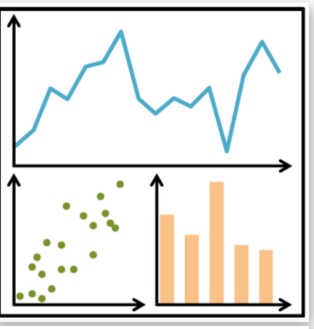
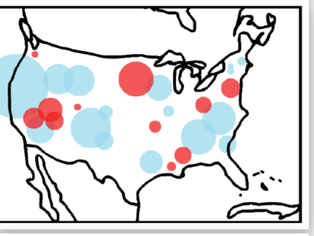
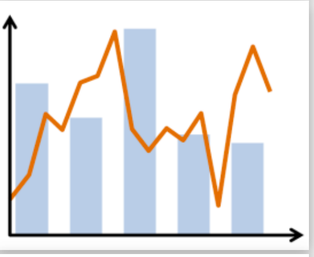
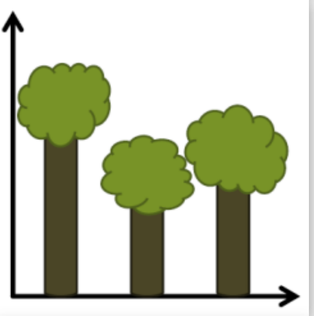
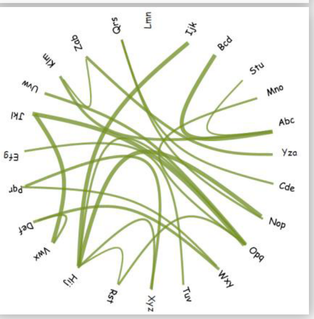
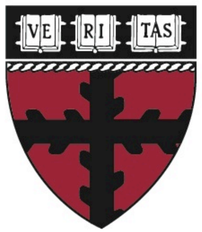






What Makes a Visualization Memorable?

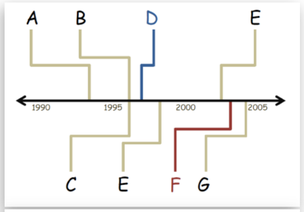
Michelle Borkin,

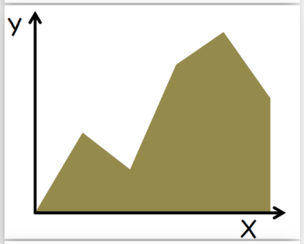
Azalea Vo, Zoya Bylinskii, Phillip Isola, Shashank Sunkavalli,

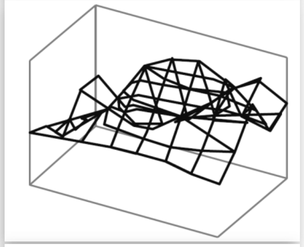
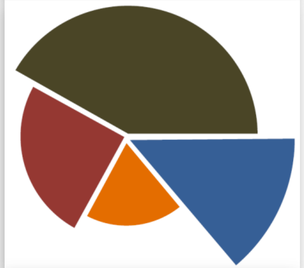
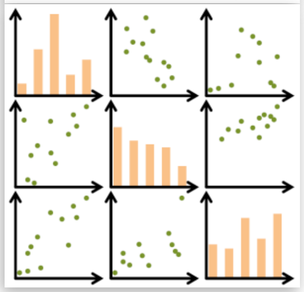
Aude Oliva, and Hanspeter Pfister

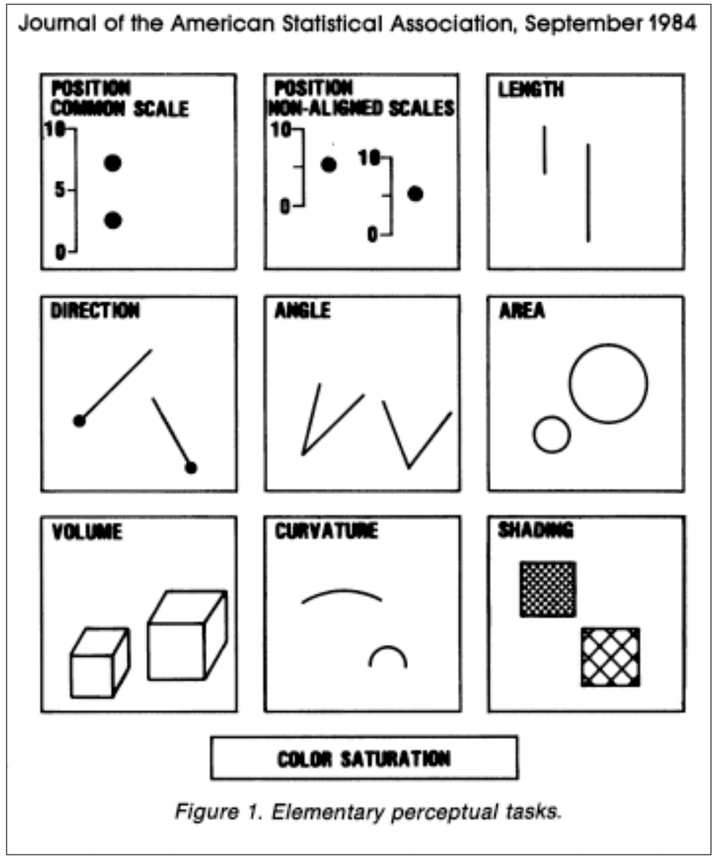


HARVARD
School of Engineering
and Applied Sciences

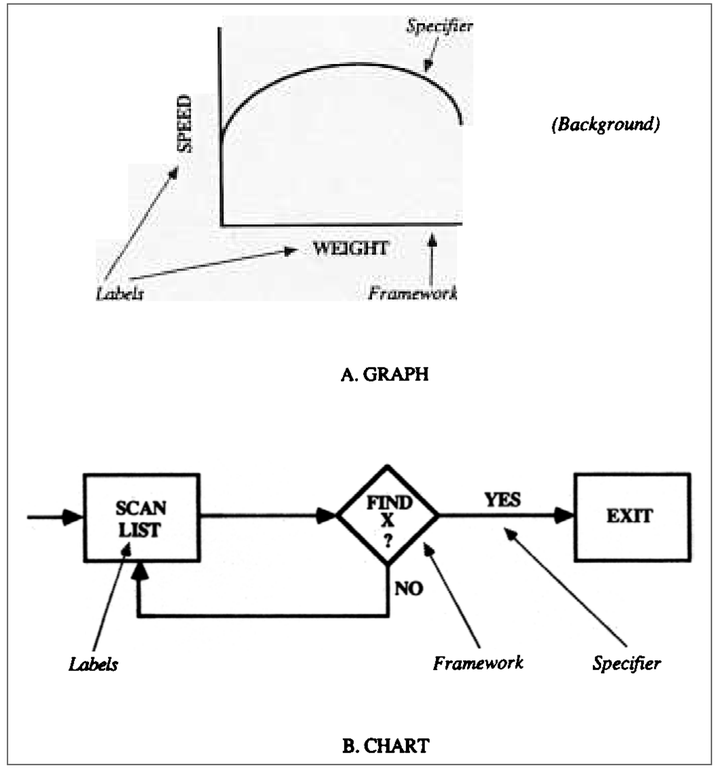




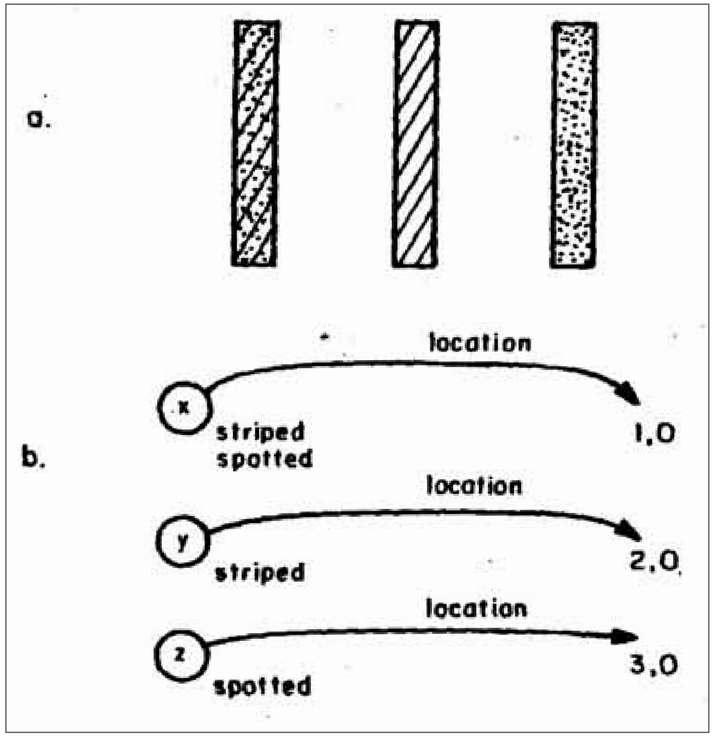






Cleveland & McGill (1984)

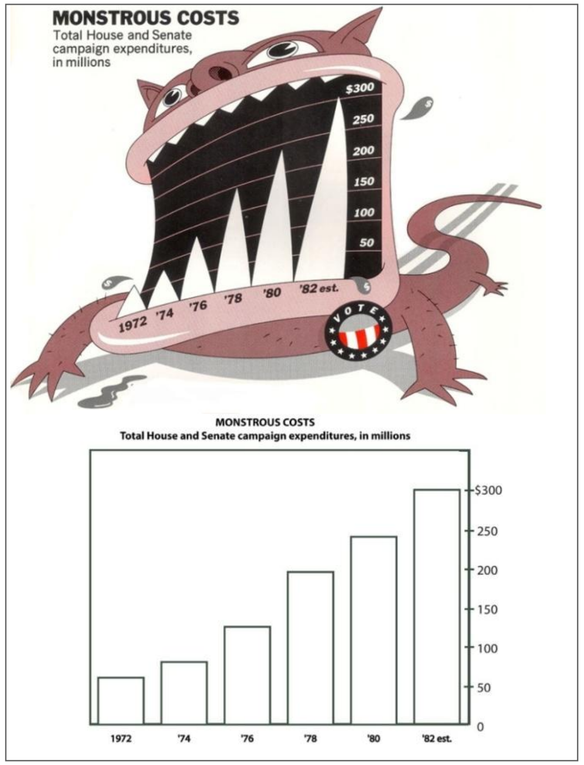


Kosslyn (1989)

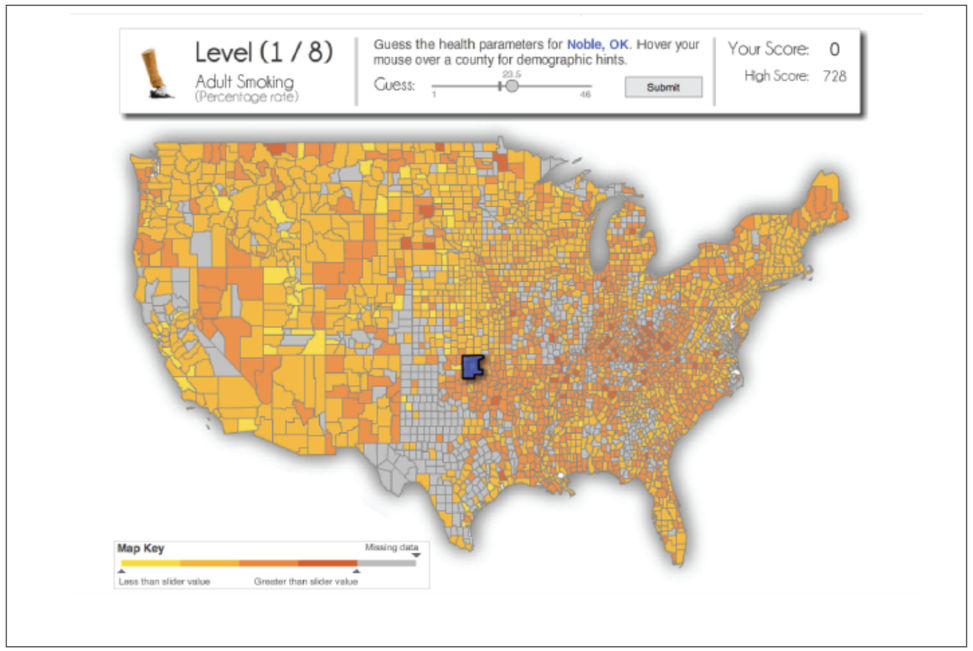


Pinker (1990)

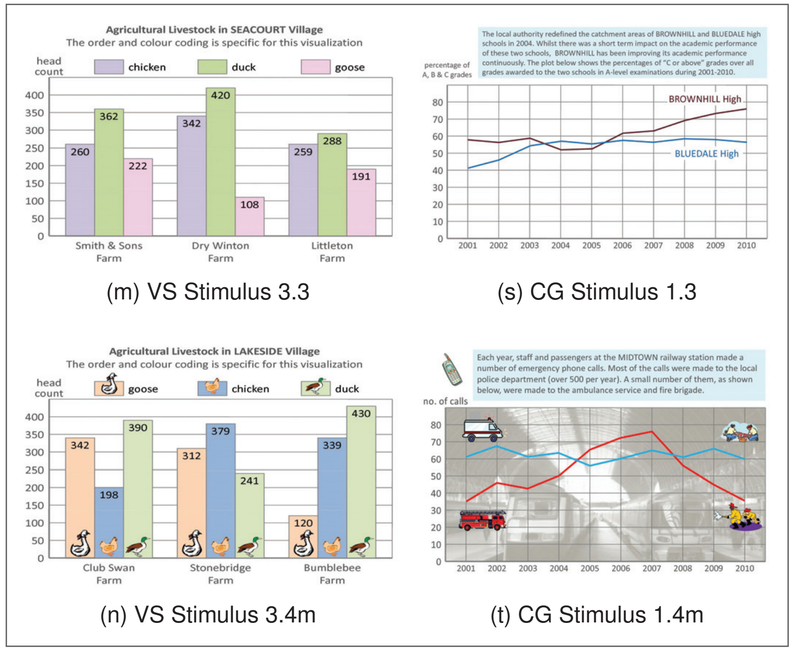
PERCEPTION



Bateman, et al. (2010)



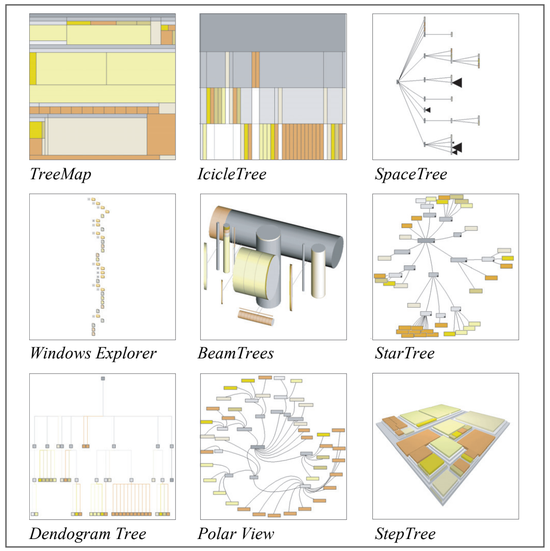
Hullman, Adar, & Shah (2011)



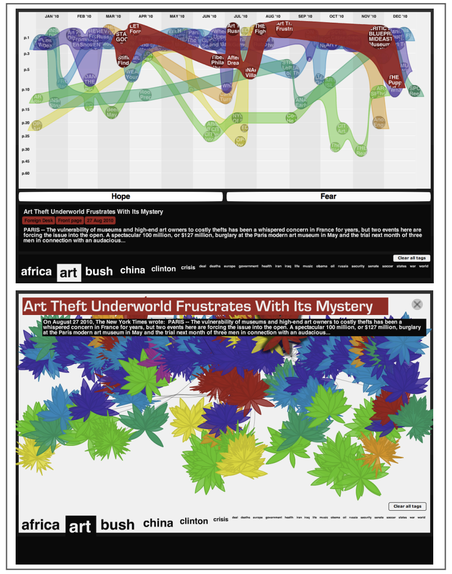
Borgo, et al. (2012)

MEMORY

PERCEPTION



Cawthon & Vande Moere (2007)



Vande Moere, et al. (2012)

AESTHETICS

MEMORY

PERCEPTION

IMPACT
COMPREHENSION
ENGAGEMENT
AESTHETICS
MEMORY
PERCEPTION

MEMORY

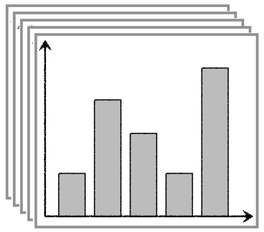
PERCEPTION

What Makes a Visualization Memorable?

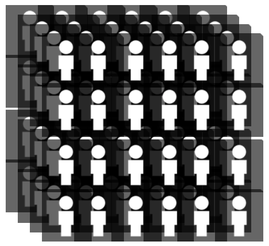
Memory

Perception

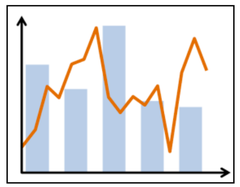
What Makes a Visualization Memorable?



