

# Software Architecture, Team Topologies and Complexity Science

*James Lewis @boicy*



**“We cannot say there is a formal definition of the microservices architectural style...”**

**- Martin Fowler, James Lewis**



**Componentisation  
via services**

**Organised around  
business capabilities**

**Decentralised data  
management**

**Products not  
projects**

**Decentralised  
governance**

**Smart endpoints  
and dumb pipes**

**Evolutionary  
design**

**Infrastructure  
automation**

**Designed  
for failure**



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# Flow, value and teams





**“The bigger we get, the easier it  
becomes to get bigger.”**





**the goal of successful  
organisational design is to optimise  
value flow**



**“Safely and sustainably reduce lead  
time to thank-you”**

**- Daniel Terhorst-North**



# What is value?

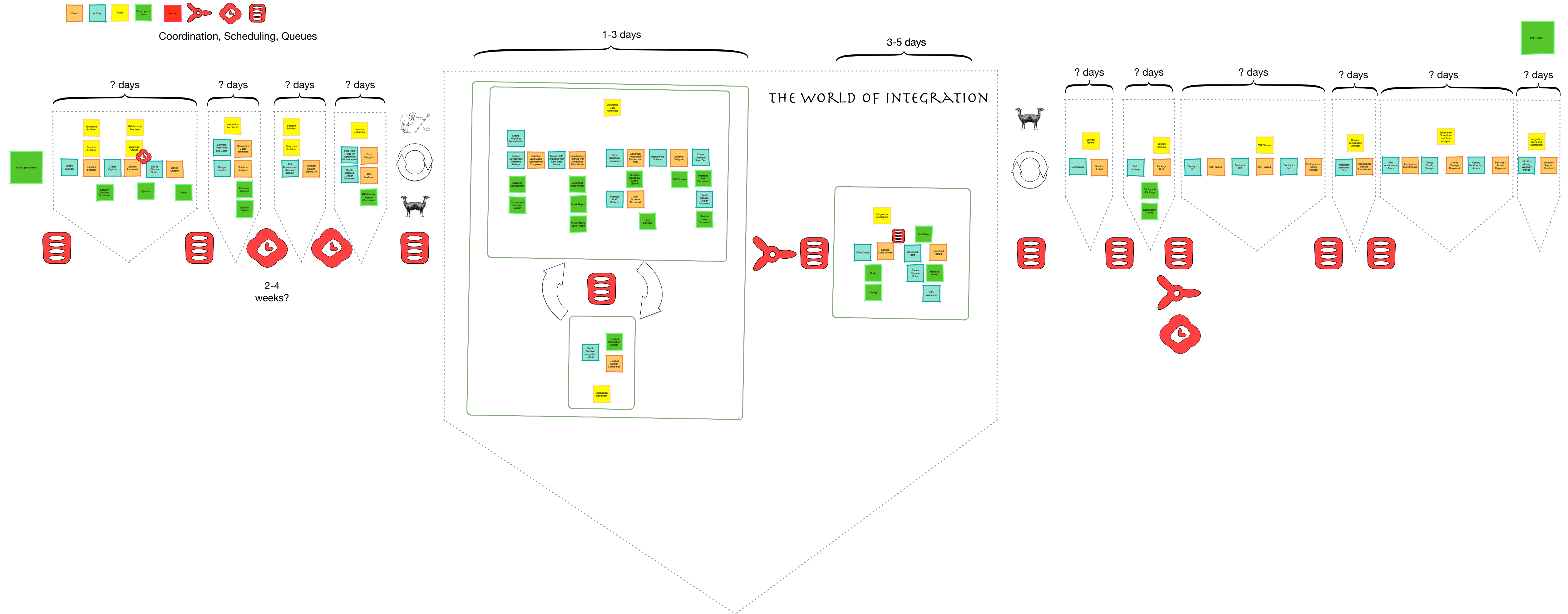
**Generally it's "stuff"**

**Squint and physical products and knowledge work are the same**

**raw materials → a thing**



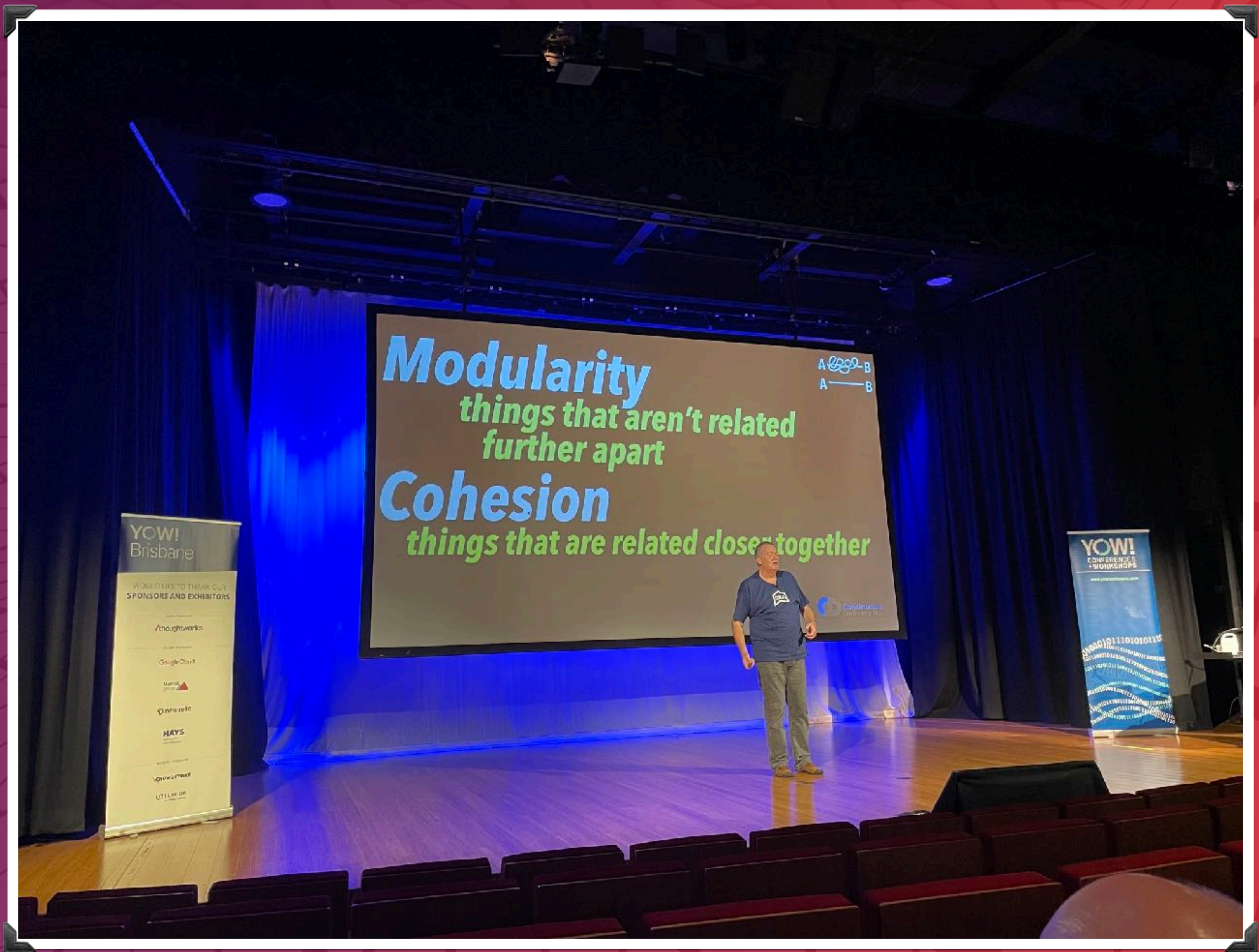
# How long does stuff take?



