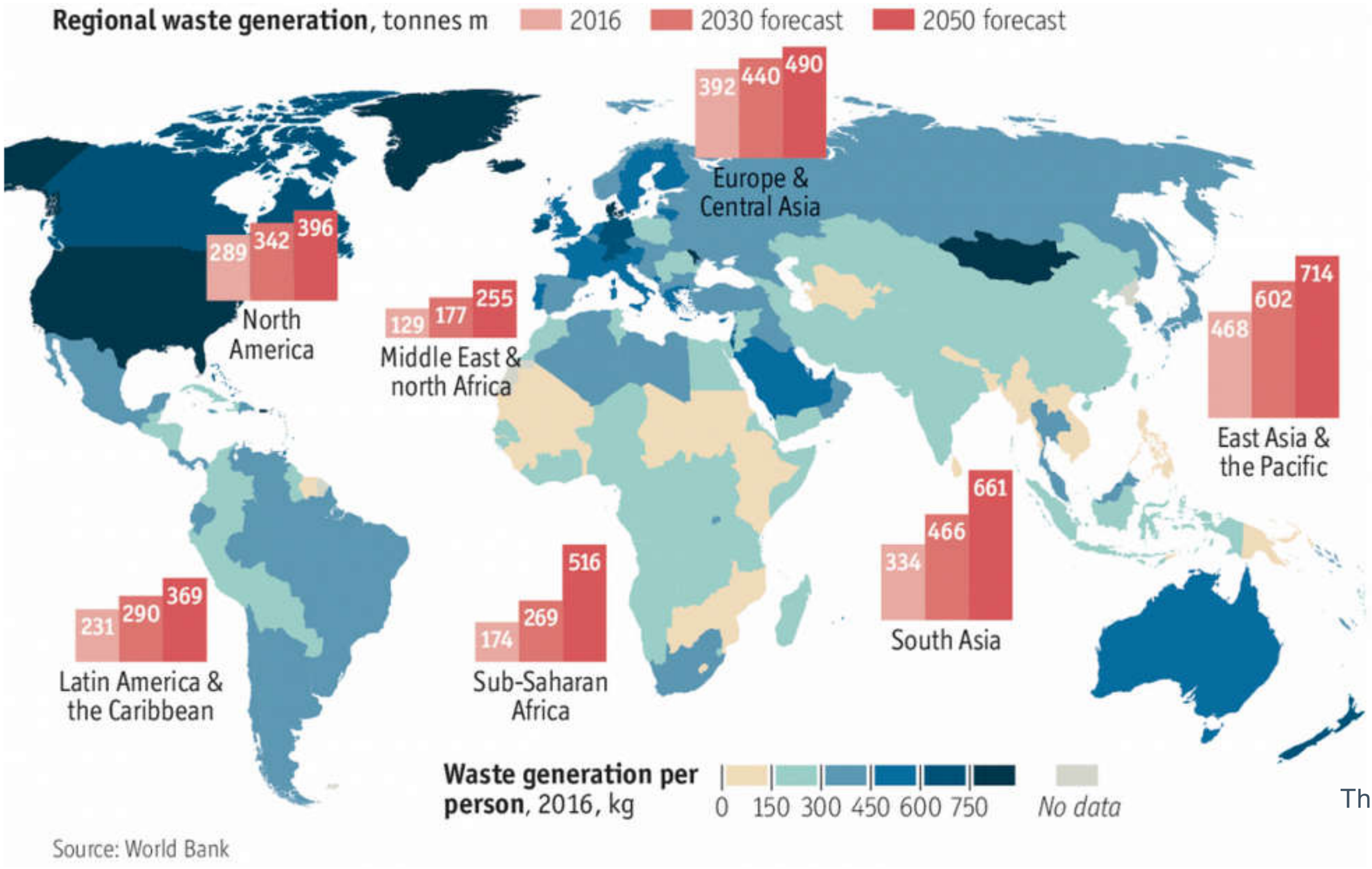

CH_4 / H_2 / lights
fuel oil
toluene
benzene
pygas
C5
other C4
butadiene
~5%
propylene
~15%
ethylene
~30%
naphtha
~3¼ lb/lb C2=
CH_4 / H_2
butadiene
propylene
ethane
~80%
ethylene
~1¼ lb/lb C2=

same amount of ethylene

DATA RICH SLIDE



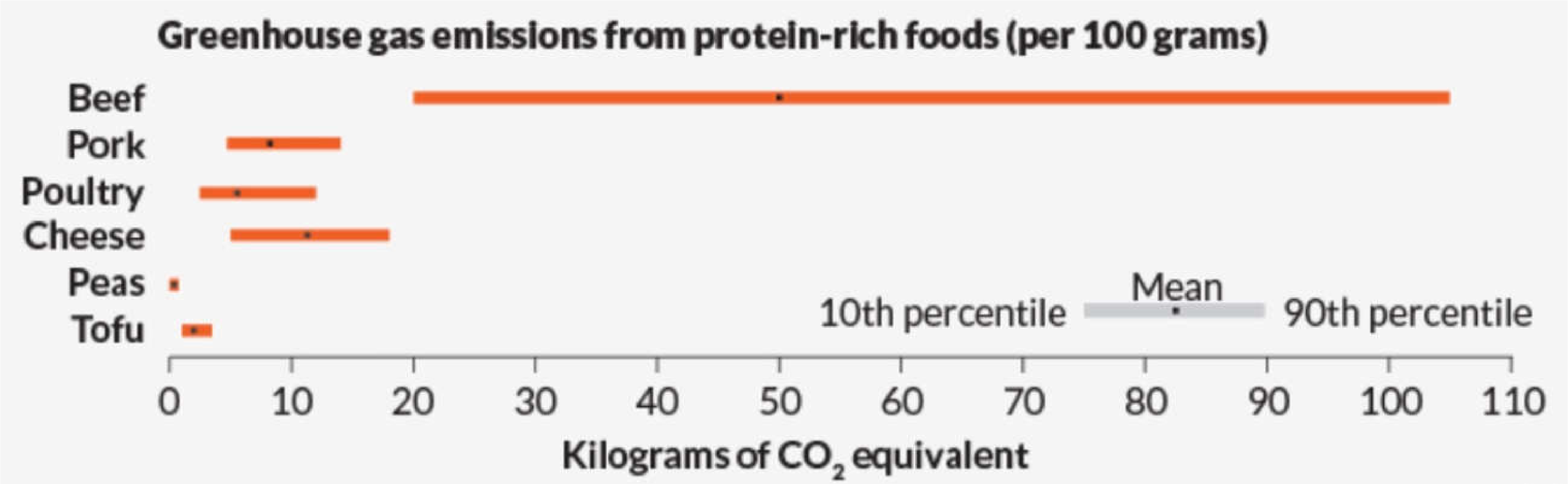
LOTS OF INFORMATION – THROWAWAY WORLD


Regional waste generation, tonnes m
2016
2030 forecast
2050 forecast
392
440
490
Europe & Central Asia
289
342
396
North America
129
177
255
Middle East & north Africa
468
602
714
East Asia & the Pacific
334
466
661
South Asia
174
269
516
Sub-Saharan Africa
231
290
369
Latin America & the Caribbean
Waste generation per person, 2016, kg
0
150
300
450
600
750
No data

Source: World Bank

The Economist; 2 Oct 2018

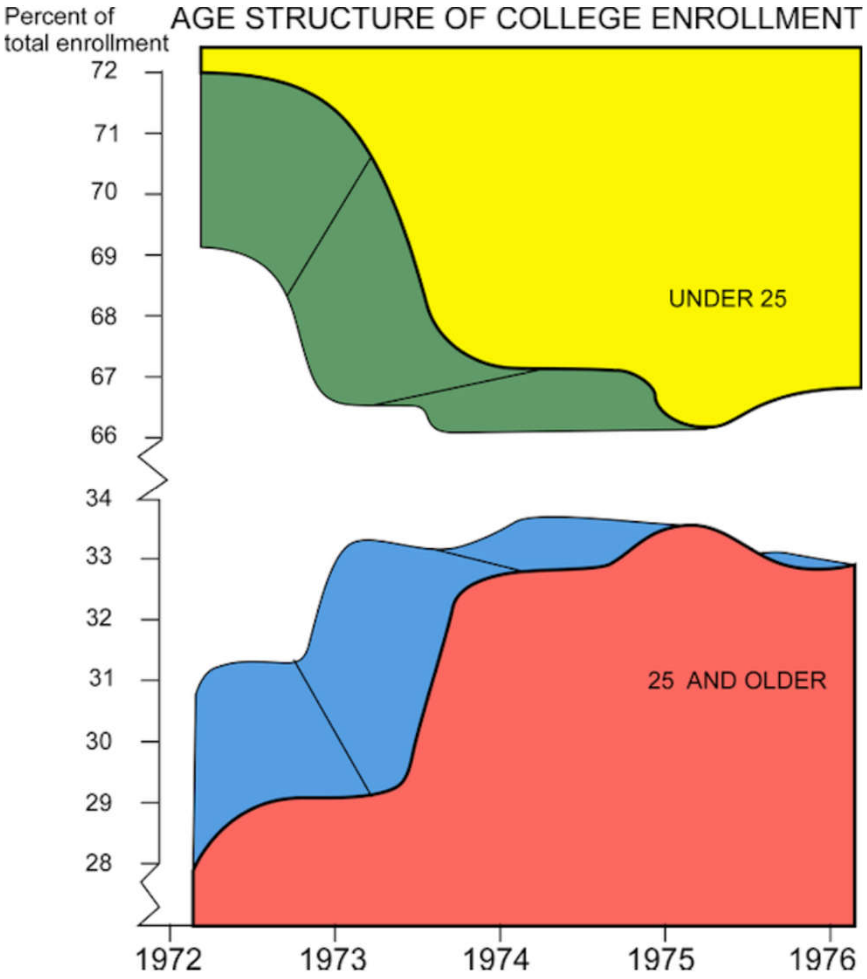
FARM TO TABLE



graphic by C. Chang in Milius, Susan; "Can science build a better burger?", *Science News*, September 20, 2018 downloaded from sciencenews.org/article/can-science-build-better-burger on 2 November 2018.

EDWARD TUFTE'S FIVE PRINCIPLES OF DATA PRESENTATION

1. Above all else show the data
2. Maximize the data-ink ratio
3. Erase non-data ink
4. Erase redundant data
5. Revise and Edit.



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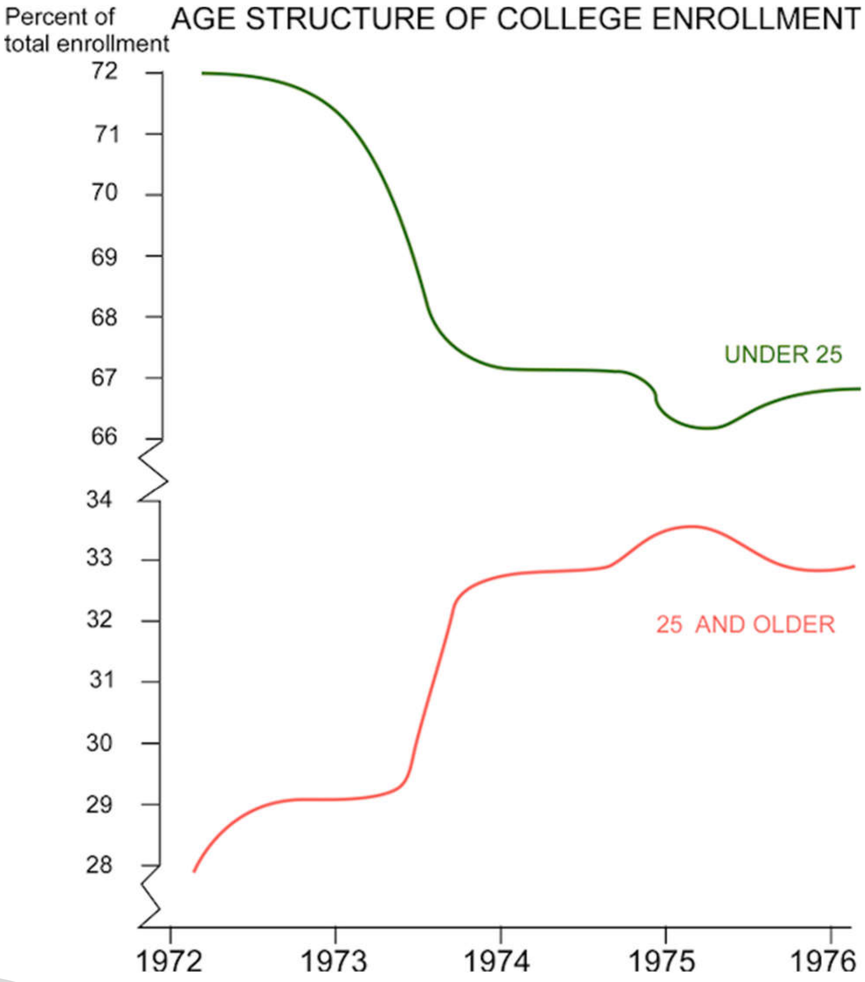

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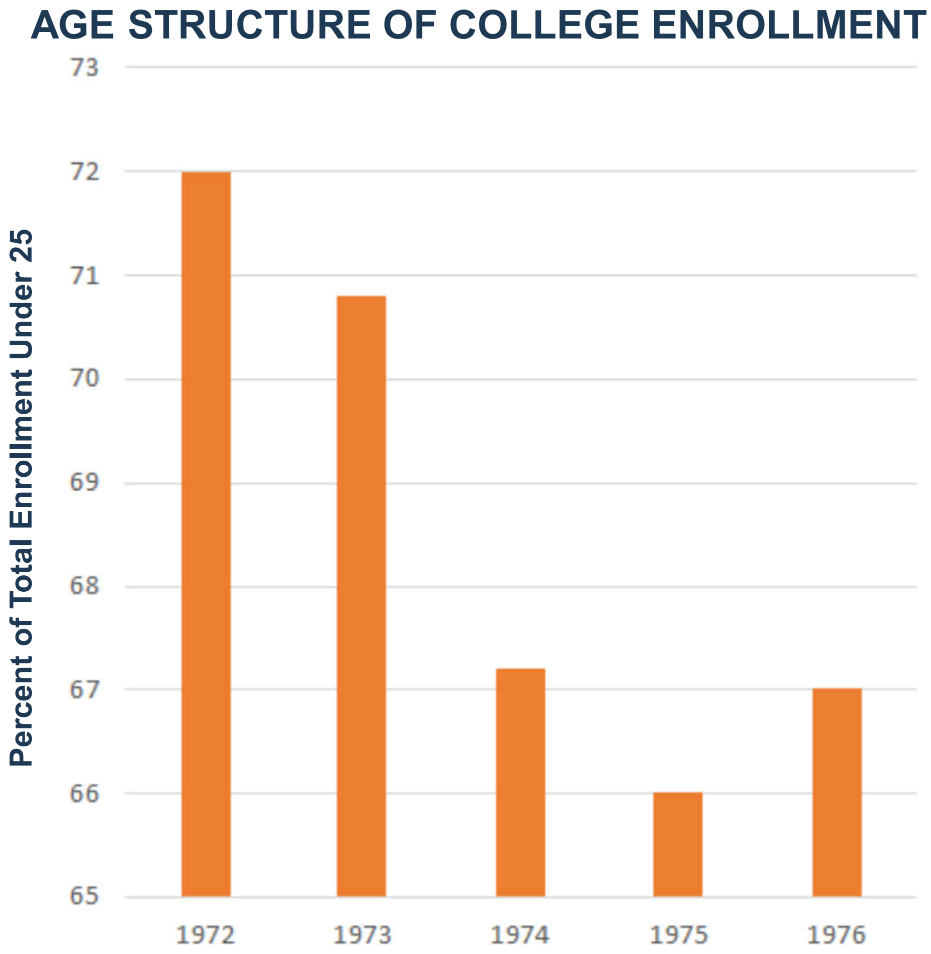


EDWARD TUFTE'S FIVE PRINCIPLES OF DATA PRESENTATION

Pick the right tool

1. Above all else show the data

Tell the truth

2. Maximize the data-ink ratio

Get to the point

3. Erase non-data ink

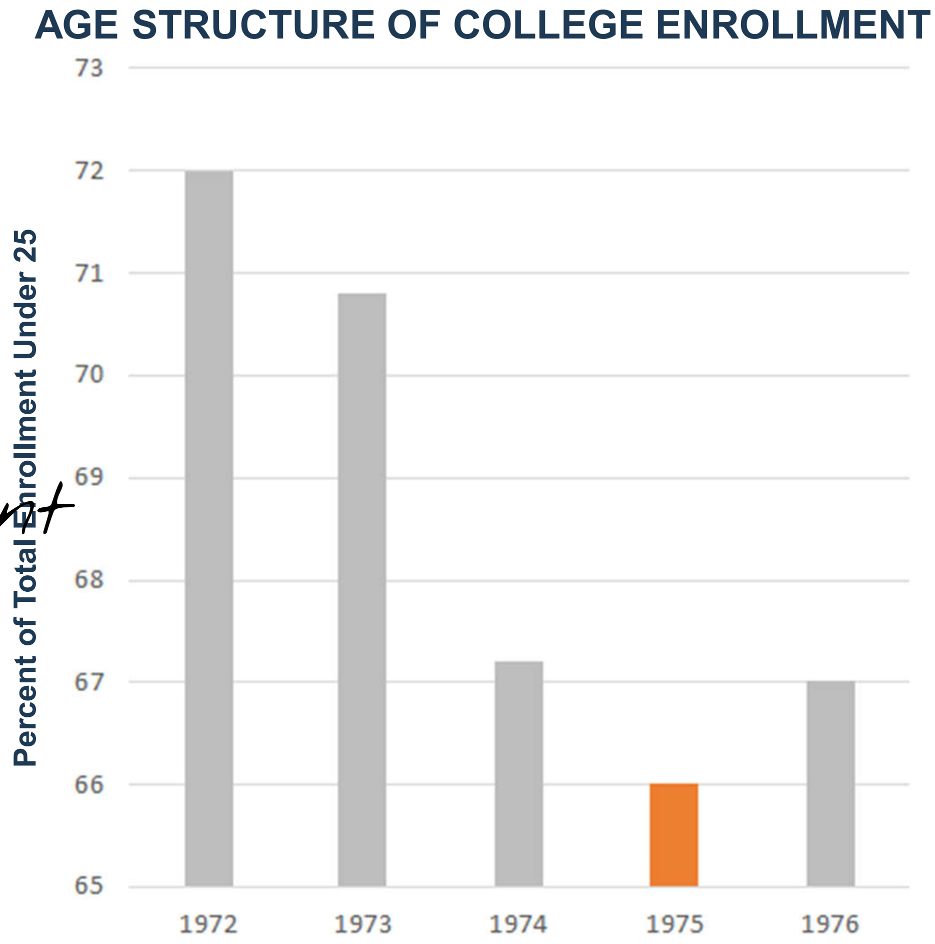
Highlight what is important

4. Erase redundant data

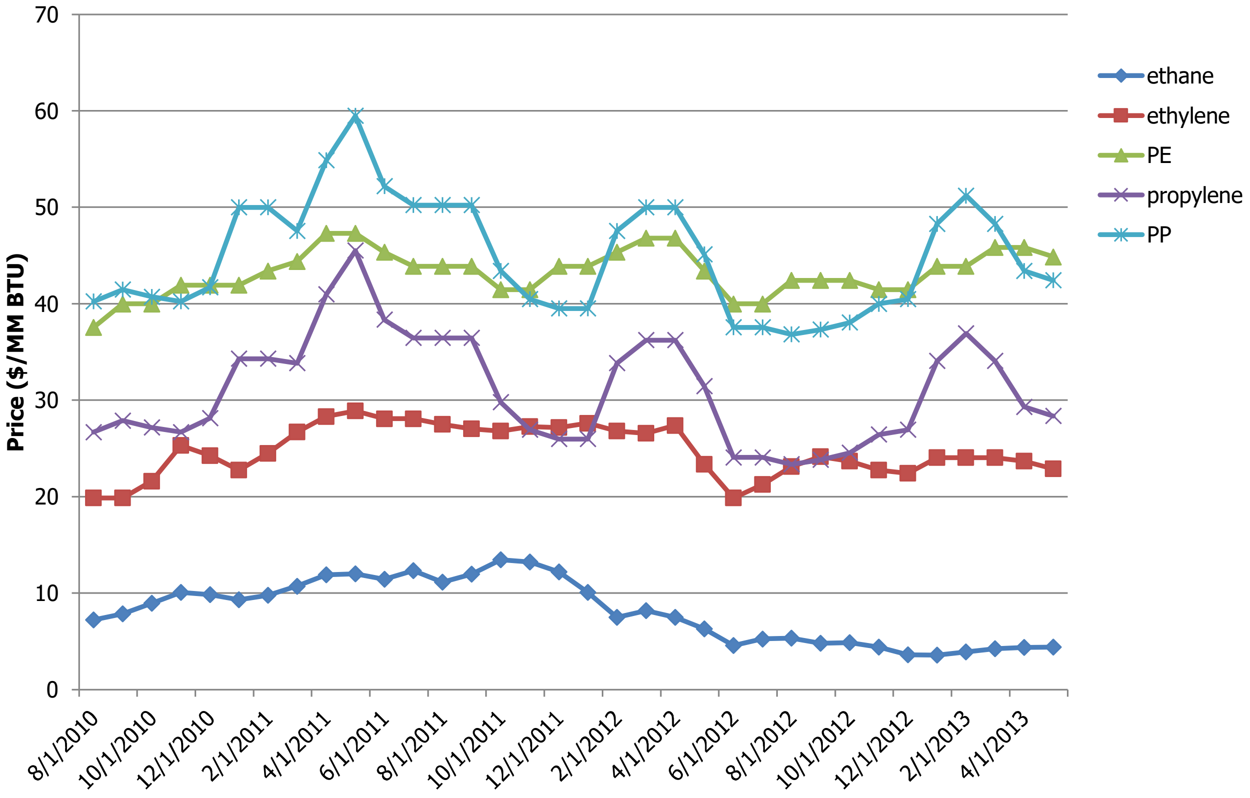
Get to the point

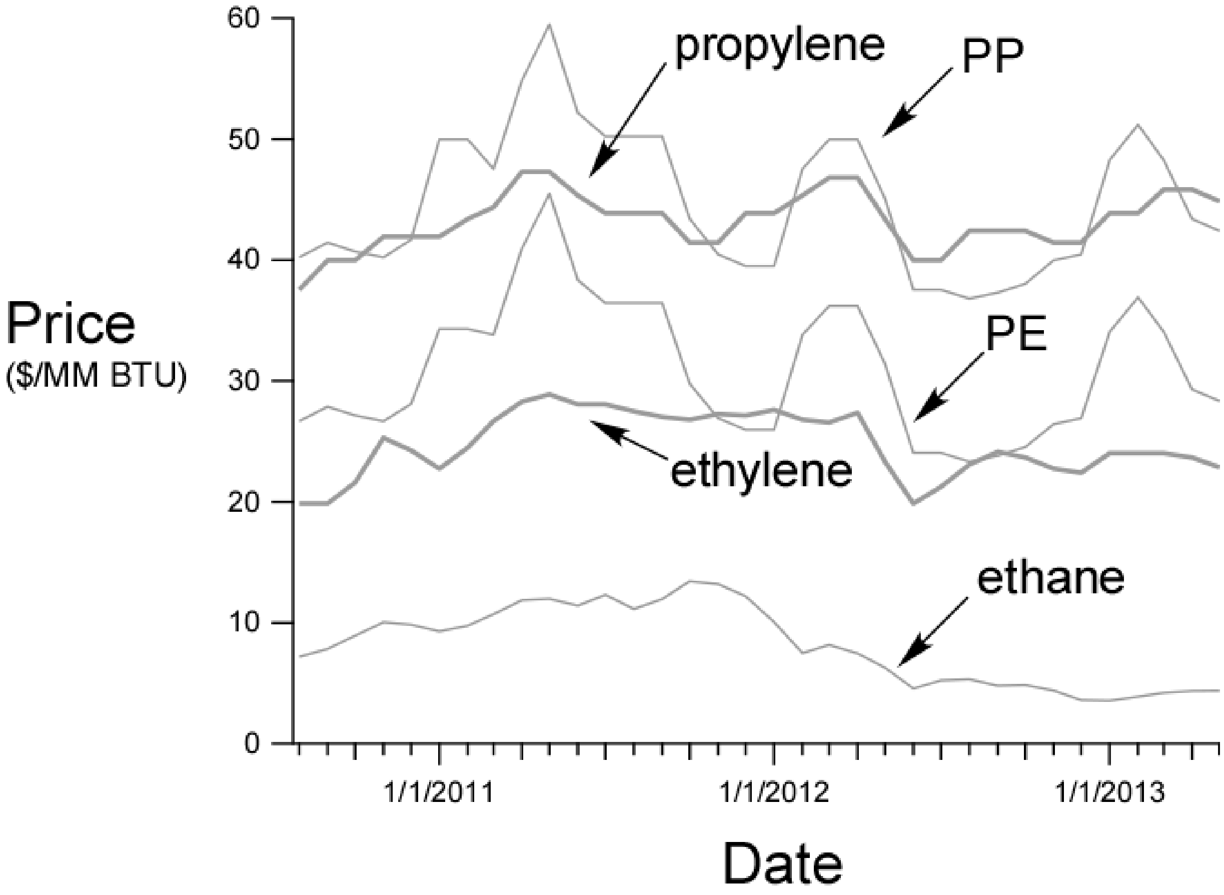
5. Revise and Edit.