Massive database with 1000s of real visualizations



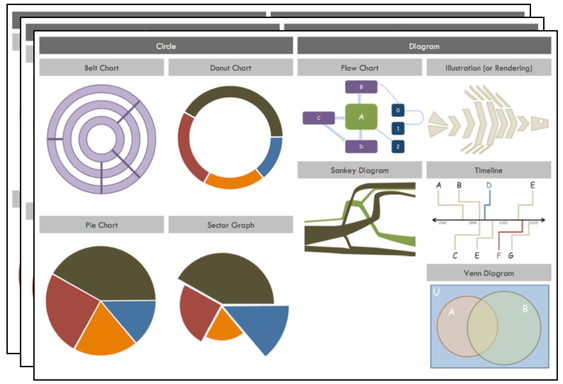
Online game with 100s of people

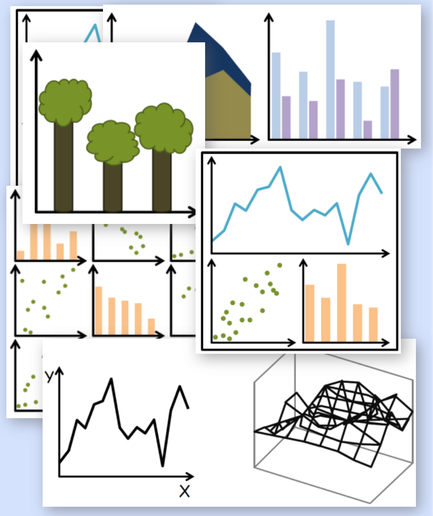


Statistically significant results

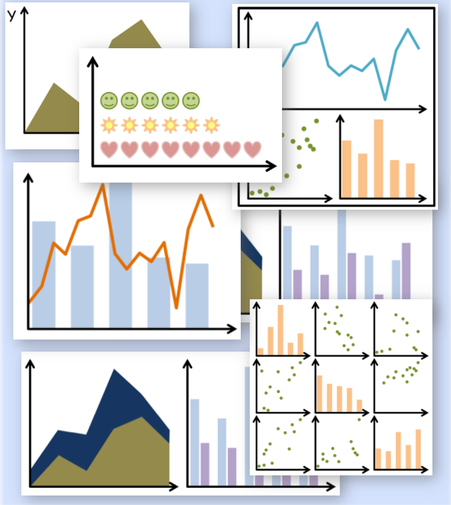
The Data

Taxonomy



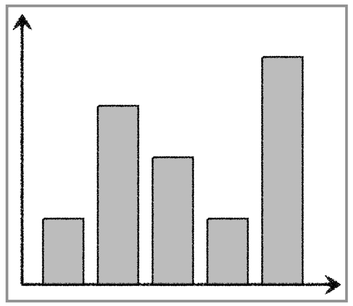


Visualization Database (5,693 images)



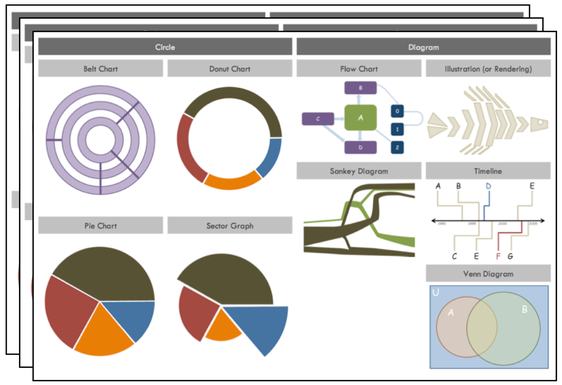
→

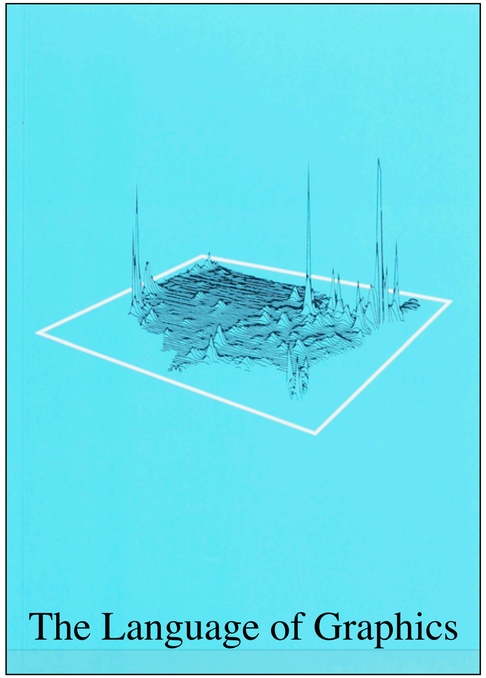
"Single" visualizations (2,070 images)



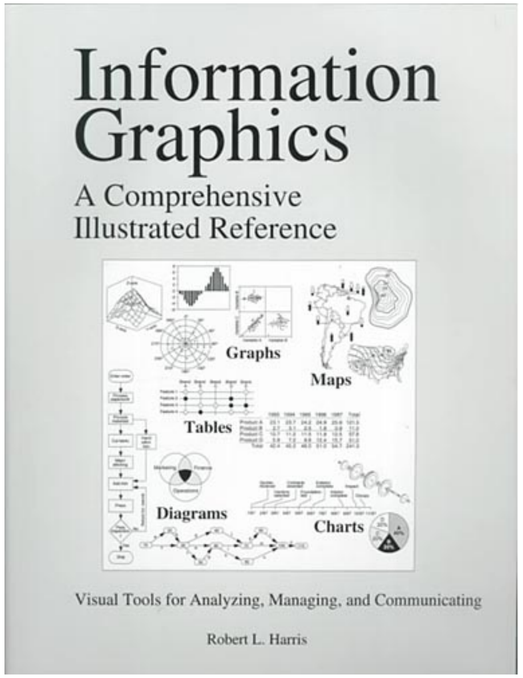
"single"

Taxonomy

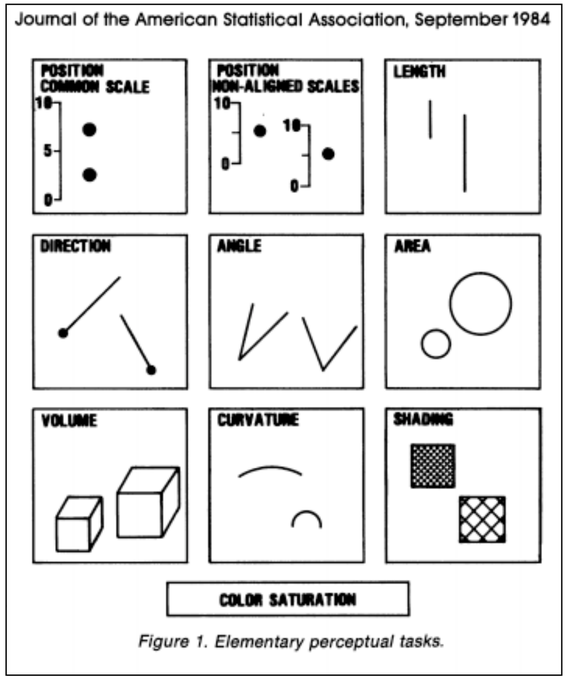




Englehardt (2002)

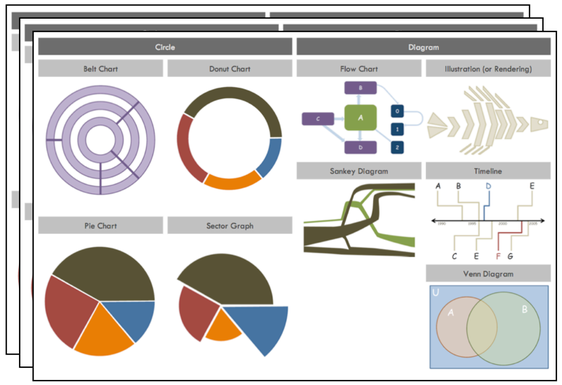


Harris (1999)



Cleveland & McGill (1984)

Taxonomy



Area

Bar

Circle

Diagram

Distribution

Tree & Network

Grid / Matrix

Line

Map

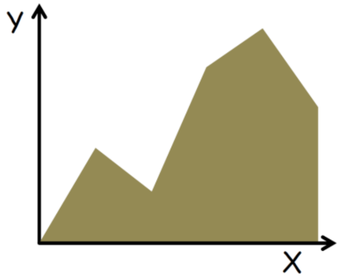
Point

⋮

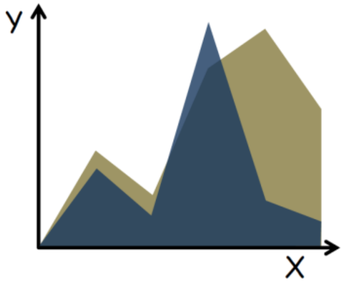
Area

Area Chart

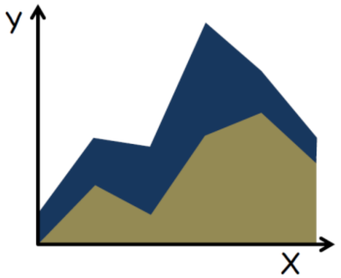
Area Chart



Overlapped Area Chart

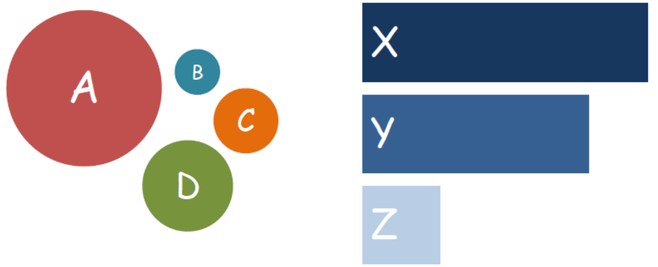


Stacked Area Chart

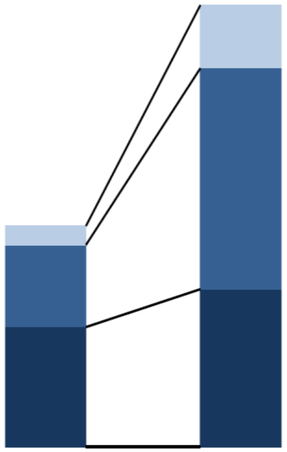


Proportional Area Chart

Aligned



Stacked and Linked

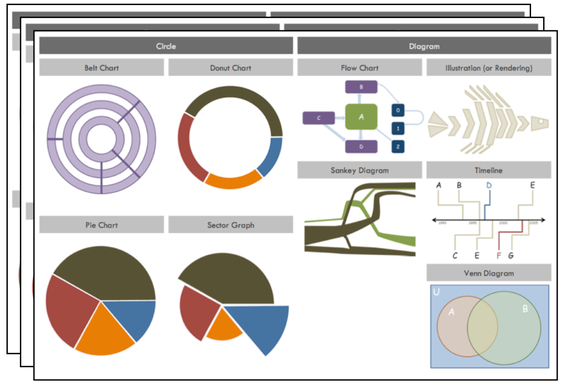


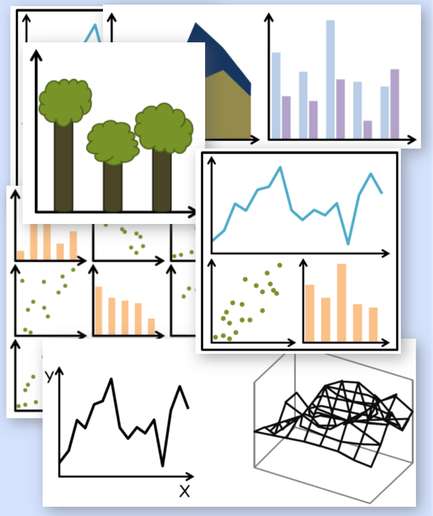
Centered

Overlapped

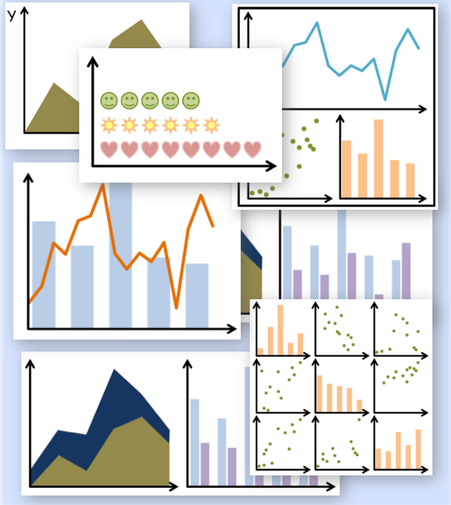
See "Supplemental Material" PDF

Taxonomy



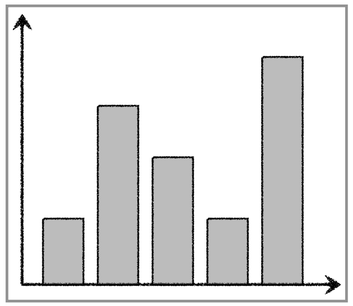


Visualization Database (5,693 images)

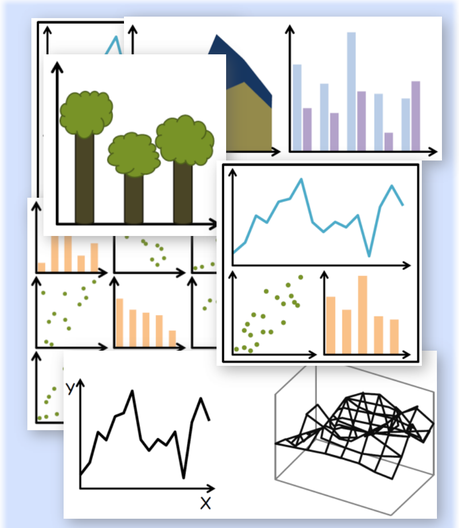


"Single" visualizations (2,070 images)

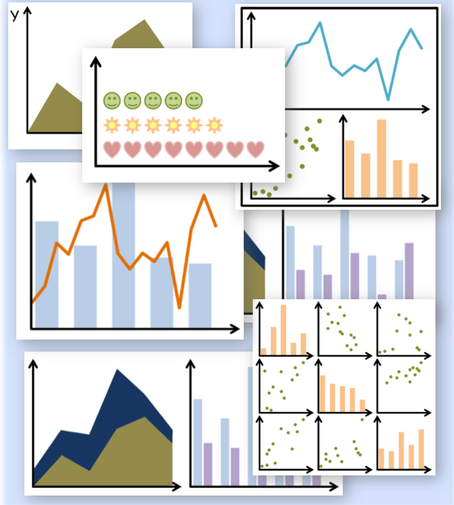
"Targets" (410)



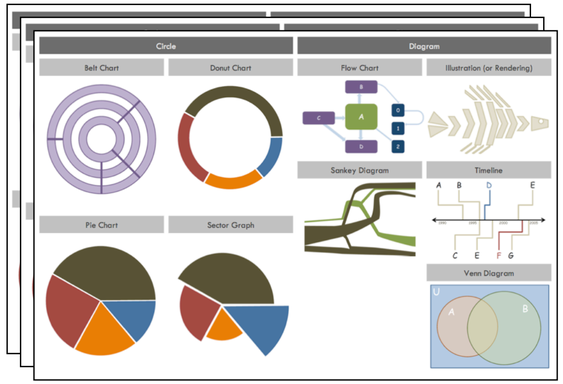
"single"



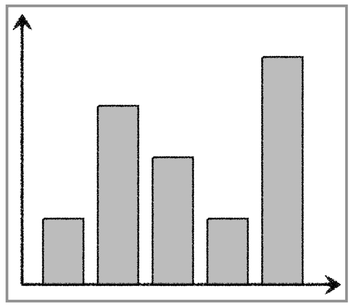
Visualization Database (5,693 images)



Taxonomy

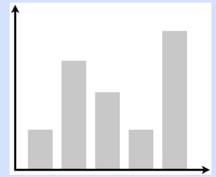
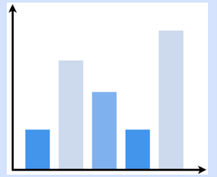
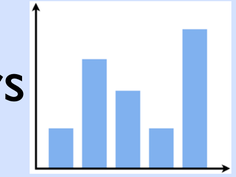
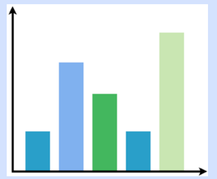
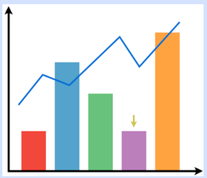
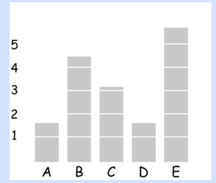
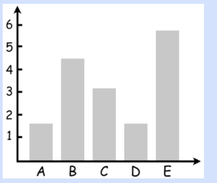
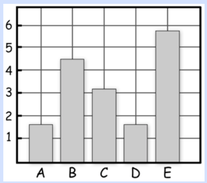
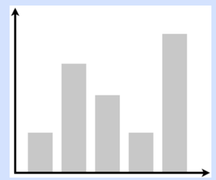
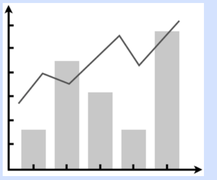
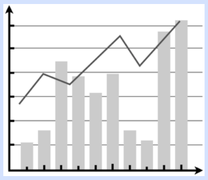
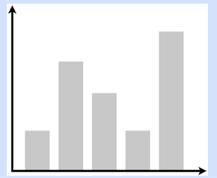