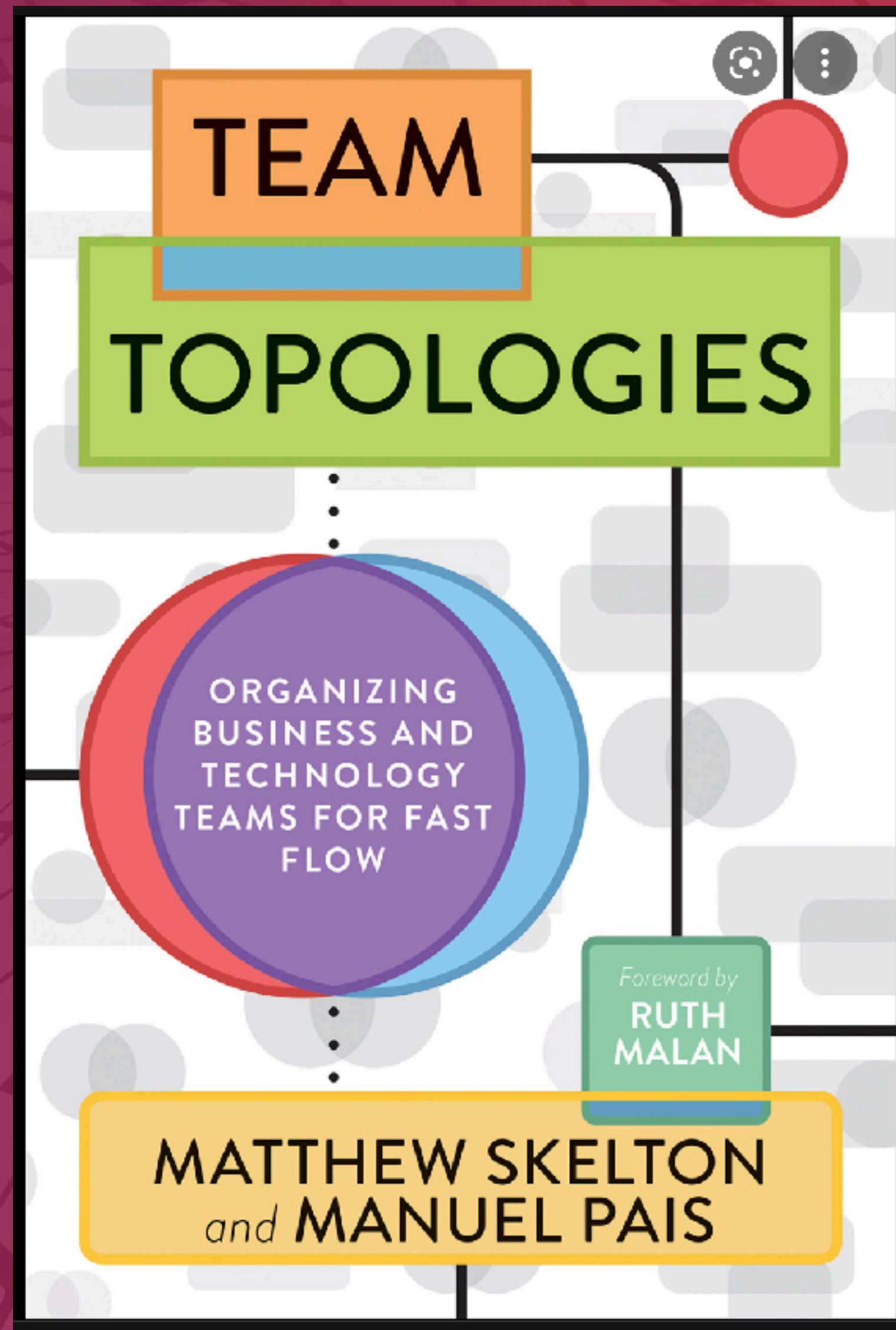














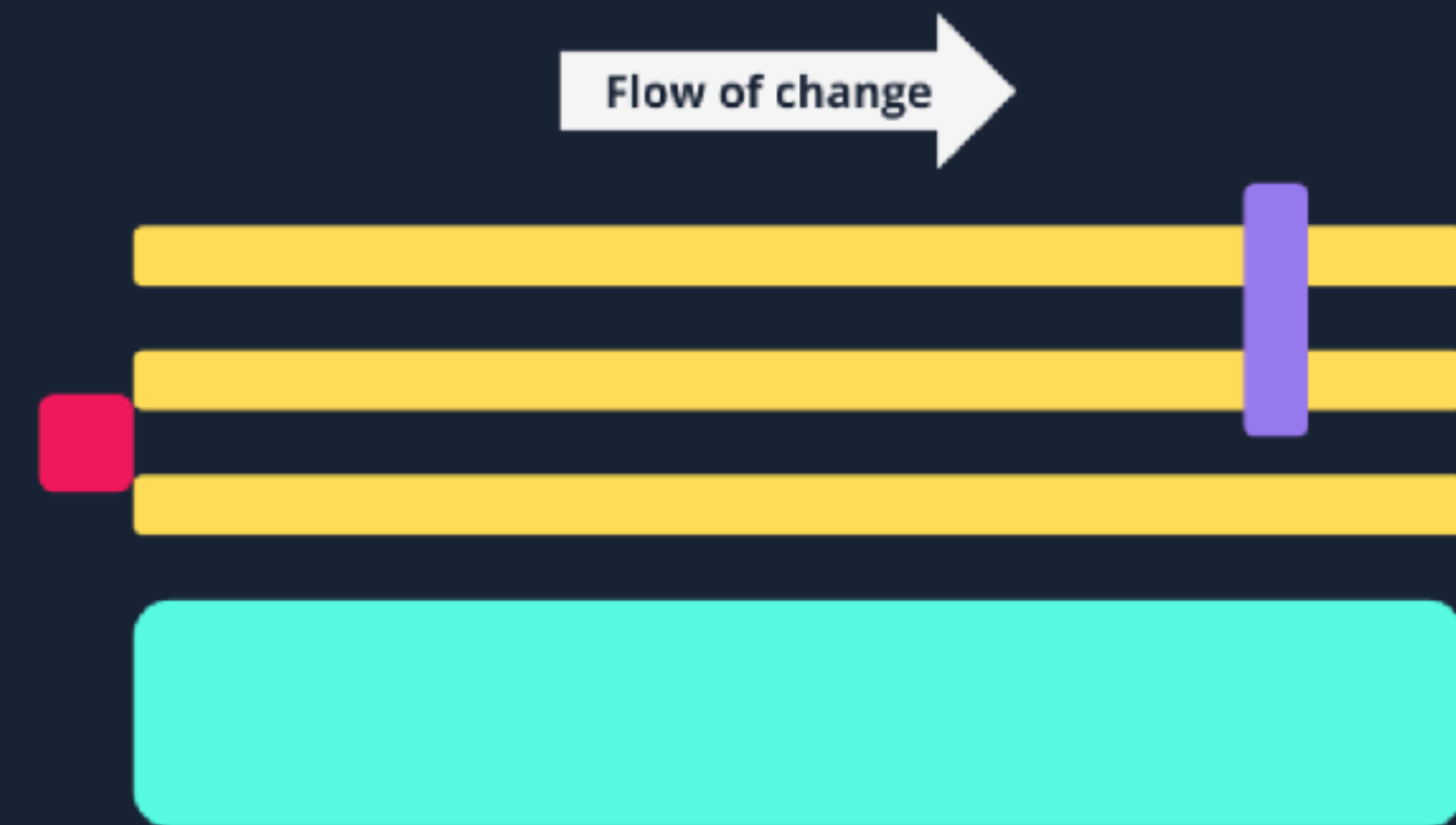
# 4 fundamental topologies

- Stream-aligned team
- Enabling team
- Complicated Subsystem team
- Platform team