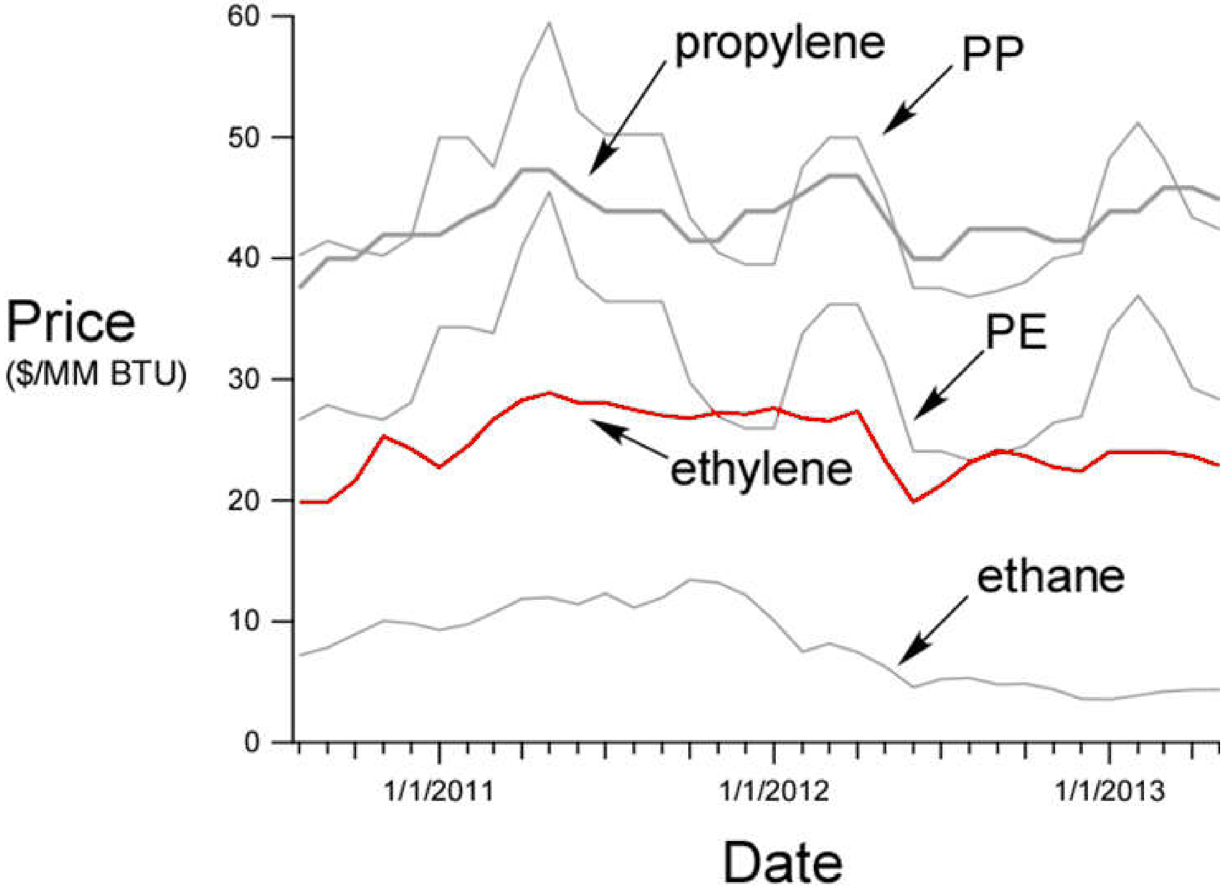
Keep it appropriate


AGE STRUCTURE OF COLLEGE ENROLLMENT

STANDARD EXCEL PLOT




60
50
40
30
20
10
0
Price
($/MM BTU)
propylene
PP
PE
ethylene
ethane
1/1/2011
1/1/2012
1/1/2013
Date


60
50
40
30
20
10
0
Price
($/MM BTU)
propylene
PP
PE
ethylene
ethane
1/1/2011
1/1/2012
1/1/2013
Date

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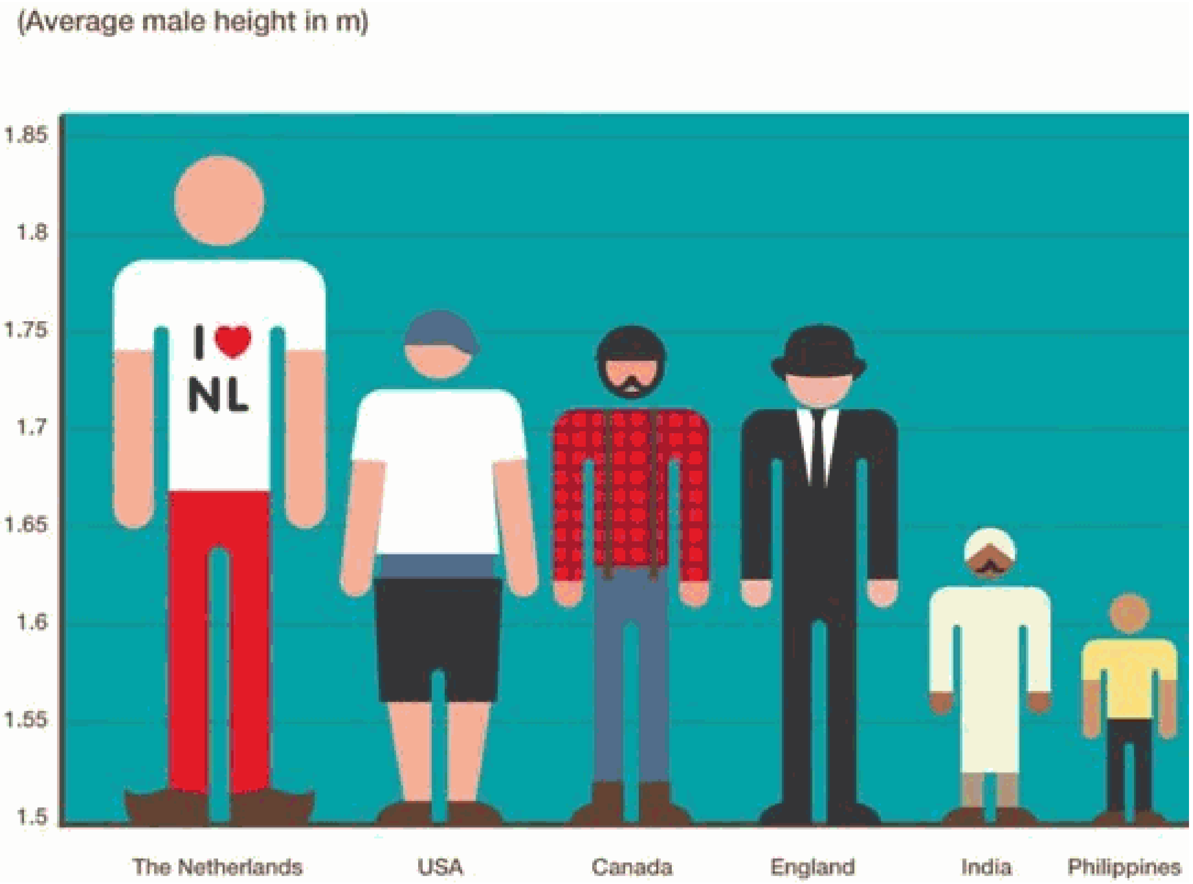
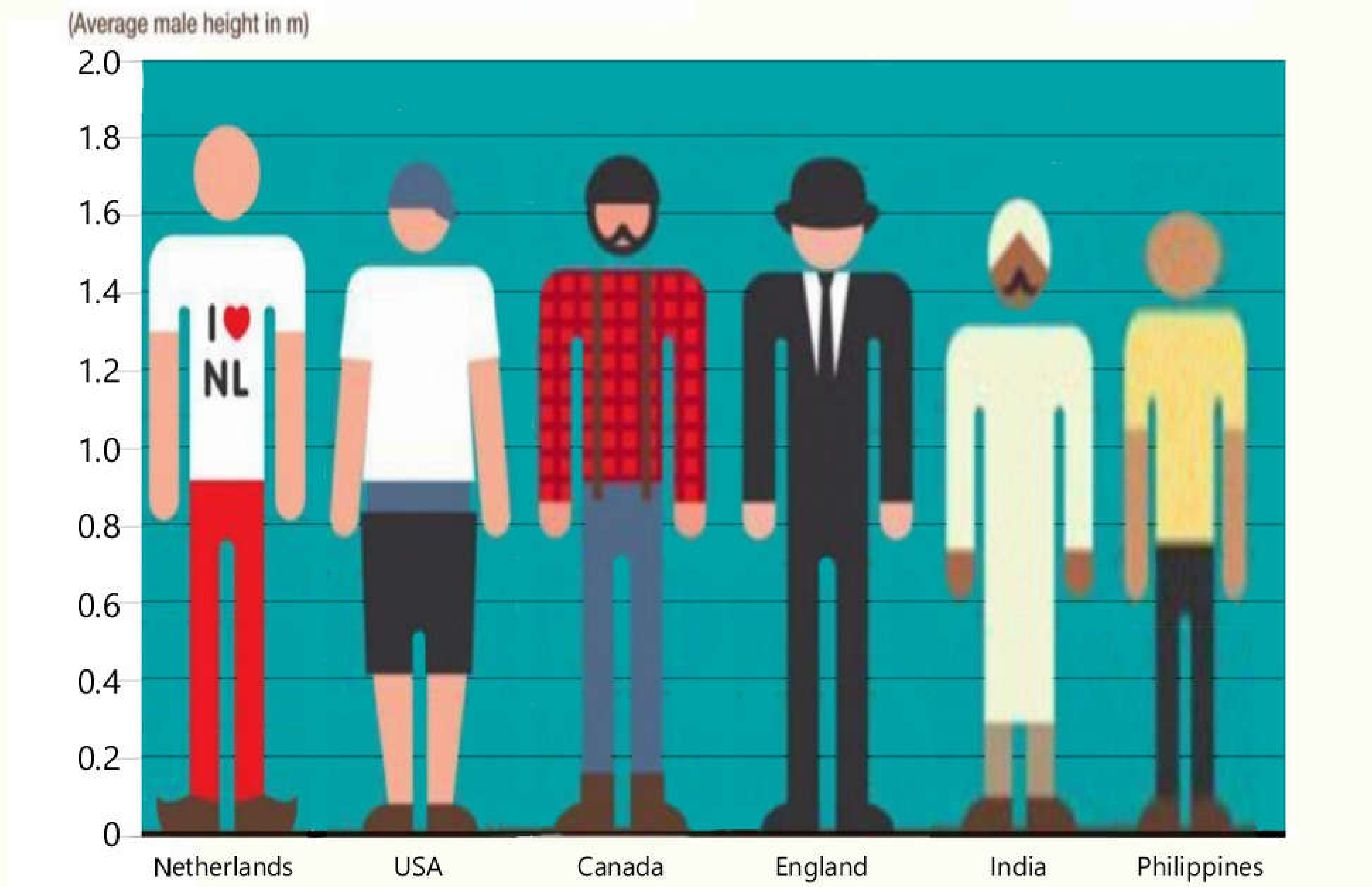
BAD GRAPHS – LOOKING DOWN ON THE REST OF THE WORLD

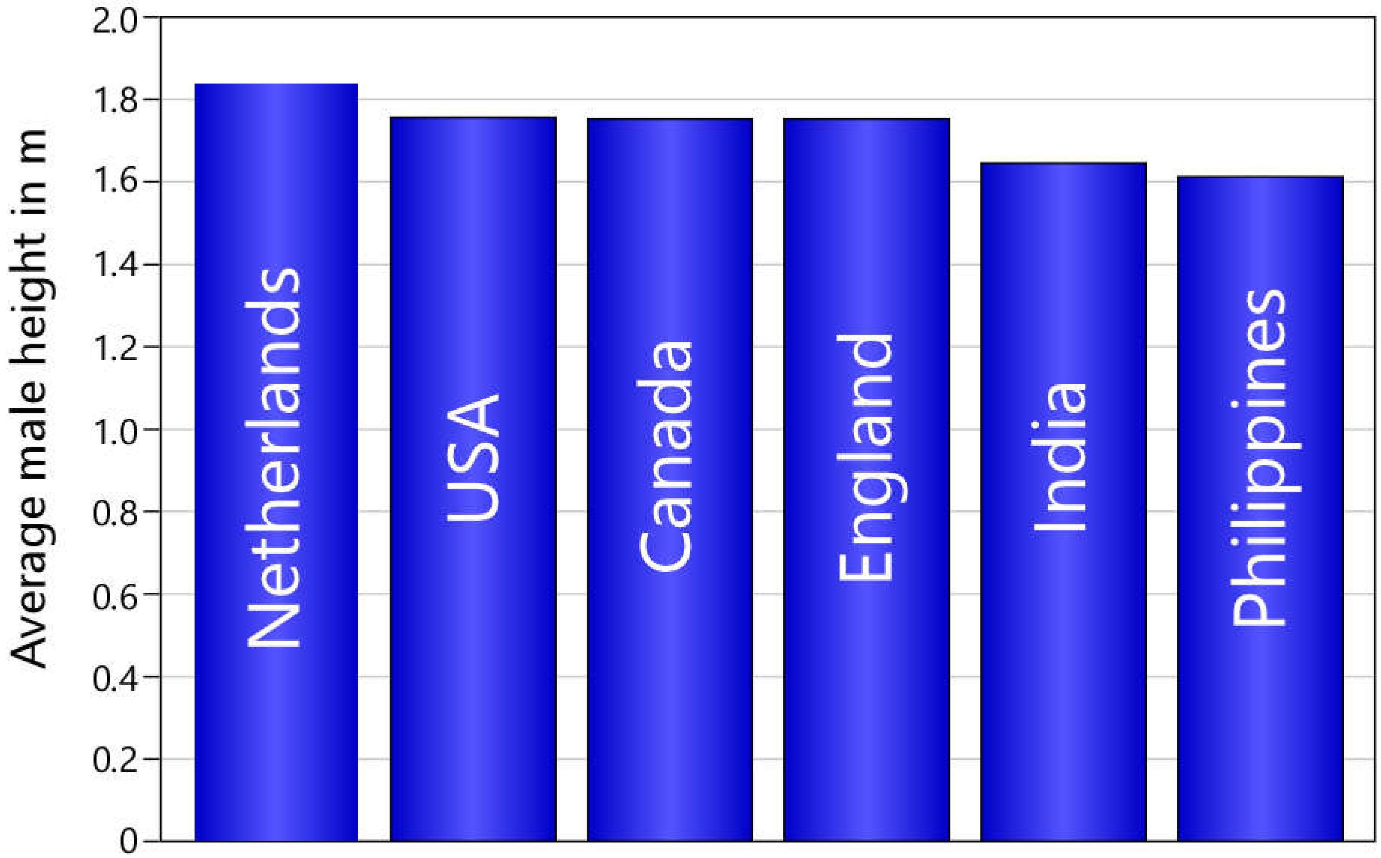


ticktockmaths.co.uk/bad-graphs/

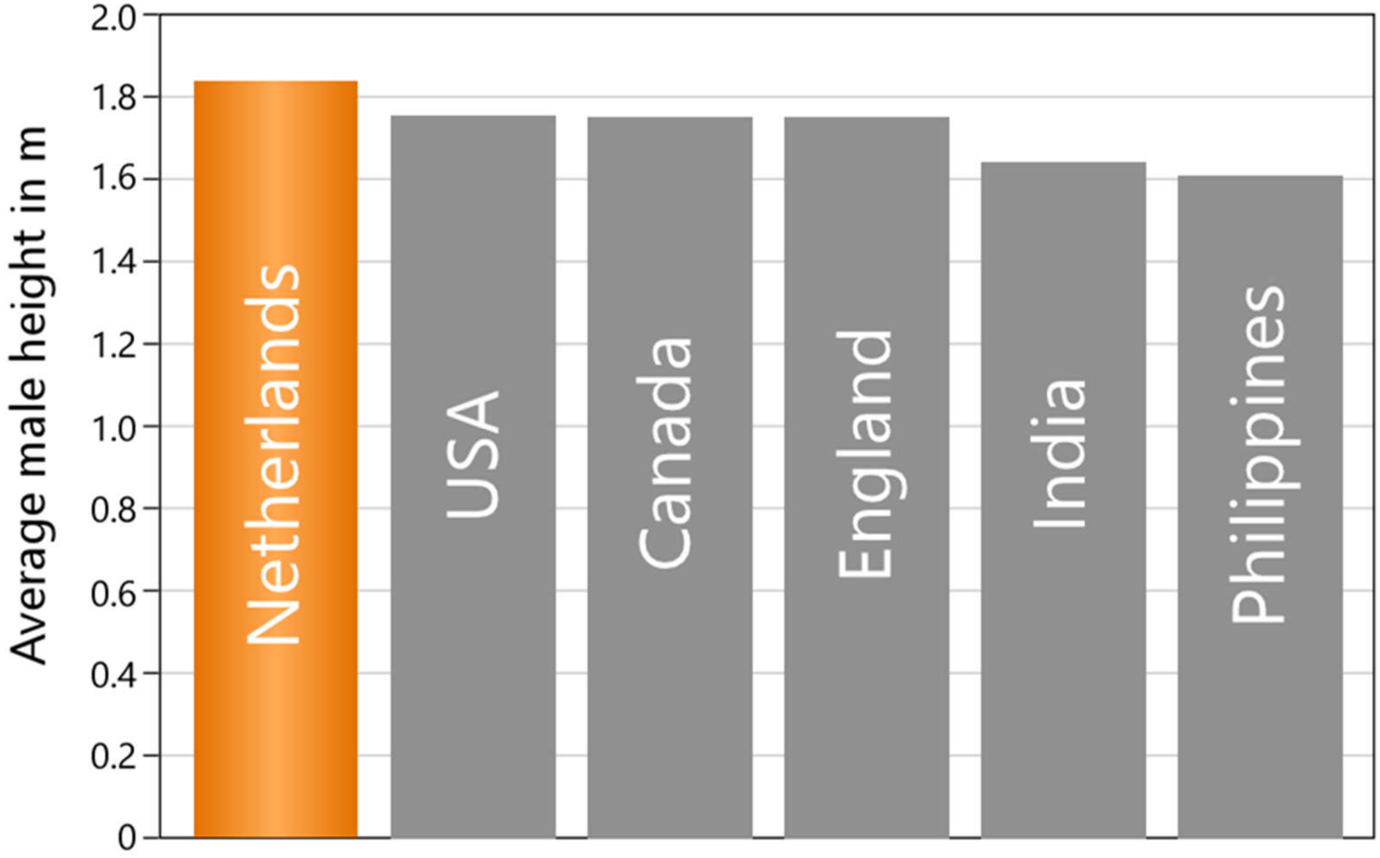
BETTER – BUT NOT GOOD ENOUGH



BETTER GRAPH

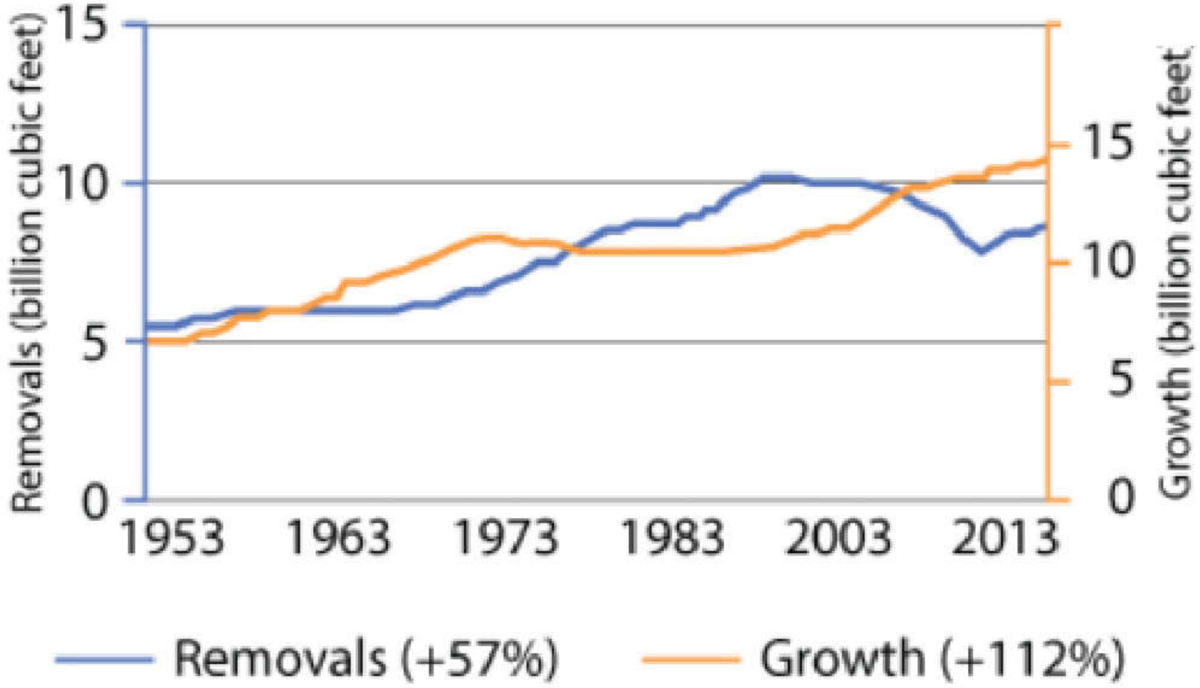


MAKING THE POINT



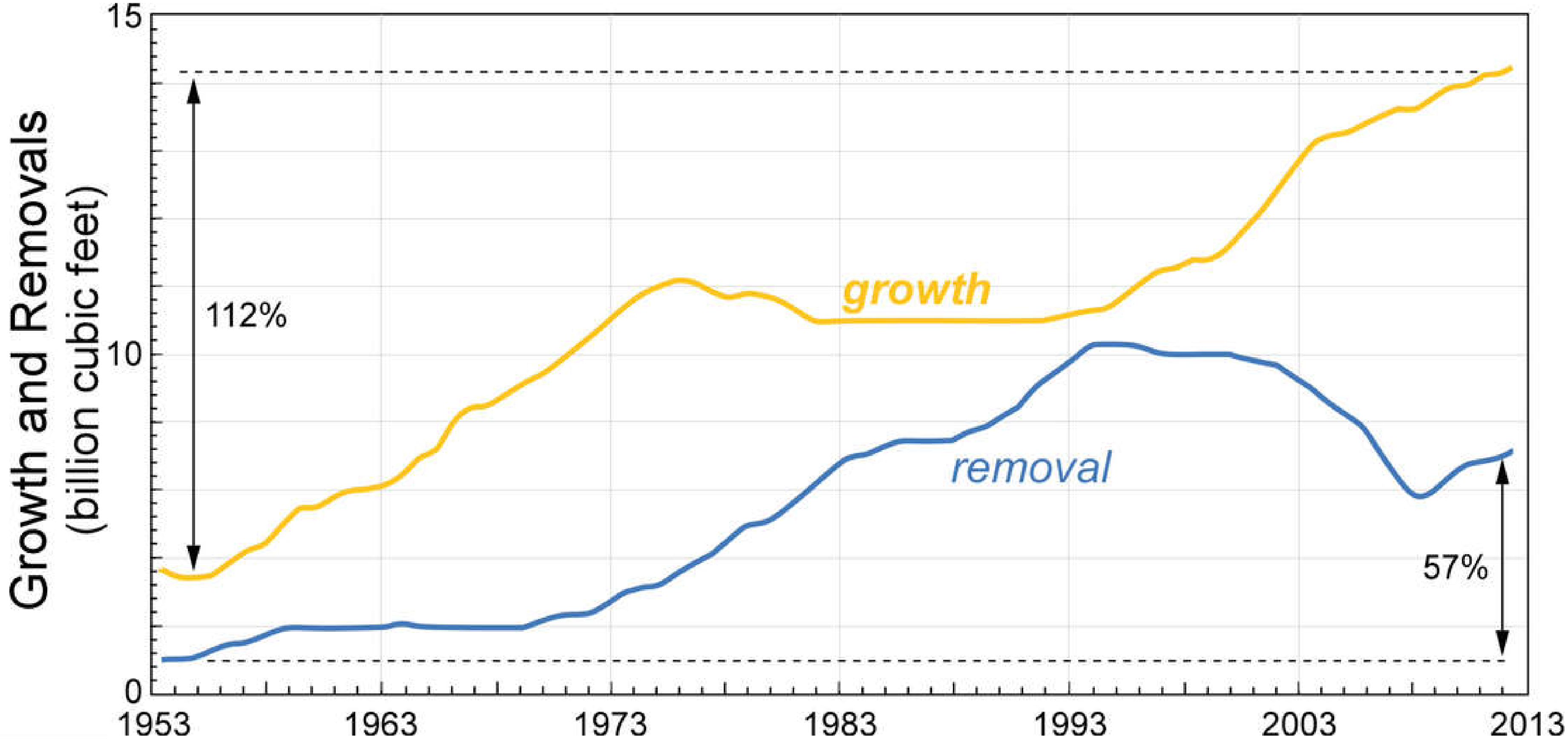
AXIS GAMES

Southern Timber Removals and Growth



biomassmagazine.com/articles/15210/healthy-demand-for-southern-timber-ensures-forested-lands-remain-forested

SOUTHERN TIMBER



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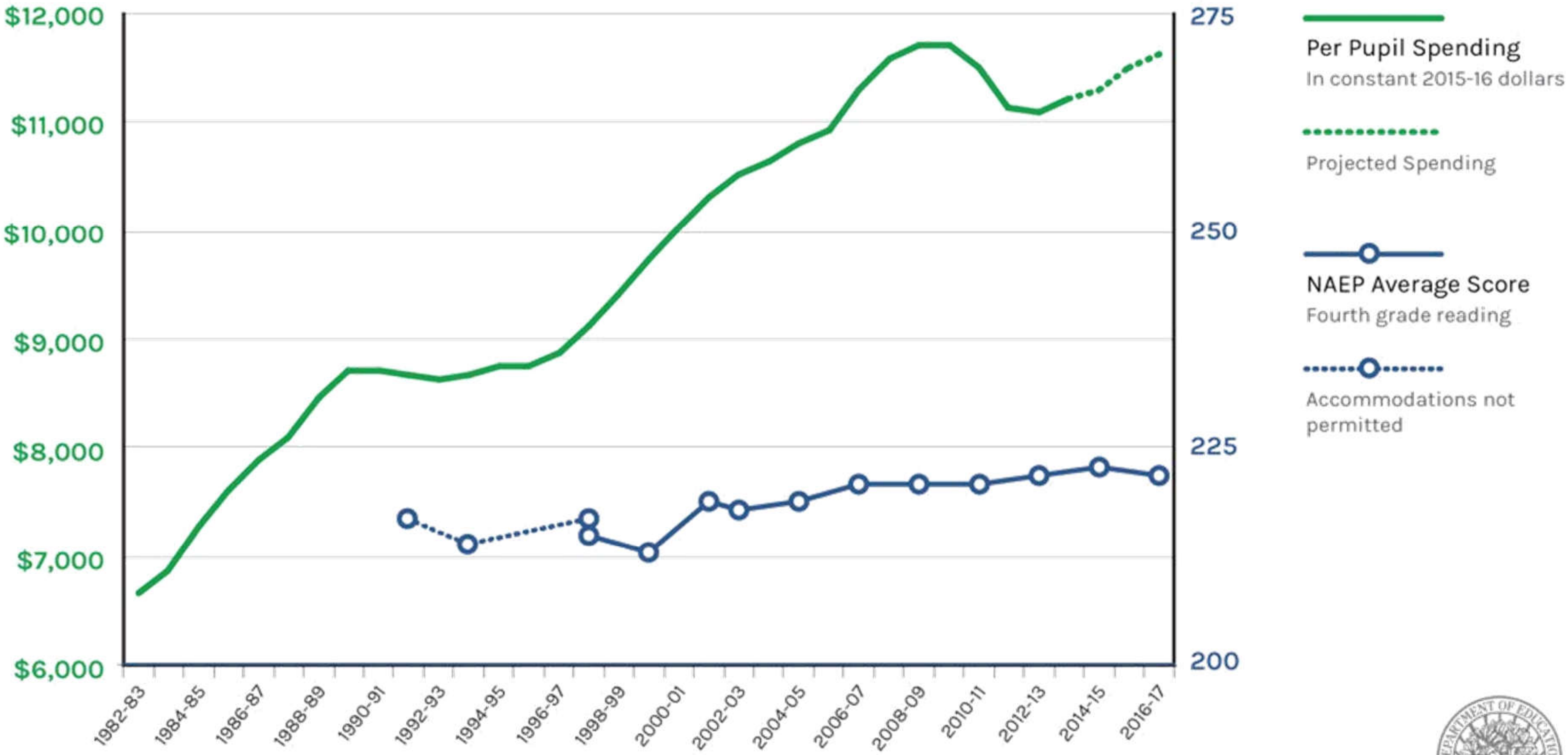
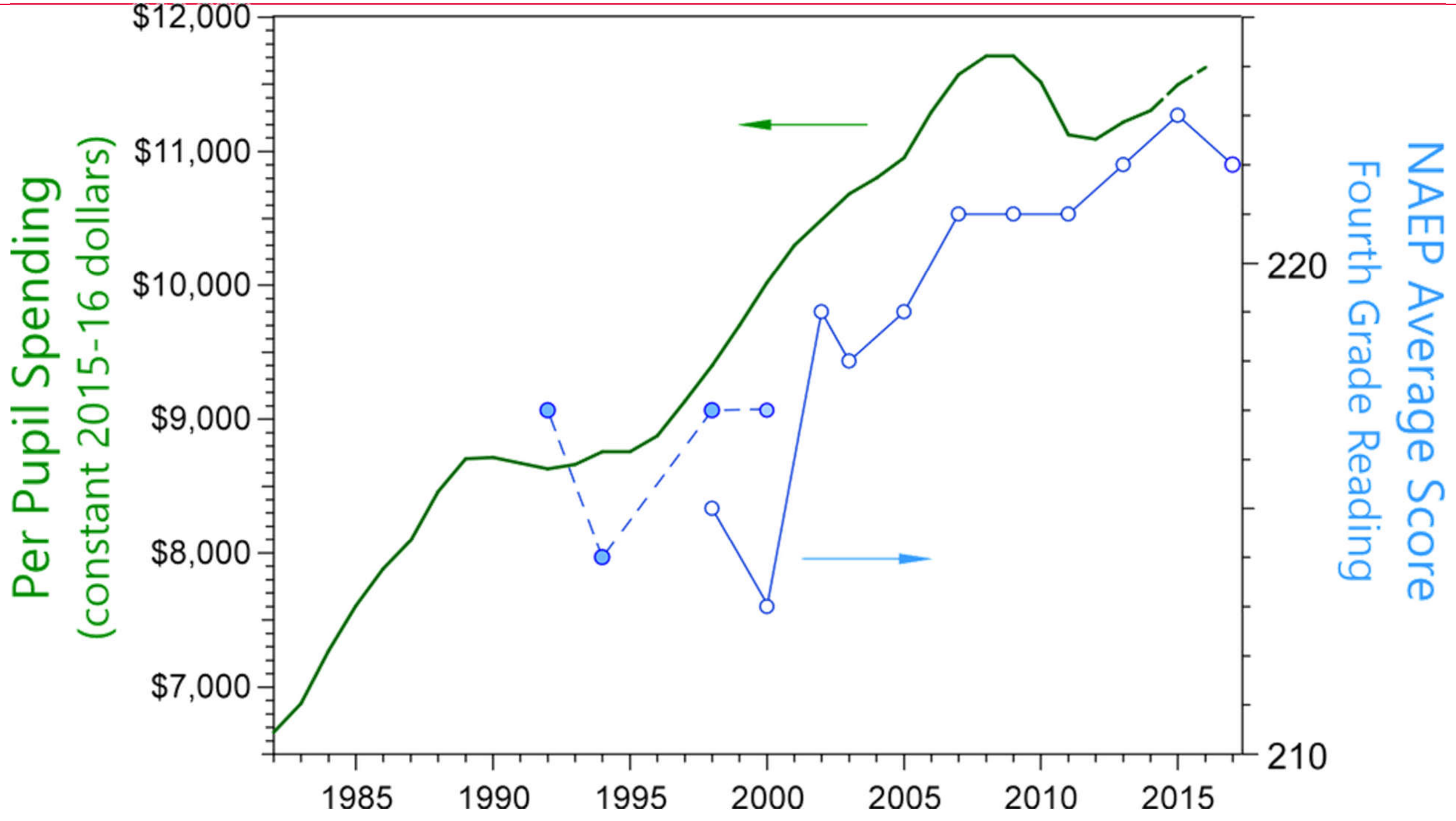
GAMES WITH 2 AXES