"Single" visualizations (2,070 images)

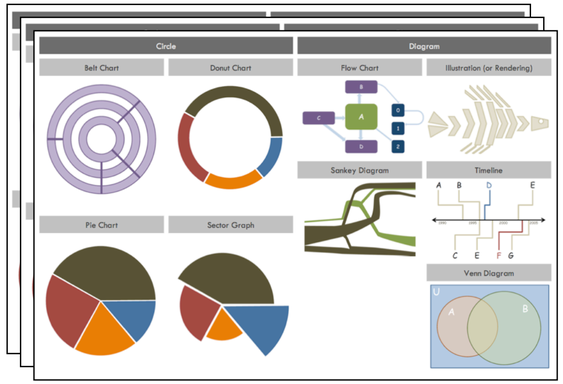


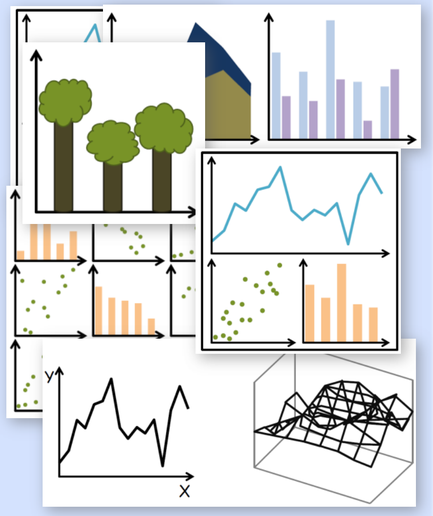
"single"

"Targets" (410)

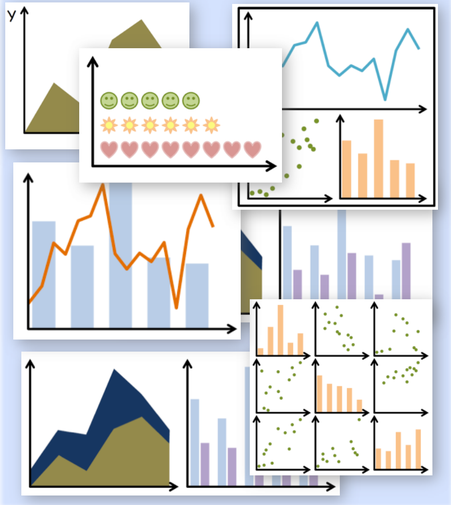
	Yes	*No*		
Black & White				
	1	*2-6*	*≥7*	
Number of Distinct Colors				
	good	*medium*	*bad*	
Data-Ink Ratio				
	low	*medium*	*high*	
Visual Density				
	Yes	*No*		
Human Recognizable Objects				

Taxonomy



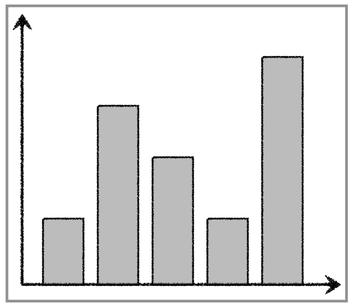


Visualization Database (5,693 images)



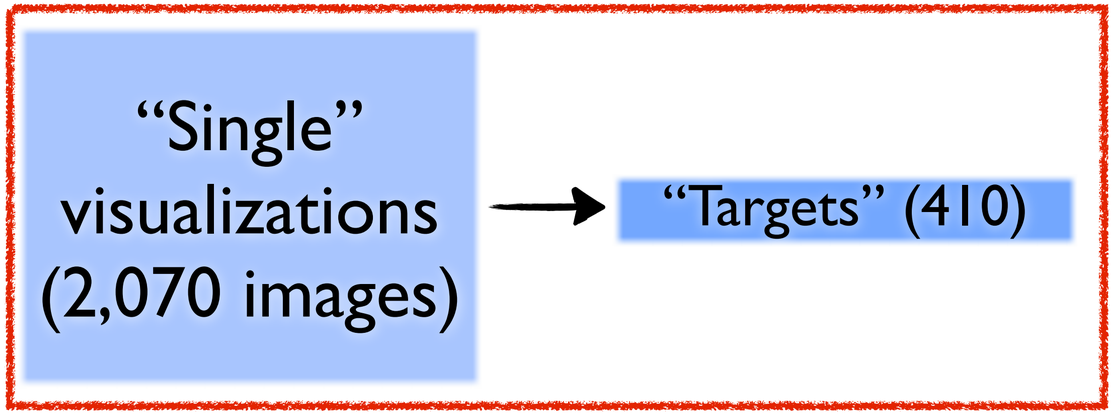
"Single" visualizations (2,070 images)

"Targets" (410)



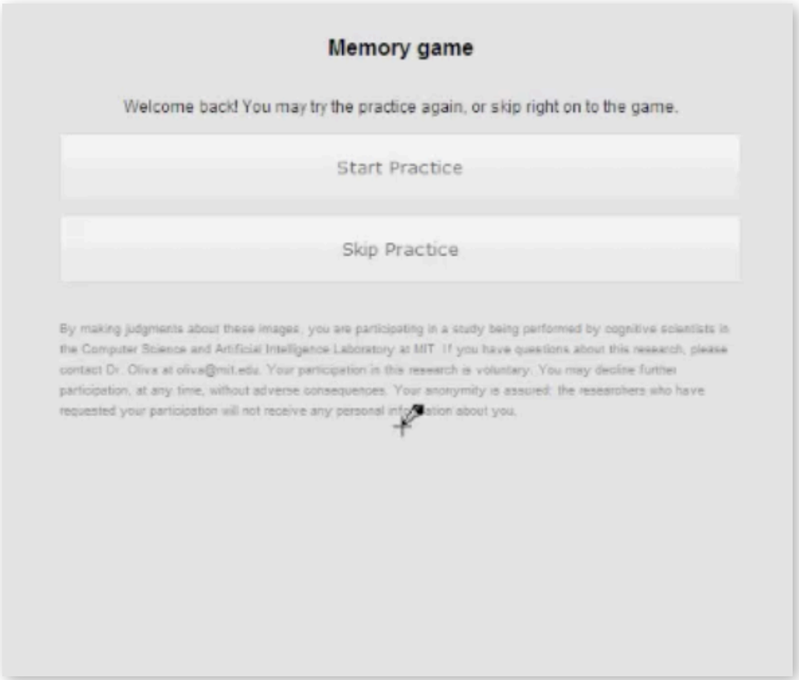
"single"

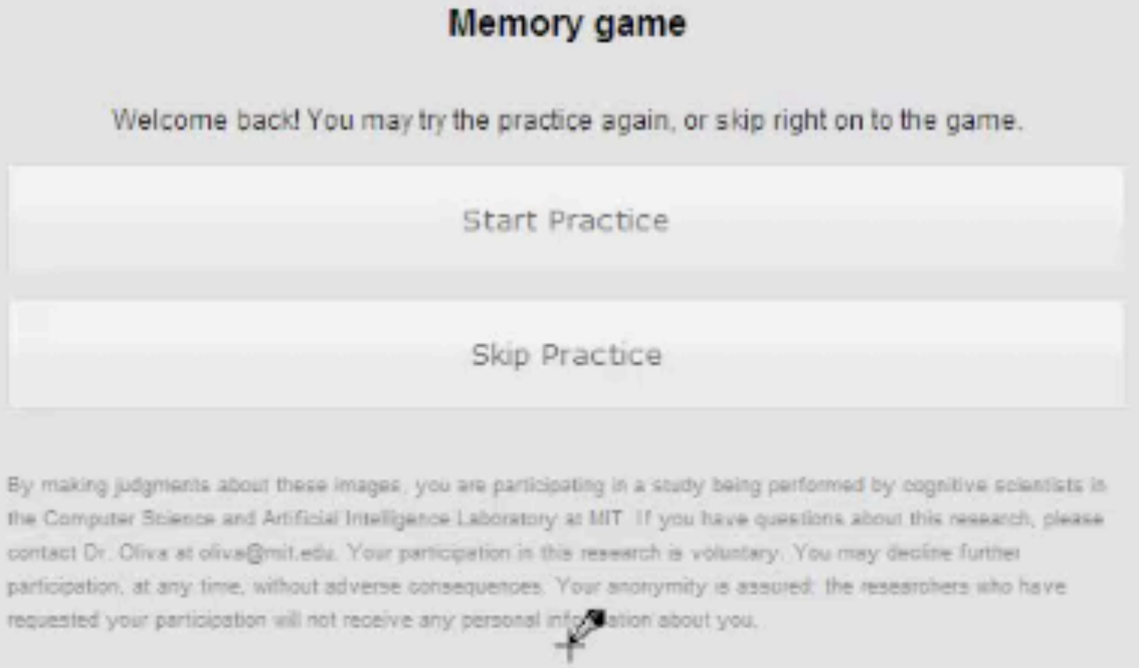
EXPERIMENT



EXPERIMENT

- Conducted on amazon mechanical turk™ Artificial Artificial Intelligence
- 261 participants
- Game with 17 levels
  - 120 visualizations per level
  - up to 2,040 visualizations per game
  - over 57% of participants played whole game

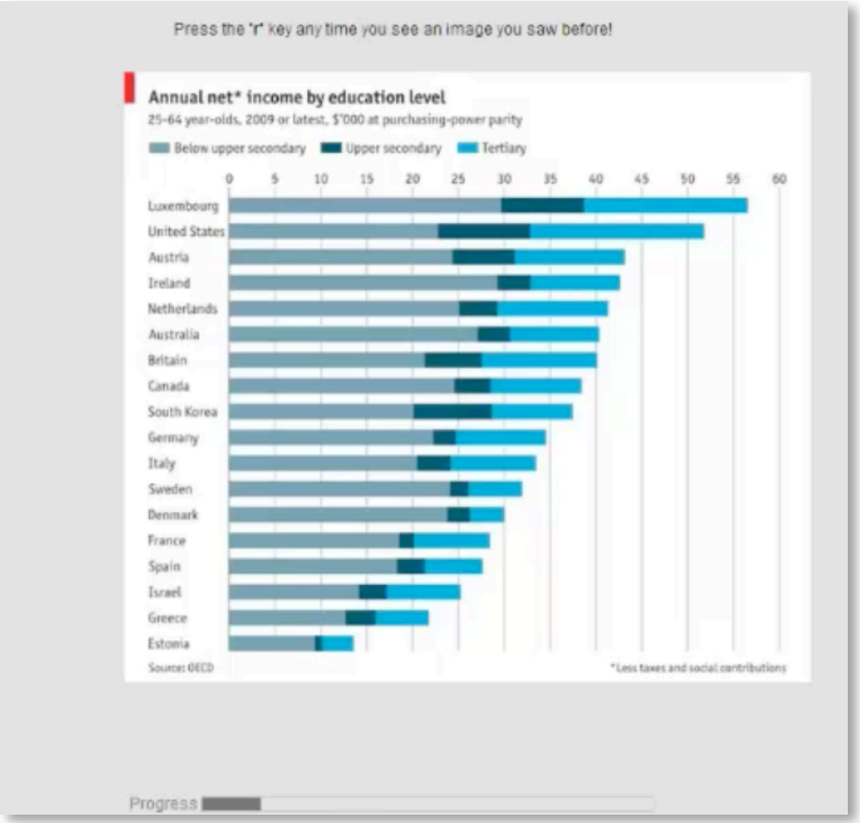




http://vcg.seas.harvard.edu/files/pfister/files/experiment-screengrab.mp4

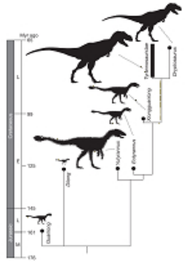
EXPERIMENT

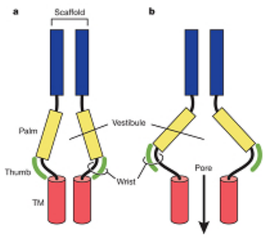
- Visualizations presented for 1 second
- 1.4 second break (‘dot’) between visualizations
- Measurements:
  - “Hit rate” = number of correct IDs of repeated viz
  - “False alarm rate” = number of pre-mature responses

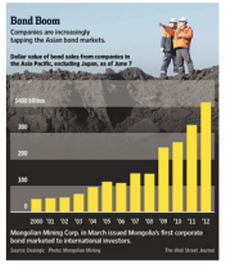


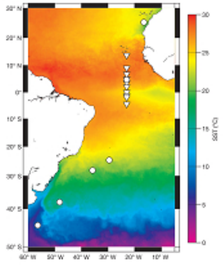
RESULTS

Top 12

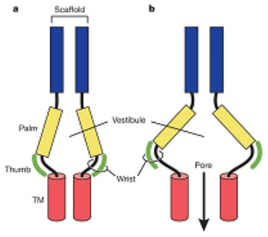


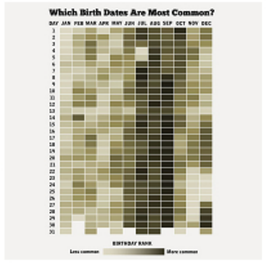


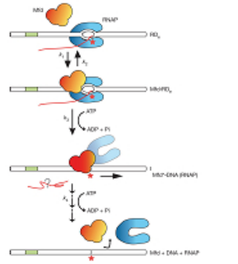


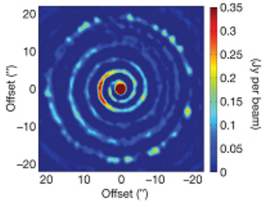


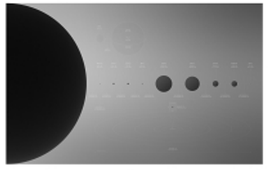
Top 12 (w/o 'objects')

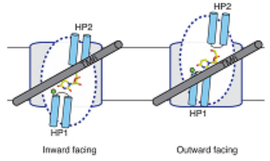


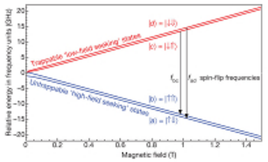












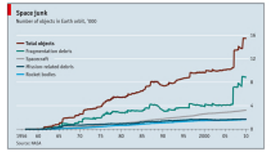
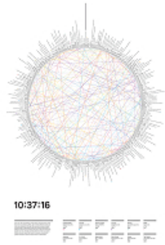
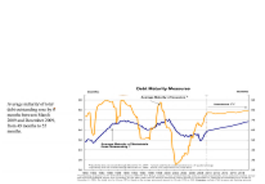
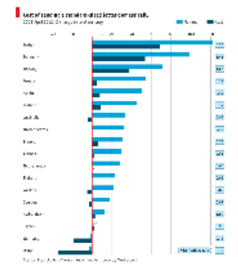


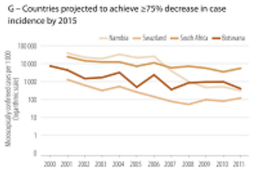
Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