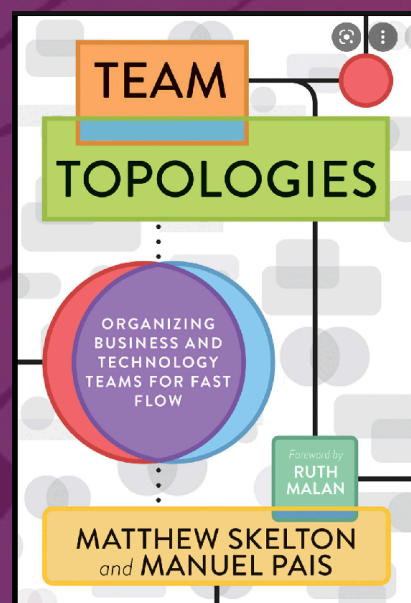


Four fundamental topologies

# 4 fundamental topologies



Four fundamental topologies shown with the flow of change





# The curious case of Amazon





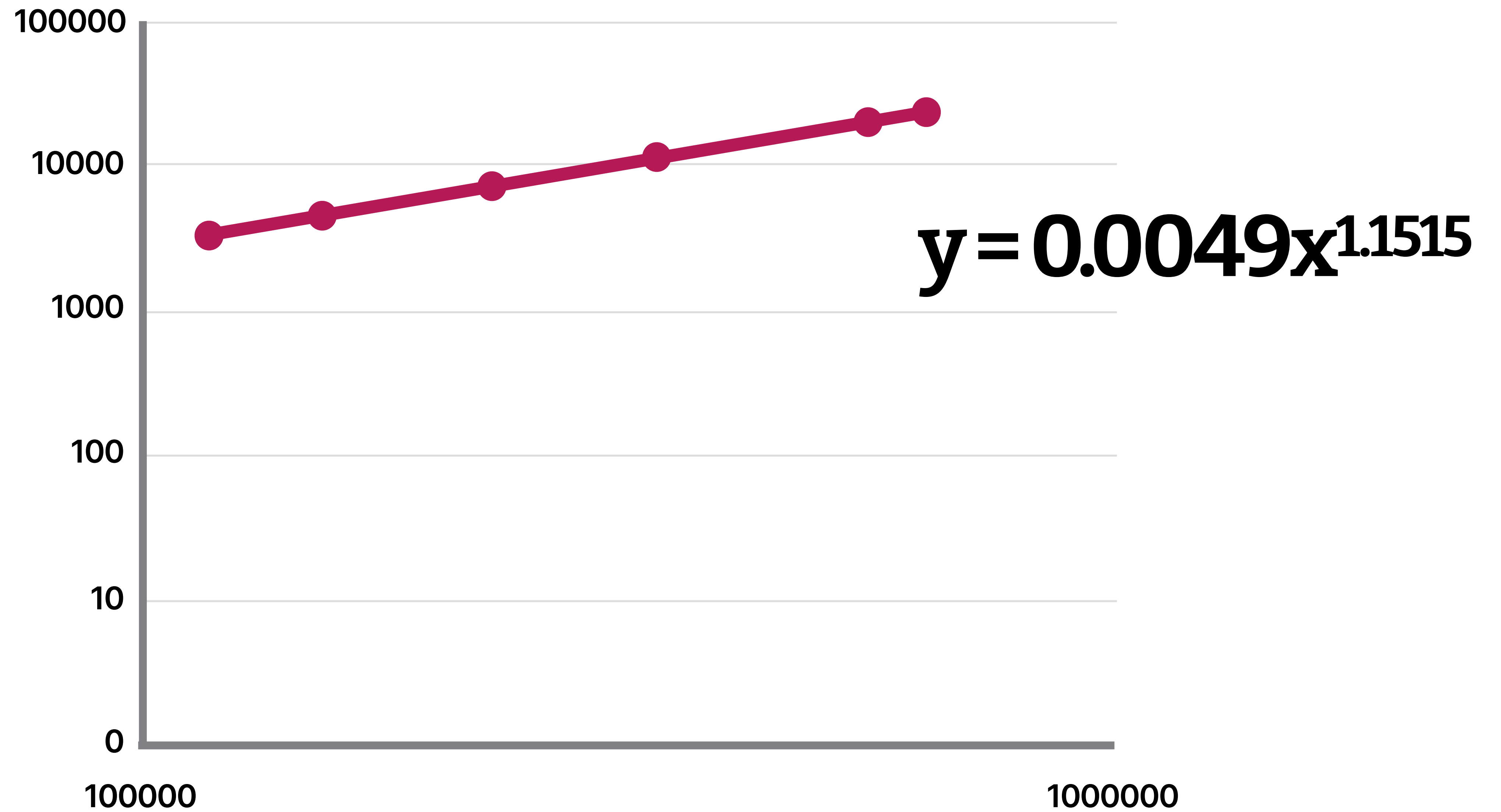
**“The bigger we get, the easier it  
becomes to get bigger.”**



**“Adding manpower to a late software project makes it later.”**

**- Fred Brooks, Mythical Man Month**









# Complexity and Flow



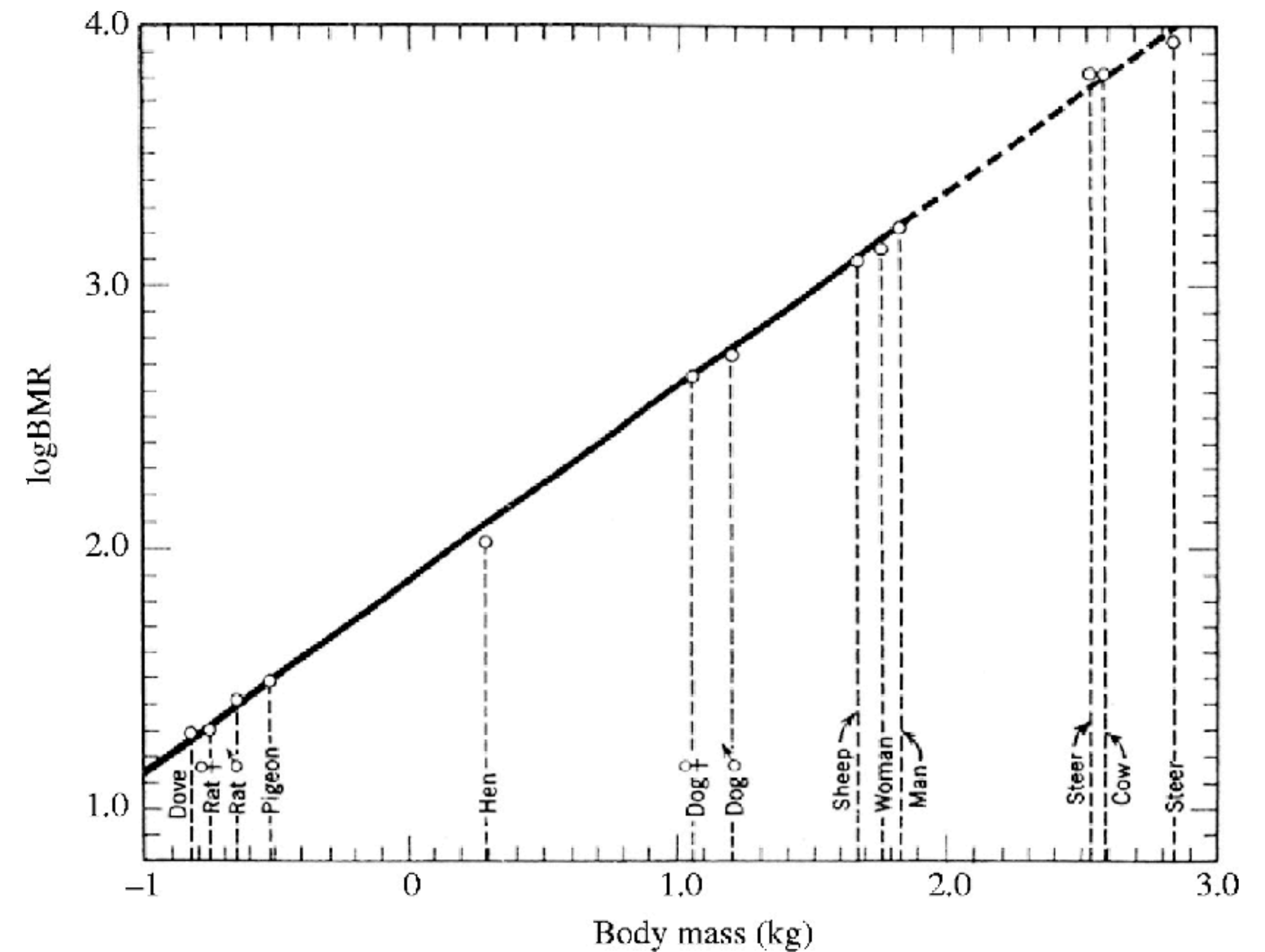
# Complex adaptive systems



**SANTA FE  
INSTITUTE**



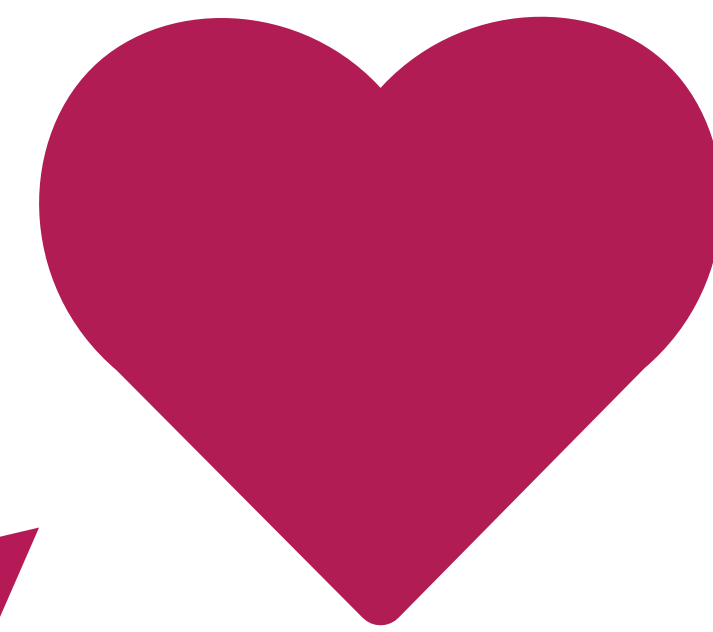
# Mice and Elephants



Geoffrey B. West, James H. Brown  
Journal of Experimental Biology 2005 208: 1575-1592;  
doi: 10.1242/jeb.01589