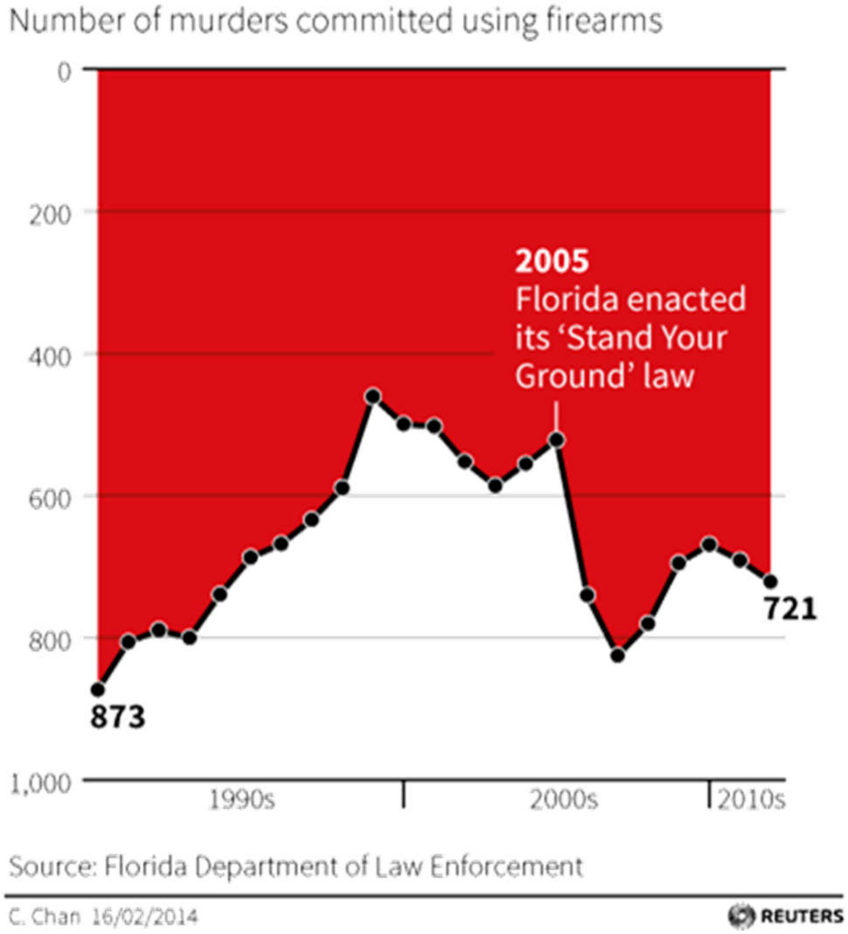
Source: U.S. Department of Education, National Center for Education Statistics, Revenues and Expenditures for Public Elementary and Secondary Education, 1970–71 through 1986–87; Common Core of Data (CCD), "National Public Education Financial Survey," 1987–88 through 2013–14; National Elementary and Secondary Enrollment Projection Model, 1972 through 2026; Public Elementary and Secondary Education Current Expenditure Projection Model, 1973–74 through 2026–27; and National Assessment of Educational Progress, Reading Report Card, 2017

http://www.shankerinstitute.org/blog/we-cant-graph-our-way-out-research-education-spending

MORE HONEST AXES

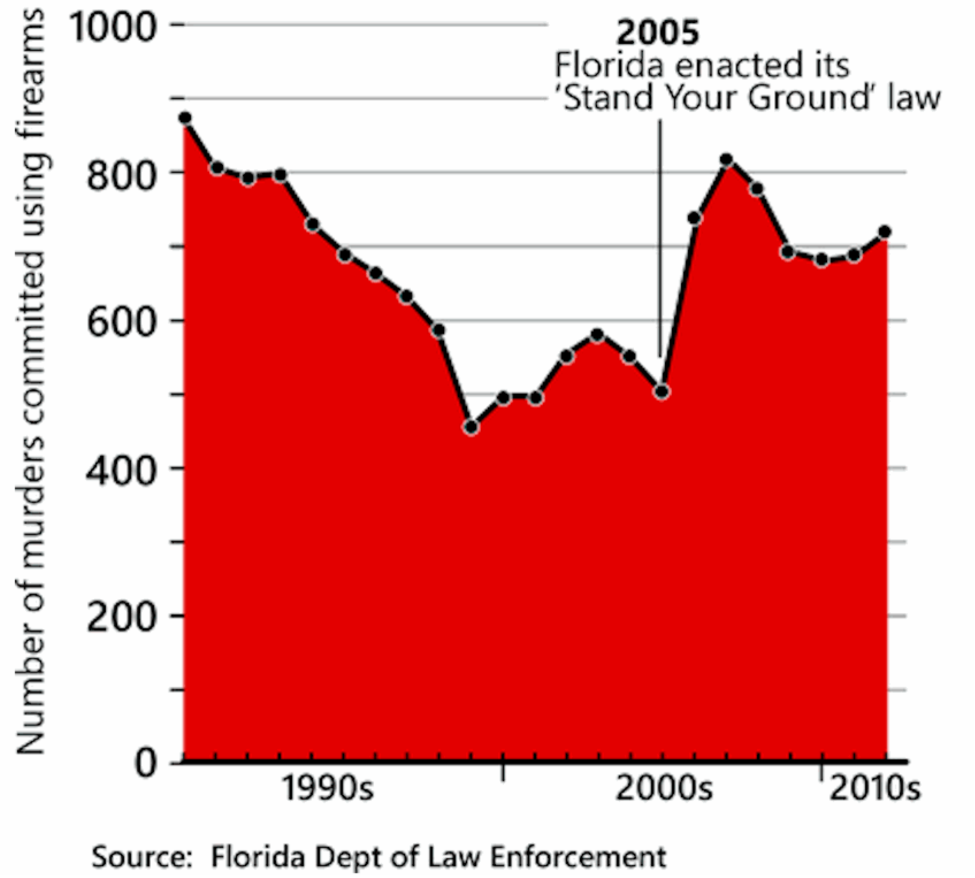


AXIS GAMES - GUN DEATHS IN FLORIDA



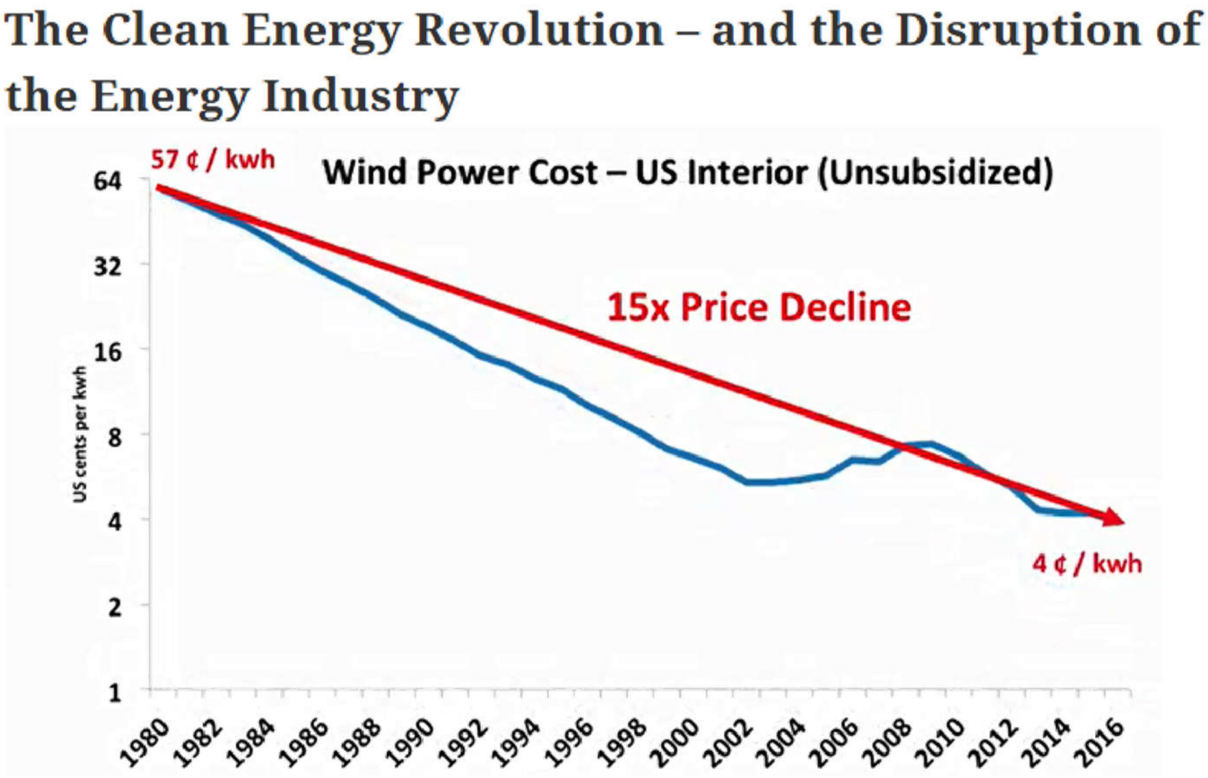
methodsavvy.com/good-data-bad-graphs/

GUN DEATHS IN FLORIDA



Source: Florida Dept of Law Enforcement

AXIS GAMES – HIDDEN LOG AXIS

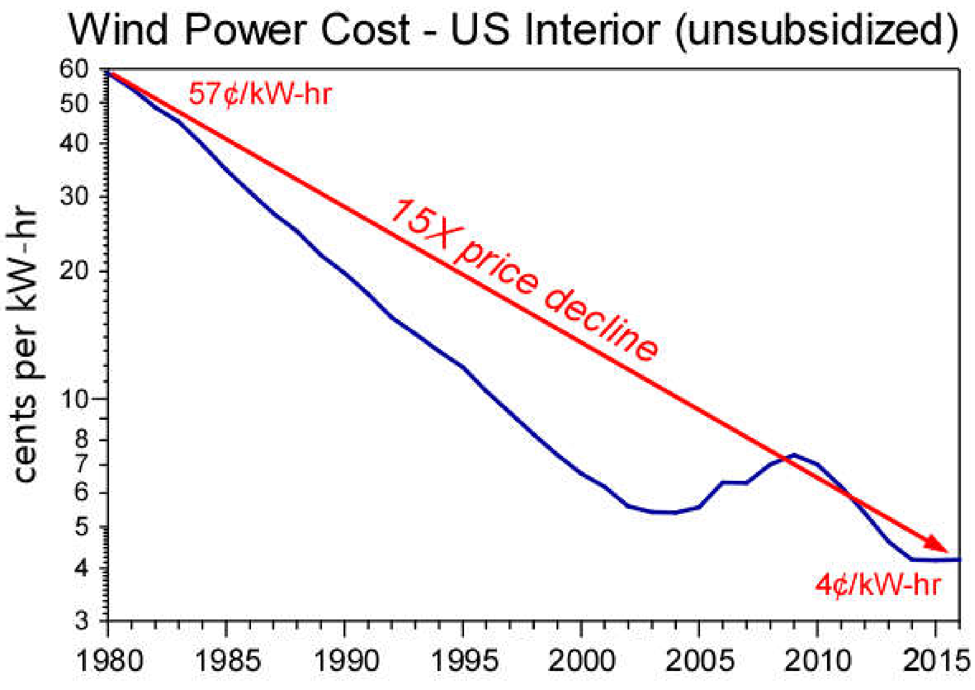


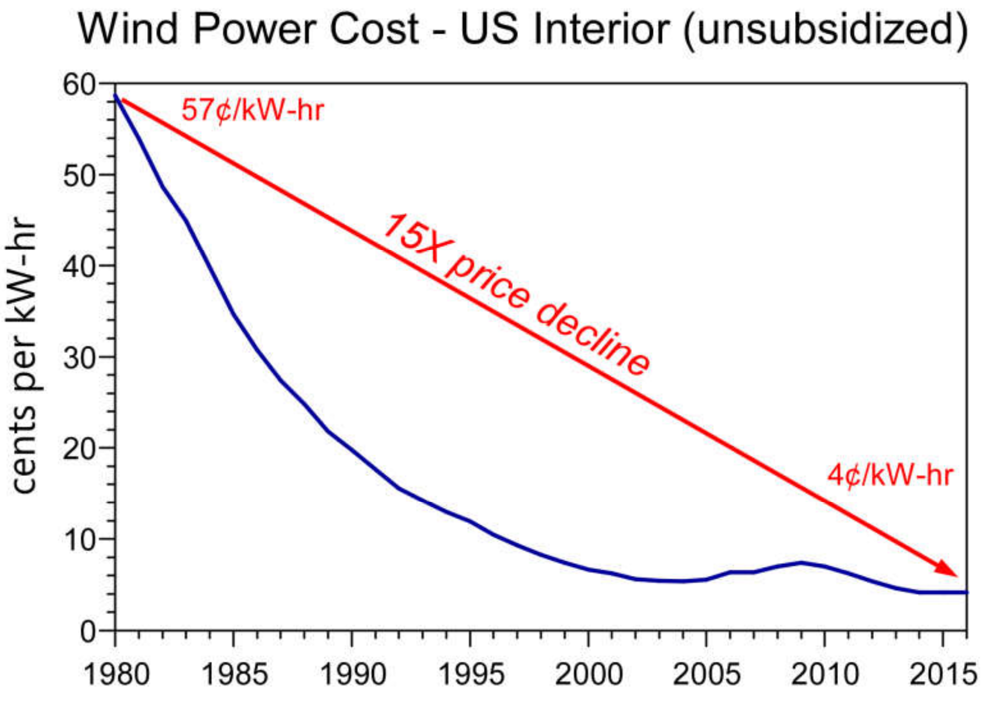
The Clean Energy Revolution – and the Disruption of the Energy Industry

rameznaam.com/ video “The Clean Energy Revolution – and the Disruption of the Energy Industry”,

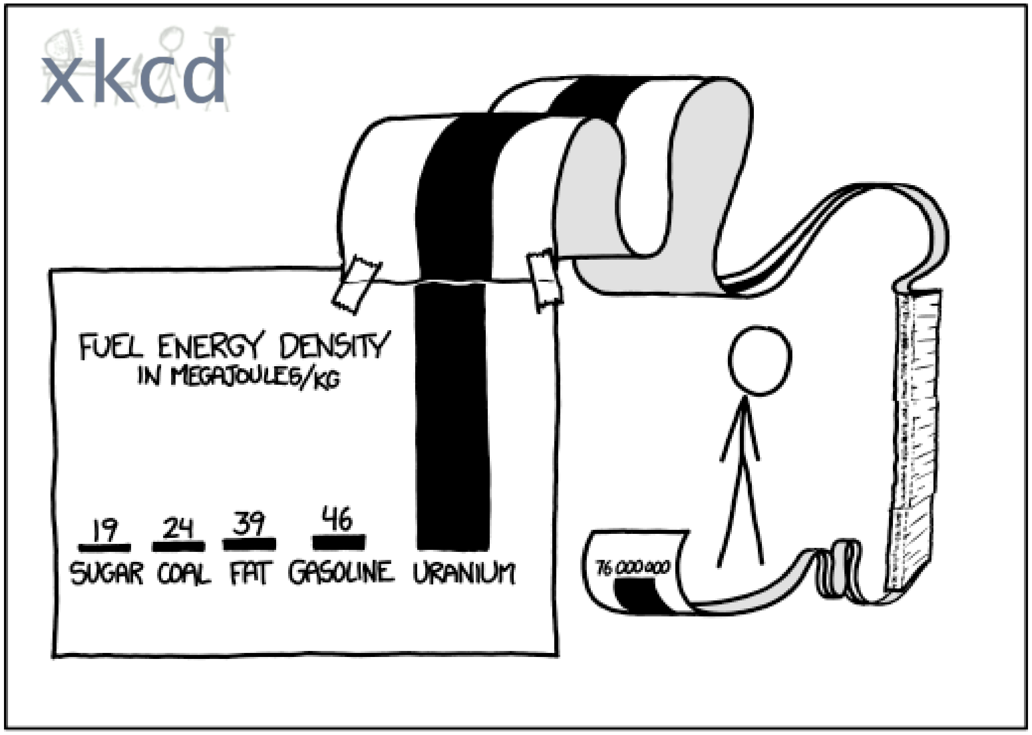
youtu.be/fwSkQa1tNmE

CLEAN ENERGY





PROBLEMS WITH LOG AXES

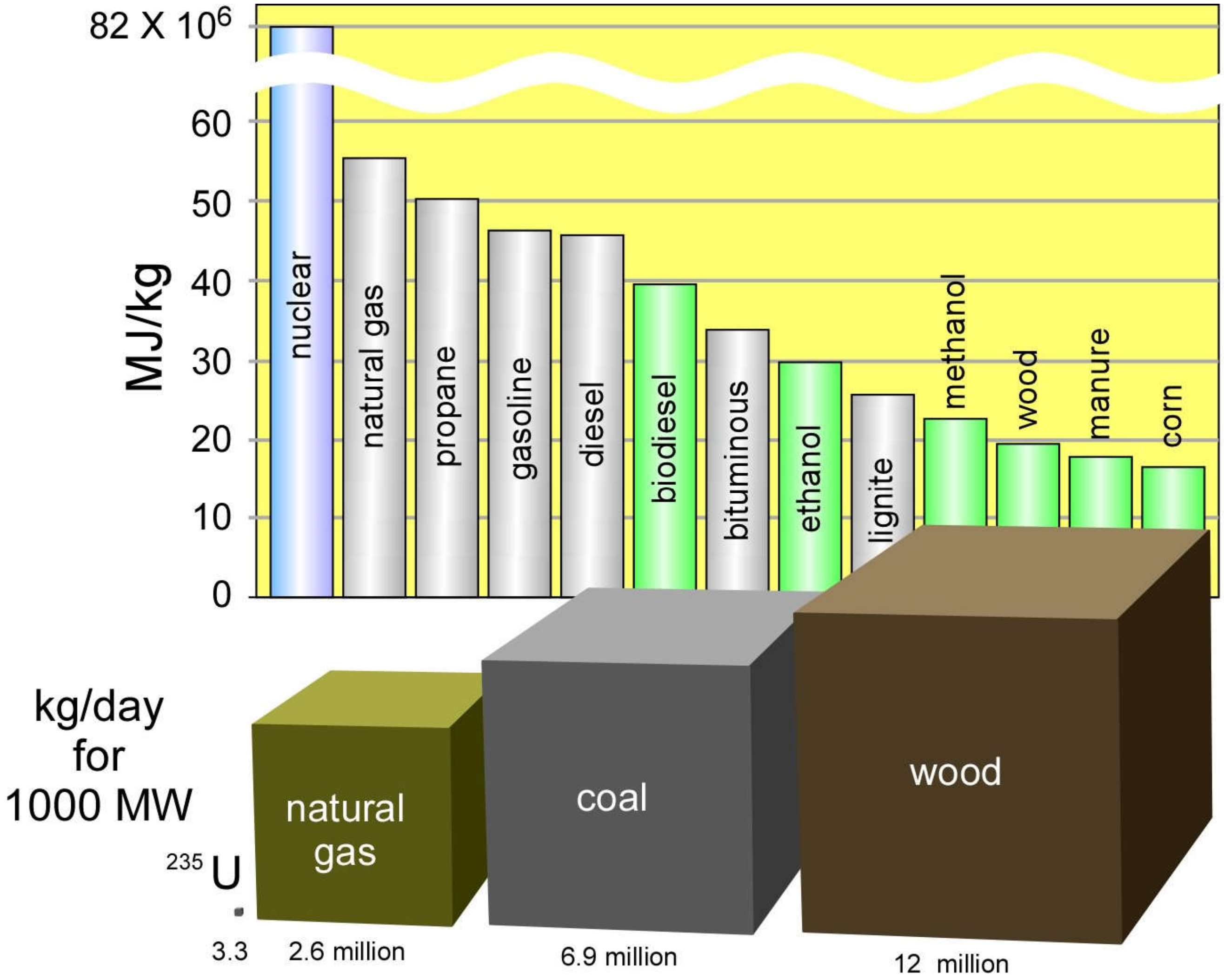

xkcd
FUEL ENERGY DENSITY
IN MEGAJOULES/KG
19
24
39
46
SUGAR
COAL
FAT
GASOLINE
URANIUM
76 000 000

SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T FIND ENOUGH PAPER TO MAKE THEIR POINT *PROPERLY.*

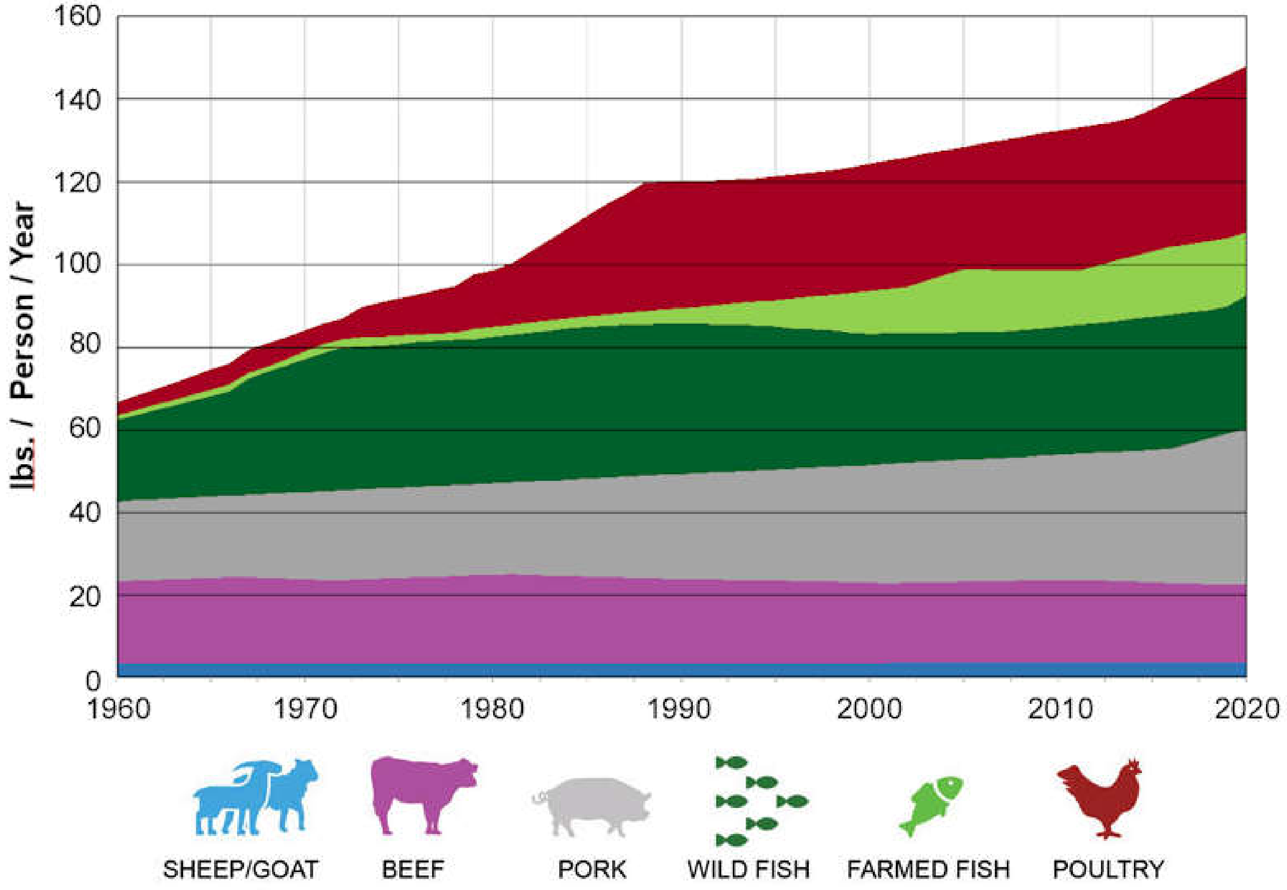
Permanent link to this comic: https://xkcd.com/1162/
Image URL (for hotlinking/embedding): https://imgs.xkcd.com/comics/log_scale.png

Human perception is linear.

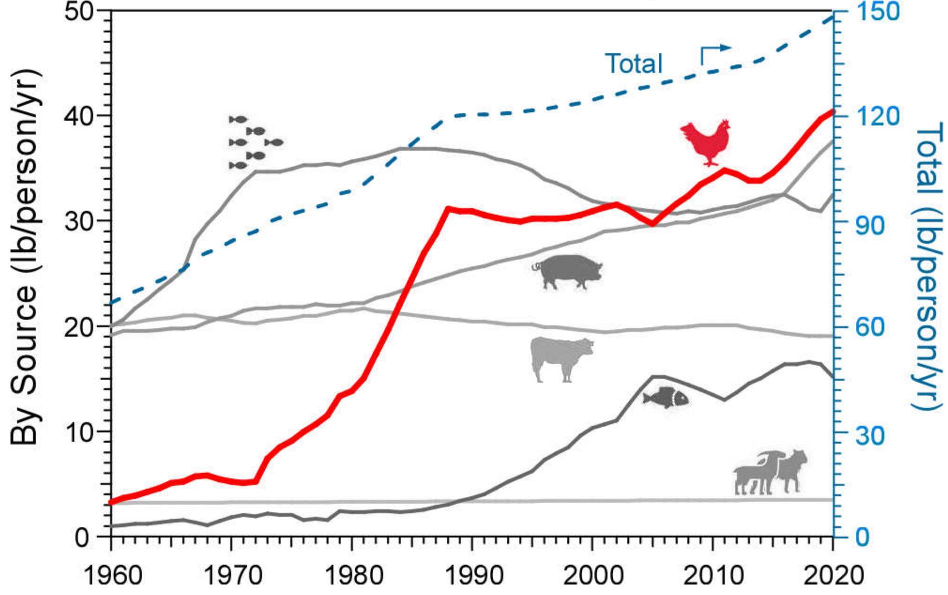
Log axes are great for detailed understanding, not for instantaneous recognition.