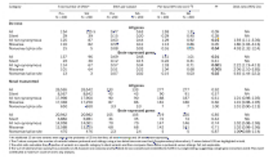


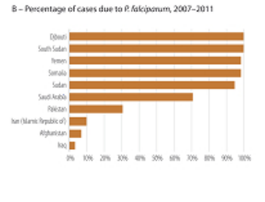
Bottom 12

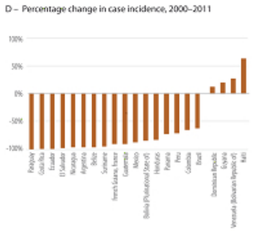


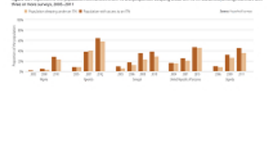


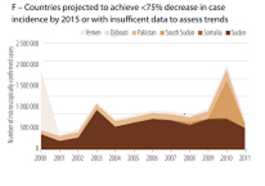


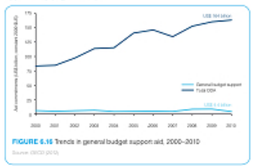


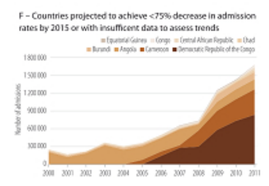




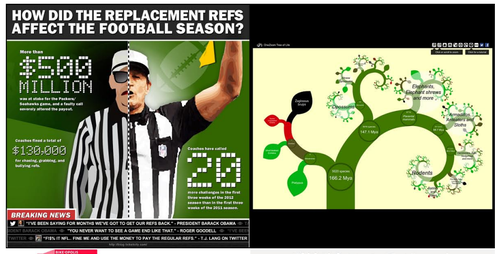


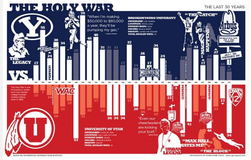




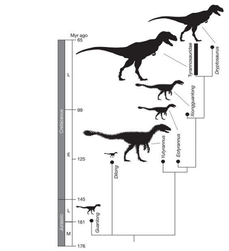


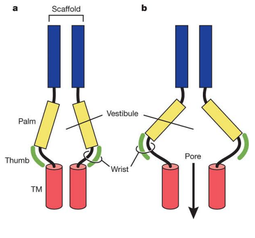
Infographic

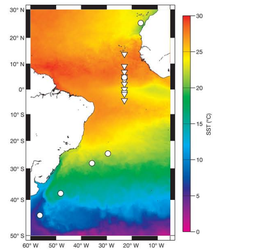


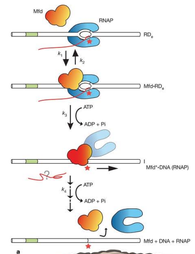


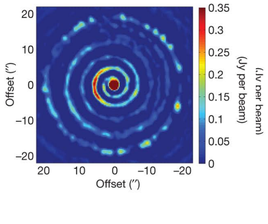
Scientific Journals

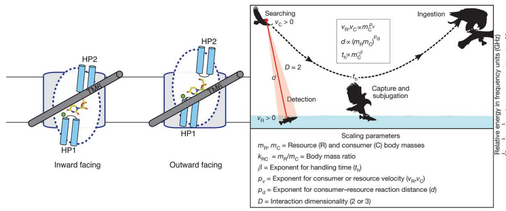


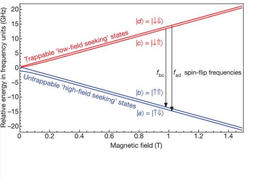


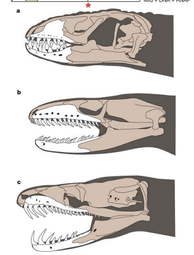


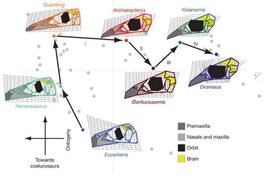




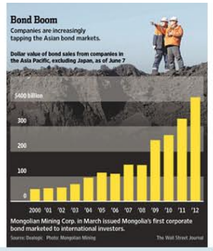


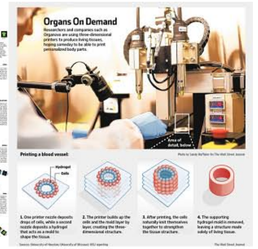


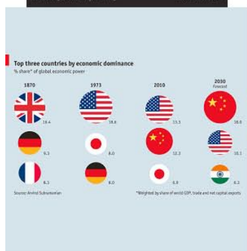


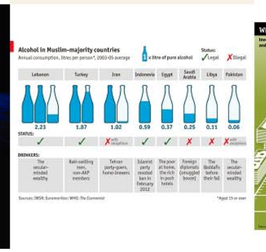


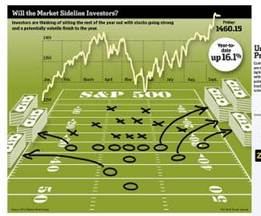
News media

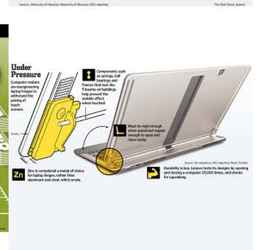












Government Reports

Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

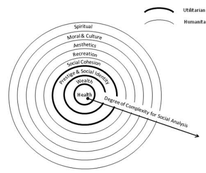


Figure 5.2: Sphere of needs met by water (from wetlandsOnline et al. 2000)

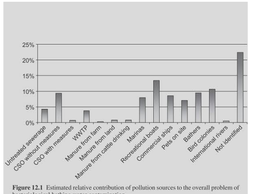


Figure 12.1 Estimated relative contribution of pollution sources to the overall problem of bacteriological bathing water contamination.
Source: Brouwer & Brenda (2005).

Table 2.1: Comparison of terms for describing the ecological character of wetlands

Millennium Ecosystem Assessment terms to apply in Ramsar guidelines and other convention usages	Terms used in previous Ramsar guidelines and other documents
Ecosystem components: physical, chemical, biological (ecosystems, species, genes)	components, features, attributes, properties
Ecological processes within and between ecosystems	processes, interactions, properties, functions
Ecosystem services: provisioning, regulating, cultural, supporting	services, benefits, values, functions, goods, products

(Source: Ramsar Convention 2005a; 2006)

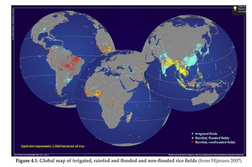


Figure 4.1: Global map of irrigated, rainfed and flooded and non-flooded rice fields (from Hijmans 2005)

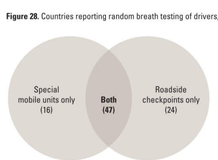


Figure 28. Countries reporting random breath testing of drivers, 2008

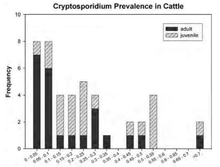


Figure 5.5 Comparison of adult and juvenile mean prevalence of *Cryptosporidium* oocysts in cattle faeces.

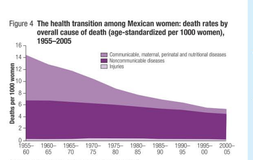
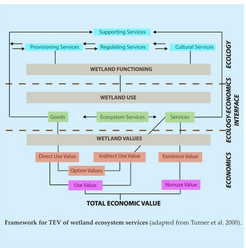
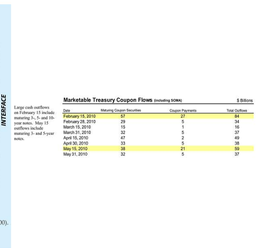


Figure 4 **The health transition among Mexican women: death rates by overall cause of death (age-standardized per 1000 women), 1955–2005**

Source: World Health Organization.[1] United Nations Population Division.[2]



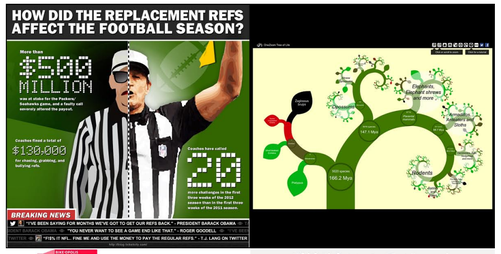
Framework for TEV of wetland ecosystem services (adapted from Turner et al. 2000).

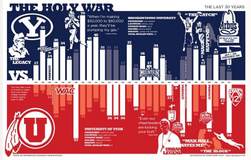


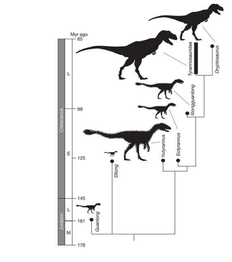
Memorability?

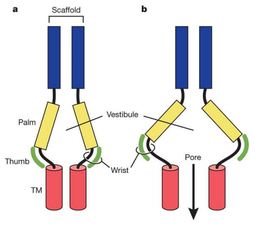
#1 Infographic

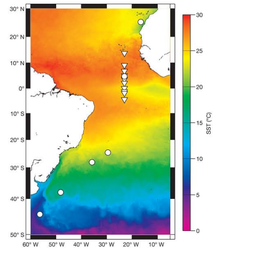
#2 Scientific Journals

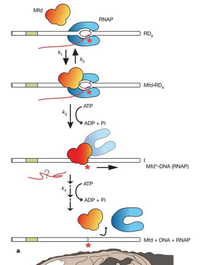


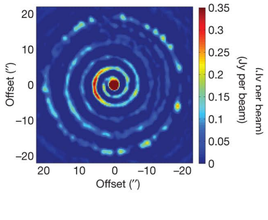


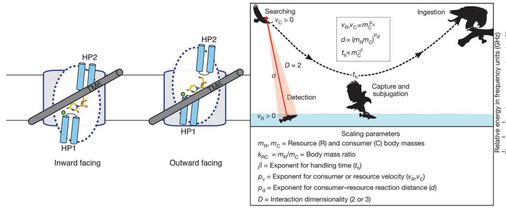


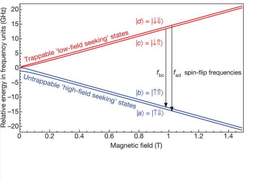


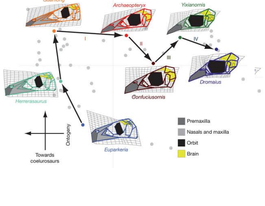


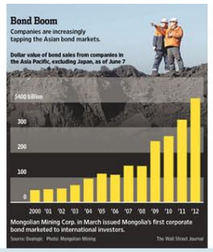


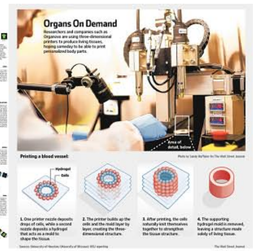


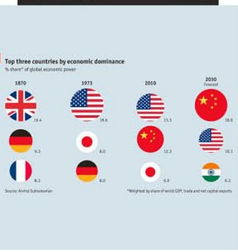


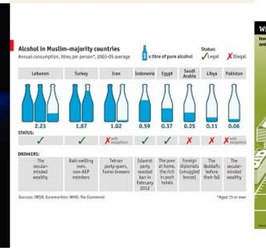


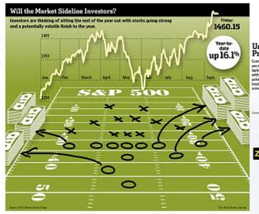


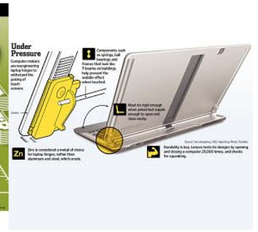












#3 News media

Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

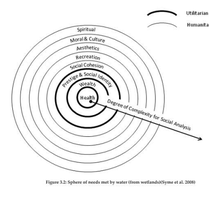


Figure 5.2: Sphere of needs met by water (from wetlandsOnline et al. 2000)

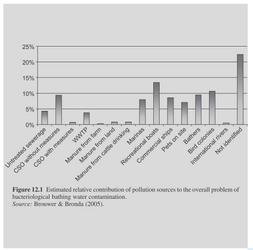


Figure 12.1 Estimated relative contribution of pollution sources to the overall problem of bacteriological bathing water contamination.
Source: Brouwer & Bronda (2005).

Table 2.1: Comparison of terms for describing the ecological character of wetlands

Millennium Ecosystem Assessment terms to apply in Ramsar guidelines and other convention usages	Terms used in previous Ramsar guidelines and other documents
Ecosystem components: physical, chemical, biological (ecosystems, species, genes)	components, features, attributes, properties
Ecological processes within and between ecosystems	processes, interactions, properties, functions
Ecosystem services: provisioning, regulating, cultural, supporting	services, benefits, values, functions, goods, products

(Source: Ramsar Convention 2005a; 2006)

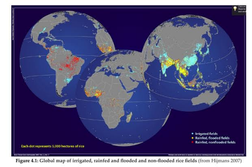


Figure 4.1: Global map of irrigated, rainfed and flooded and non-flooded rice fields (from Hijmans 2007)

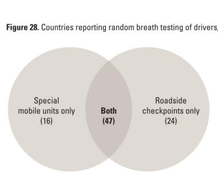


Figure 28. Countries reporting random breath testing of drivers, 2008

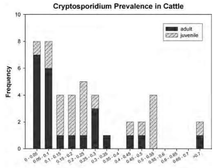


Figure 5.5 Comparison of adult and juvenile mean prevalence of *Cryptosporidium* oocysts in cattle faeces.

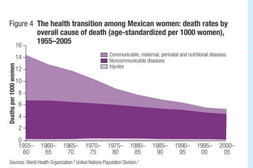
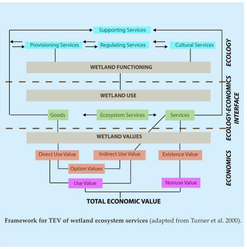
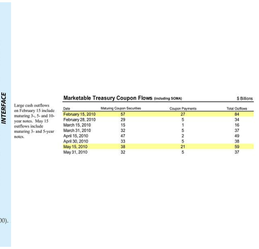


Figure 4 The health transition among Mexican women: death rates by overall cause of death (age-standardized per 1000 women), 1955–2005

Source: World Health Organization * United Nations Population Division.*



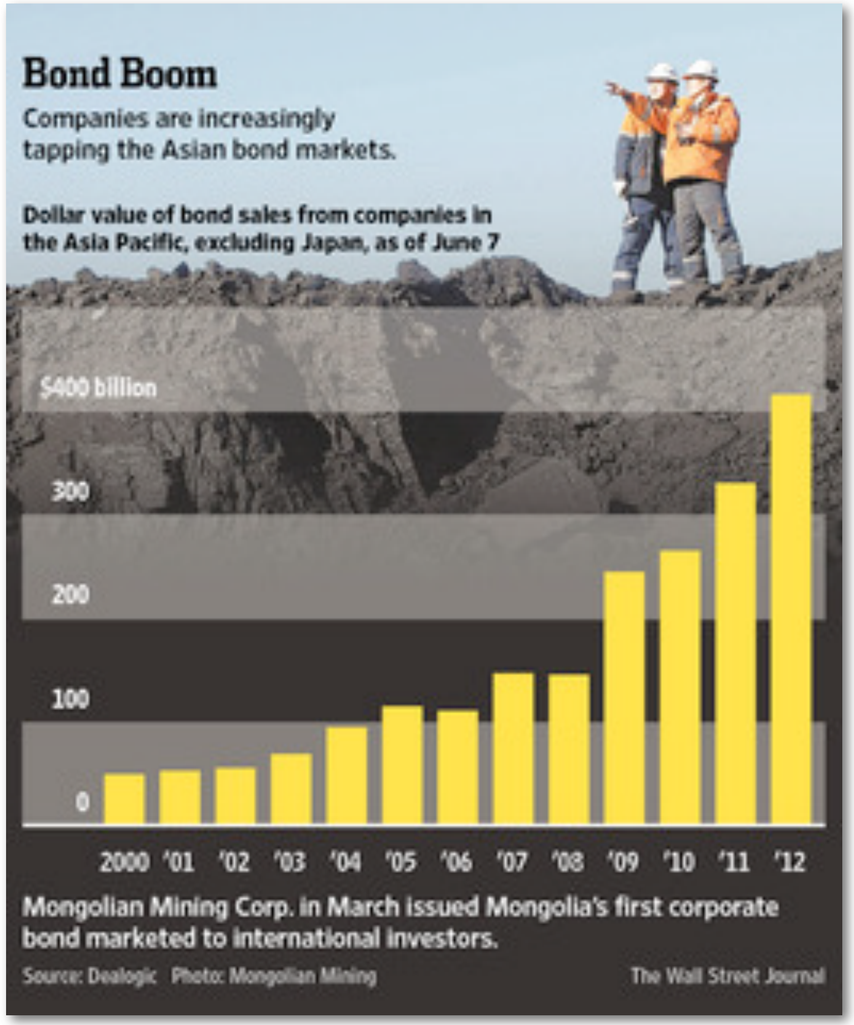
Framework for TEV of wetland ecosystem services (adapted from Turner et al. 2000).

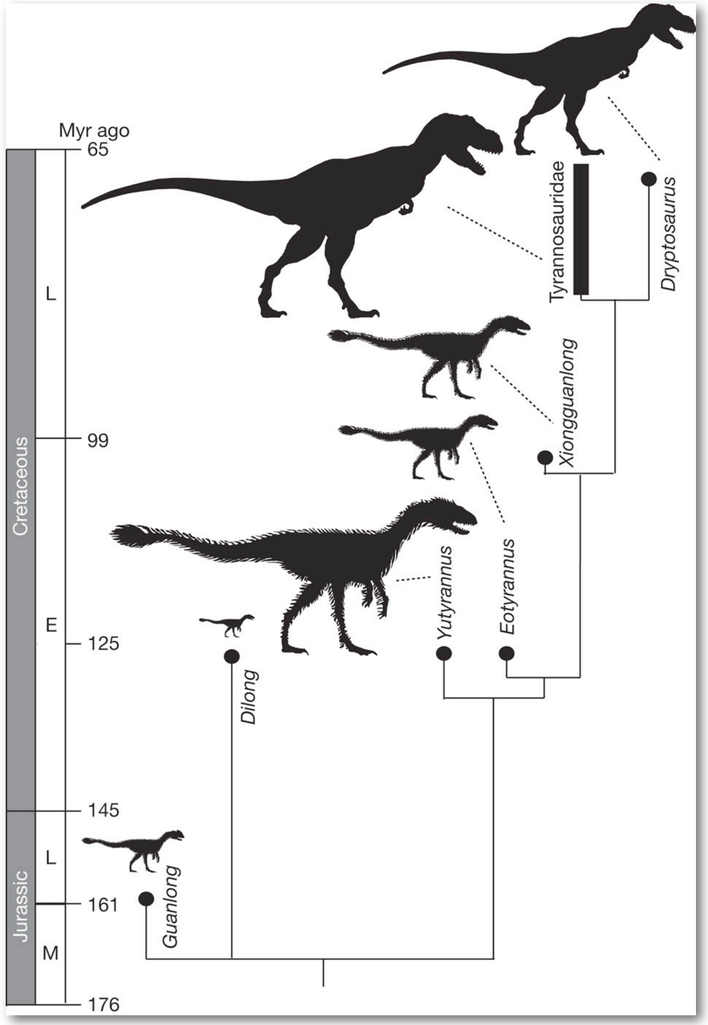


#4 Government Reports

A visualization was more memorable if...