**Metabolic rates in mammals follow a scaling law with an exponent of  $3/4$ .**

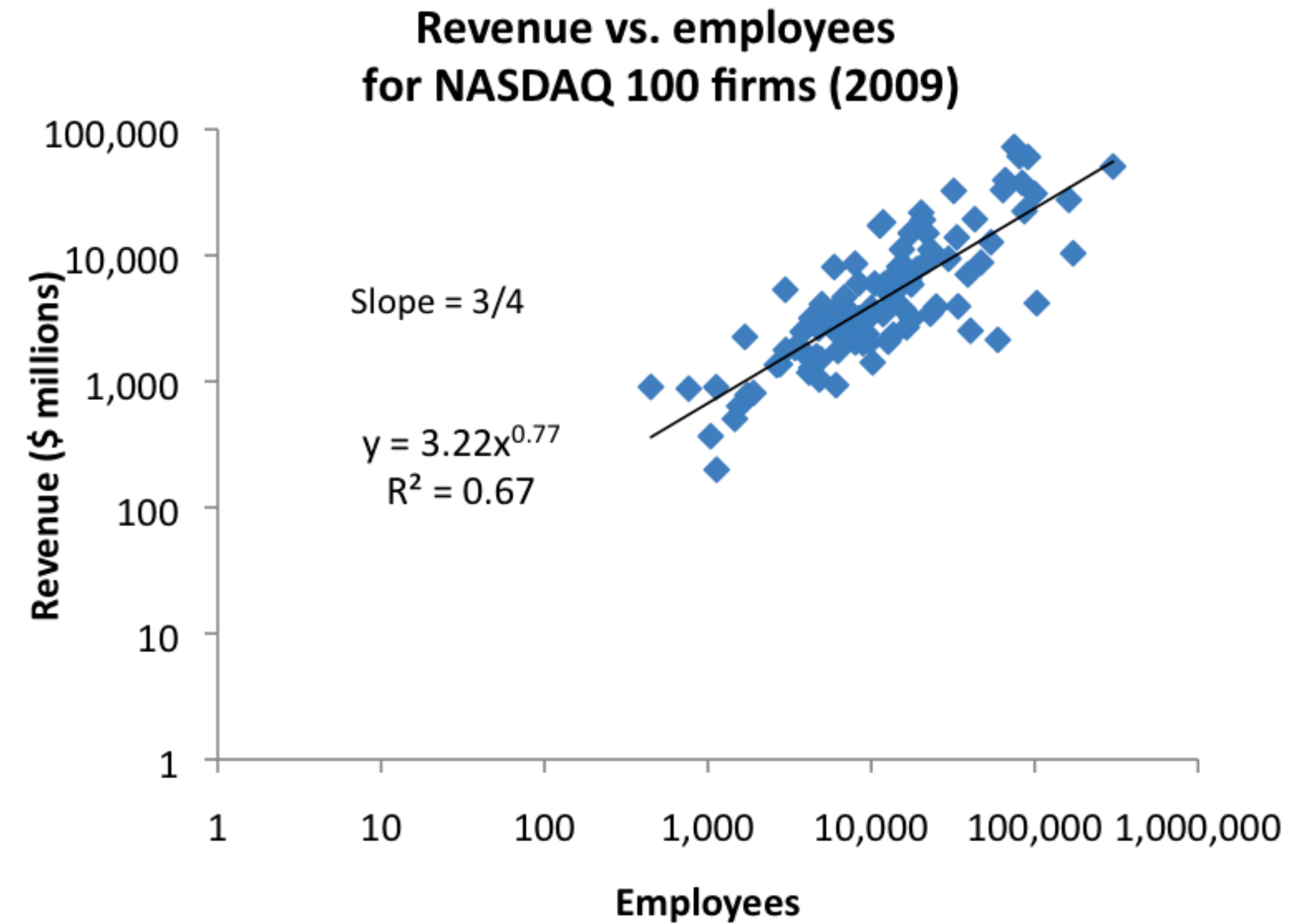


**0.75**

**As a mammal doubles in size it needs only 75% of the calories.**



# Mom 'n Pop stores and Aldi



Source data: Google Finance

<https://protobi.com/post/revenue-per-employee-and-biologic-scaling-laws>



**Revenue scales with  
# employees following  
a scaling law with an  
exponent of 0.85.**

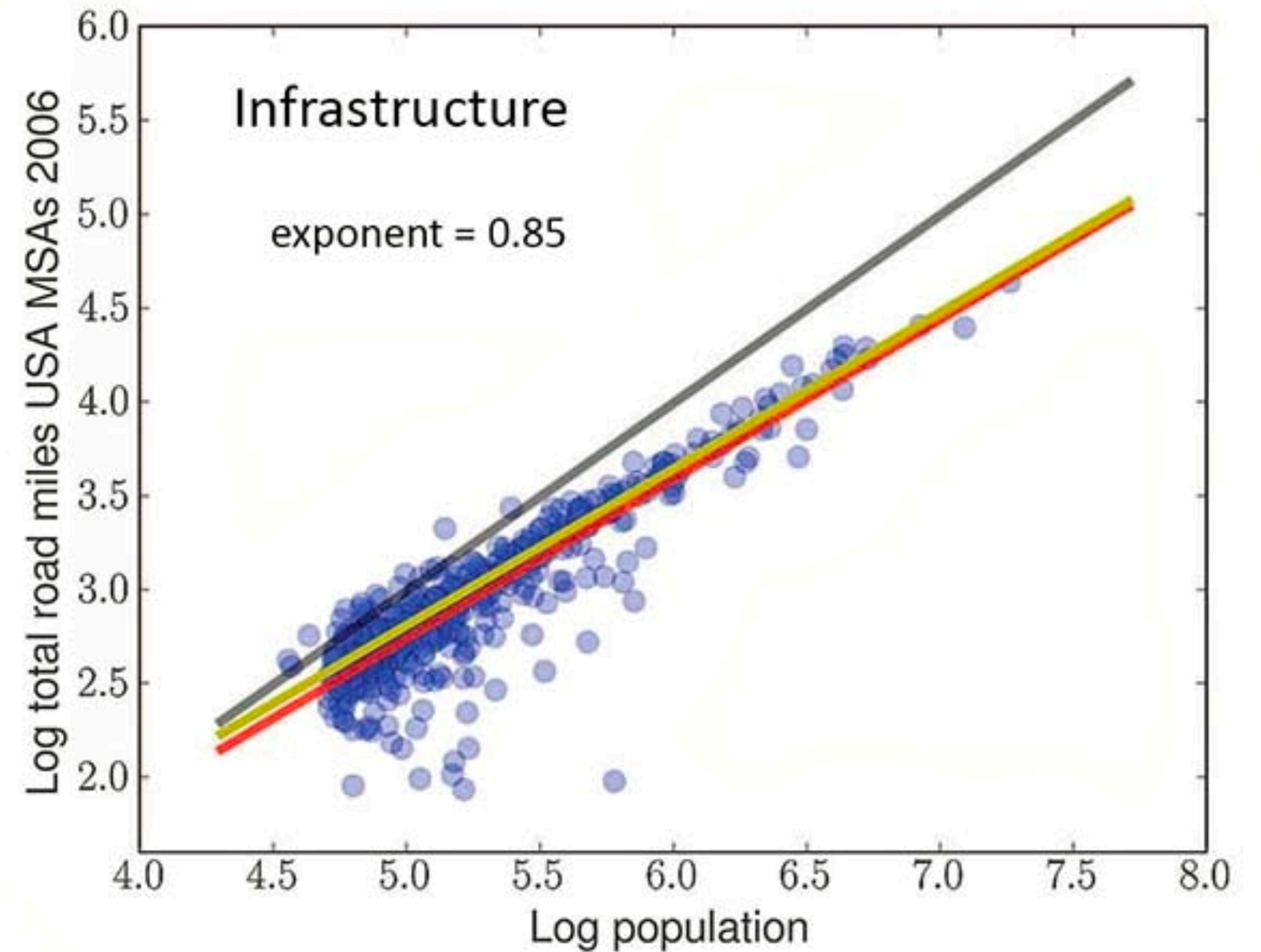


**0.85**

**As a company  
doubles in size it  
generates 85% of  
the revenue.**



# Utrecht and Rotterdam



Bettencourt, Luís M. A.  
2013 The Origins of Scaling in Cities. Science 340: 1438-1441.