82 X 10^6
60
50
40
30
20
10
0
MJ/kg
nuclear
natural gas
propane
gasoline
diesel
biodiesel
bituminous
ethanol
lignite
methanol
wood
manure
corn
kg/day
for
1000 MW
^{235}U
natural gas
coal
wood
3.3
2.6 million
6.9 million
12 million

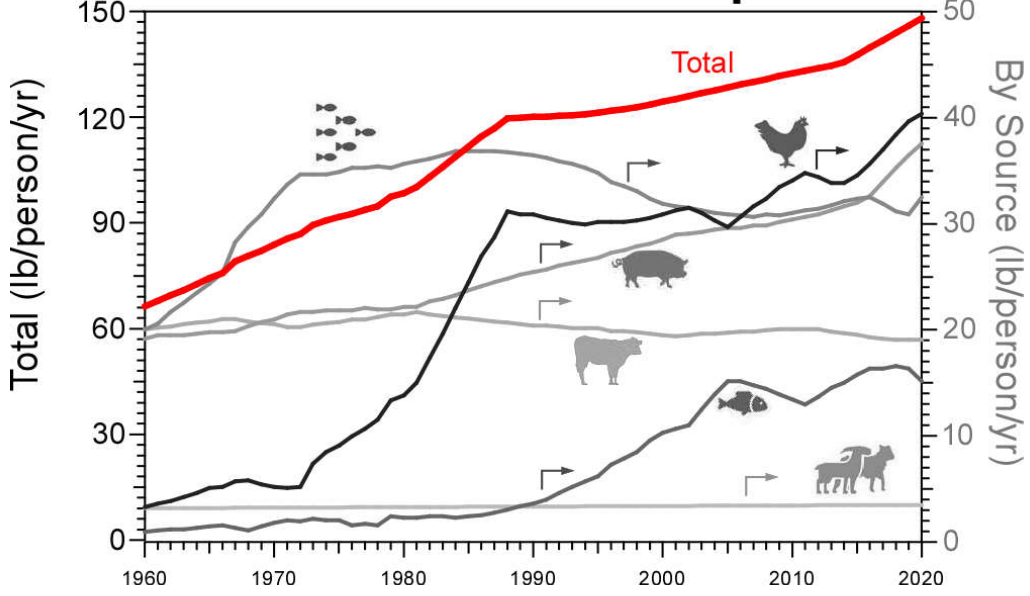
MEAT CONSUMPTION



www.ethanolproducer.com/articles/16179/opportunities-in-high-protein-feed



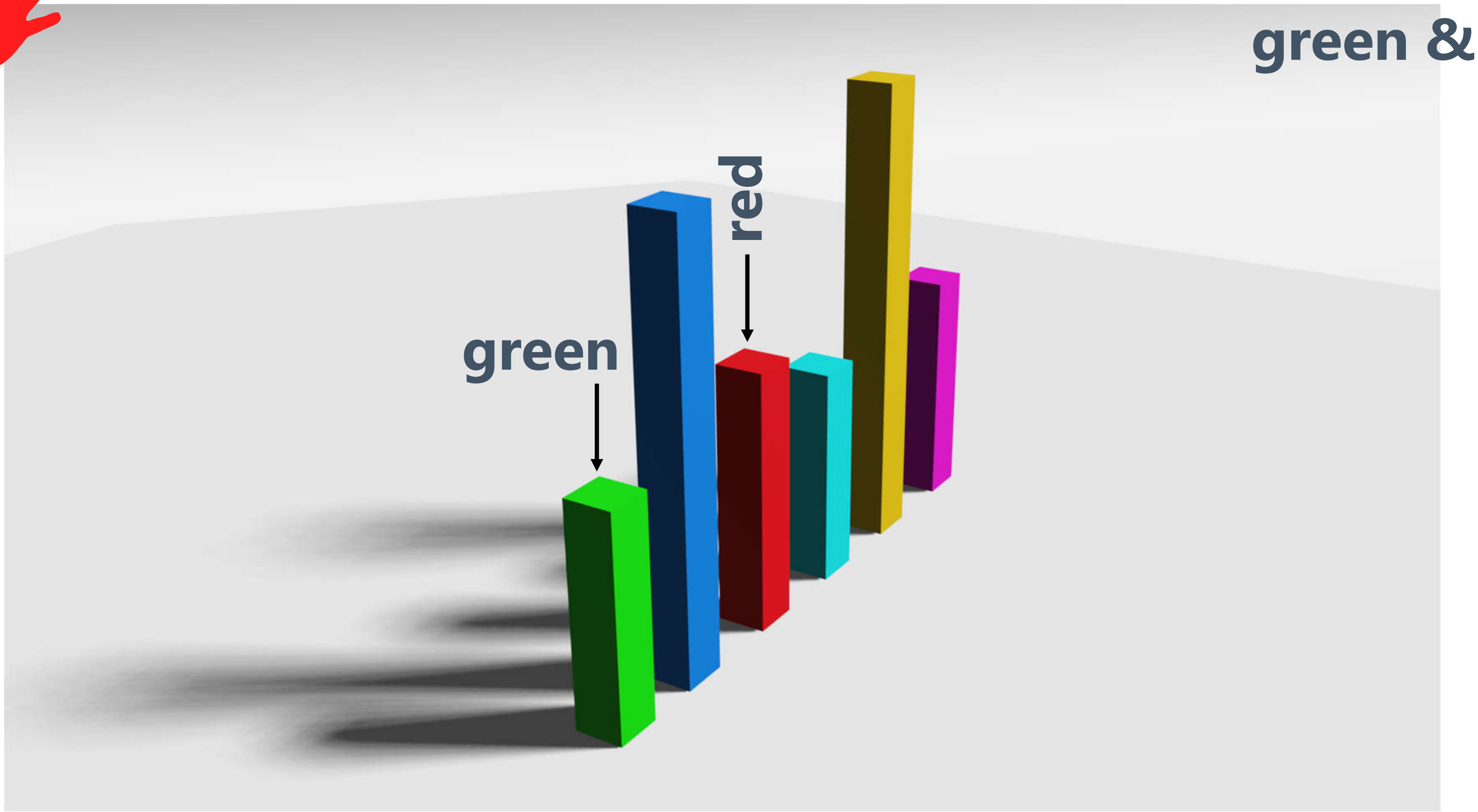
Global Meat Consumption



Global Meat Consumption

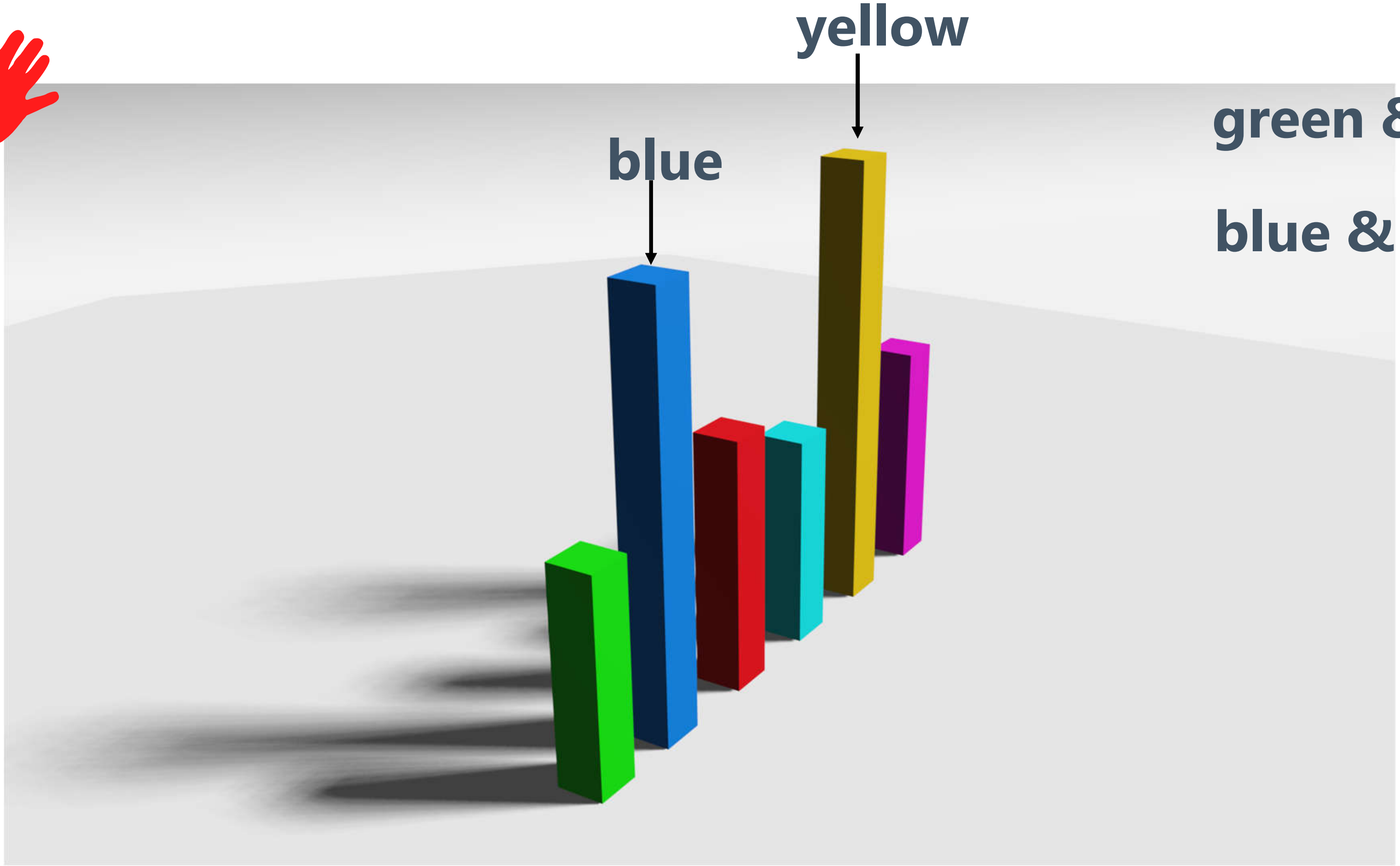
MJPhD

Which Bars Are the Same Height?



green & red

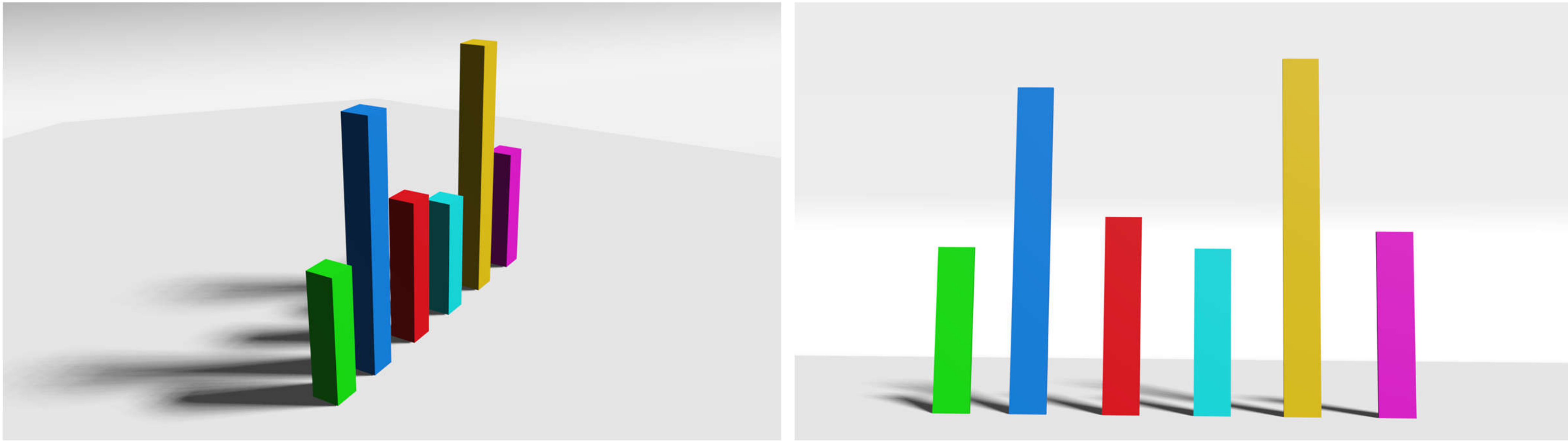
WHICH BARS ARE THE SAME HEIGHT?


yellow
blue

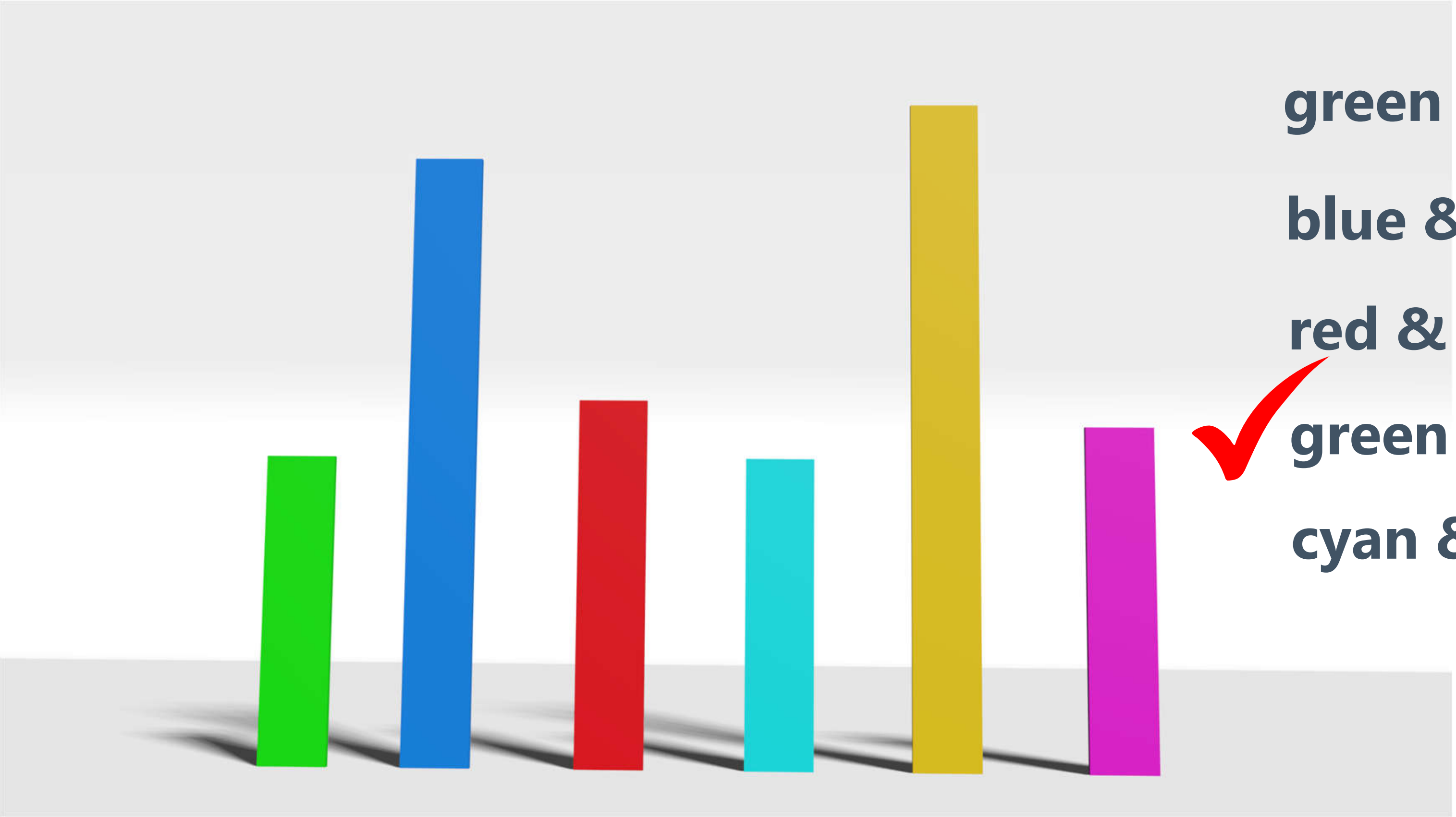
green & red

blue & yellow

WHICH BARS ARE THE SAME HEIGHT?



WHICH BARS ARE THE SAME HEIGHT?



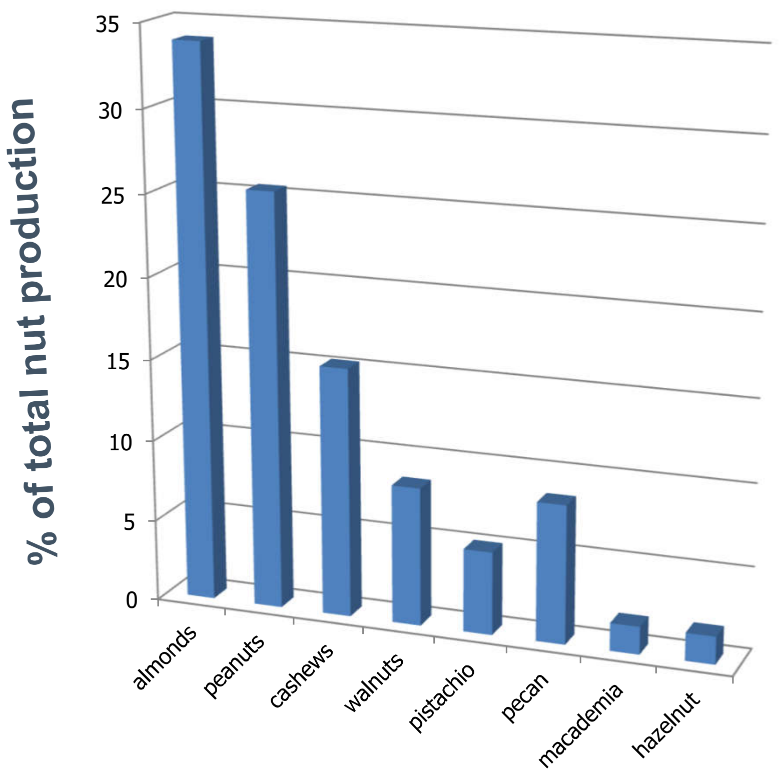
green & red

blue & yellow

red & magenta

✓ green & cyan

cyan & magenta


% of total nut production
35
30
25
20
15
10
5
0
almonds
peanuts
cashews
walnuts
pistachio
pecan
macademia
hazelnut

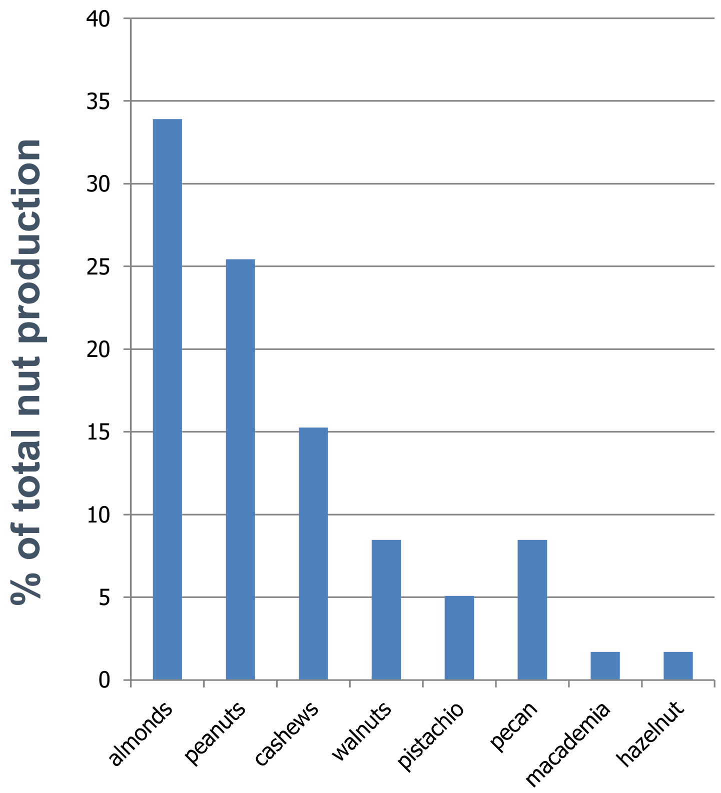

% of total nut production
40
35
30
25
20
15
10
5
0
almonds
peanuts
cashews
walnuts
pistachio
pecan
macademia
hazelnut

CHART JUNK

Median student debt of households headed by people 55-64 and owing student loans (all figures in 2016 dollars).

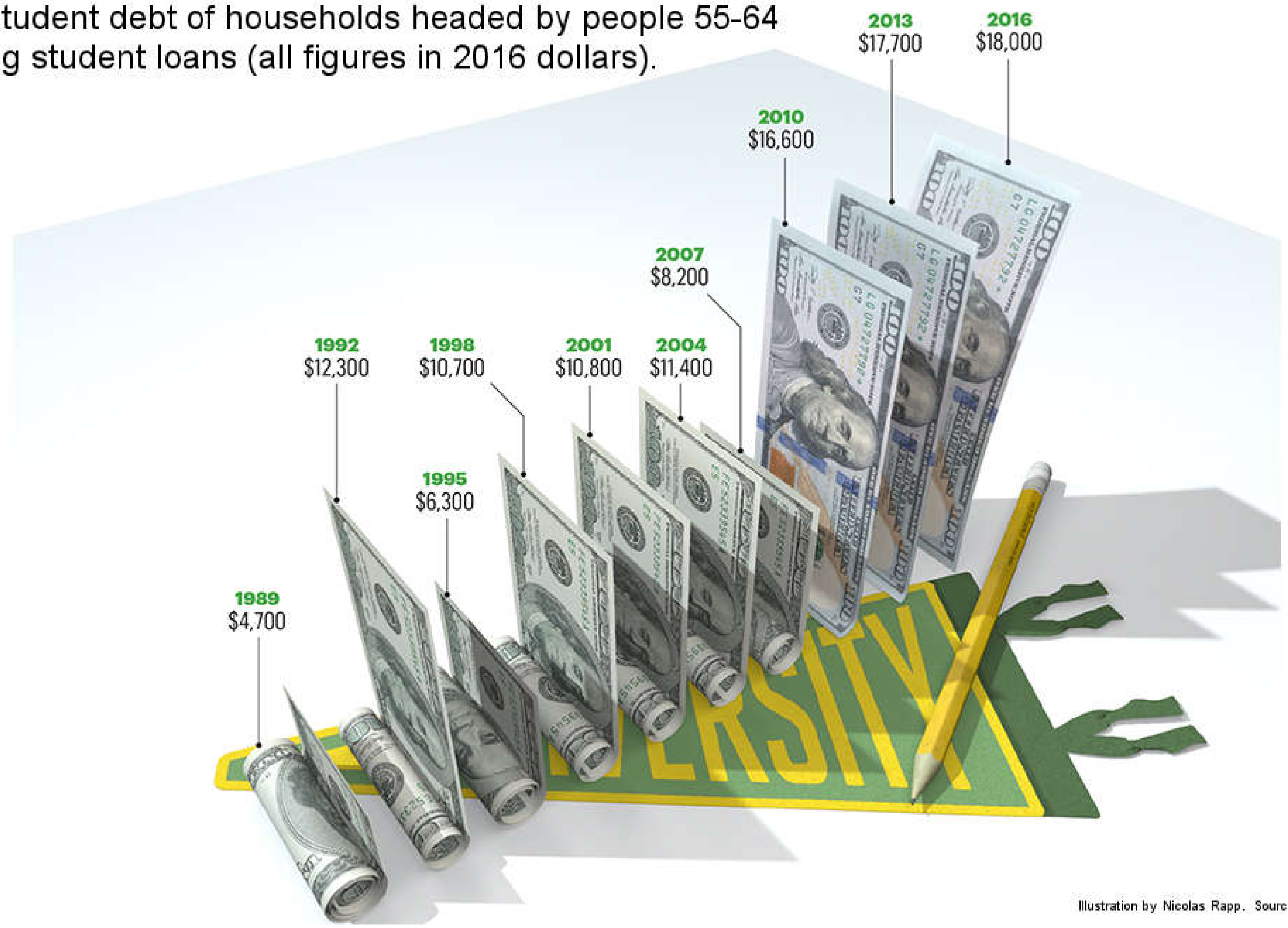
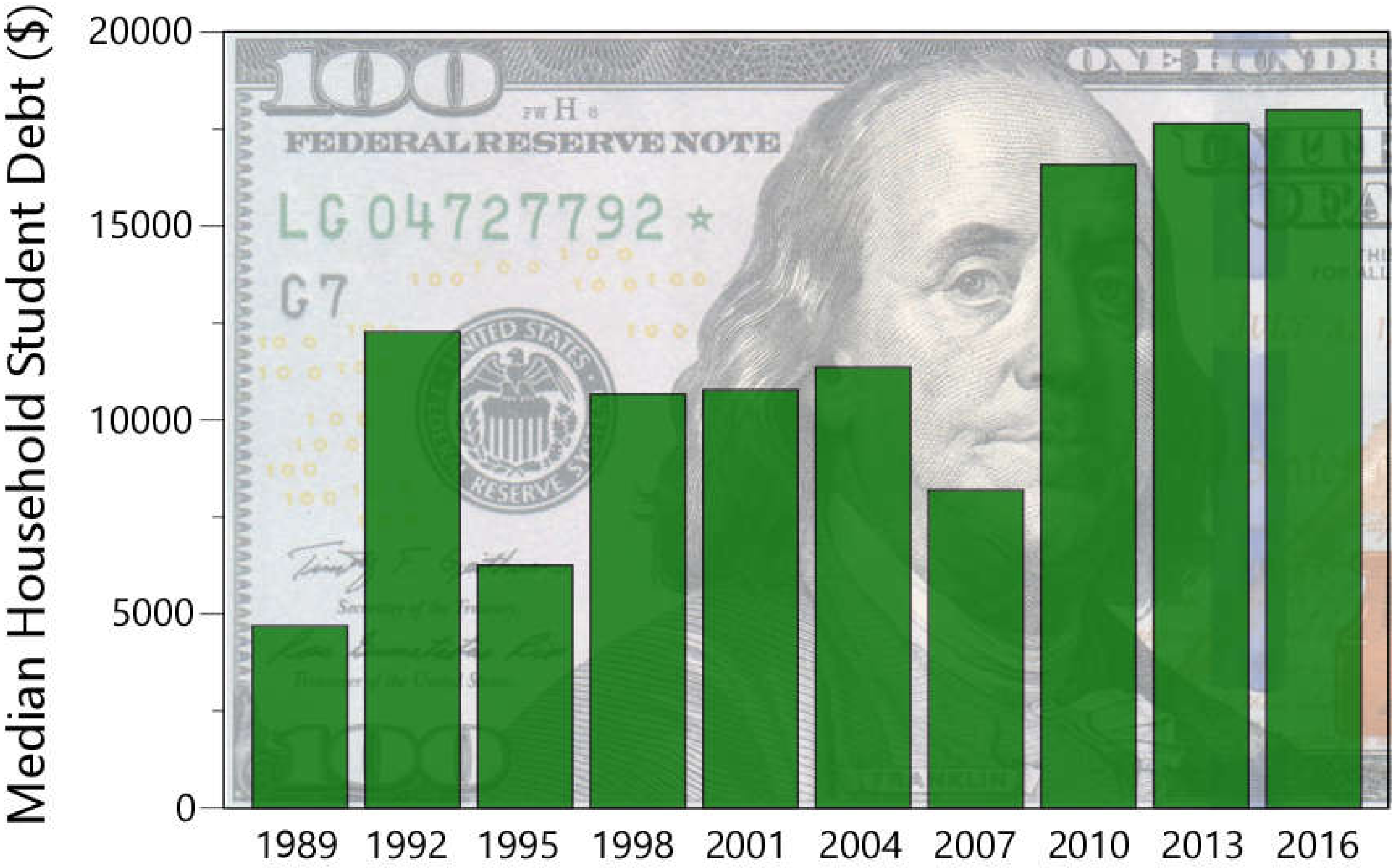
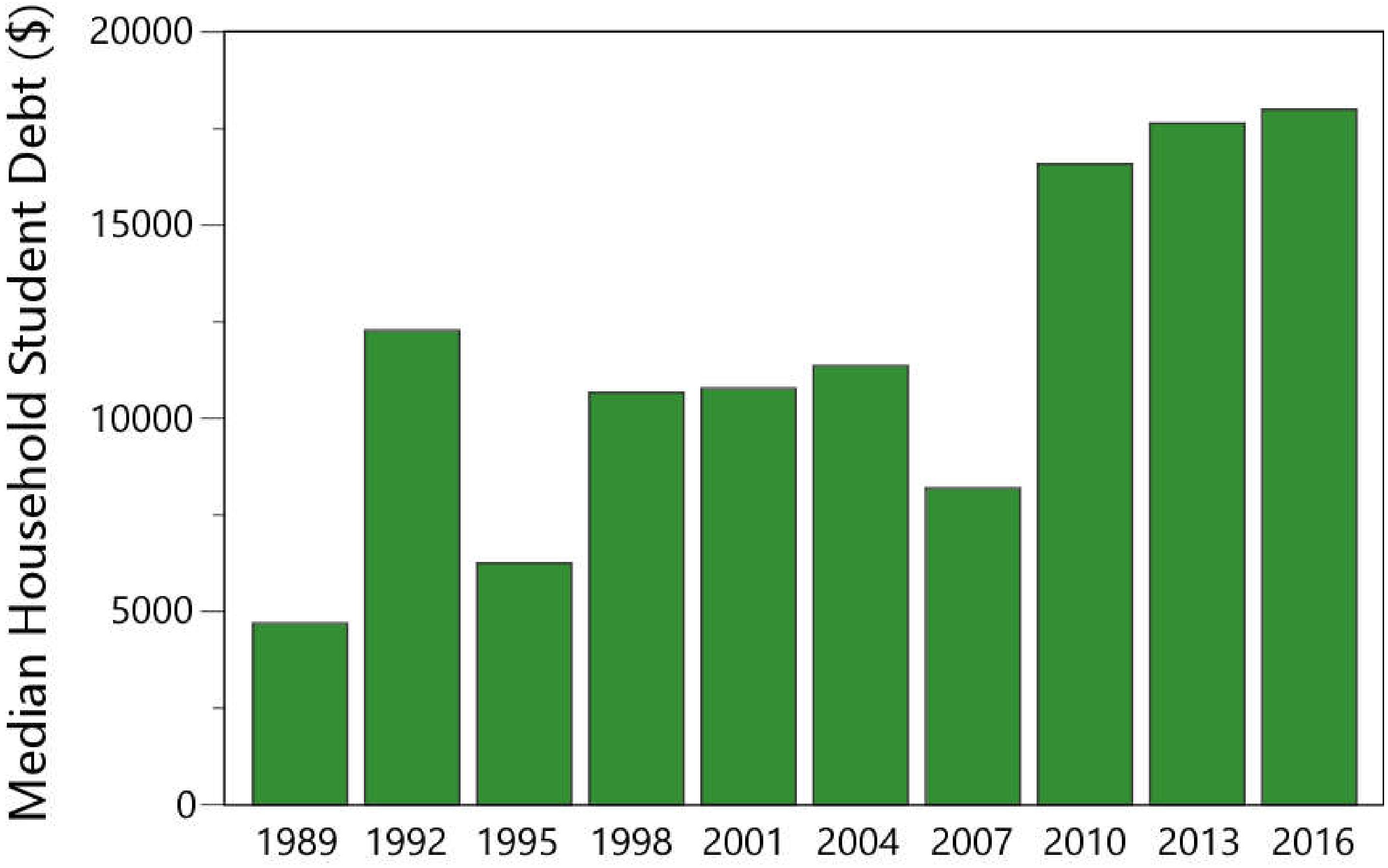