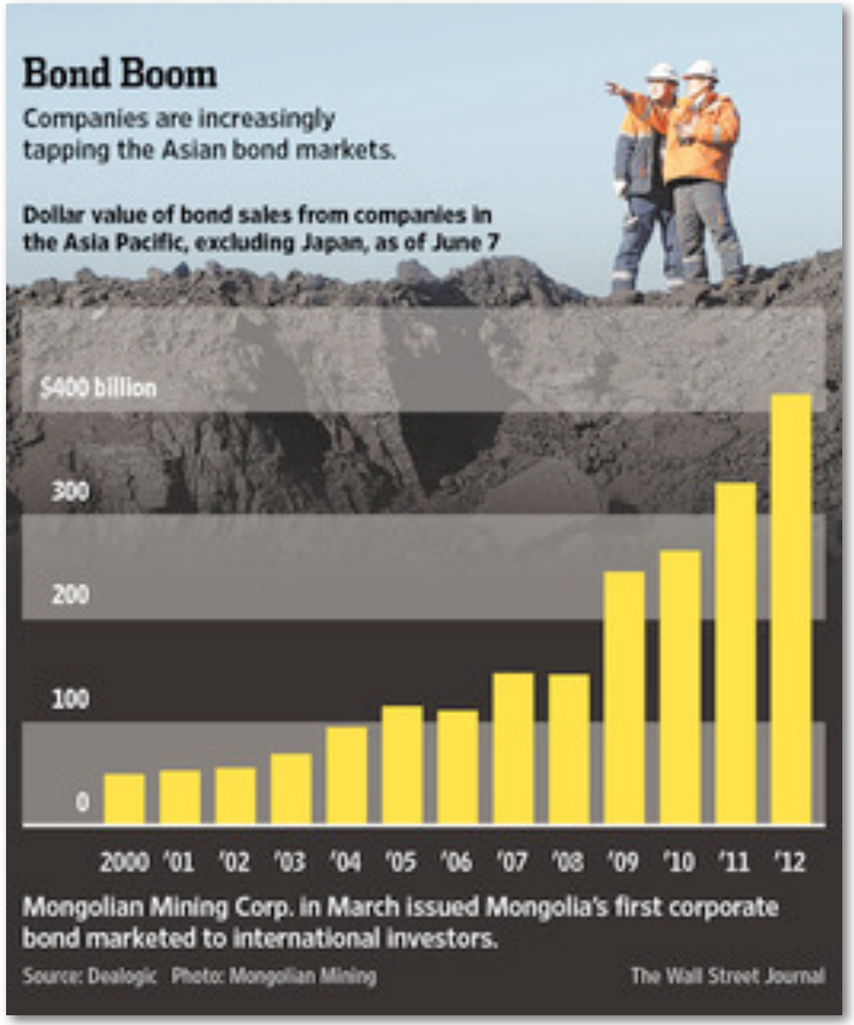
it contains human recognizable objects.

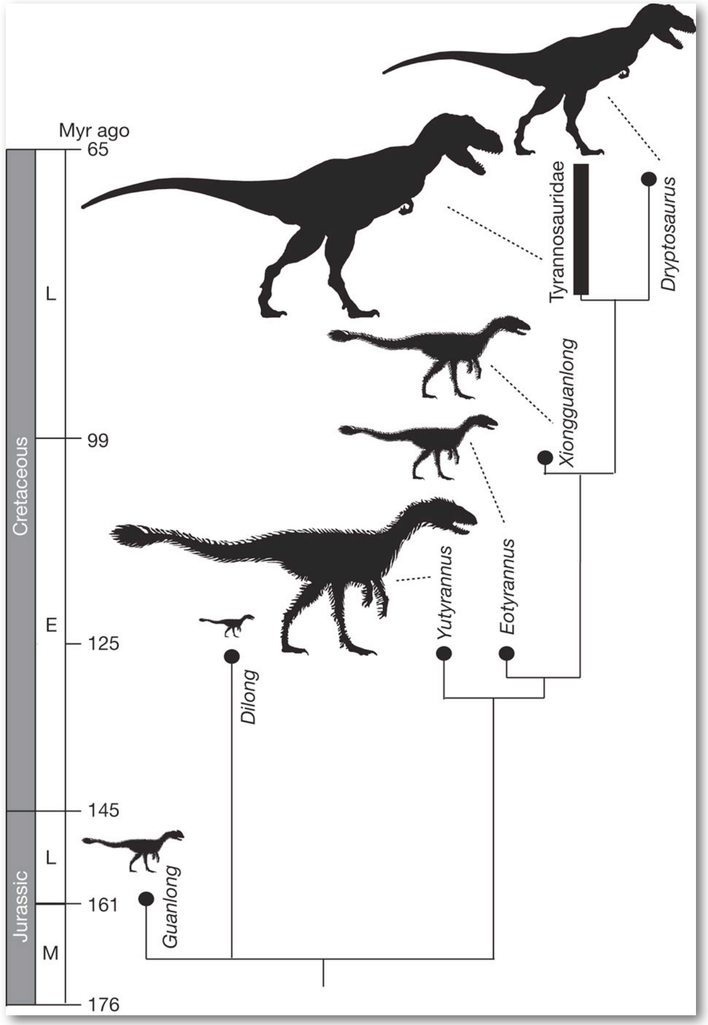




A visualization was more memorable if...

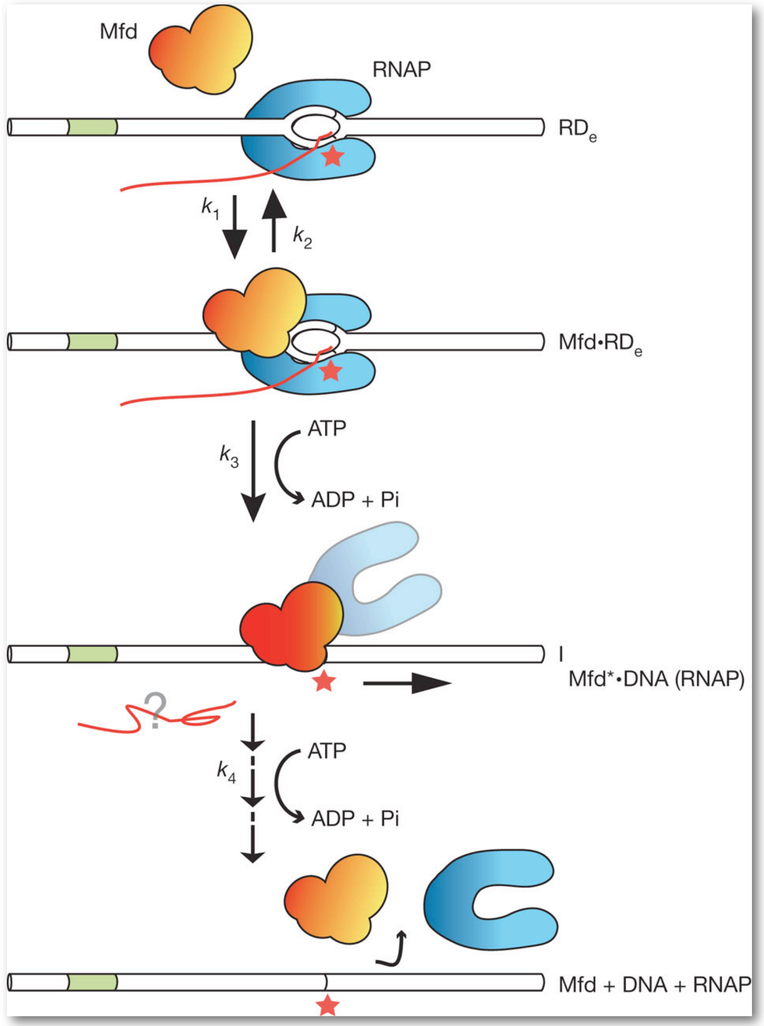
it is distinct.

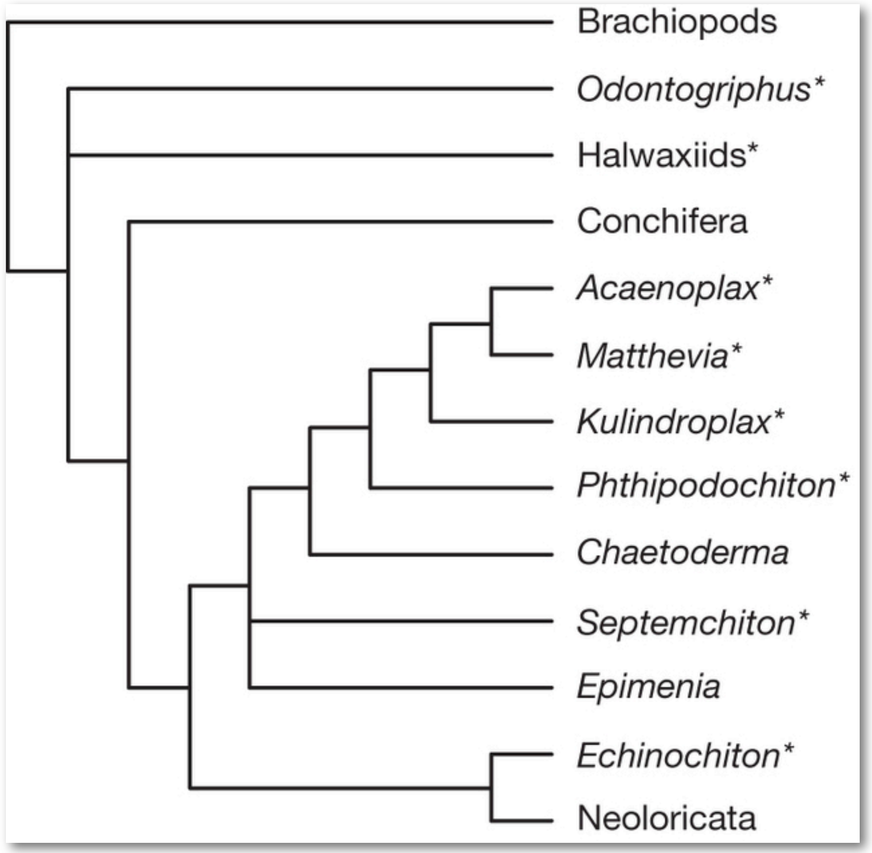


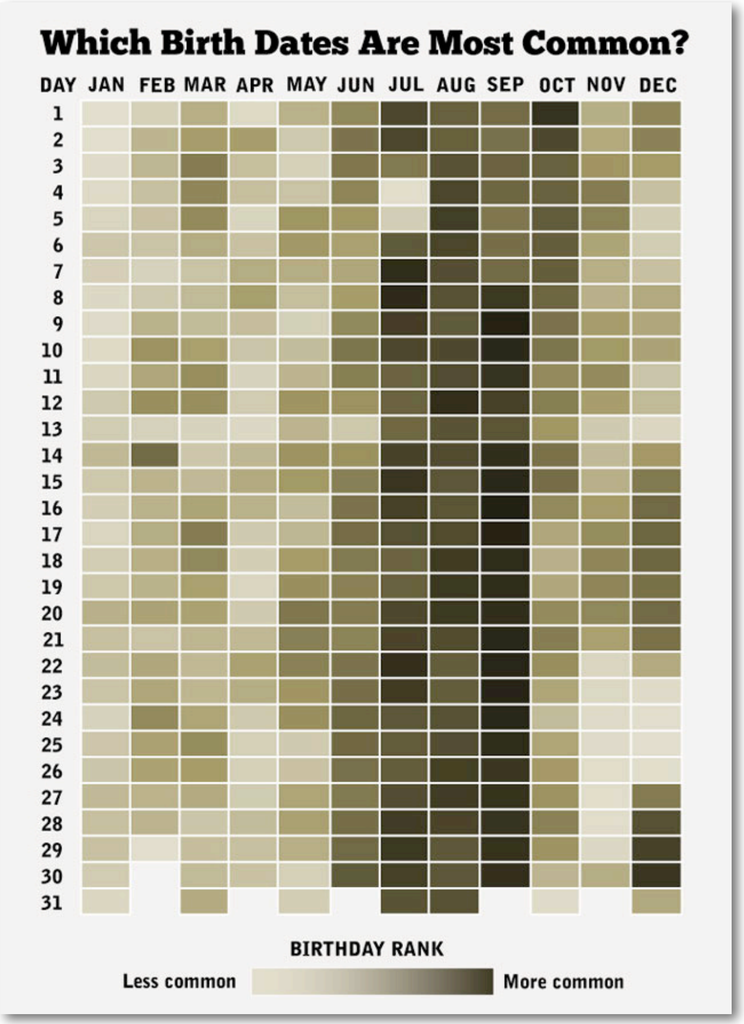


A visualization was more memorable if...

it is a distinct visualization type.

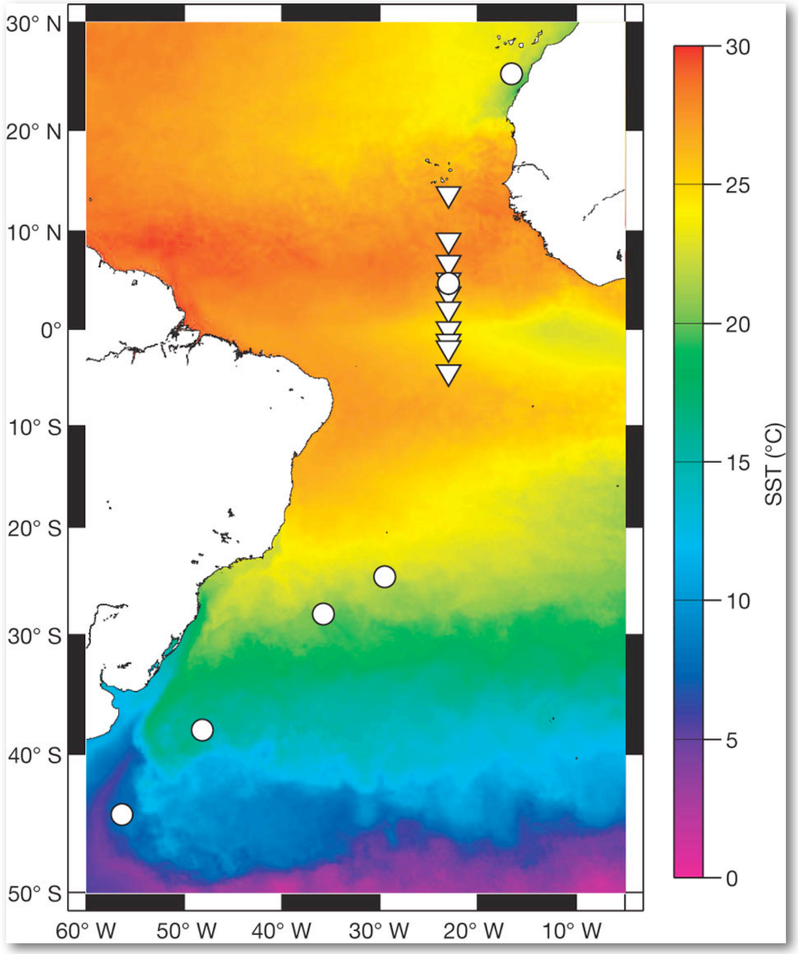






A visualization was more memorable if...

it is colorful.