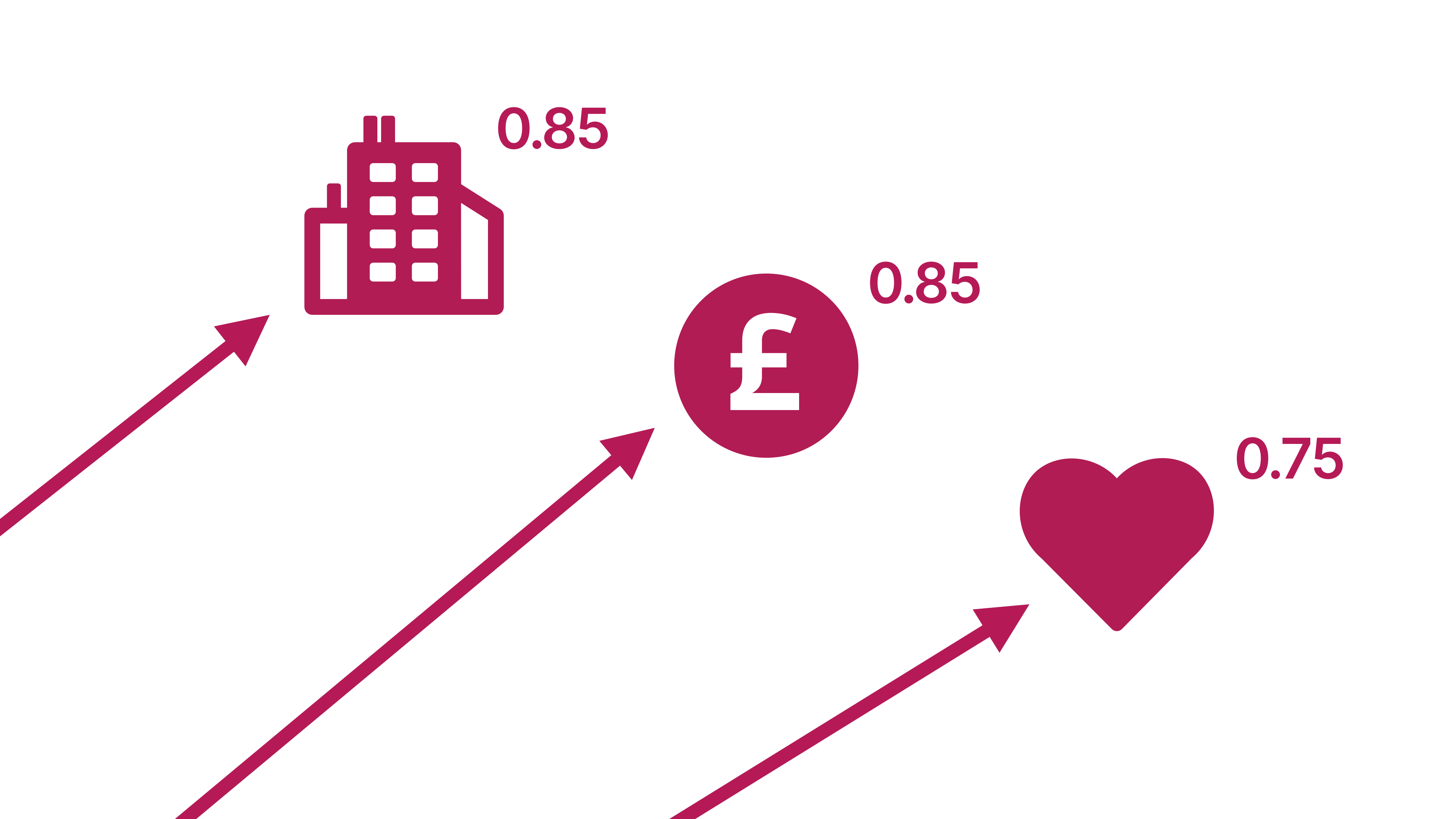


**Infrastructure scales  
with population with an  
exponent of 0.85.**



**Road length,  
# petrol stations,  
# restaurants,  
water pipes,  
electricity cables.**



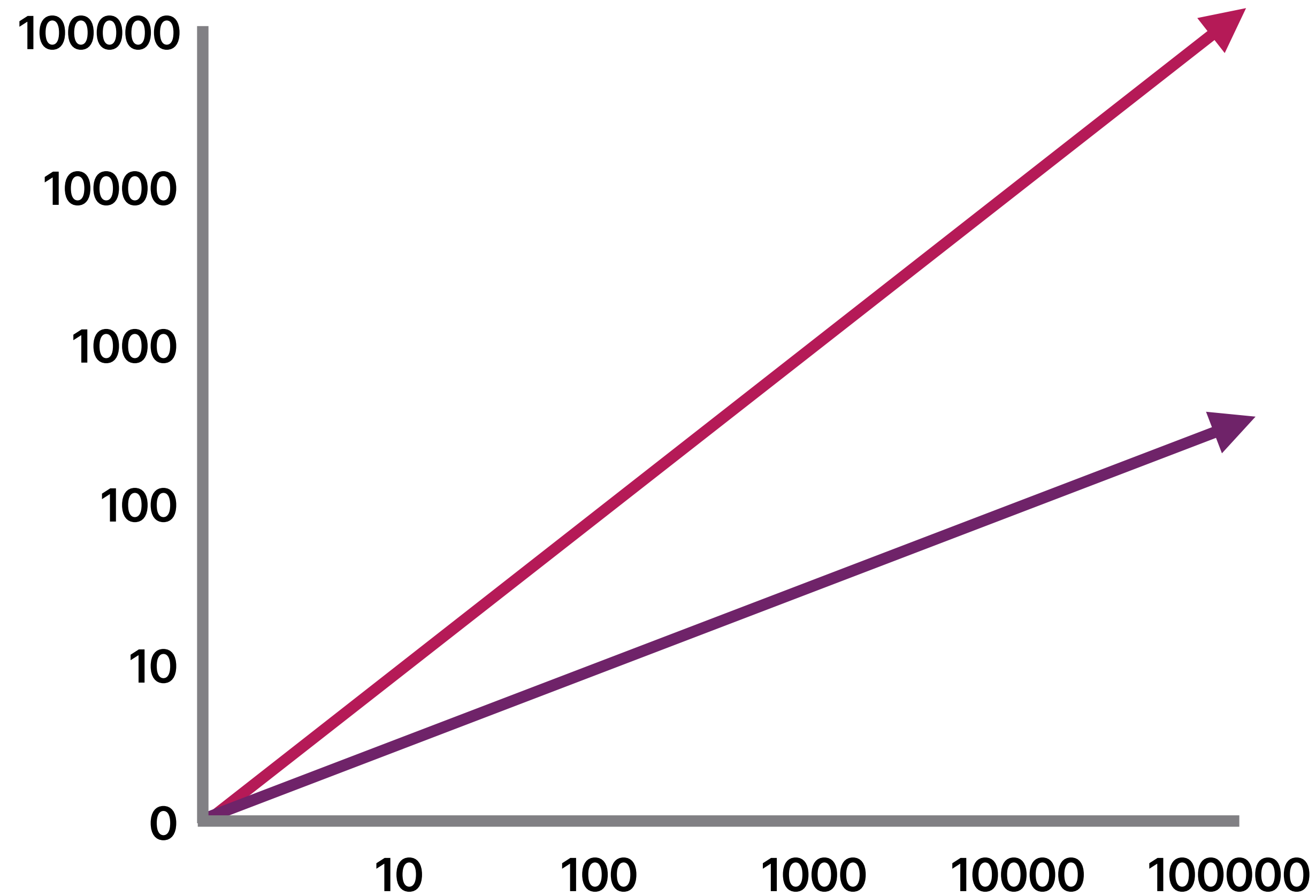




**“Quantities that do not change when other parameters of the system change play a special role in science...”**

**- Geoffrey West. Scale: The Universal Laws of Life and Death in Organisms, Cities and Companies.**





**Linear scaling:**  
As x doubles, y also doubles

**Sub-linear scaling:**  
As x doubles, y increases  
by less than double