Illustration by Nicolas Rapp. Source: Federal Reserve Board

REMOVE THE JUNK

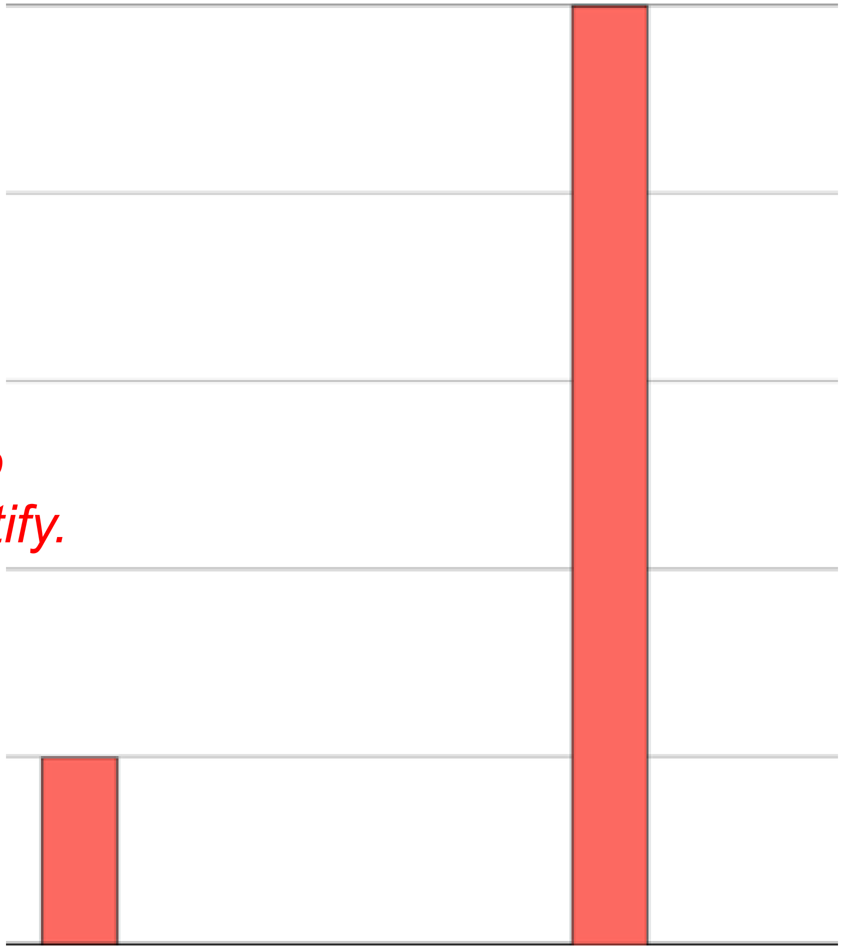


REMOVE THE JUNK



HOW MANY TIMES BIGGER?

aligned with axis is easiest to accurately quantify.



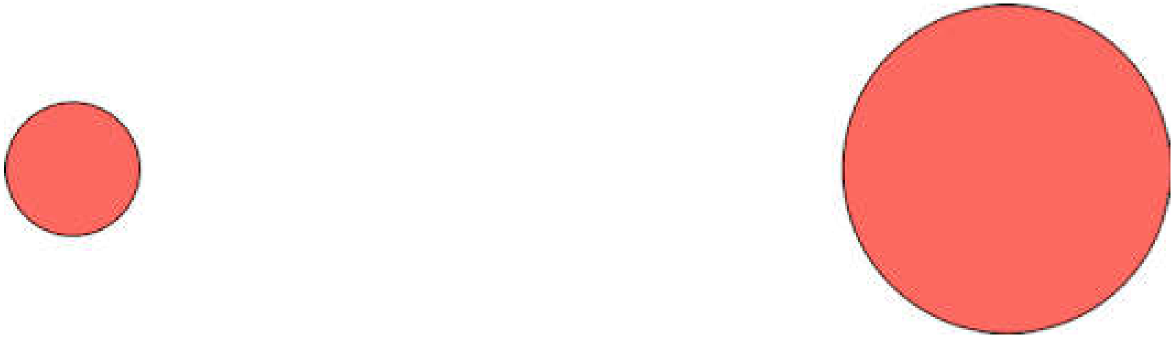
4x

[✓ 5x]

6x

7x

HOW MANY TIMES BIGGER?



3x

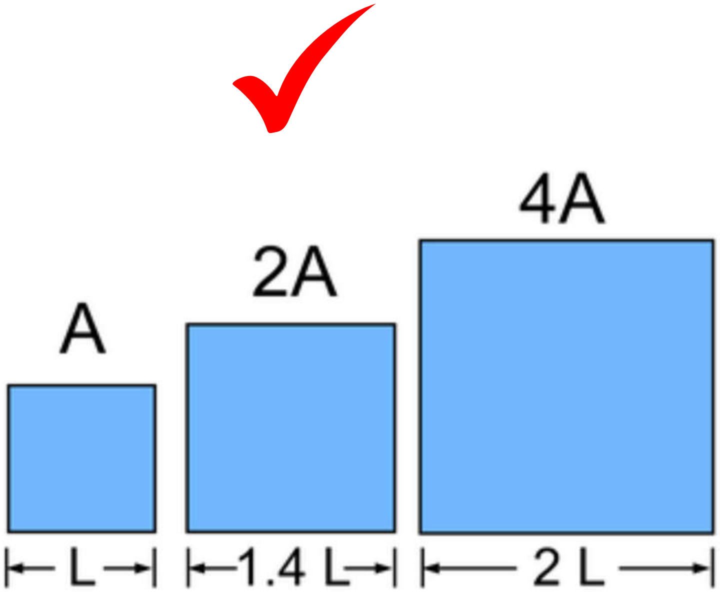
4x

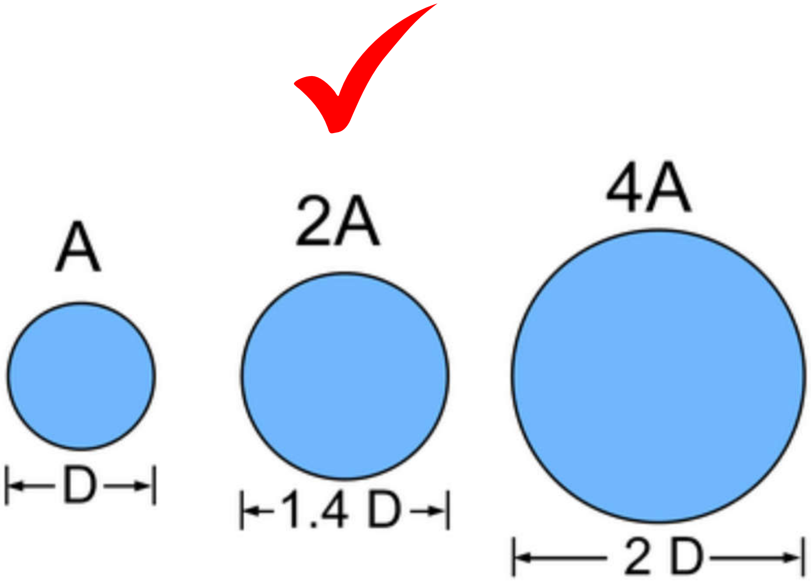
5x

[✓ 6x]

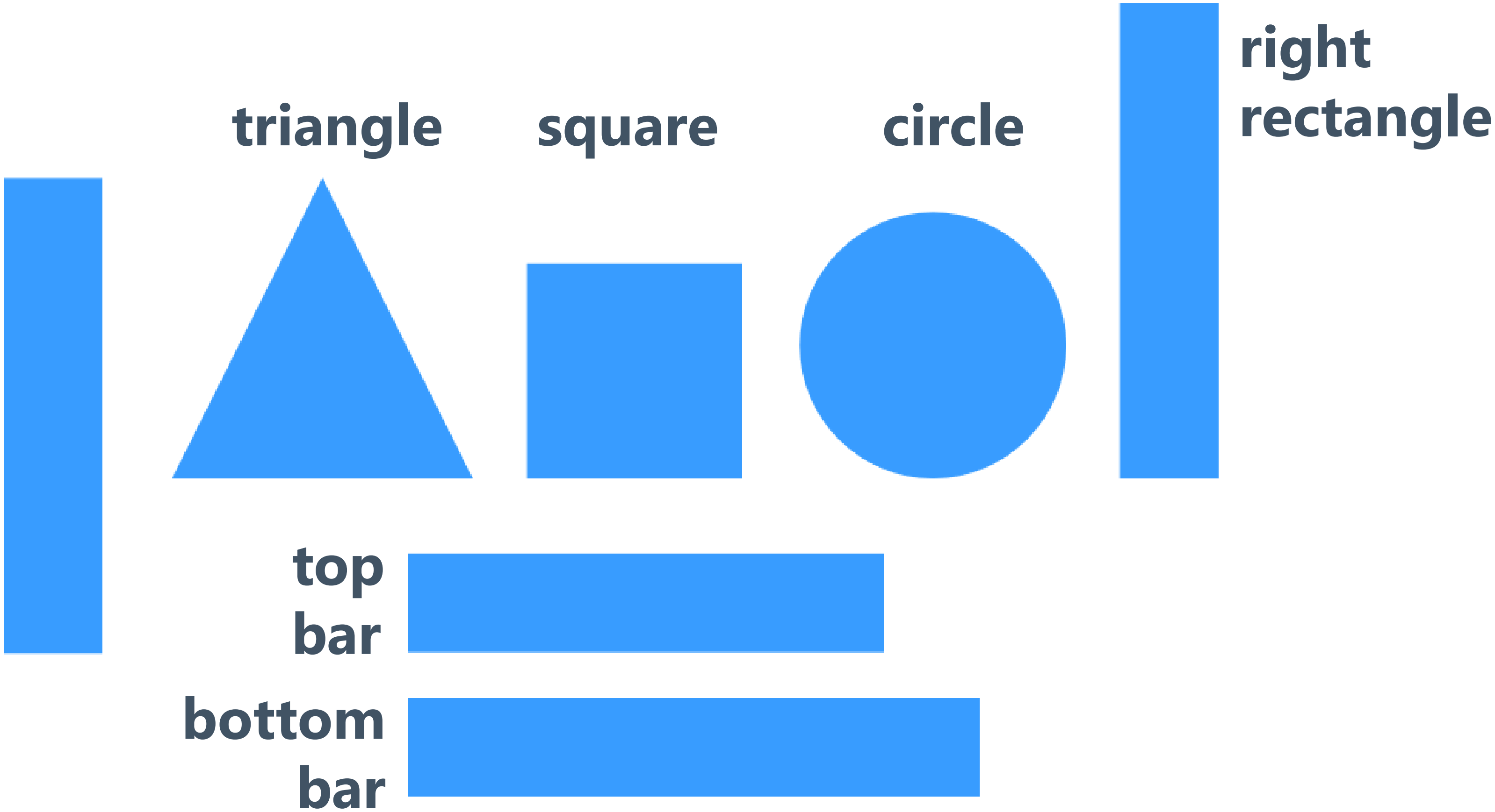
area is hard to judge

AREA CONFUSION

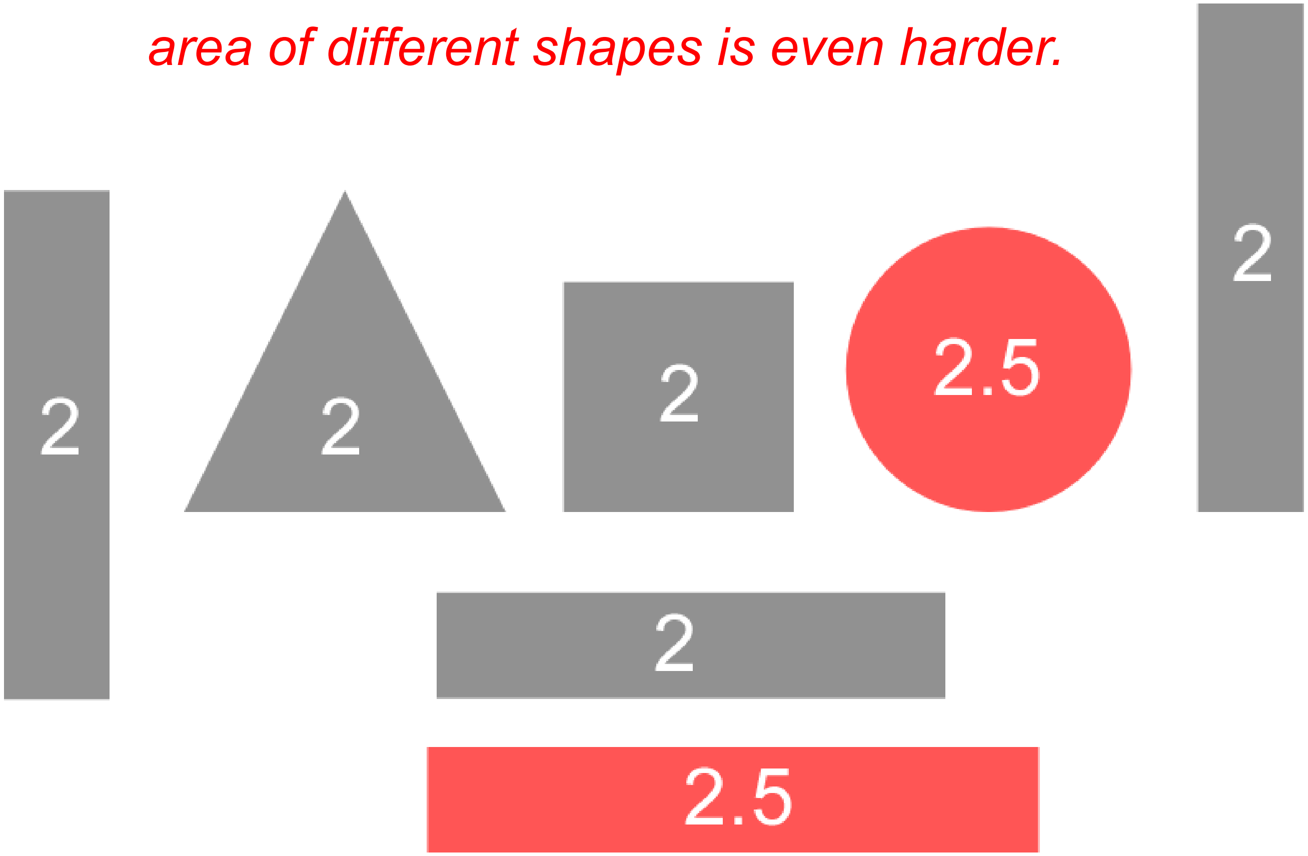

✓
A
2A
4A
L
1.4 L
2 L


✓
A
2A
4A
D
1.4 D
2 D

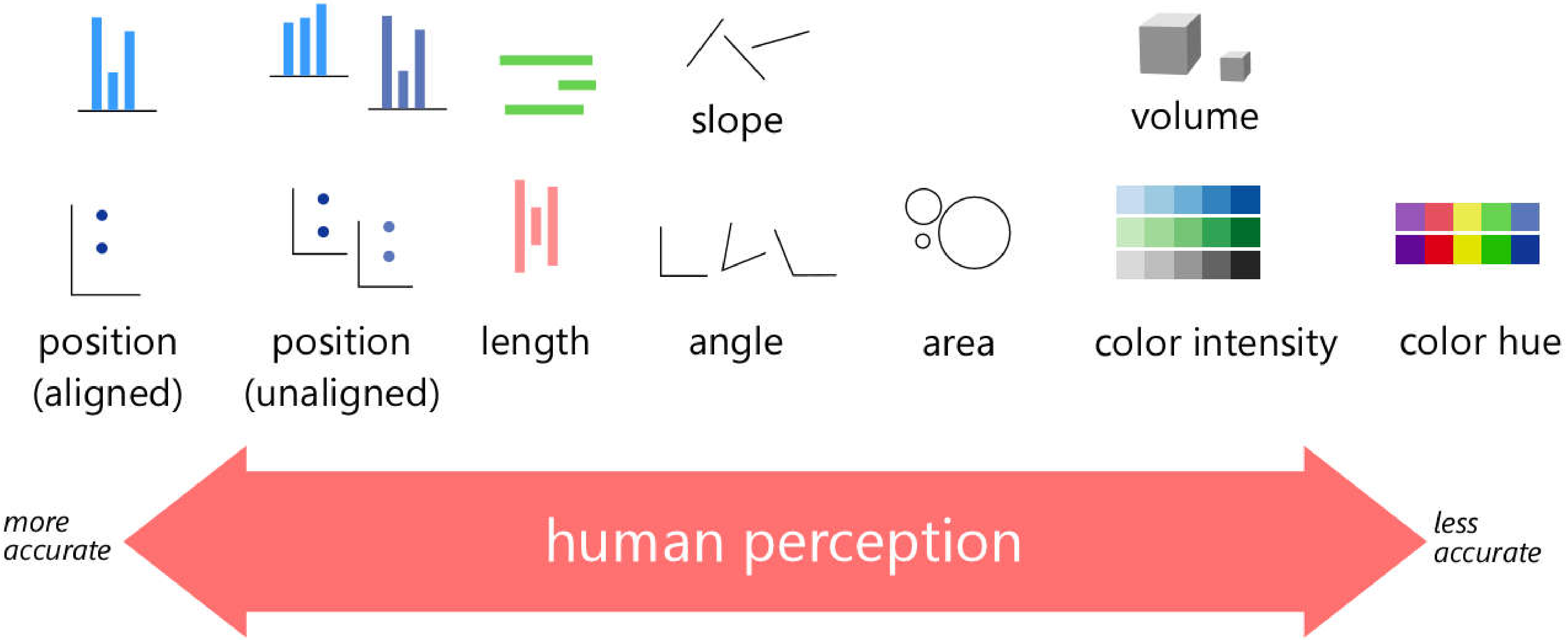
WHICH IS LARGEST?


triangle
square
circle
right rectangle
left rectangle
top bar
bottom bar

area of different shapes is even harder.



HUMAN PERCEPTION



slope

volume

position (aligned)

position (unaligned)

length

angle

area

color intensity

color hue

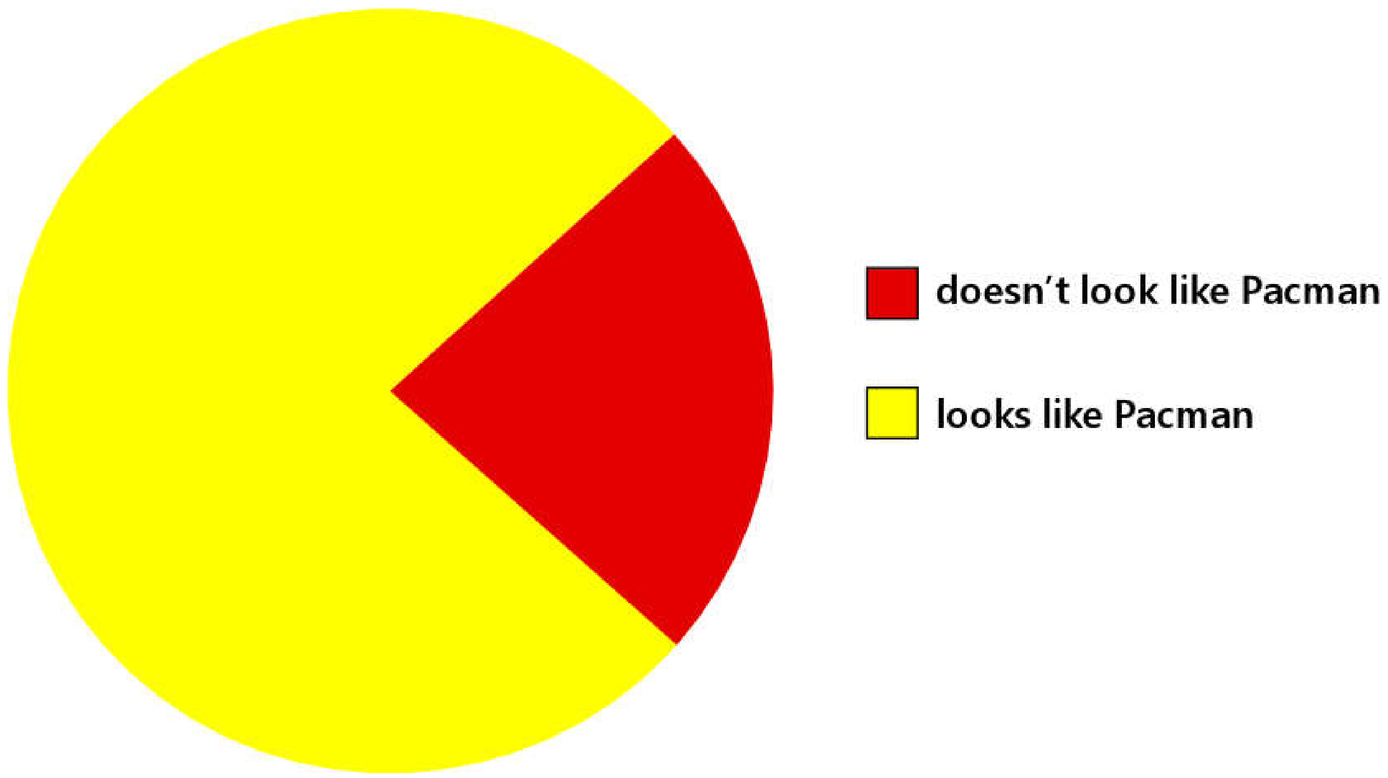
more accurate

human perception

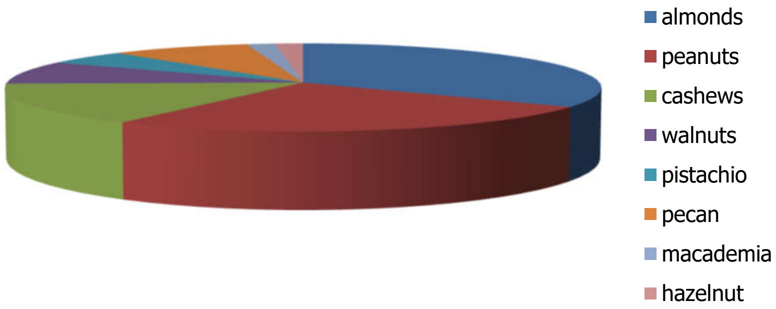
less accurate

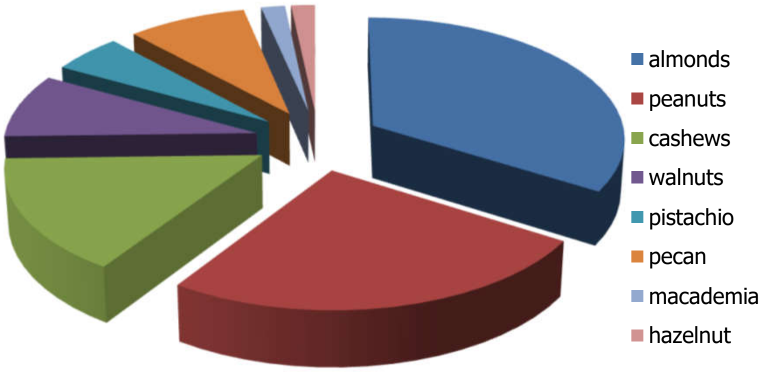
Cleveland, W.S. and McGill, R., 1984. Graphical perception: Theory, experimentation, and application to the development of graphical methods. *Journal of the American statistical association*, *79*(387), pp.531-554.