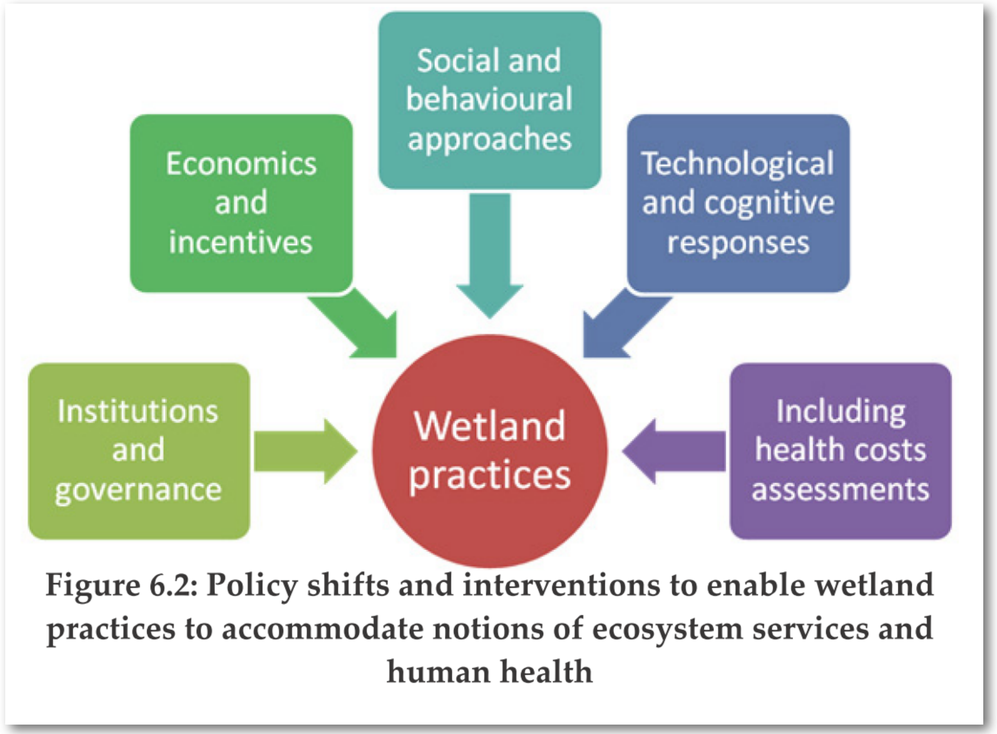
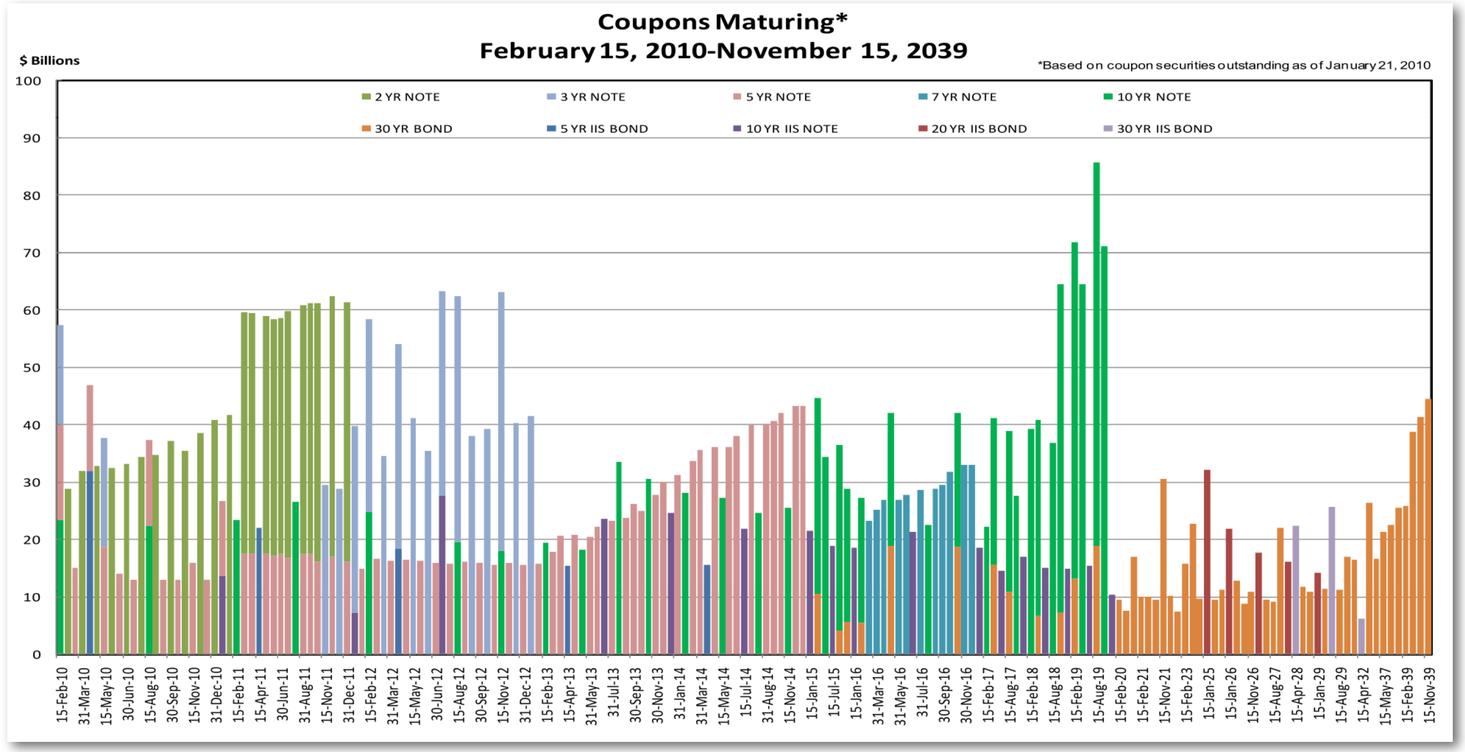
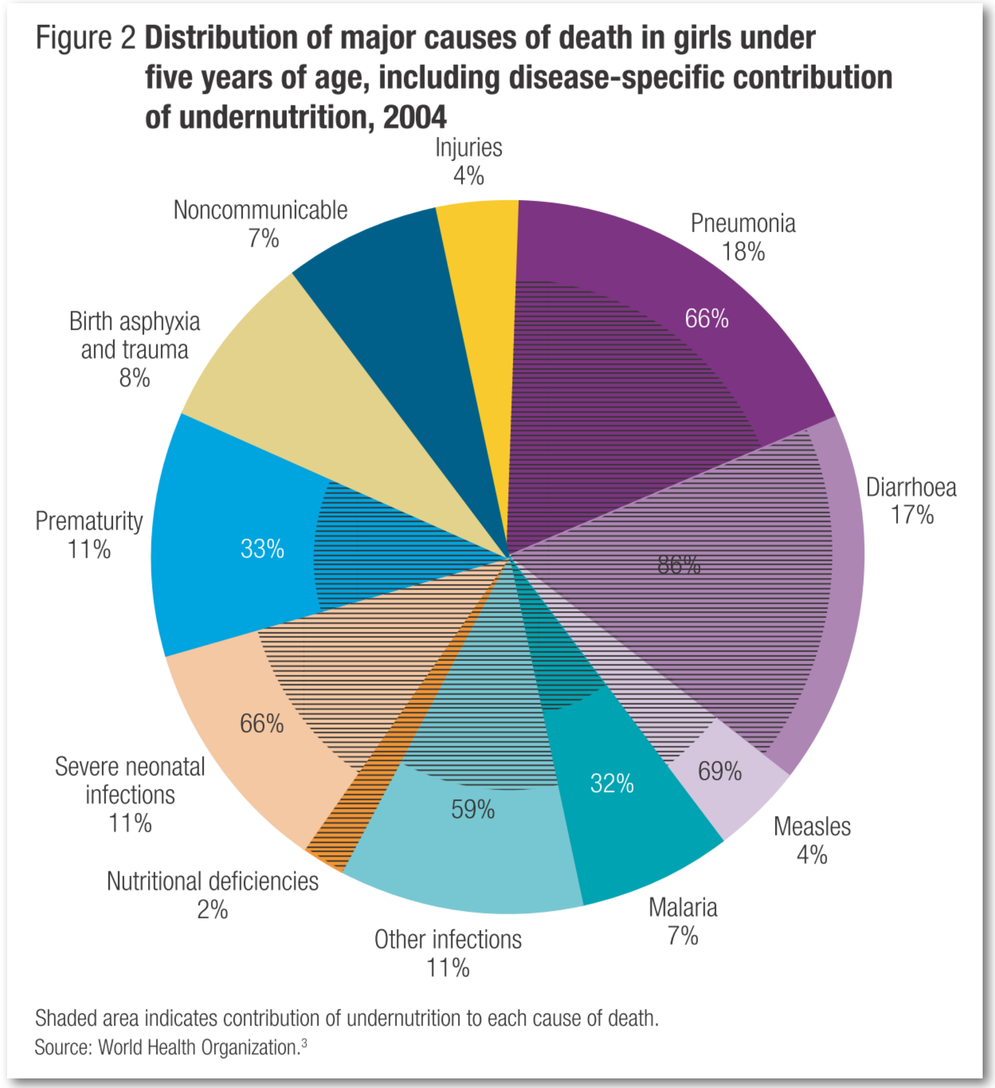


Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

A visualization was more memorable if...

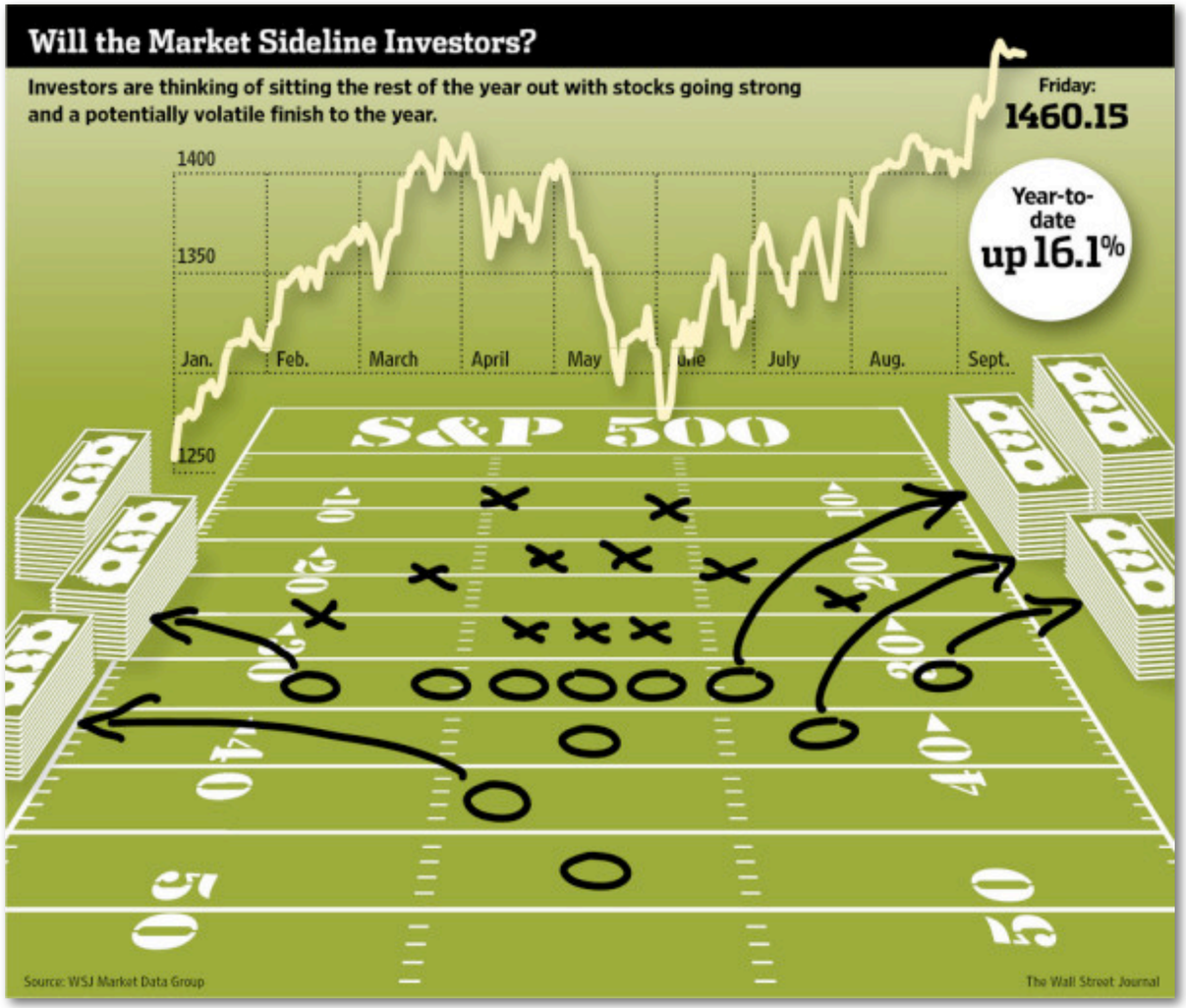
it is visually dense.

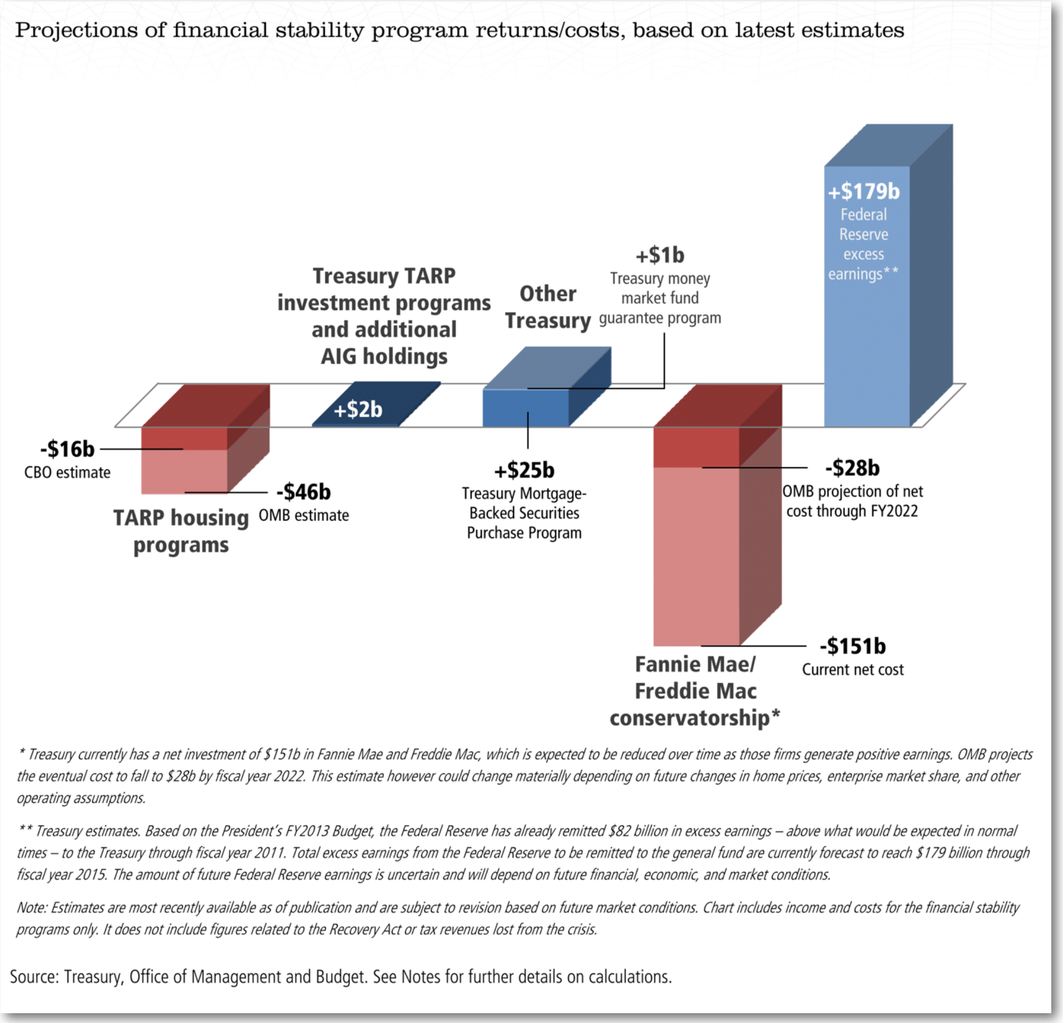




A visualization was more memorable if...

it has a low data-to-ink ratio.



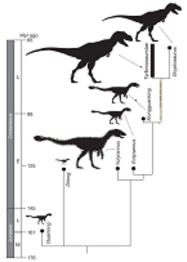


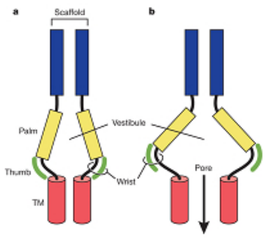
A FEW MORE RESULTS...

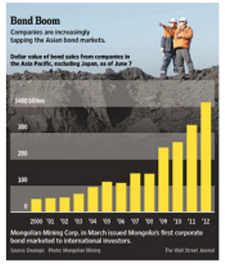
Visualization memorability is consistent and intrinsic

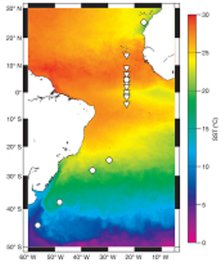
IN SUMMARY…

Top 12

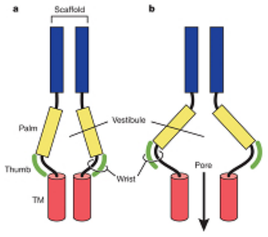


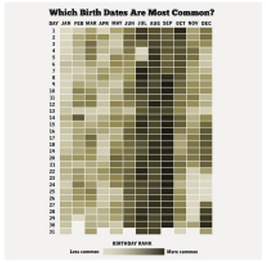


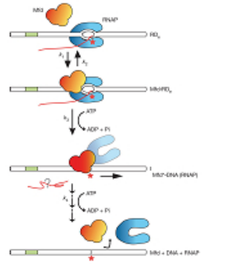


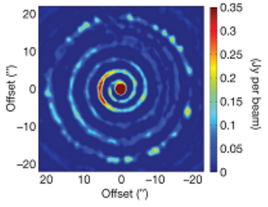


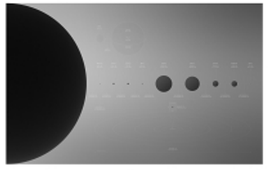
Top 12 (w/o 'objects')

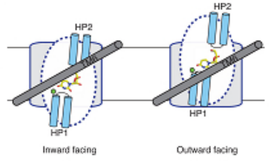


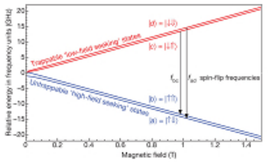












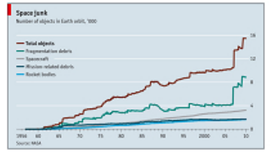
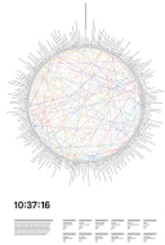
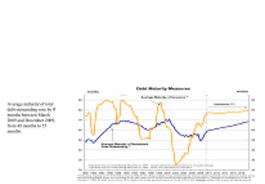
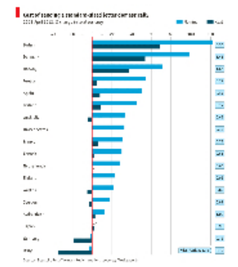