# **Complex adaptive systems**

**Self-similarity**

**Self-organisation**

**Complexity**

**Emergence**



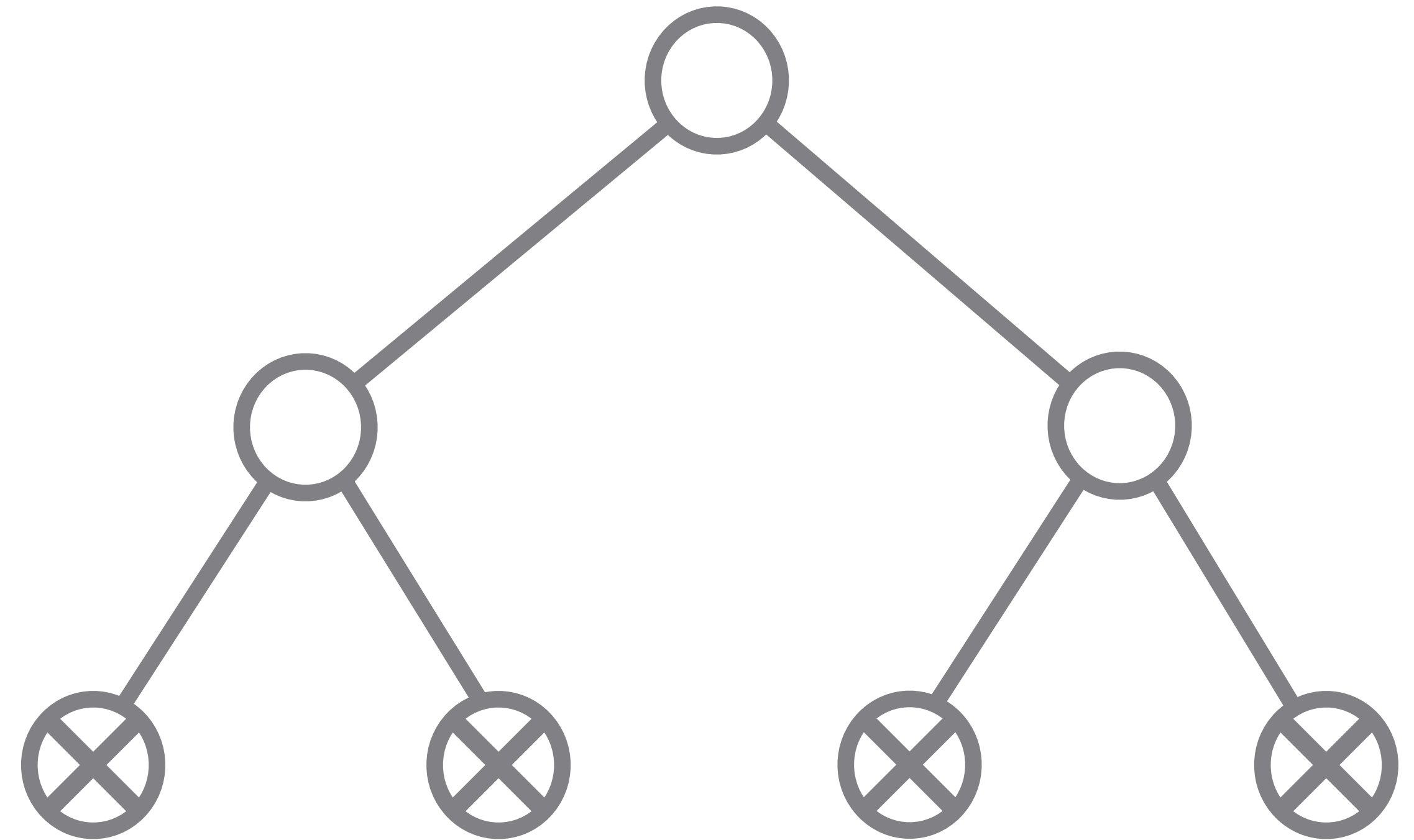
# 3 simple principles



**1. Space filling fractal networks**

**2. Invariant terminating units**

**3. Optimisation**





# **Complex adaptive systems are everywhere**

**Patterns can be described  
using 3 principles**

**Hierarchical fractal networks  
scale following a power law  
with an exponent  $<1$**

**...Walmart and a convenience  
store are the same. (just different  
sizes)**

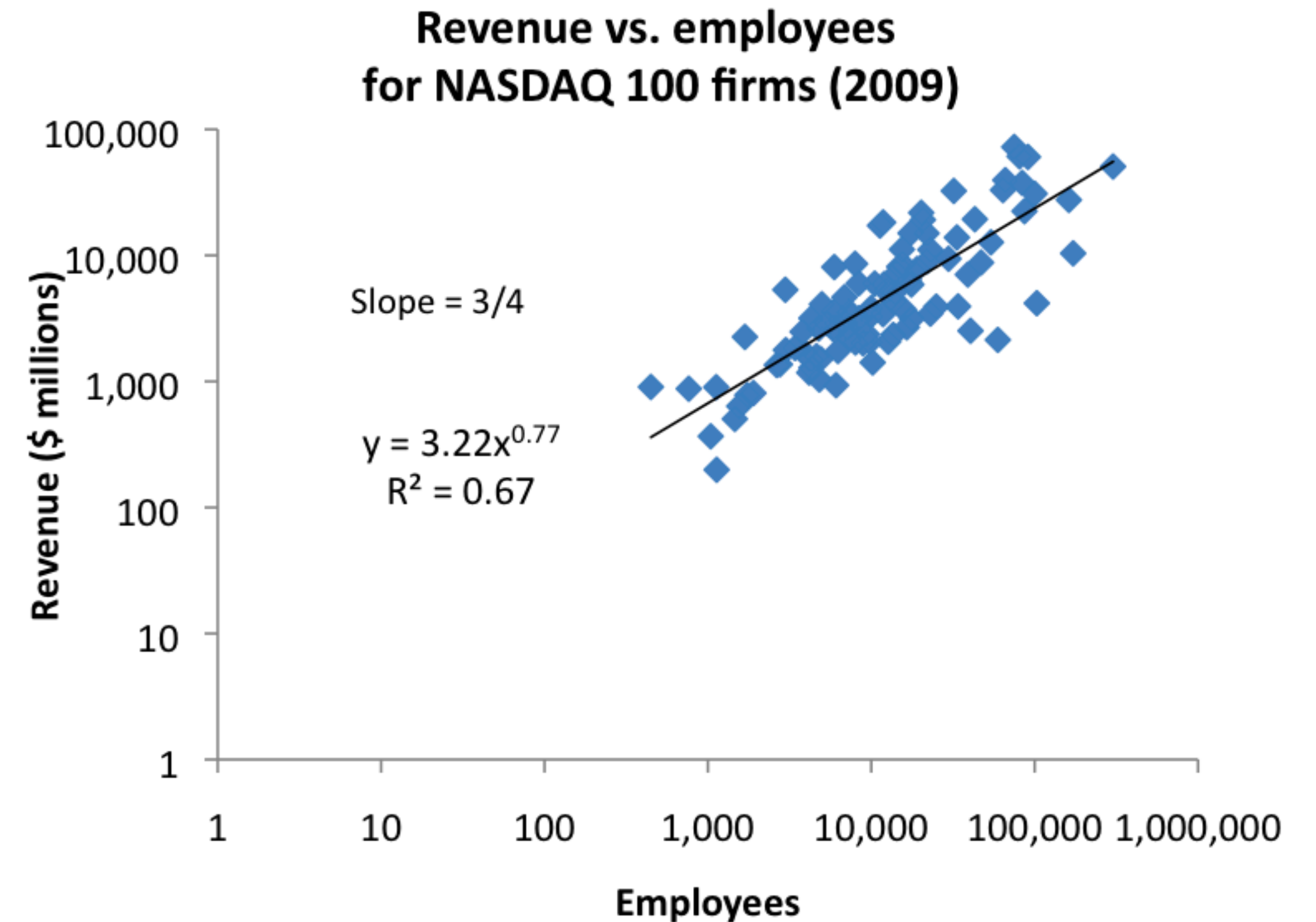




# Corporate Metabolism



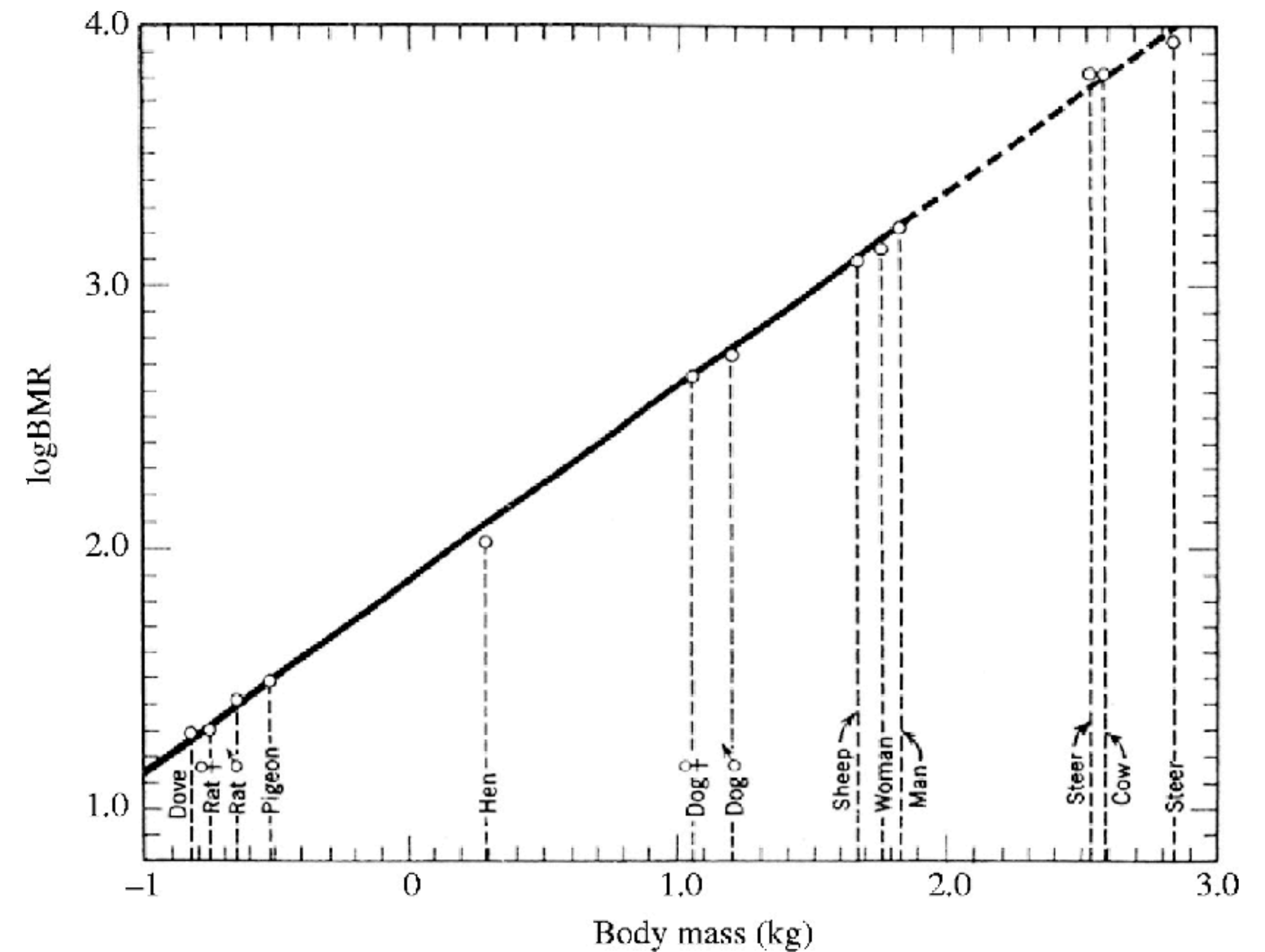
Why does  
revenue growth  
slow as size  
increases?