PIE CHARTS

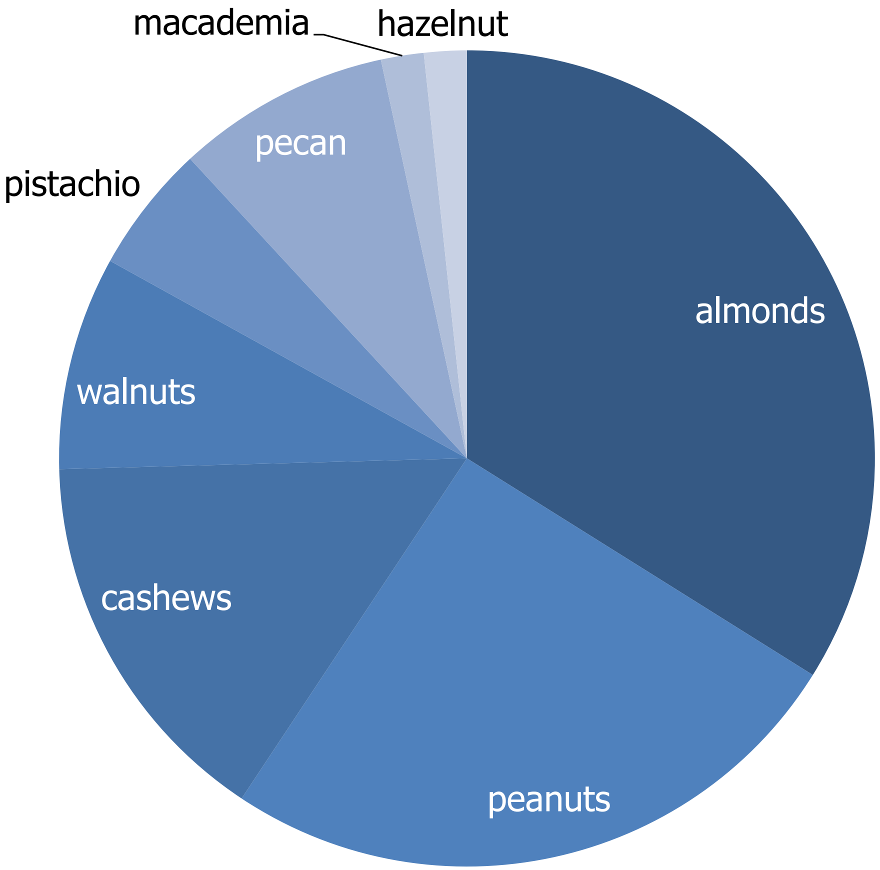


U.S. NUT PRODUCTION

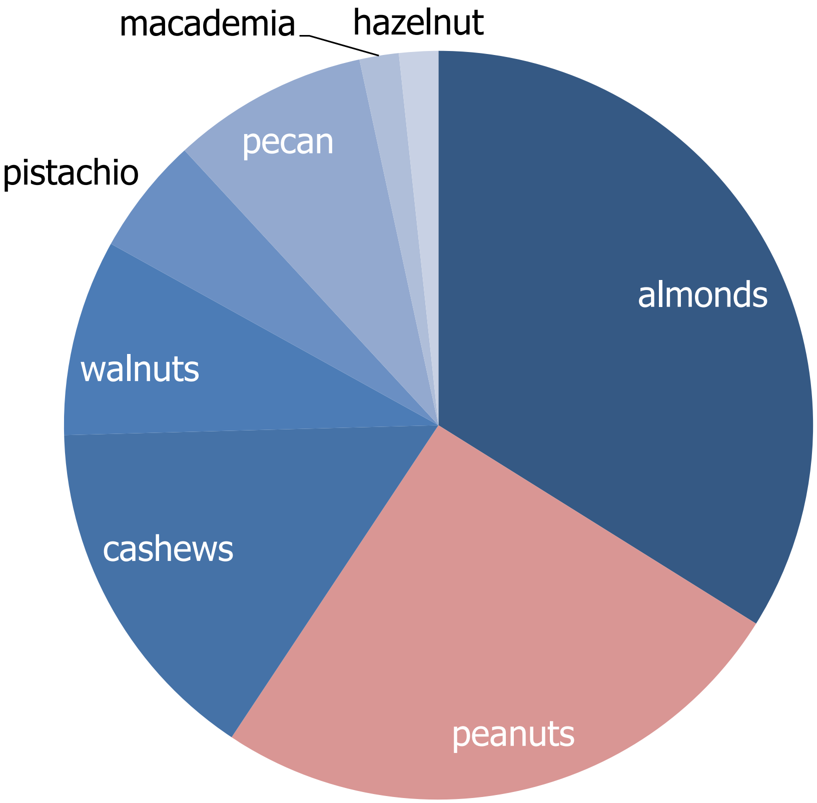




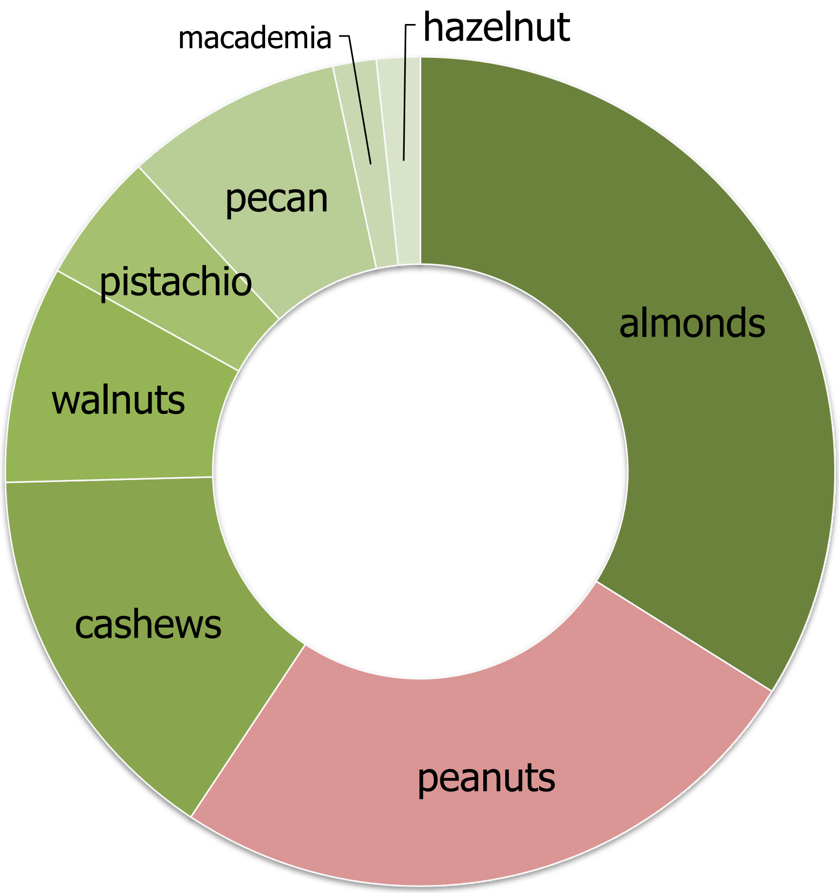
U.S. NUT PRODUCTION



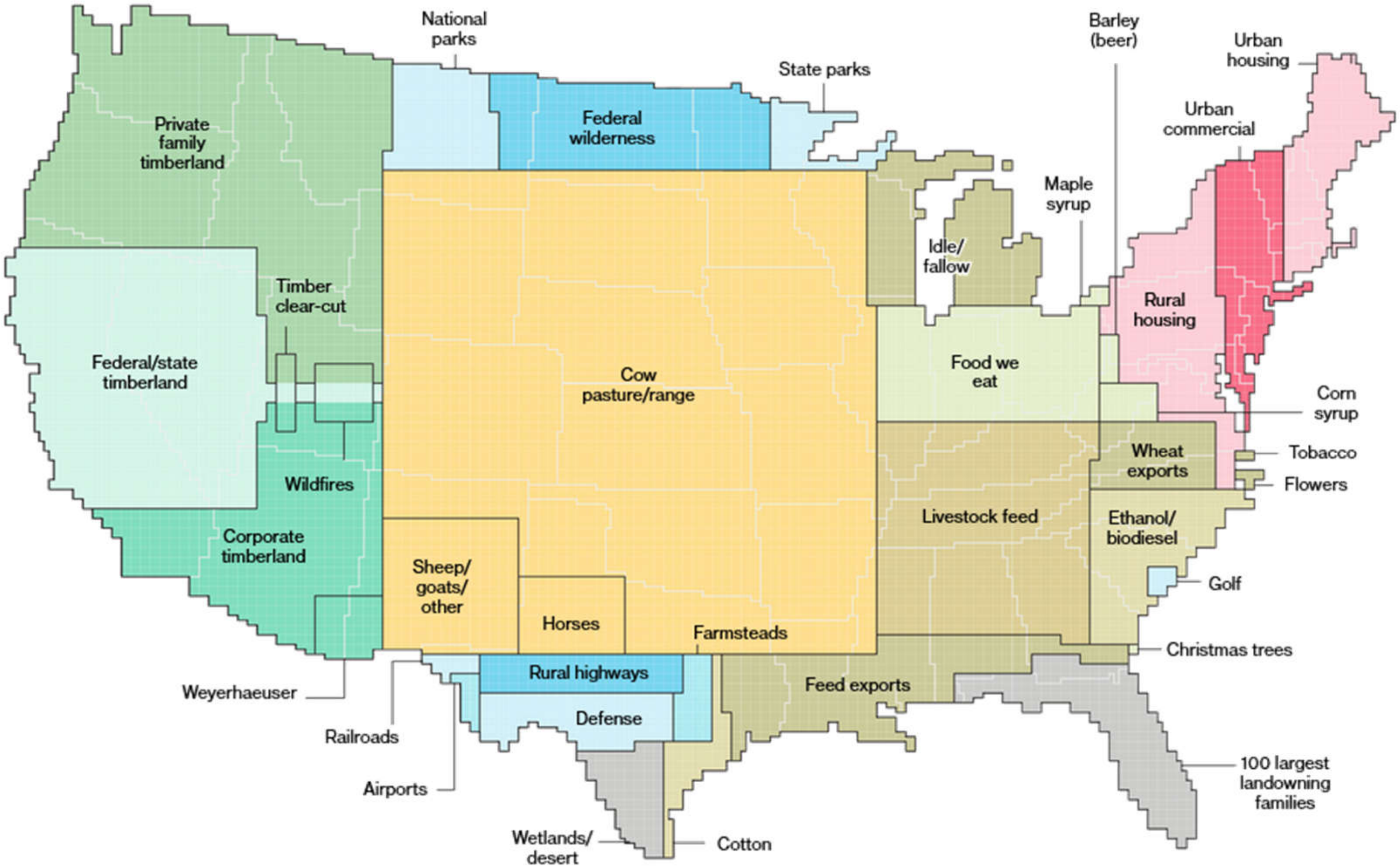
U.S. NUT PRODUCTION



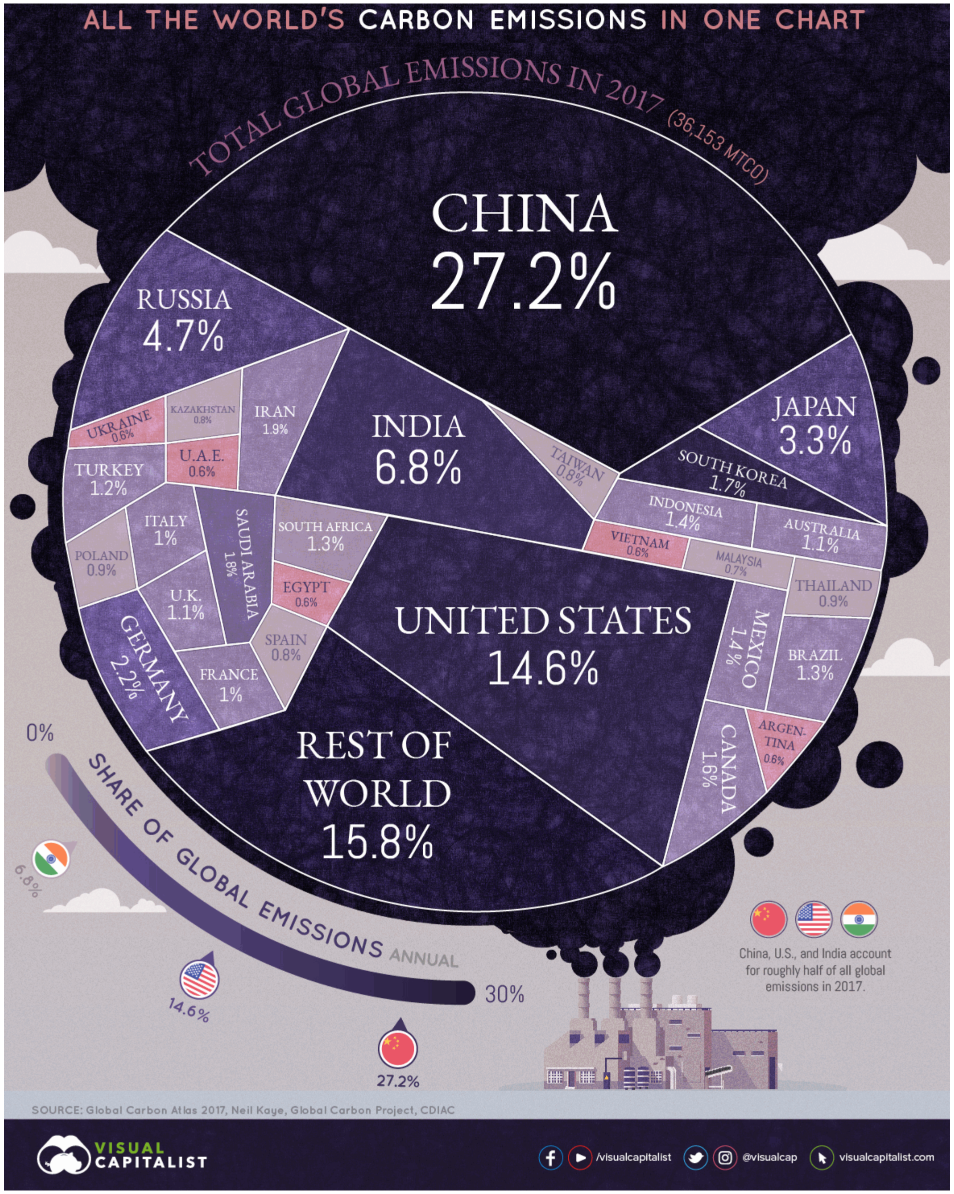
U.S. NUT PRODUCTION



U.S. LAND USE

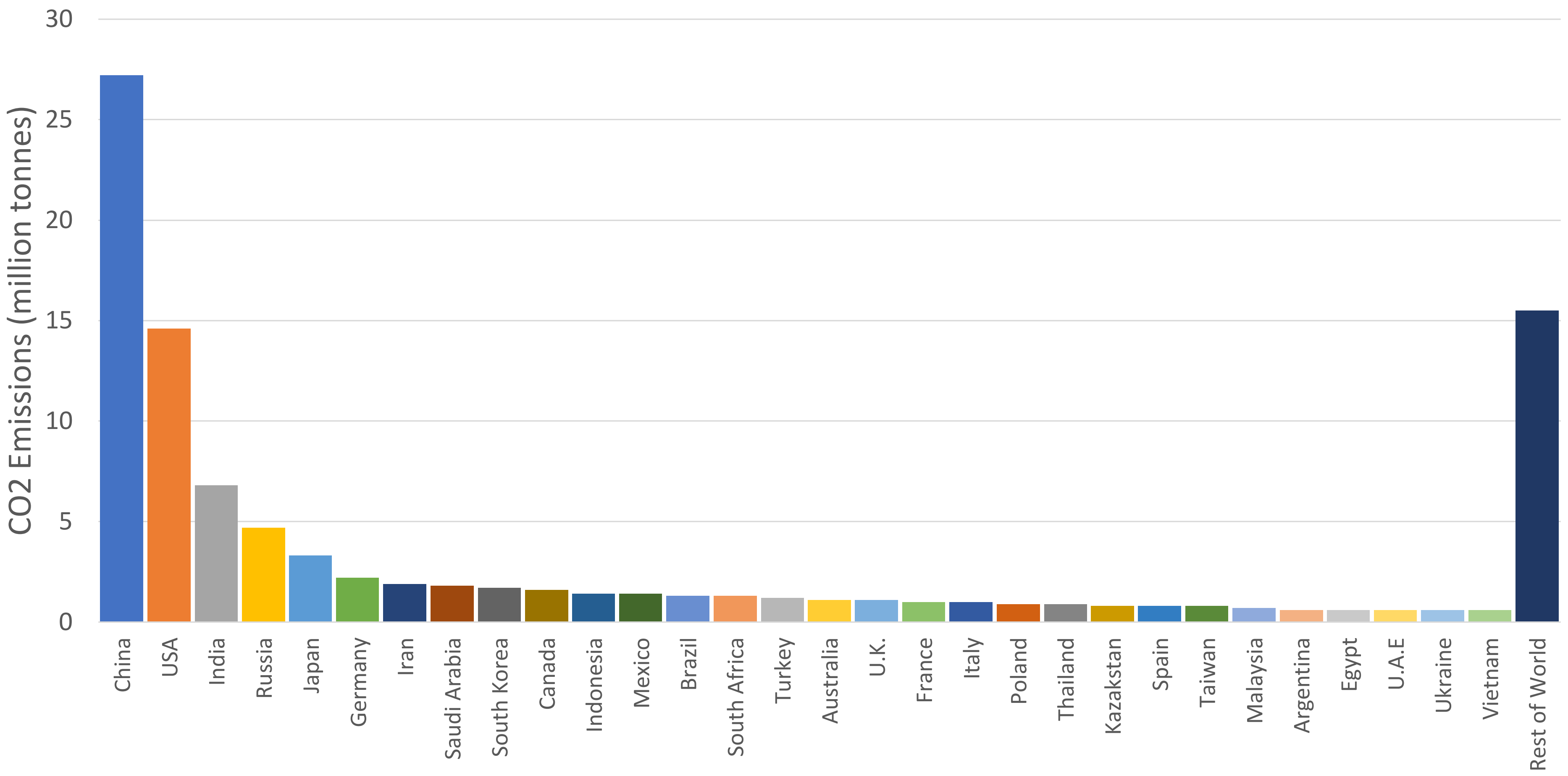

National parks
Federal wilderness
State parks
Barley (beer)
Urban housing
Urban commercial
Private family timberland
Maple syrup
Idle/ fallow
Timber clear-cut
Rural housing
Federal/state timberland
Food we eat
Cow pasture/range
Corn syrup
Wheat exports
Tobacco
Wildfires
Flowers
Livestock feed
Ethanol/ biodiesel
Corporate timberland
Sheep/ goats/ other
Golf
Horses
Farmsteads
Christmas trees
Rural highways
Feed exports
Weyerhaeuser
Defense
Railroads
100 largest landowning families
Airports
Wetlands/ desert
Cotton