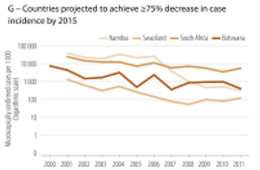
Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

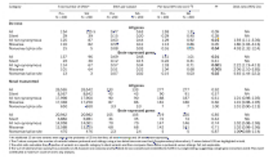


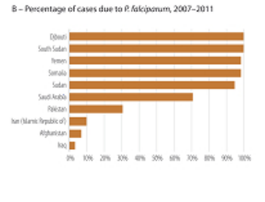
Bottom 12

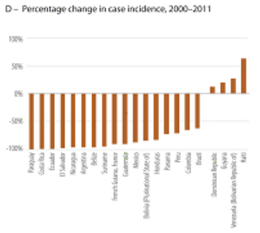


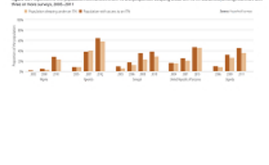


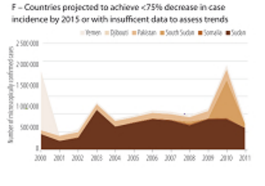


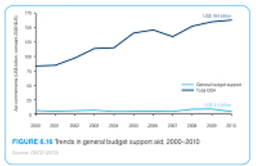


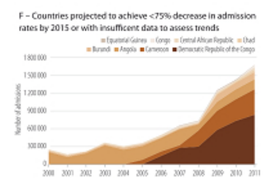




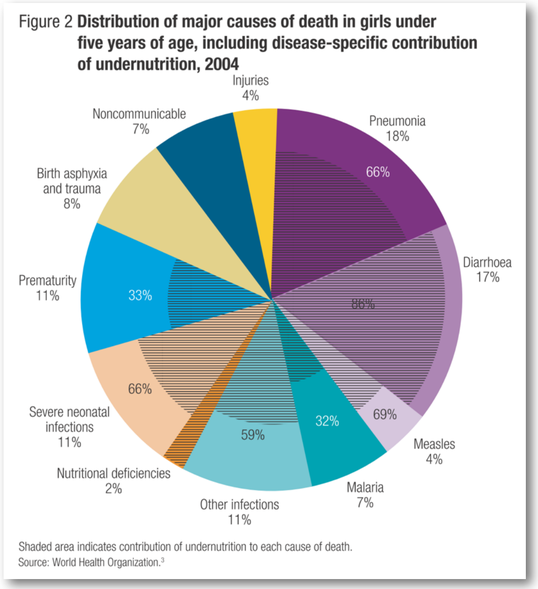


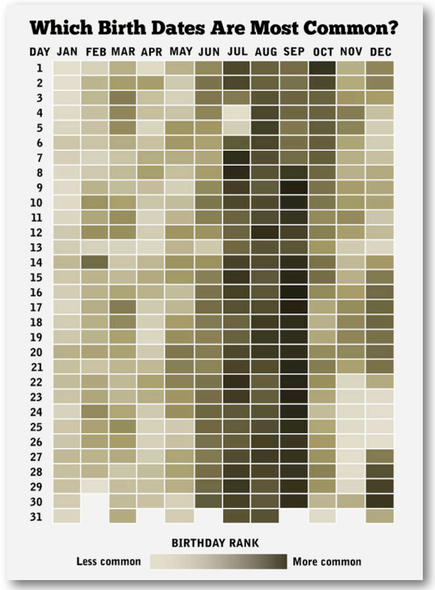


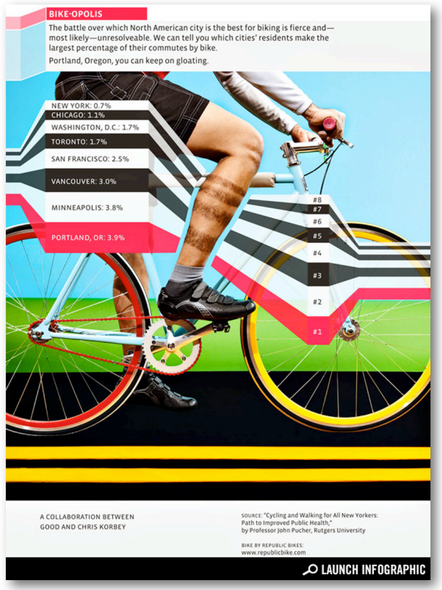


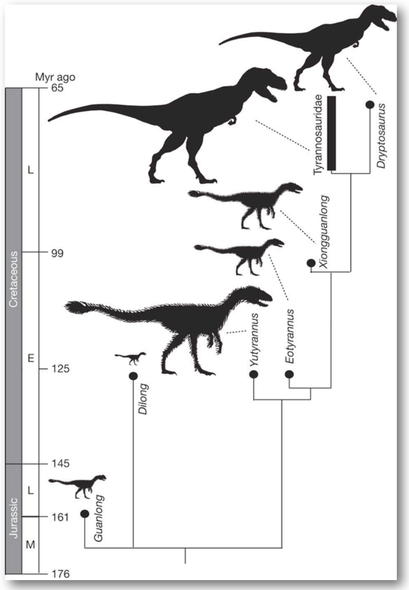


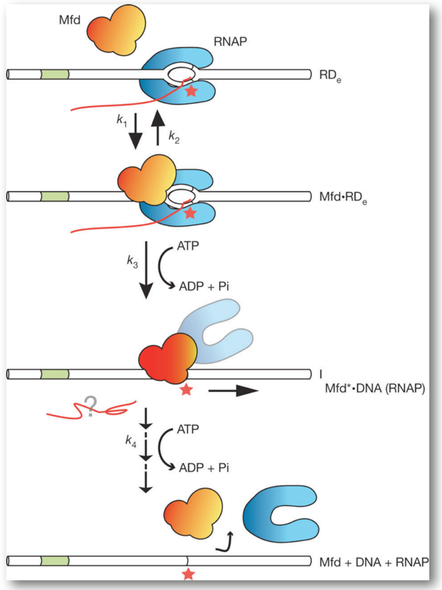
Distinct visualizations are more memorable.

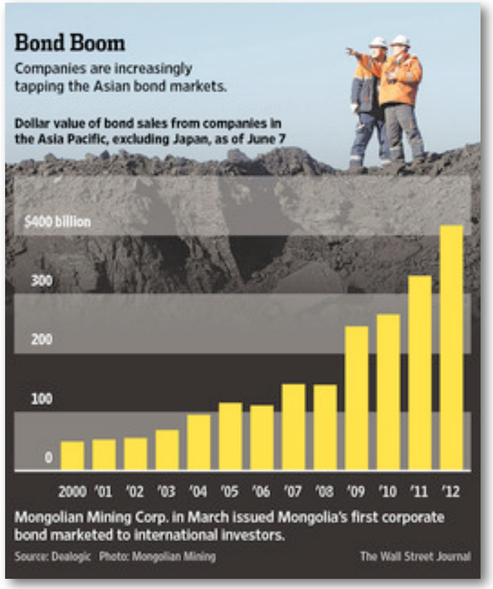












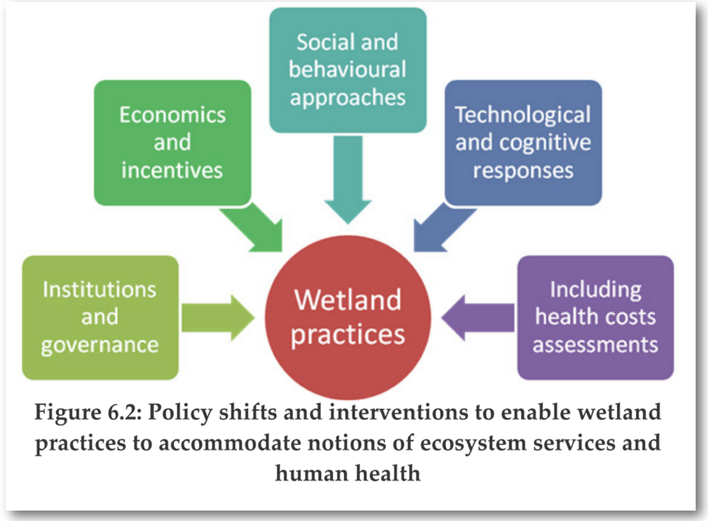
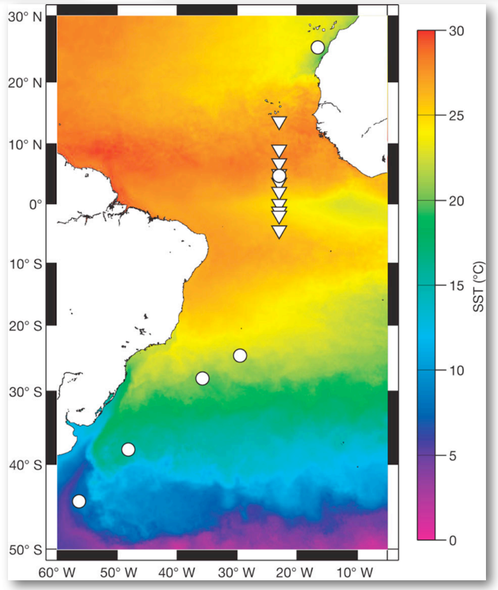
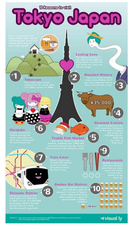


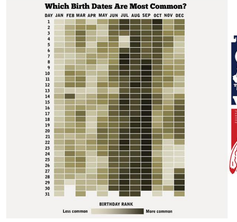
Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

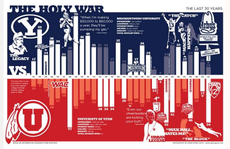


Memorability varies across publication type.

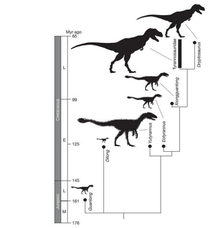
#1 Infographic

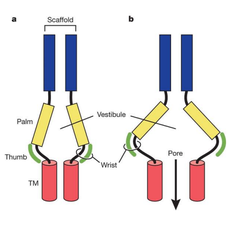


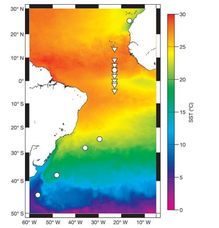


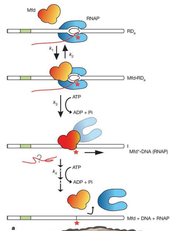


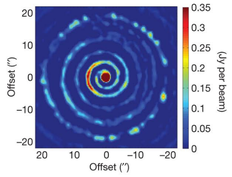
#2 Scientific Journals

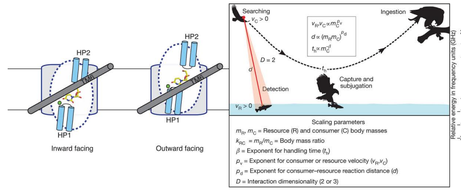


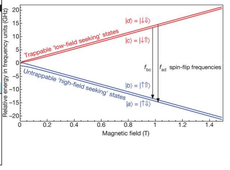


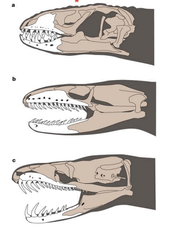


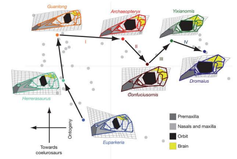




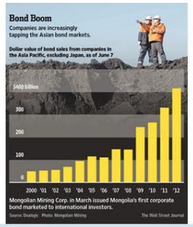


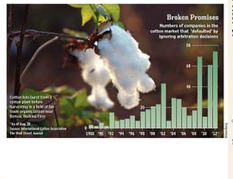


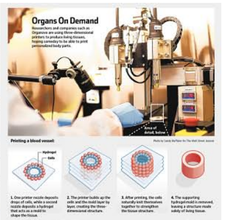


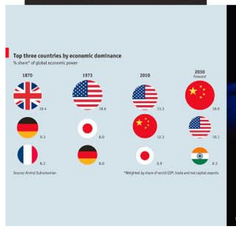


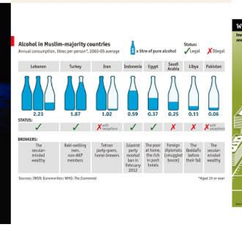
#3 News media

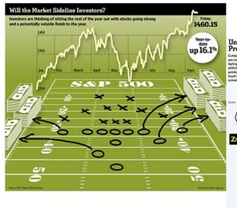


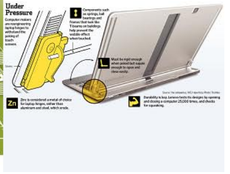












#4 Government Reports

Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

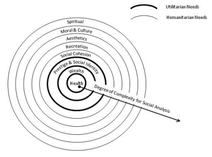


Figure 3.2: Spheres of needs met by water (from wetlandsDrylynne et al. 2000)

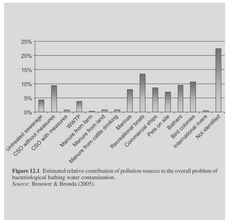


Figure 12.1 Estimated relative contribution of pollution sources to the overall problem of bacteriological bathing water contamination.
Source: Brouwer & Bronda (2005).

Table 2.1: Comparison of terms for describing the ecological character of wetlands

Millennium Ecosystem Assessment terms to apply in Ramsar guidelines and other convention usages	Terms used in previous Ramsar guidelines and other documents
Ecosystem components: physical, chemical, biological (ecosystems, species, genes)	components, features, attributes, properties
Ecological processes within and between ecosystems	processes, interactions, properties, functions
Ecosystem services: provisioning, regulating, cultural, supporting	services, benefits, values, functions, goods, products

(Source: Ramsar Convention 2005a; 2006)

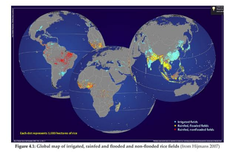


Figure 4.1: Global map of irrigated, rainfed and flooded and non-flooded rice fields (Sean Hijmans 2007).

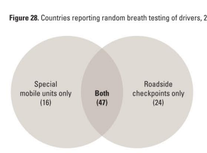


Figure 28. Countries reporting random breath testing of drivers, 2008

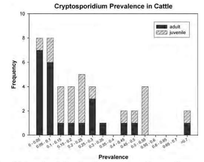


Figure 5.5 Comparison of adult and juvenile mean prevalence of *Cryptosporidium* oocysts in cattle faeces.

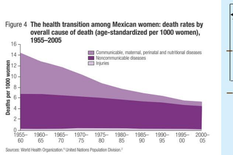
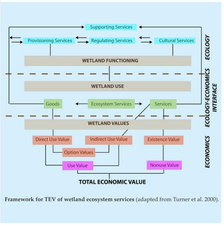
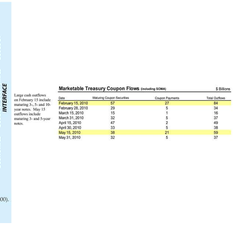


Figure 4 The health transition among Mexican women: death rates by overall cause of death (age-standardized per 1000 women), 1955–2005

Source: World Health Organization / United Nations Population Division.



Framework for TEV of wetland ecosystem services (adapted from Turner et al. 2000).