Source data: Google Finance  
<https://protobi.com/post/revenue-per-employee-and-biologic-scaling-laws>



# Why do metabolic rates slow as size increases?

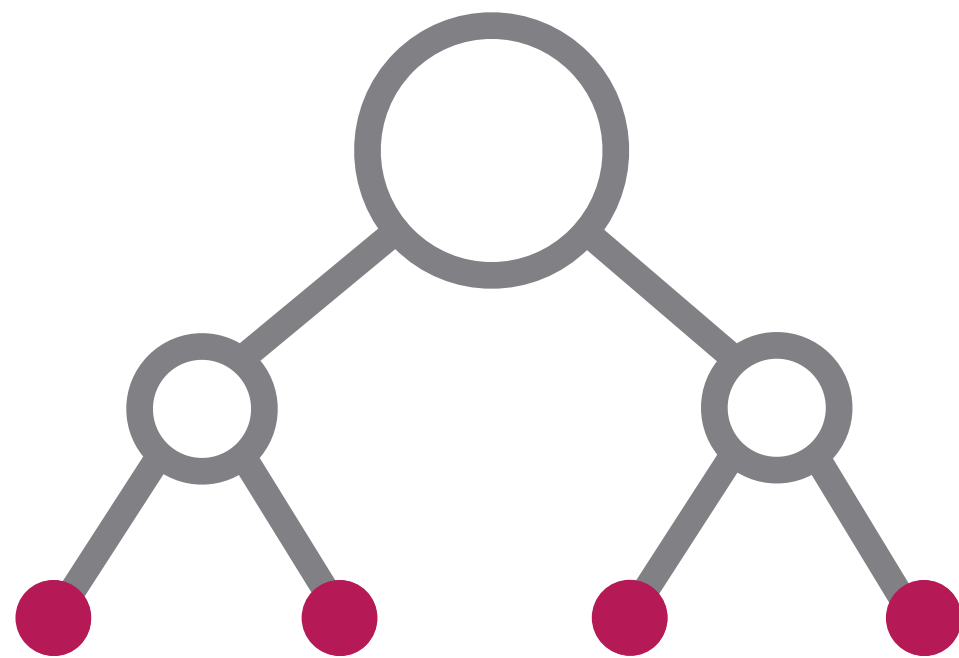
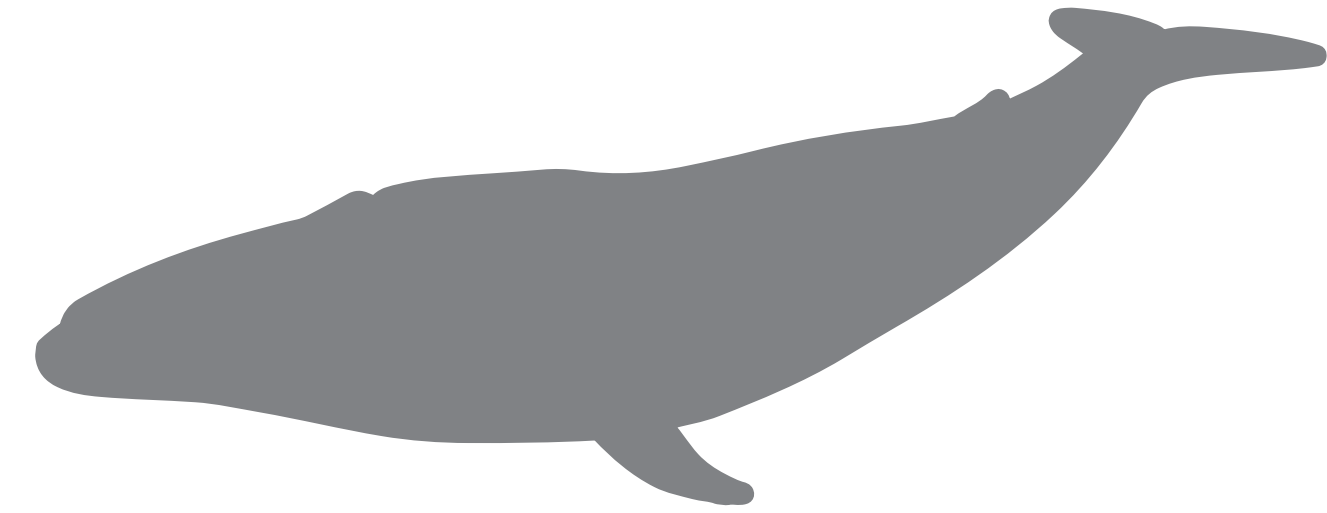


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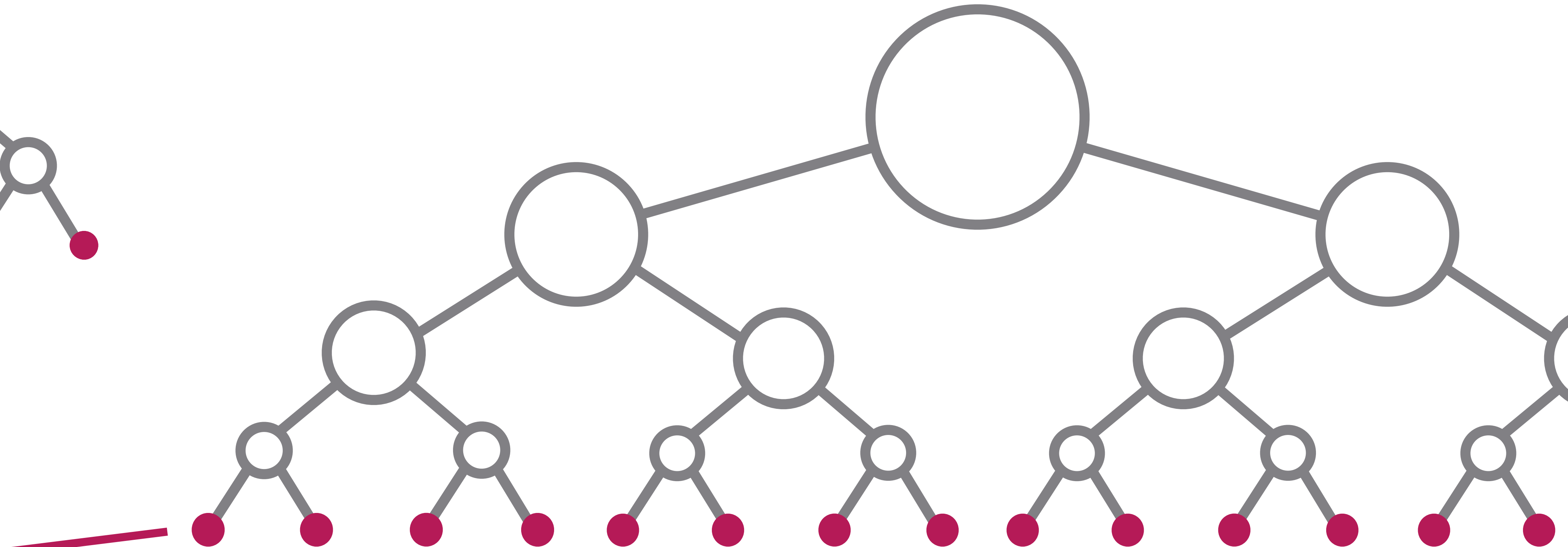