www.bloomberg.com/graphics/2018-us-land-use/

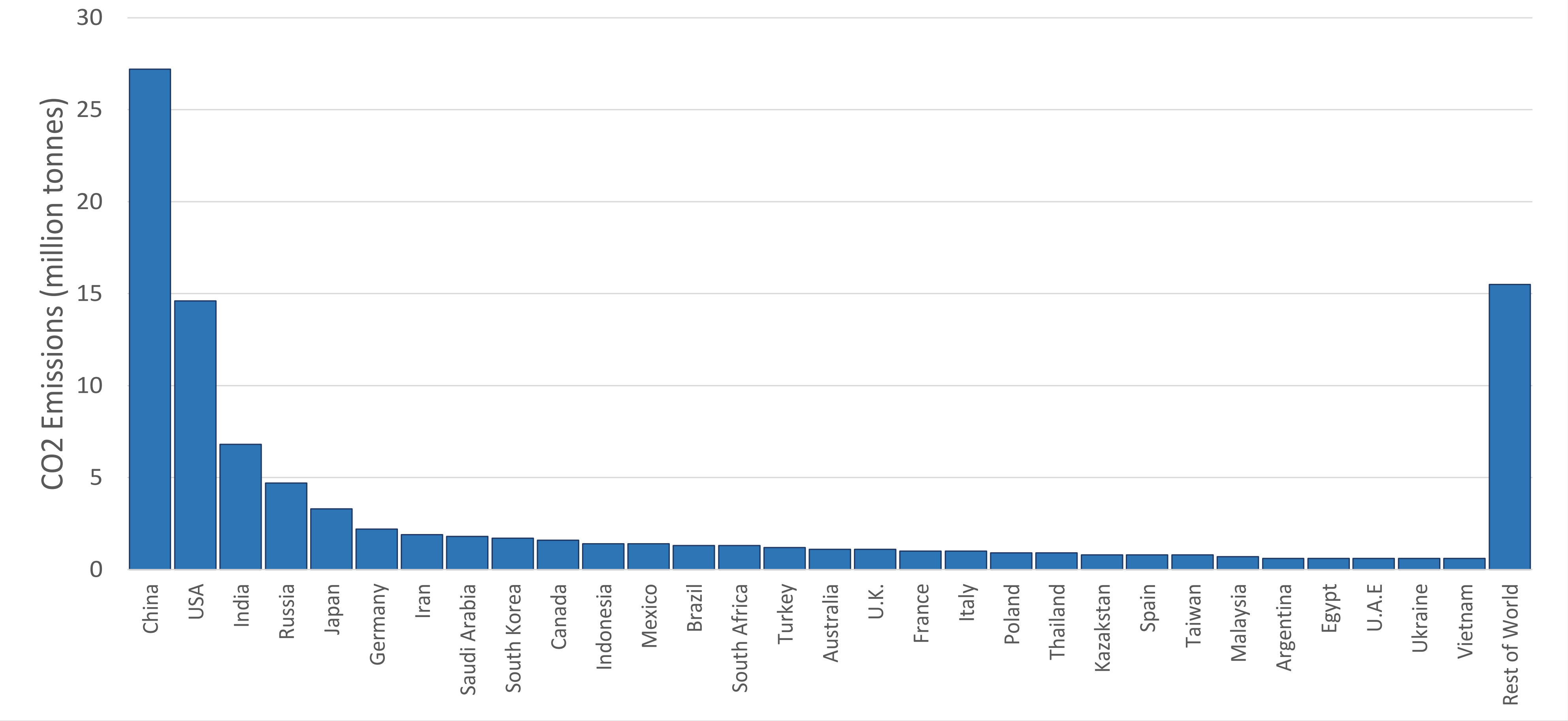


Voronoi Treemap in an irregular shaped container

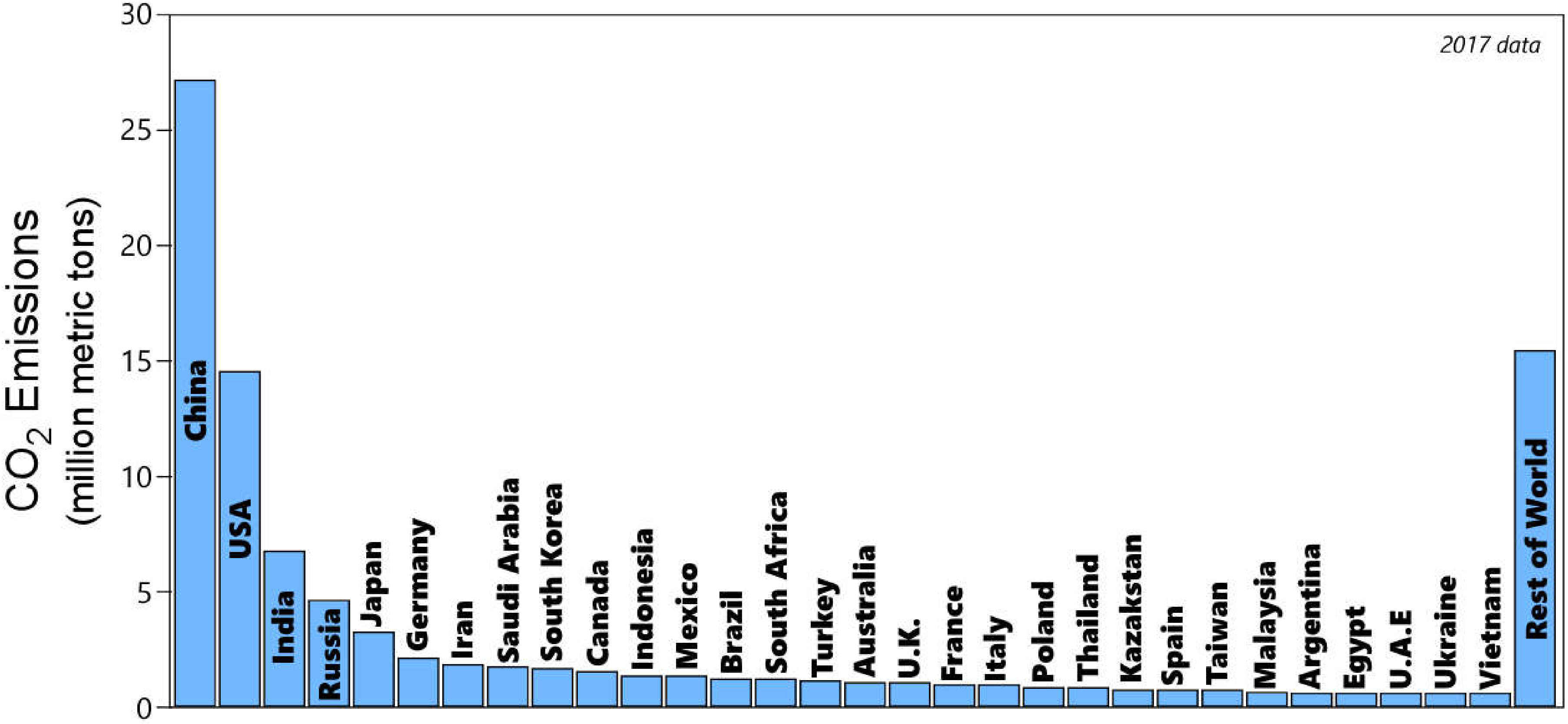
CARBON EMISSIONS



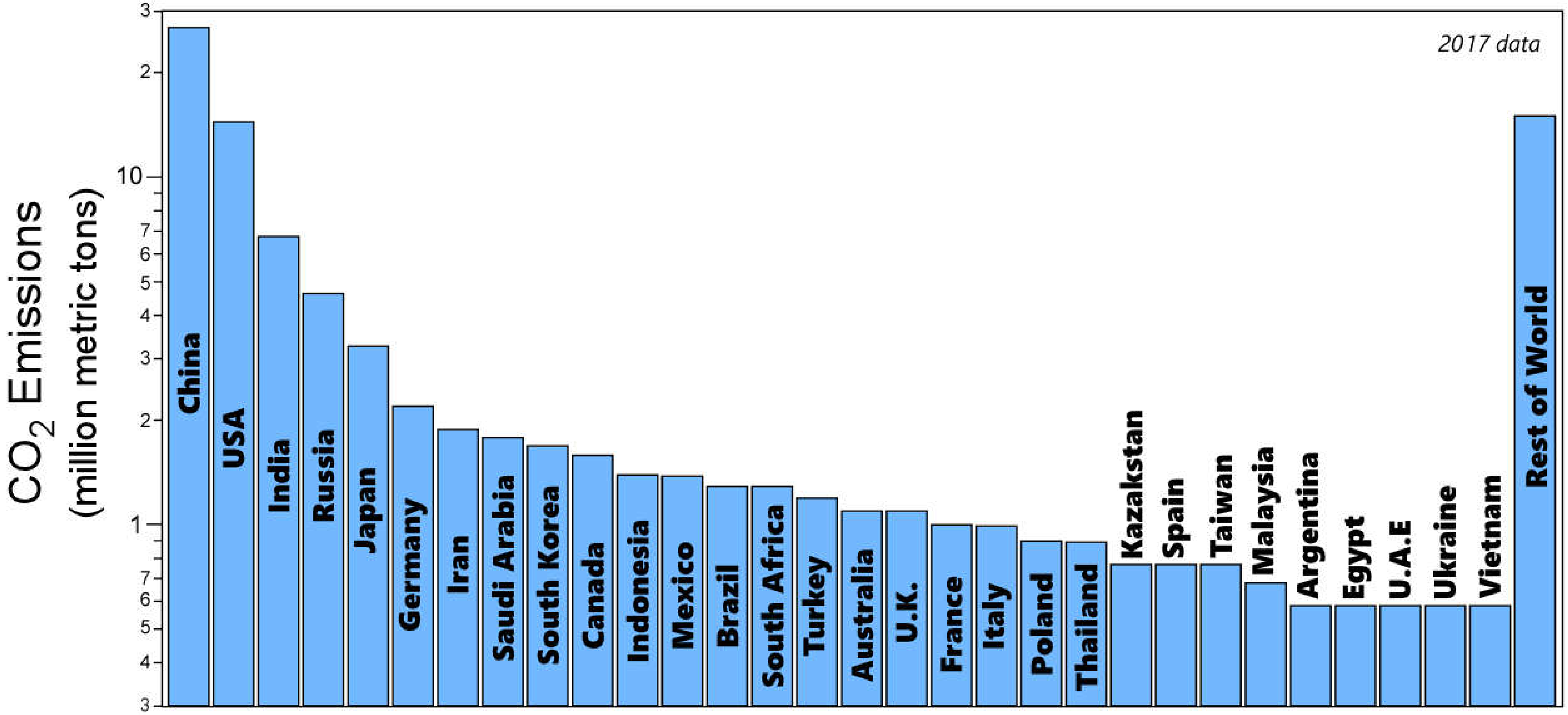
CARBON EMISSIONS



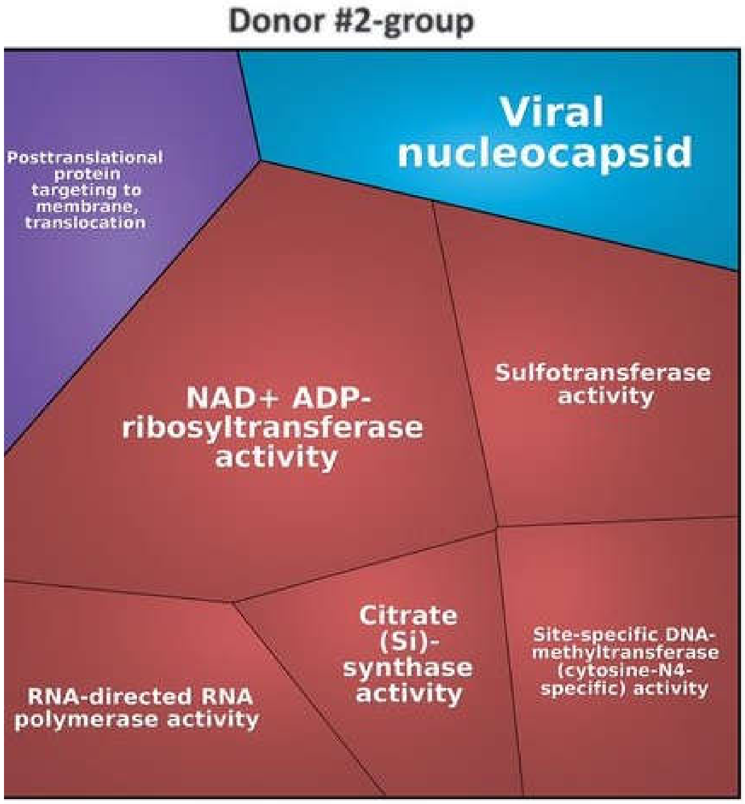
CARBON EMISSIONS



CARBON EMISSIONS



ENRICHED MICROBIOTA IN FECAL TRANSPLANTATION

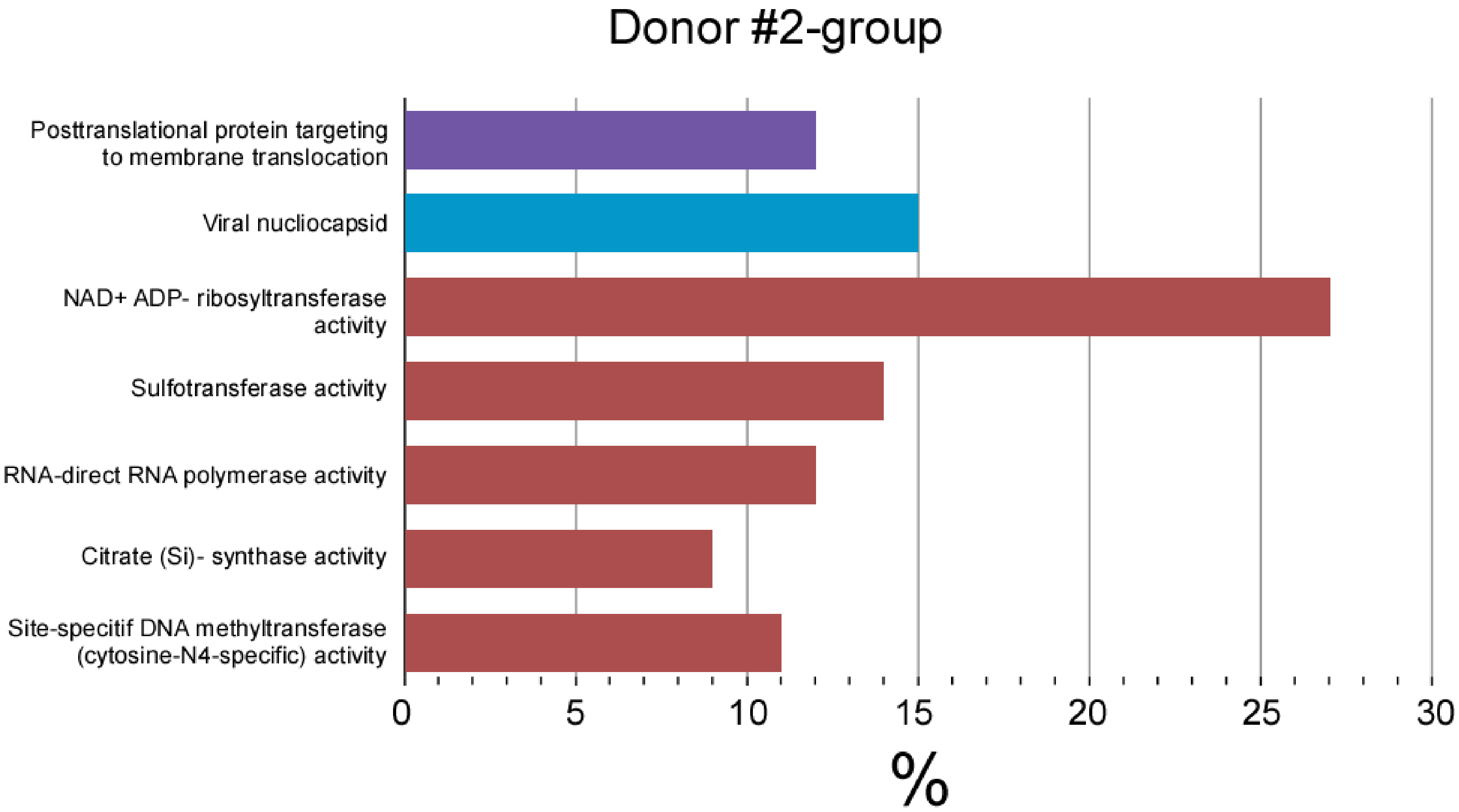

Donor #2-group
Viral nucleocapsid
Posttranslational protein targeting to membrane, translocation
NAD+ ADP-ribosyltransferase activity
Sulfotransferase activity
Citrate (Si)-synthase activity
Site-specific DNA-methyltransferase (cytosine-N4-specific) activity
RNA-directed RNA polymerase activity

Voronoi tessellation

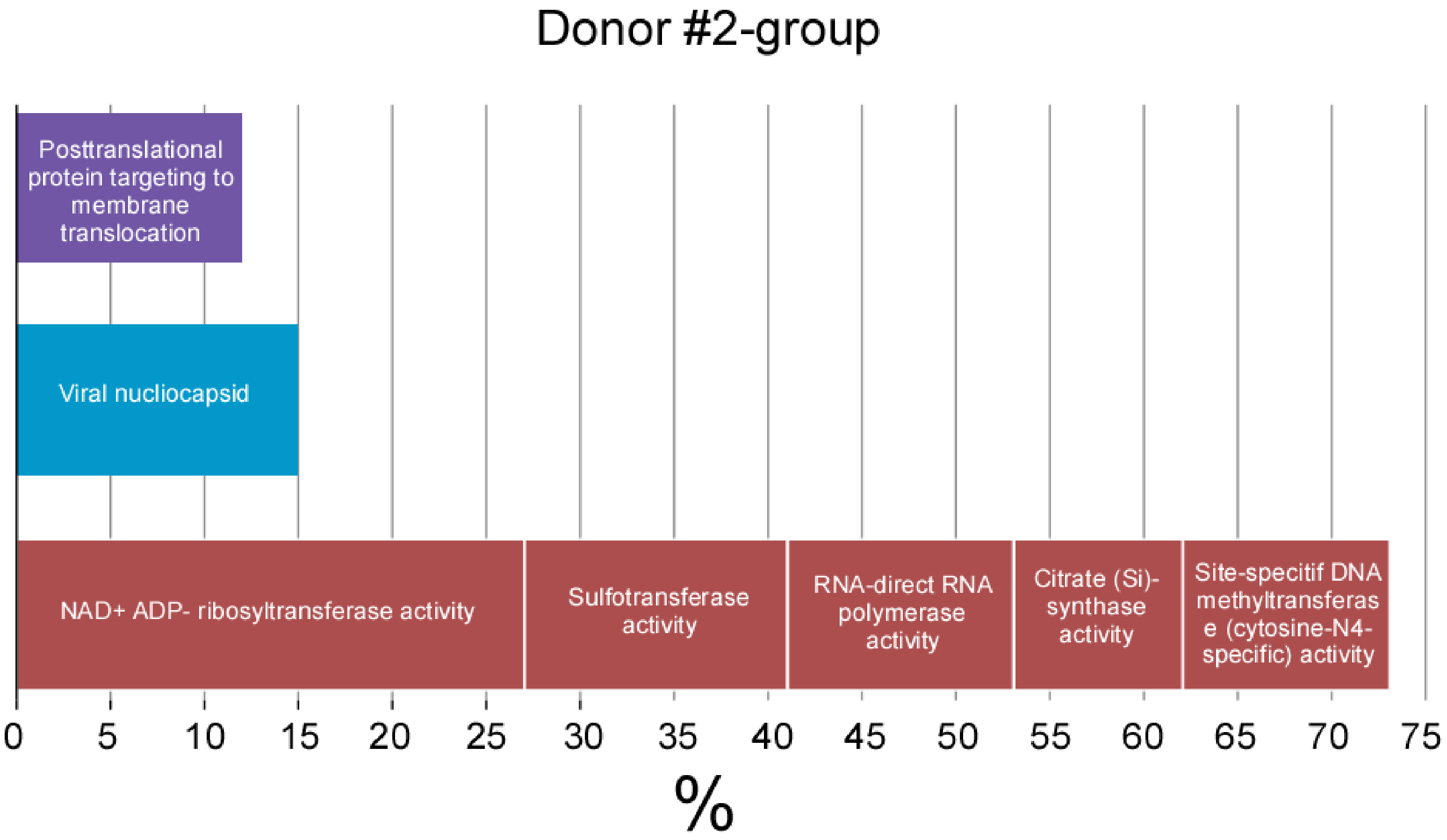
tessellation is fancy word for tiling

Baruch et al., "Fecal microbiota transplant promotes response in immunotherapy-refractory melanoma patients", Science 05 Feb 2021, DOI: 10.1126/science.abb5920

ENRICHED MICROBIOTA IN FECAL TRANSPLANTATION

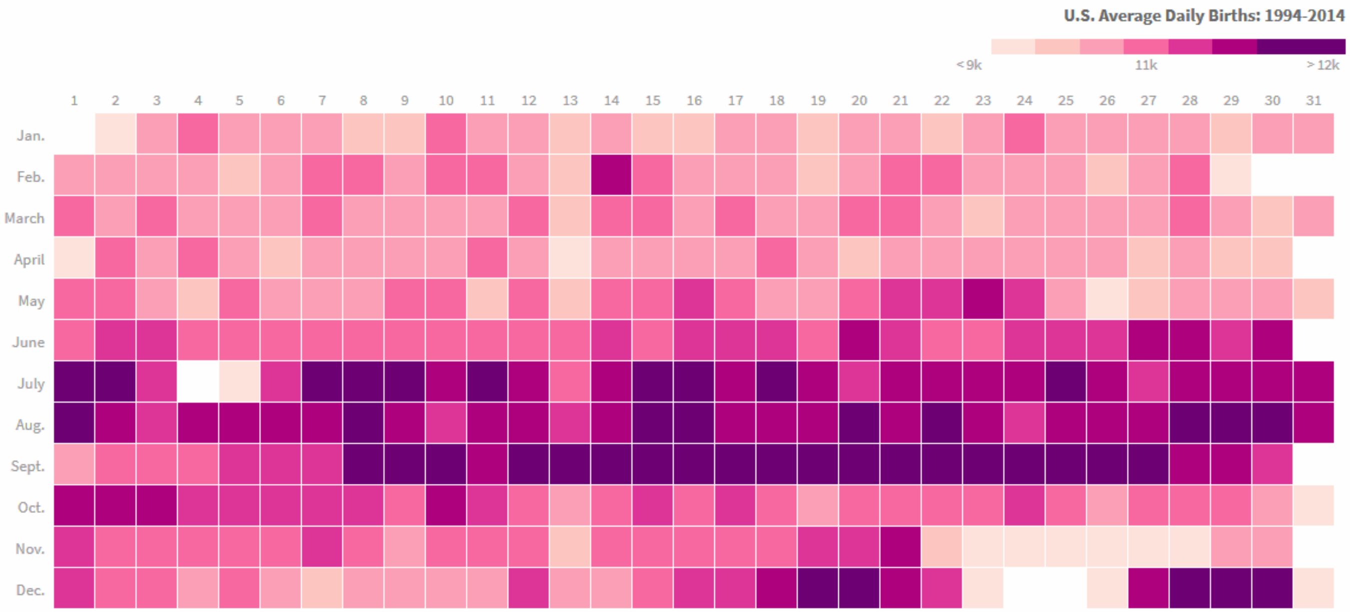


ENRICHED MICROBIOTA IN FECAL TRANSPLANTATION



HOW POPULAR IS YOUR BIRTHDAY?

Two decades of American birthdays, averaged by month and day.



Notes: The conception date, purely for illustration, is 266 days prior to birth. It represents a hypothetical "moment of conception" based on the normal gestation period for humans, 280 days, minus the average time for ovulation, two weeks.

Data: U.S. National Center for Health Statistics (1994-2003); U.S. Social Security Administration (2004-2014) — via FiveThirthyEight

Credit: Matt Stiles/The Daily Viz

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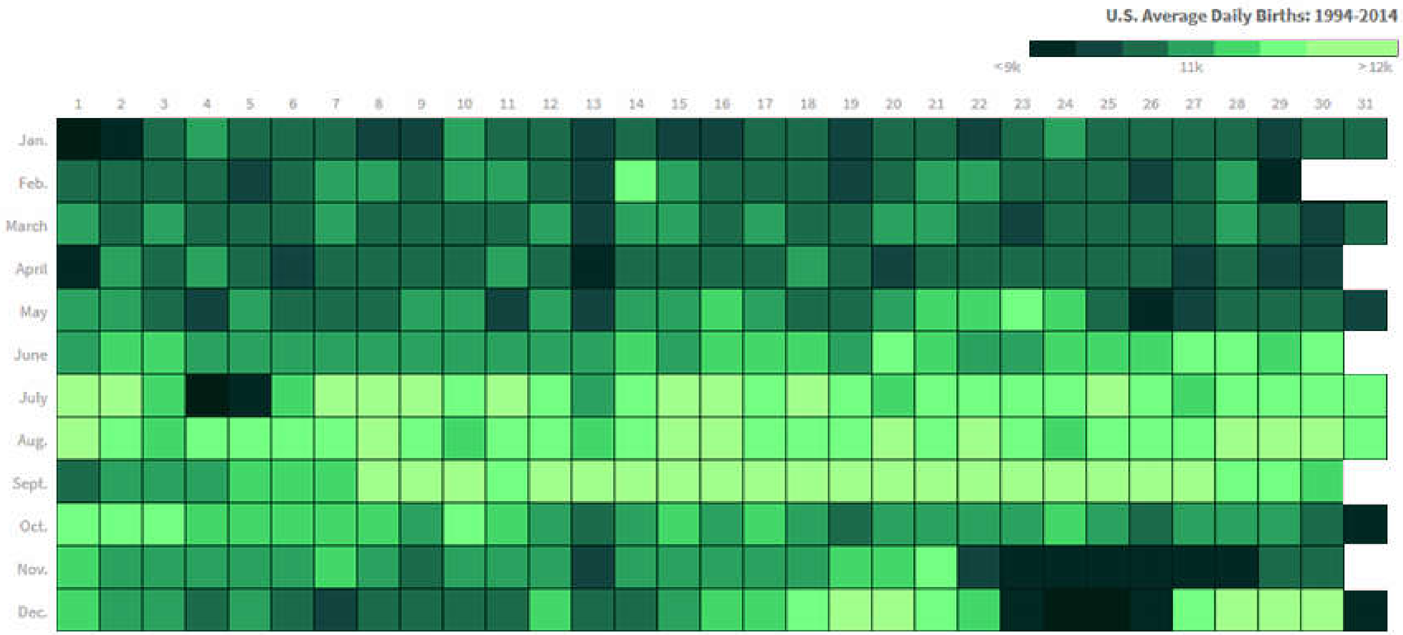

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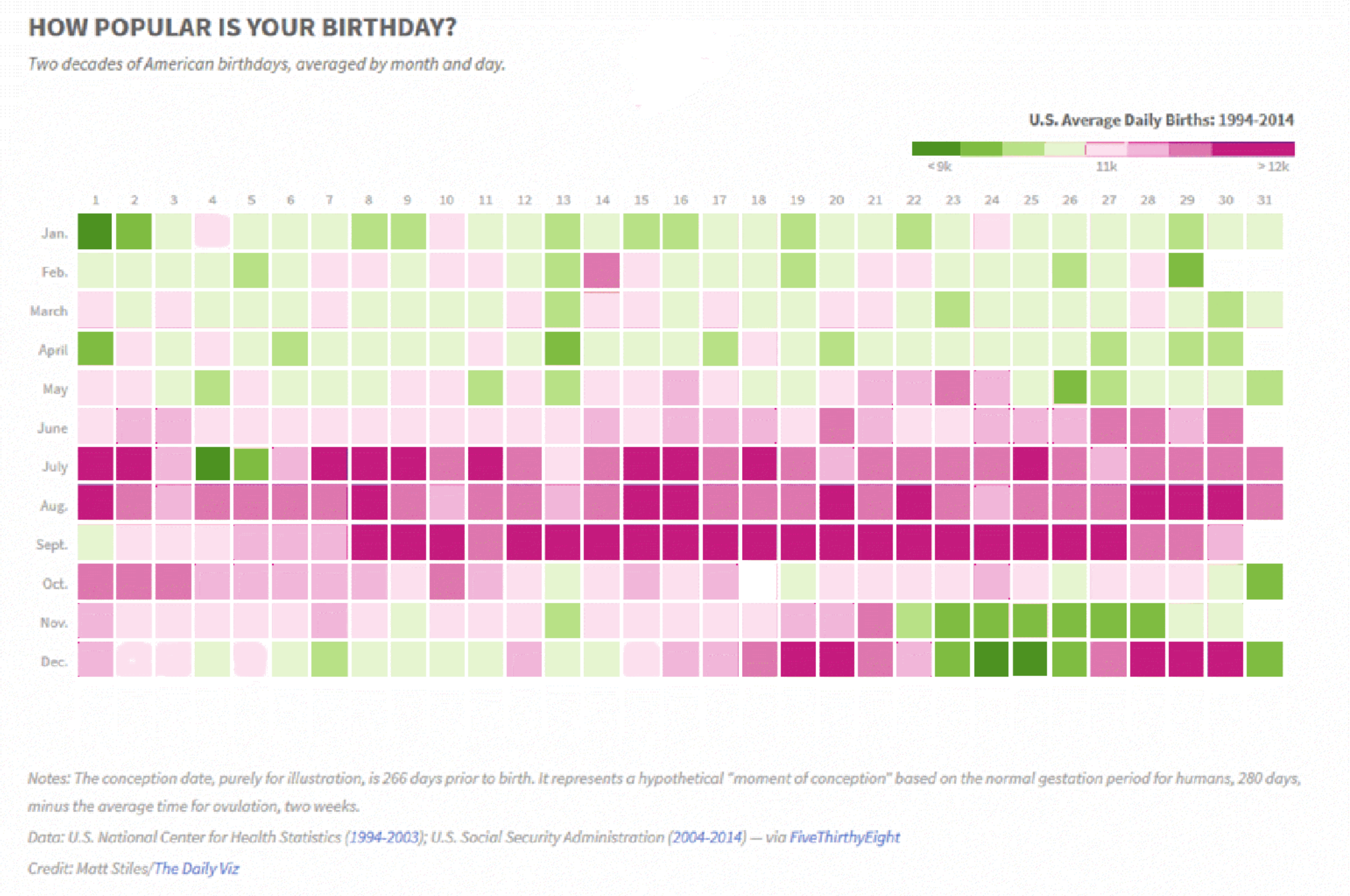

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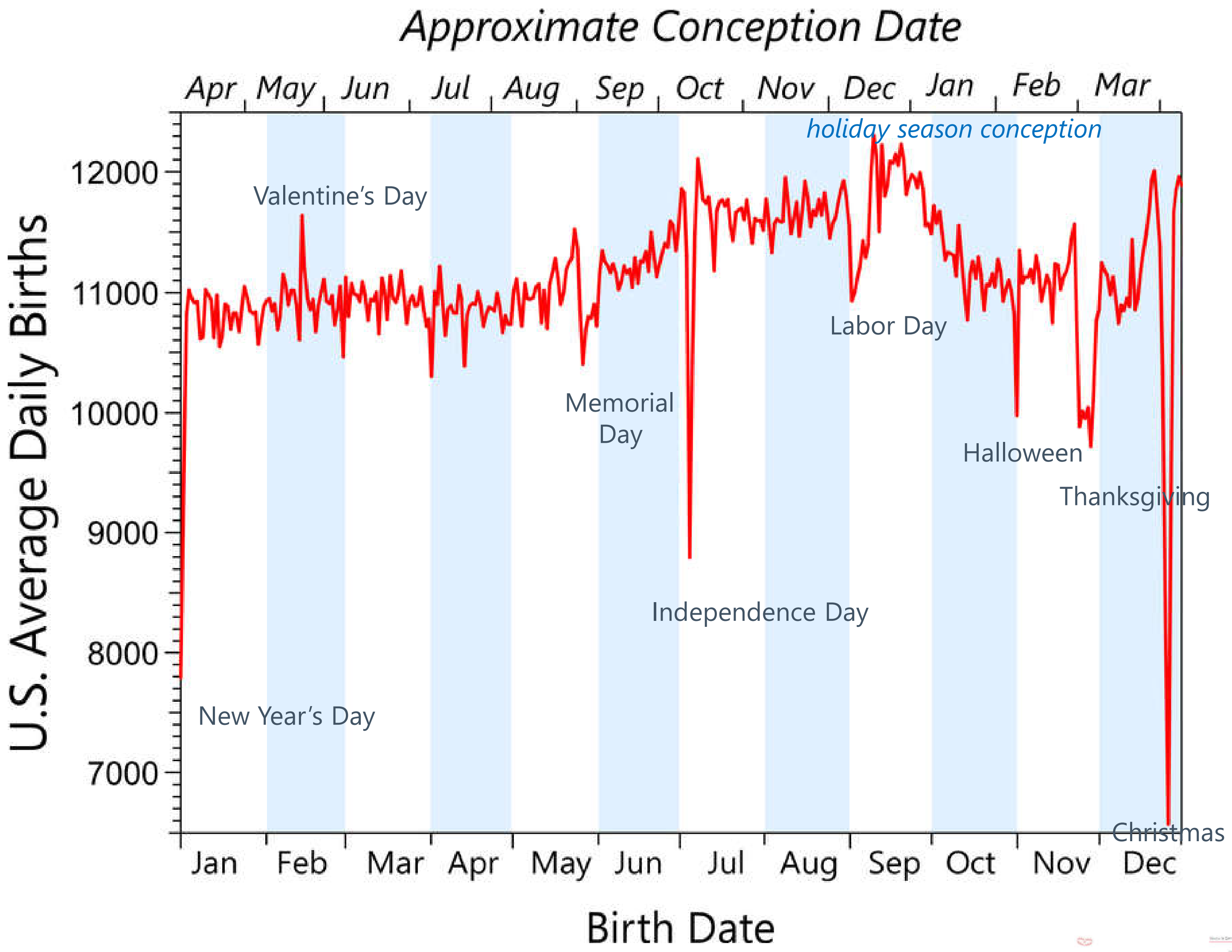
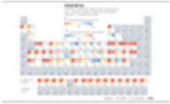
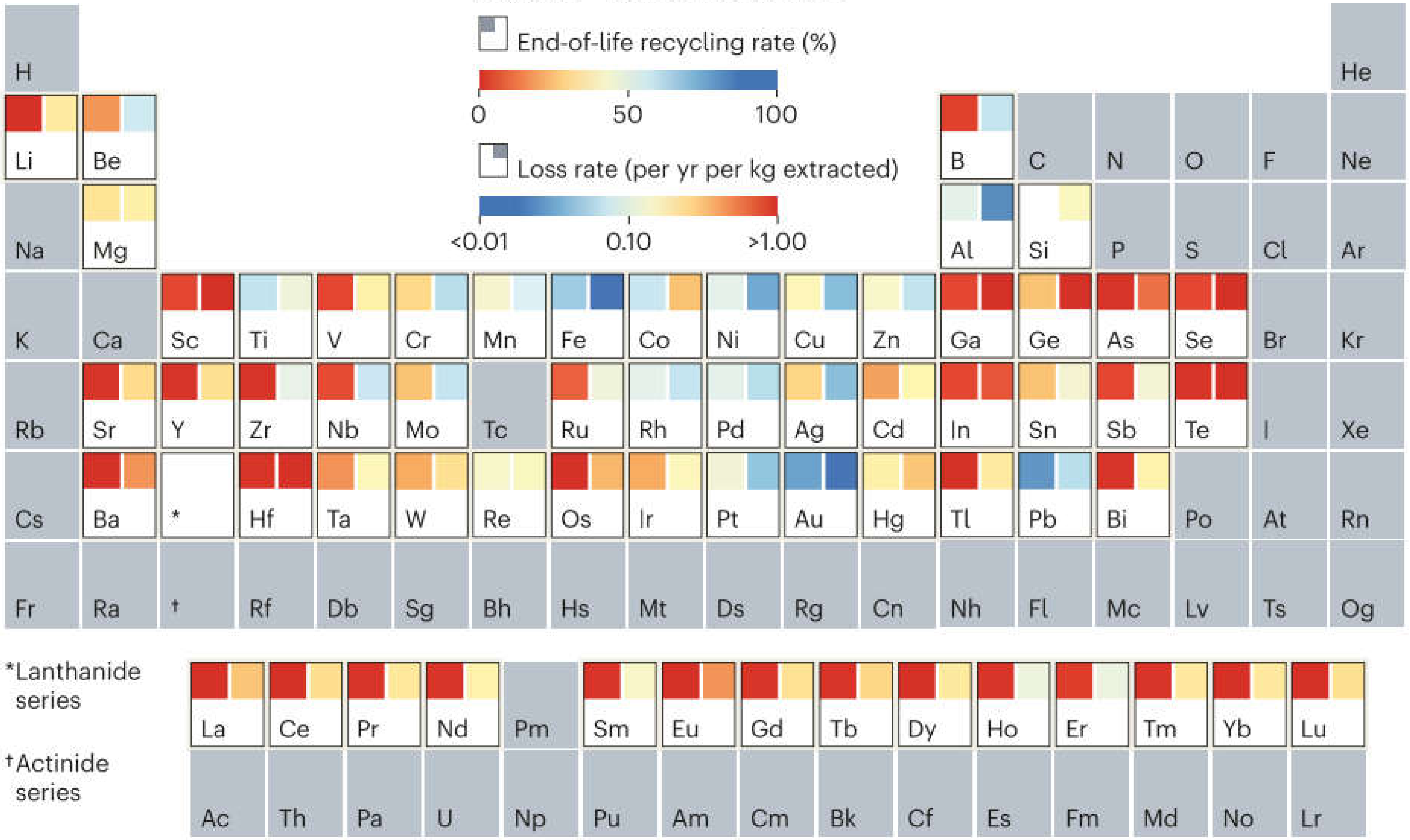

Approximate Conception Date
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
holiday season conception
12000
11000
10000
9000
8000
7000
U.S. Average Daily Births
Valentine's Day
Memorial Day
Labor Day
Halloween
Thanksgiving
Independence Day
New Year's Day
Christmas
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Birth Date



SCRAP METAL

In general, metals with a higher end-of-life recycling rate — the percentage of scrap that is functionally recycled — have lower loss rates.