MEMORABLE

MEMORABLE

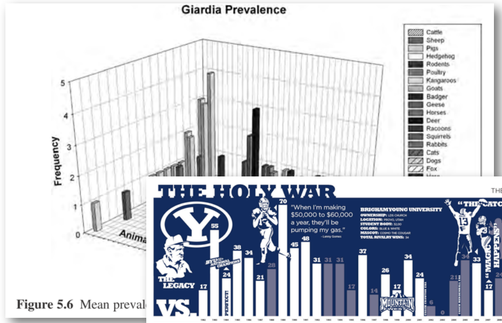
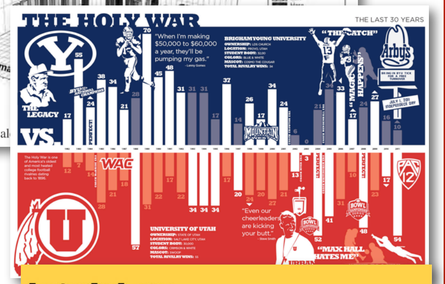
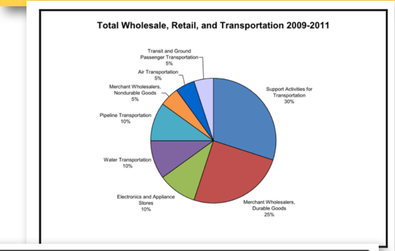
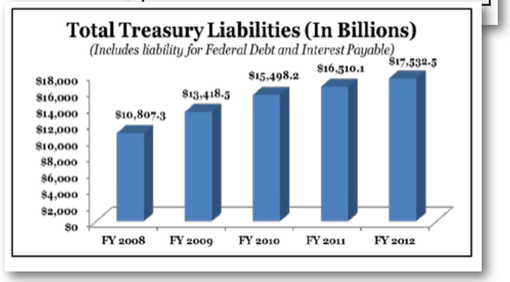
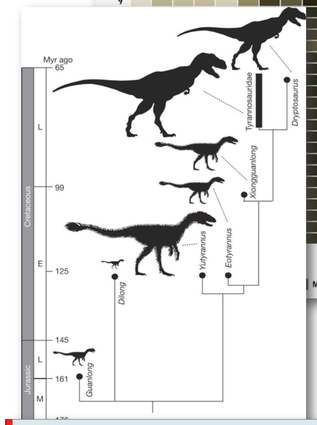


Figure 5.6 Mean preval









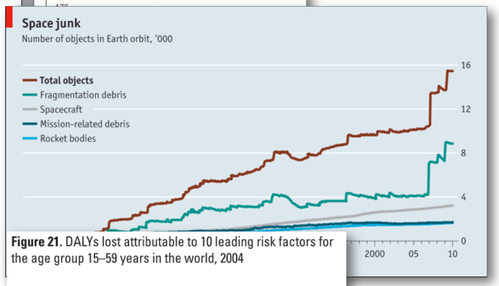
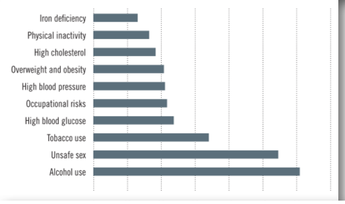
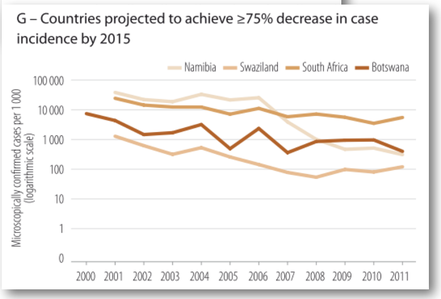


Figure 21. DALYs lost attributable to 10 leading risk factors for the age group 15–59 years in the world, 2004





MEMORABLE

"GOOD"

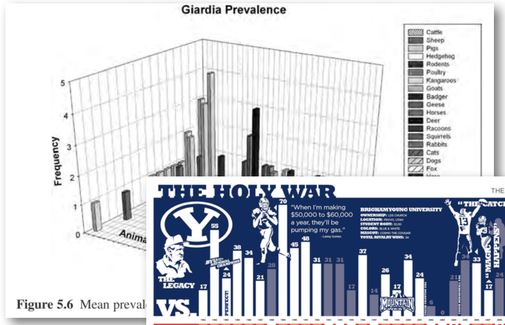
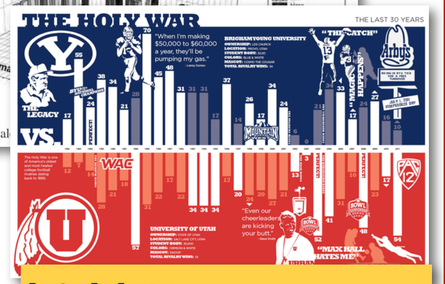
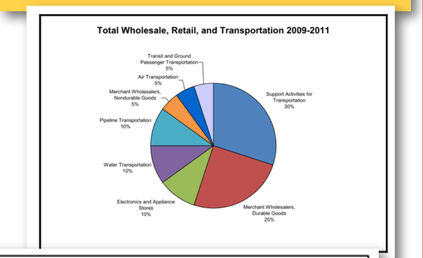
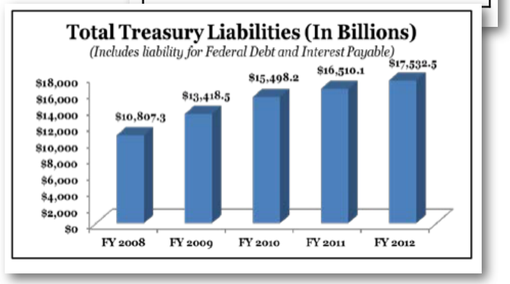
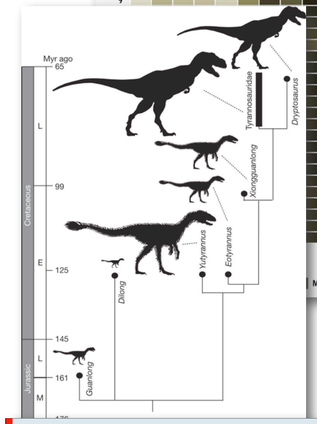


Figure 5.6 Mean preval









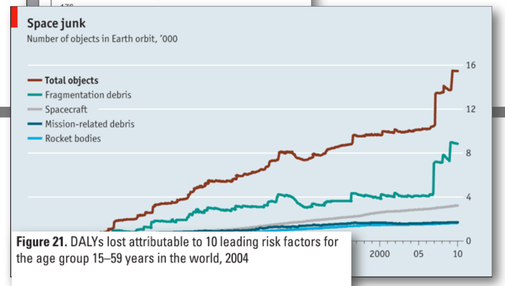
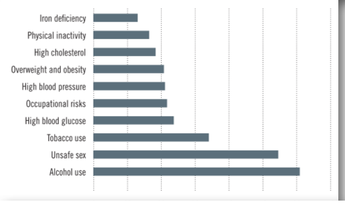
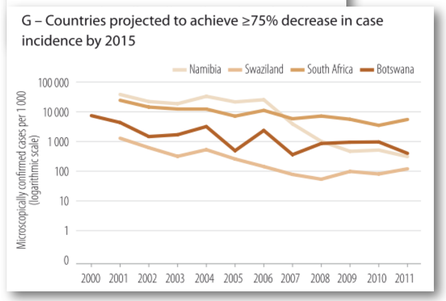


Figure 21. DALYs lost attributable to 10 leading risk factors for the age group 15–59 years in the world, 2004





MEMORABLE

"GOOD"

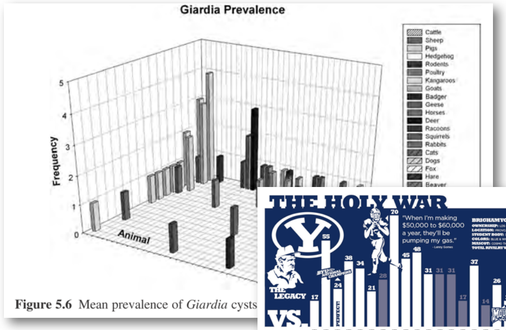
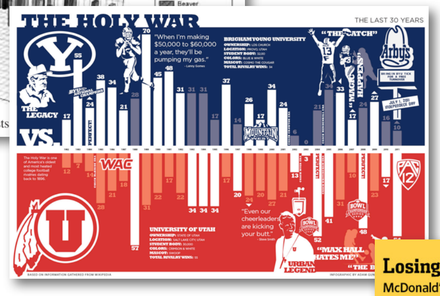
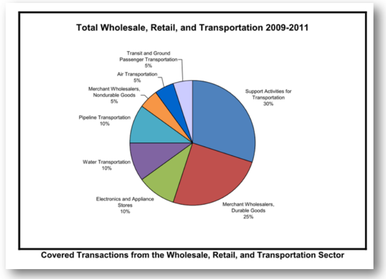
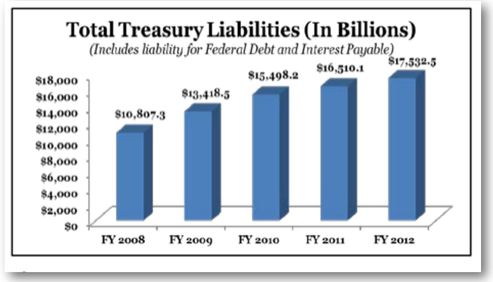
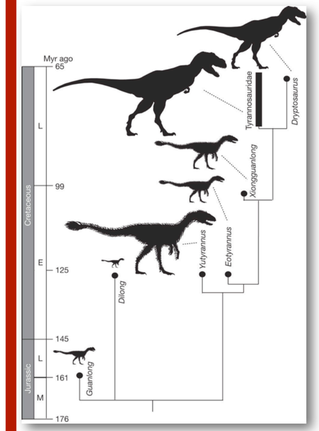


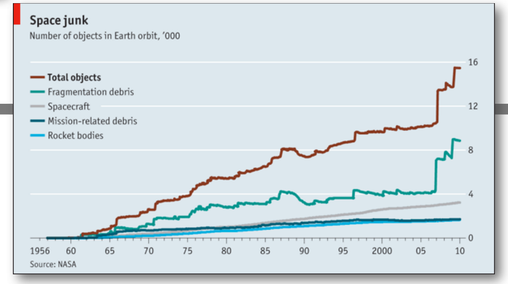
Figure 5.6 Mean prevalence of *Giardia* cysts

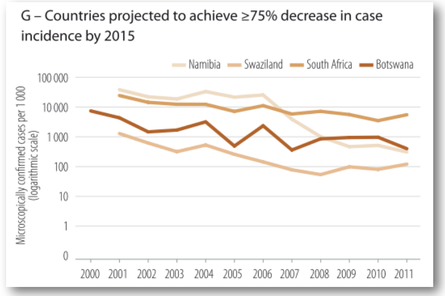


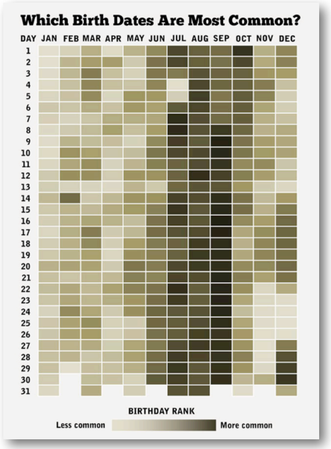












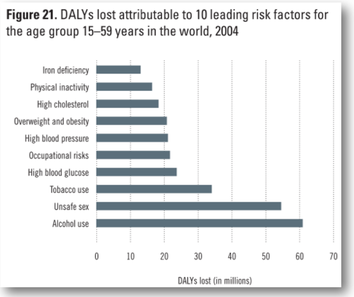


Figure 21. DALYs lost attributable to 10 leading risk factors for the age group 15–59 years in the world, 2004

MEMORABLE

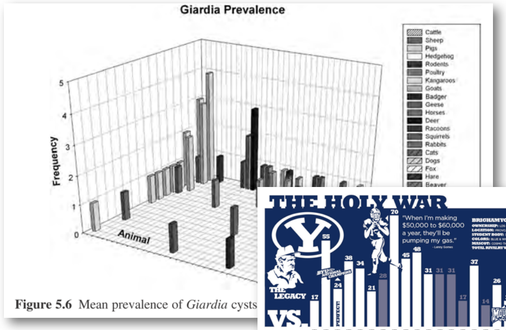
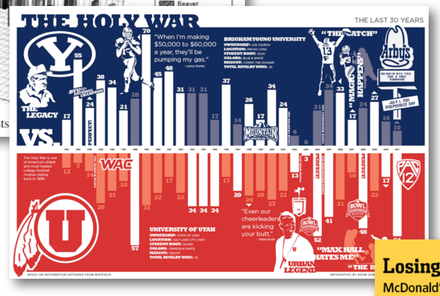
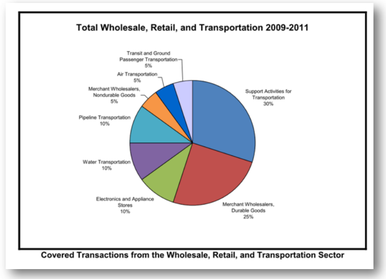
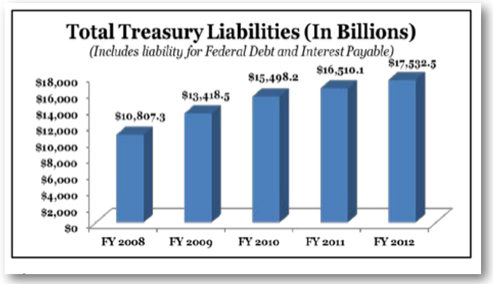
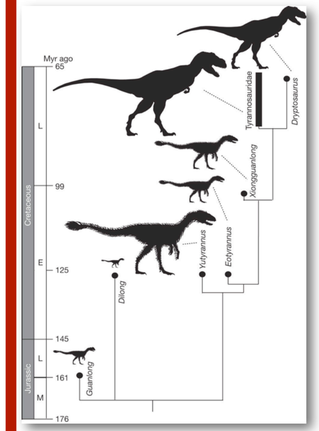


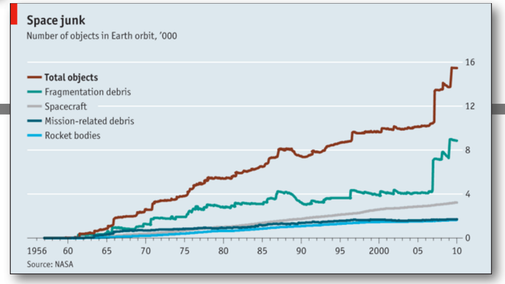
Figure 5.6 Mean prevalence of *Giardia* cysts

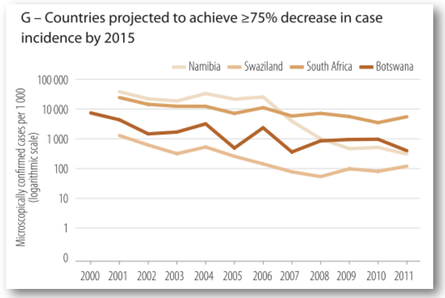


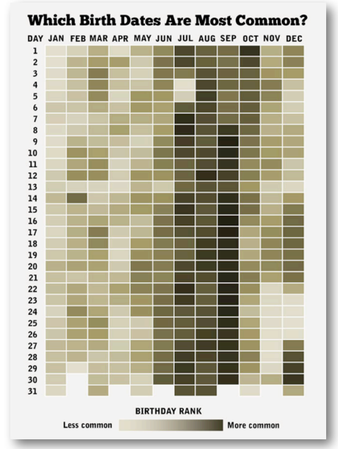




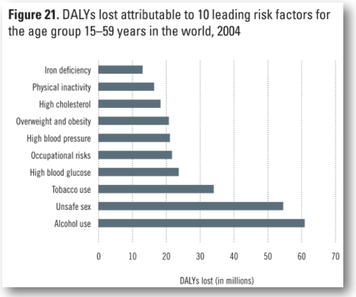


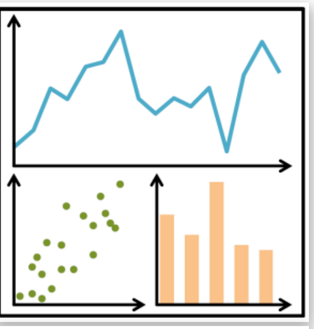


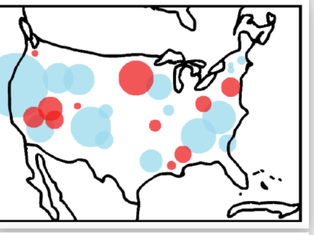


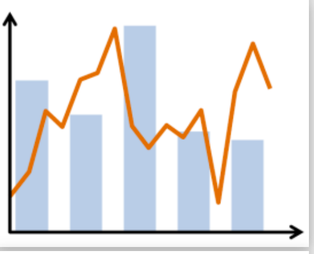


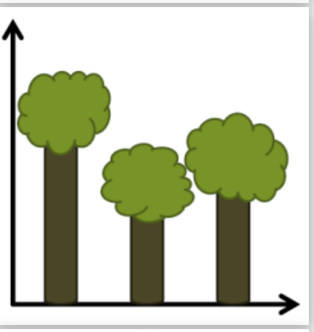
"GOOD" IMPACT ENGAGEMENT

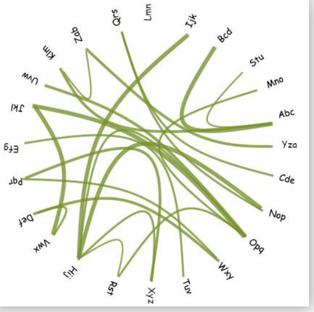






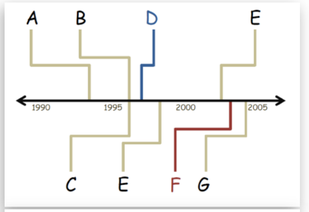
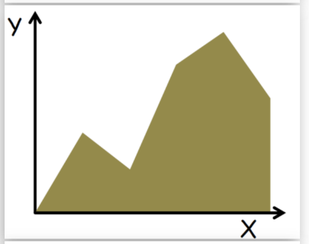
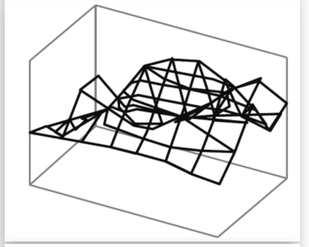
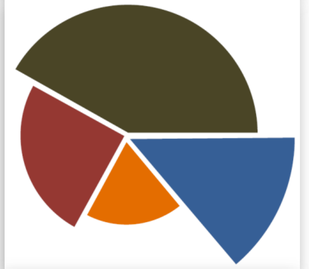
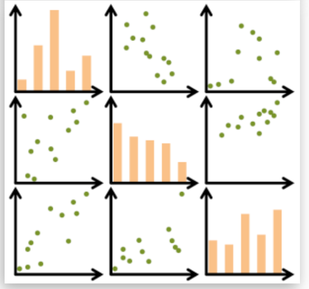






FOR MORE INFORMATION...

On this paper/project: **http://bit.ly/vizmemory**

On my other research: **http://bit.ly/mborkin**

Special thanks to Krzysztof Gajos, the Harvard SEAS IT team, Sean Yeh, Chelsea Yeh, the Department of Defense through the NDSEG Fellowship Program, the NSF through the NSF Graduate Research Fellowship and grant #1016862, Google, and Xerox.