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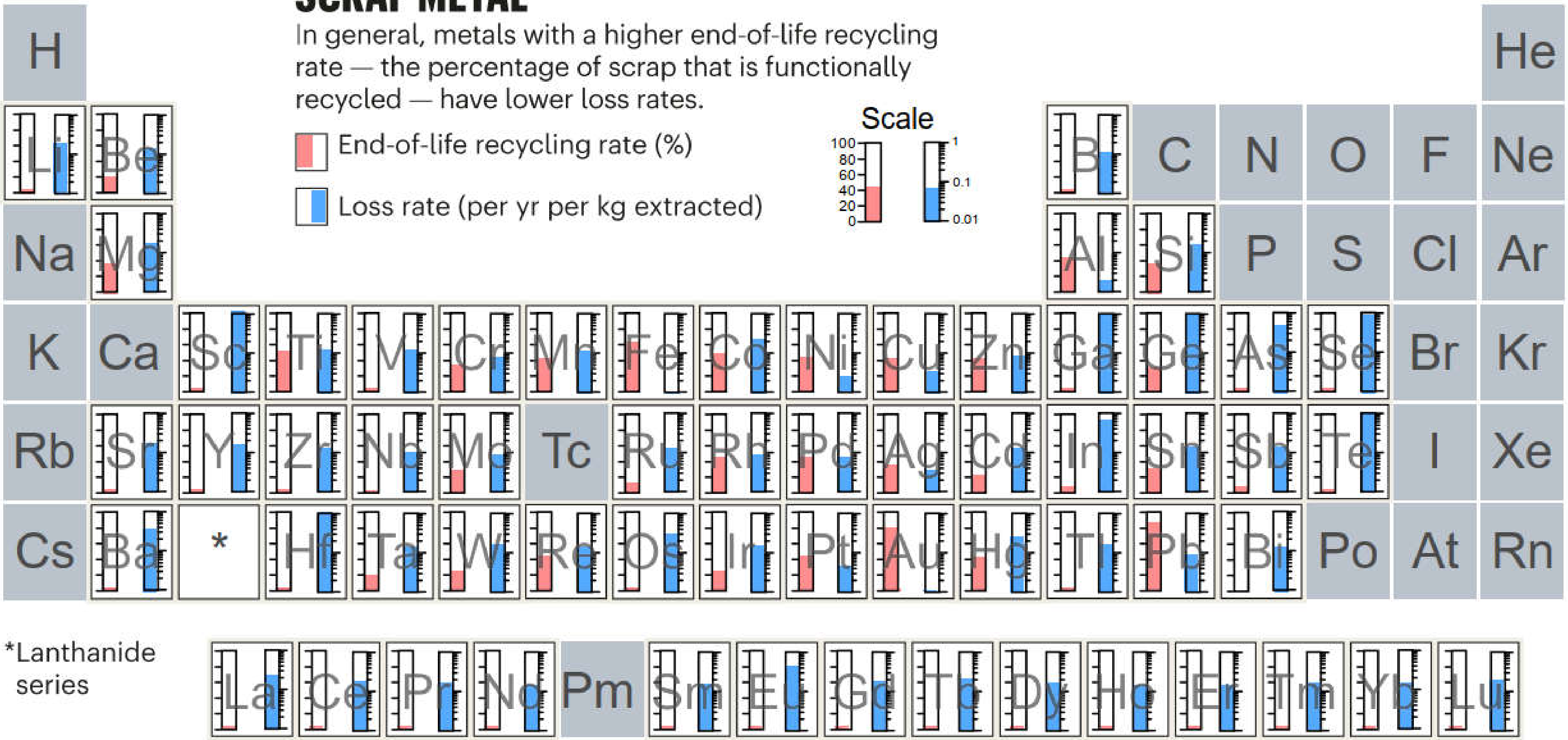

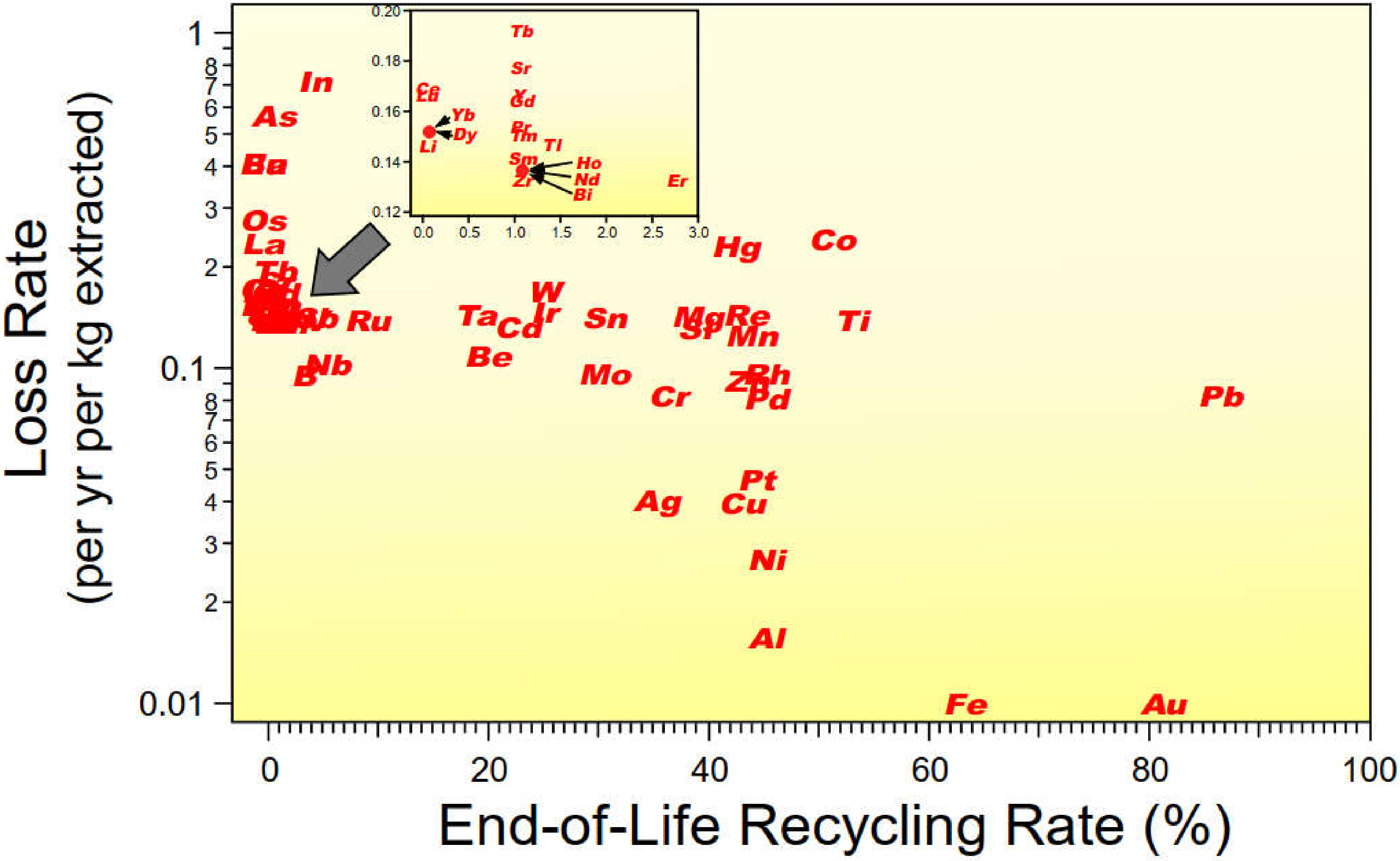

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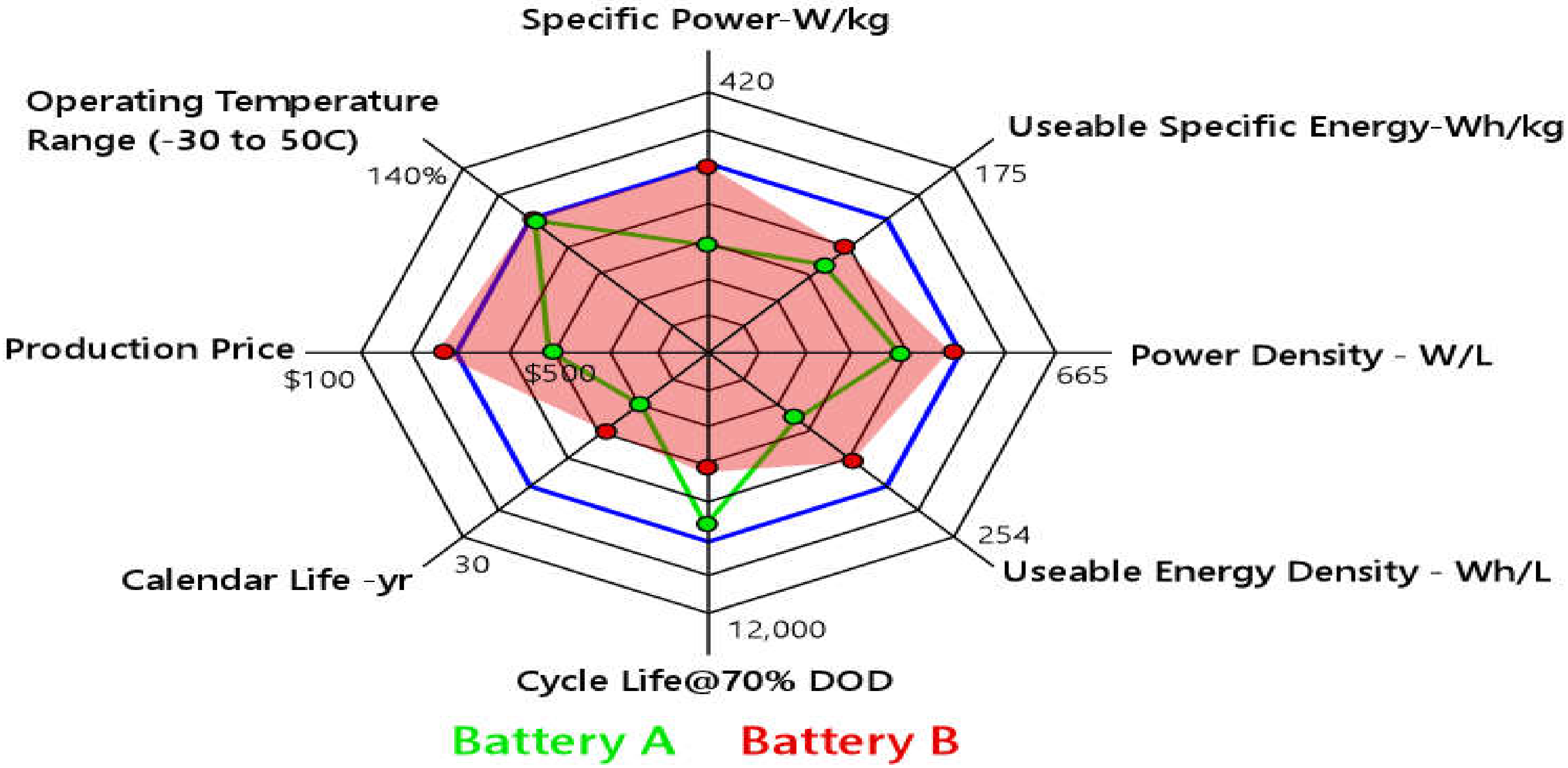

Specific Power-W/kg
420
Useable Specific Energy-Wh/kg
175
Power Density - W/L
665
254
Useable Energy Density - Wh/L
12,000
Cycle Life@70% DOD
30
Calendar Life -yr
Production Price
$100
$500
Operating Temperature Range (-30 to 50C)
140%
Battery A
Battery B

graphs used to gain understanding are unlikely to be good for explaining

graphs used to gain understanding are unlikely to be good for presentation

PREPARE PLOTS FOR YOUR AUDIENCE

- Know your audience and craft the presentation for them
  - focus on your key message(s)

COMMUNICATION HIERARCHY

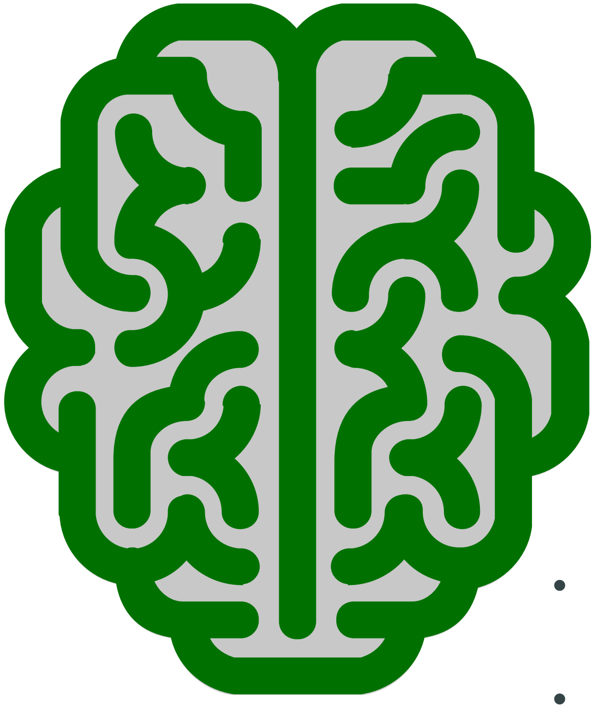
Tools

Tactics

Strategy

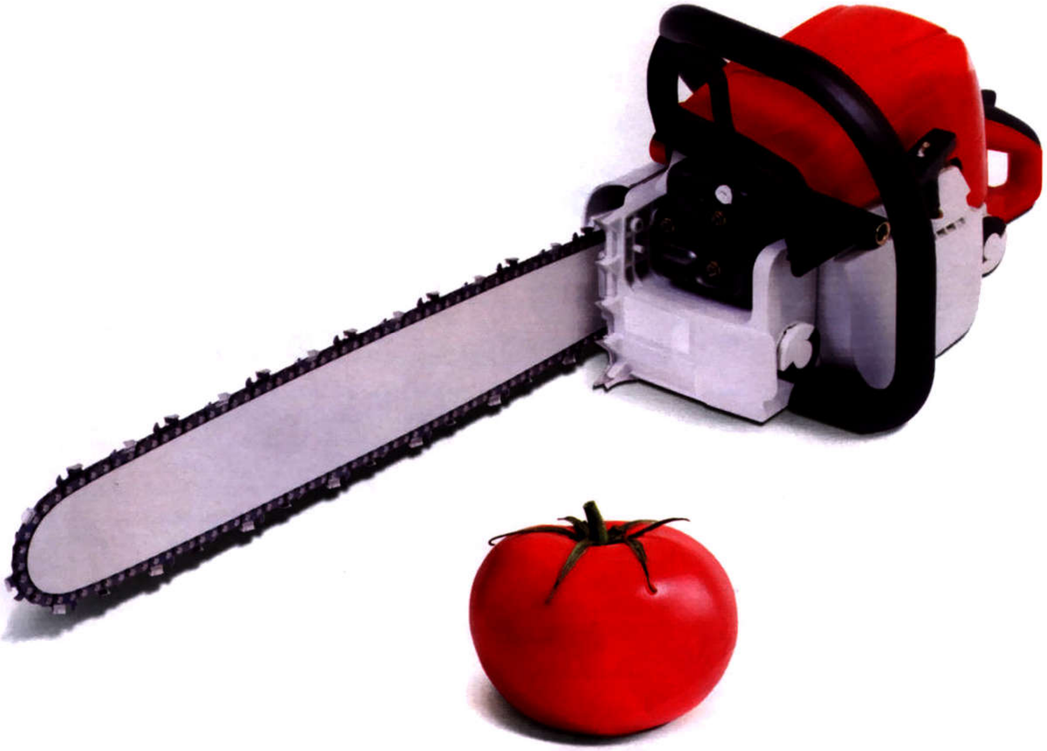
Audience

Goal



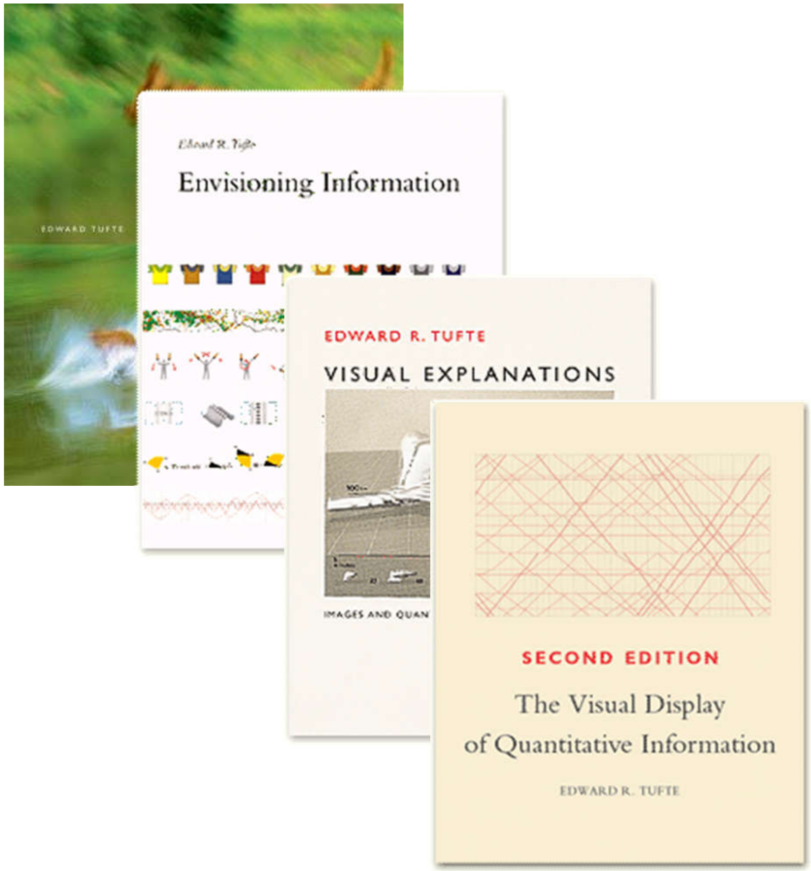
ready

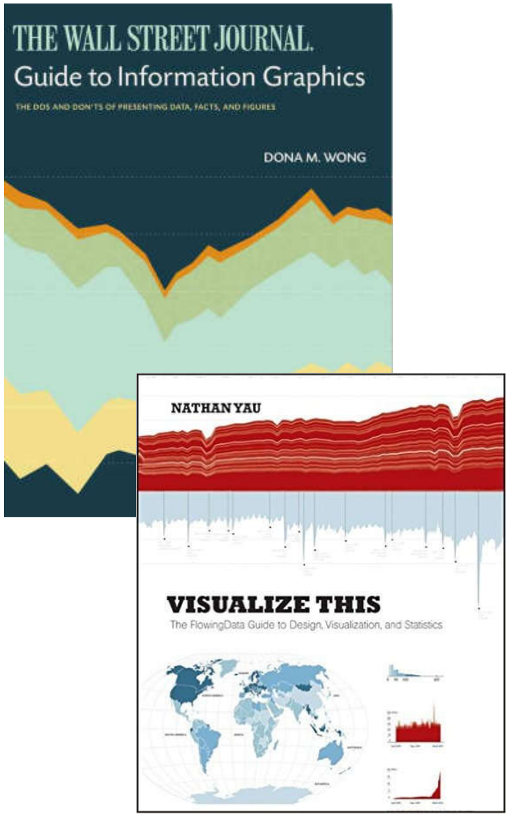
- memorable is better than forgettable (pics memorable)
- make graphics *mind ready*
- info density right for material and audience

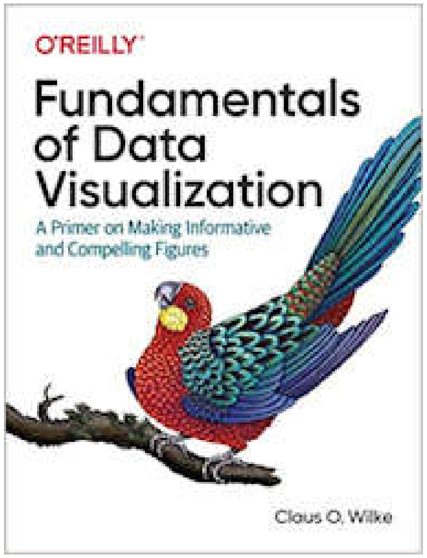


- don’t let tools get in the way

FAVORITE REFERENCES – DISPLAY OF INFORMATION


EDWARD TUFTE
Edward R. Tufte
Envisioning Information
EDWARD R. TUFTE
VISUAL EXPLANATIONS
IMAGES AND QUAN
SECOND EDITION
The Visual Display of Quantitative Information
EDWARD R. TUFTE


THE WALL STREET JOURNAL.
Guide to Information Graphics
THE DOS AND DON'TS OF PRESENTING DATA, FACTS, AND FIGURES
DONA M. WONG
NATHAN YAU
VISUALIZE THIS
The FlowingData Guide to Design, Visualization, and Statistics


O'REILLY
Fundamentals of Data Visualization
A Primer on Making Informative and Compelling Figures
Claus O. Wilke

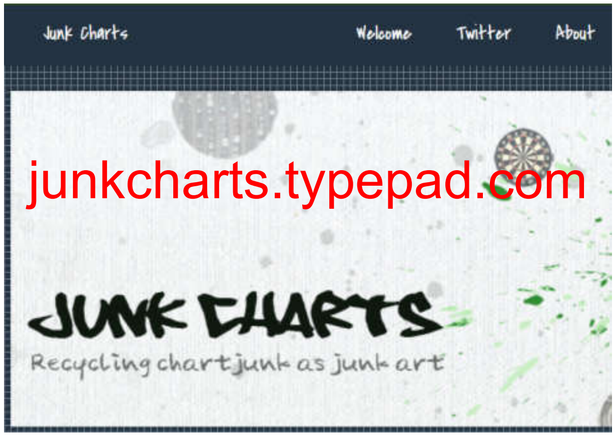
FAVORITE DATA VISUALIZATION WEBSITES - SAMPLES

howmuch.net
Understanding Money
Visualizations
Remodeling
Loans
Insurance

Understanding Money

Helping you make all the right money moves

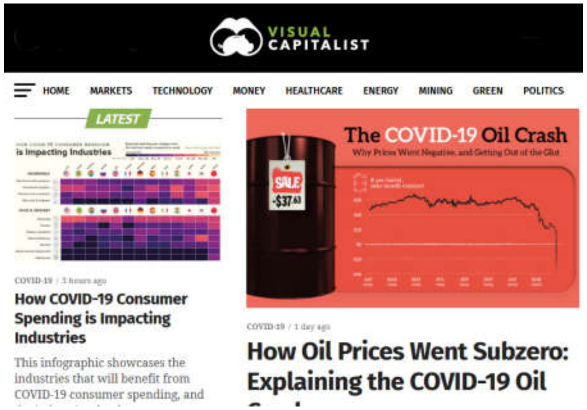
howmuch.net


Junk Charts
Welcome
Twitter
About

JUNK CHARTS

Recycling chartjunk as junk art

junkcharts.typepad.com


VISUAL CAPITALIST
HOME
MARKETS
TECHNOLOGY
MONEY
HEALTHCARE
ENERGY
MINING
GREEN
POLITICS
LATEST

COVID-19 / 3 hours ago

How COVID-19 Consumer Spending is Impacting Industries

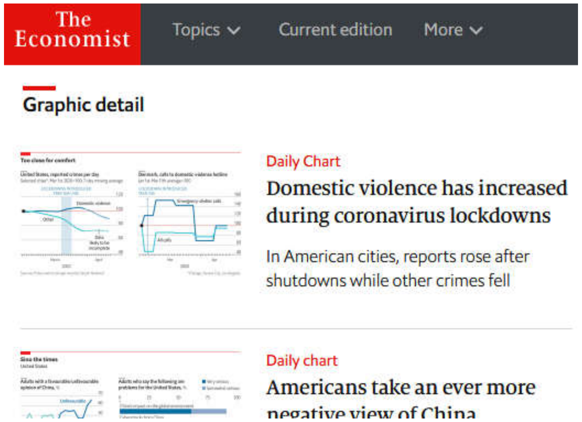
This infographic showcases the industries that will benefit from COVID-19 consumer spending, and

The COVID-19 Oil Crash

COVID-19 / 1 day ago

How Oil Prices Went Subzero: Explaining the COVID-19 Oil

visualcapitalist.com


The Economist
Topics
Current edition
More

Graphic detail

Daily Chart

Domestic violence has increased during coronavirus lockdowns

In American cities, reports rose after shutdowns while other crimes fell

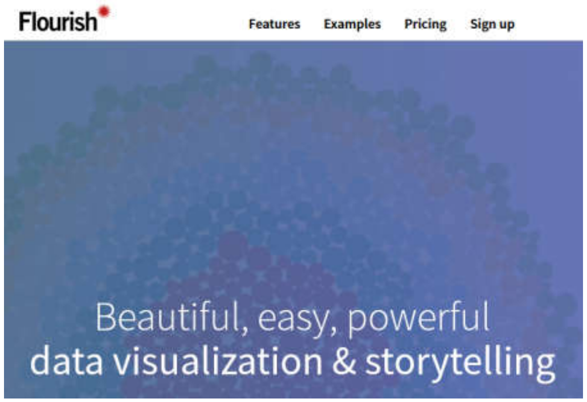
Daily chart

Americans take an ever more negative view of China

economist.com/graphic-detail/

FAVORITE DATA VISUALIZATION WEBSITES - TOOLS

*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Examples
Pricing
Sign up
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data visualization & storytelling

flourish.studio

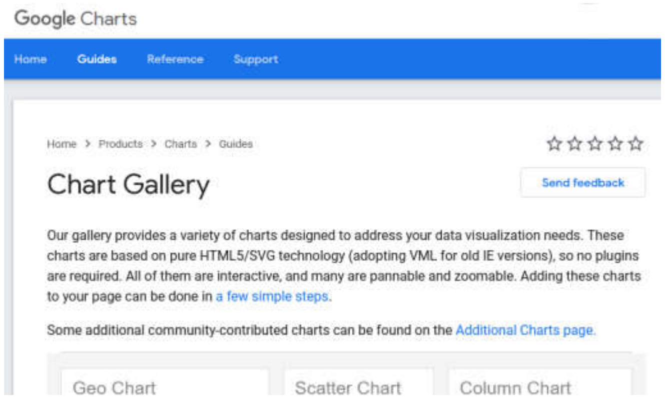
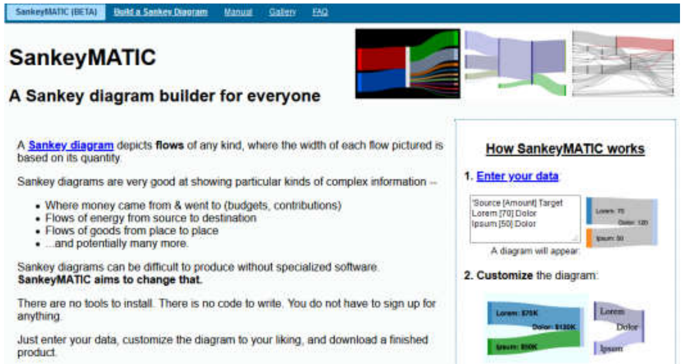

Google Charts
Home
Guides
Reference
Support
Home > Products > Charts > Guides
☆☆☆☆☆
Send feedback
Geo Chart
Scatter Chart
Column Chart

Chart Gallery

Our gallery provides a variety of charts designed to address your data visualization needs. These charts are based on pure HTML5/SVG technology (adopting VML for old IE versions), so no plugins are required. All of them are interactive, and many are pannable and zoomable. Adding these charts to your page can be done in a few simple steps.

Some additional community-contributed charts can be found on the Additional Charts page.

developers.google.com/chart/
interactive/docs/gallery


SankeyMATIC (BETA)
Build a Sankey Diagram
Manual
Gallery
FAQ
Lorem: $75K
Dolor: $120K
Ipsum: $50K
Lorem
Dolor
Ipsum

SankeyMATIC

A Sankey diagram builder for everyone

A Sankey diagram depicts **flows** of any kind, where the width of each flow pictured is based on its quantity.

Sankey diagrams are very good at showing particular kinds of complex information --

- Where money came from & went to (budgets, contributions)
- Flows of energy from source to destination
- Flows of goods from place to place
- ...and potentially many more.

Sankey diagrams can be difficult to produce without specialized software.
SankeyMATIC aims to change that.

There are no tools to install. There is no code to write. You do not have to sign up for anything.

Just enter your data, customize the diagram to your liking, and download a finished product.

How SankeyMATIC works

1. Enter your data:

'Source [Amount] Target
Lorem [70] Dolor
Ipsum [50] Dolor

A diagram will appear.

2. **Customize** the diagram:

sankeymatic.com

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https://www.mjphd.net/Workshop/forFun.html