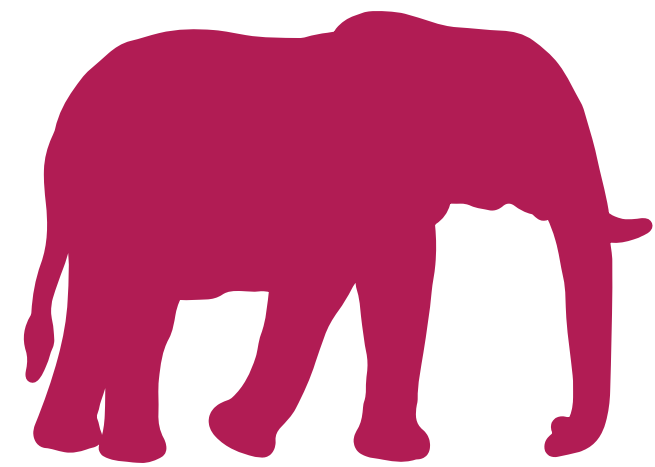
# Hierarchies



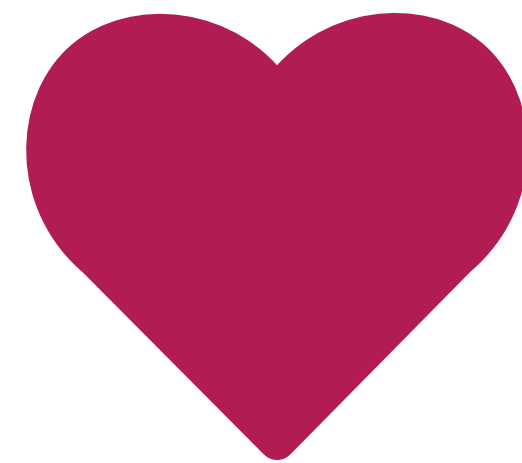
Same  
size







**Bigger animals  
are more  
efficient (0.75)**

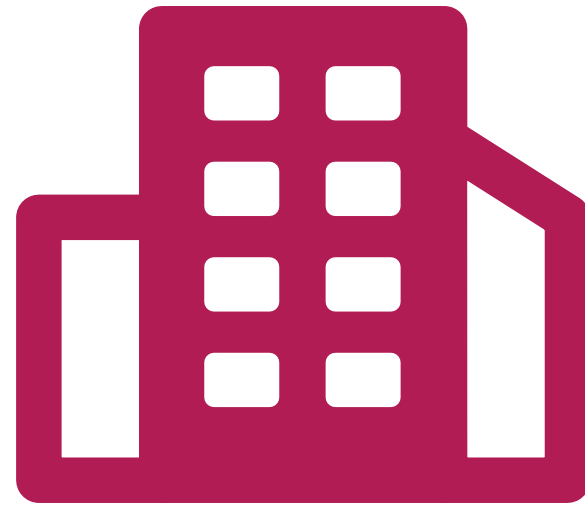


**Due to impedance  
matching in the  
circulatory system**

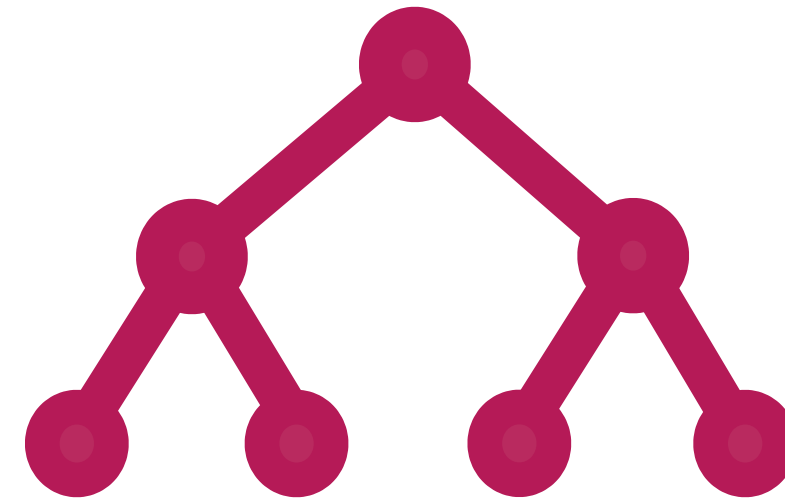


**Driven by  
feedback from  
evolution.**





**Bigger companies  
are more efficient  
(0.85)**



**They develop deeper  
hierarchies as they  
age**



**Feedback  
from market  
forces.**





**And both slow down as they age...**

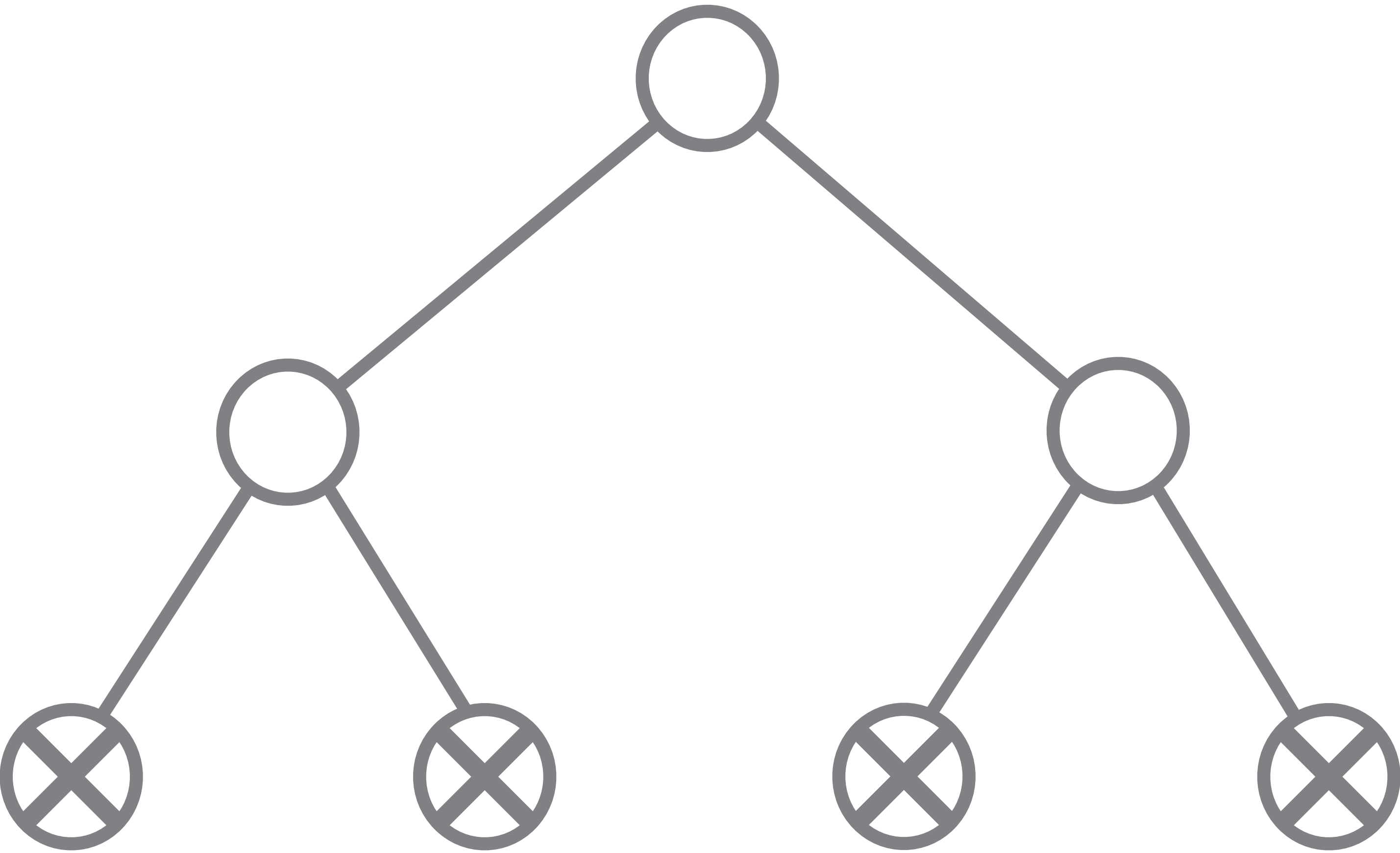
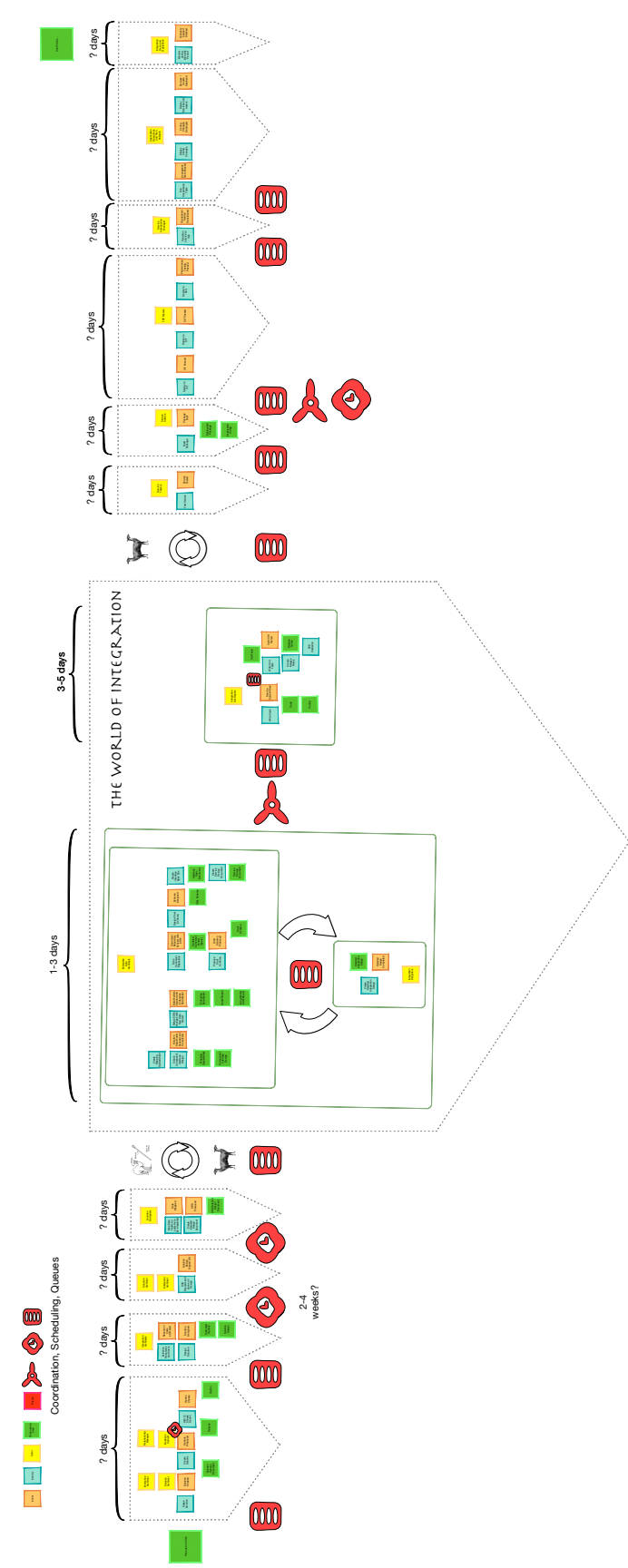




**Back to flow**

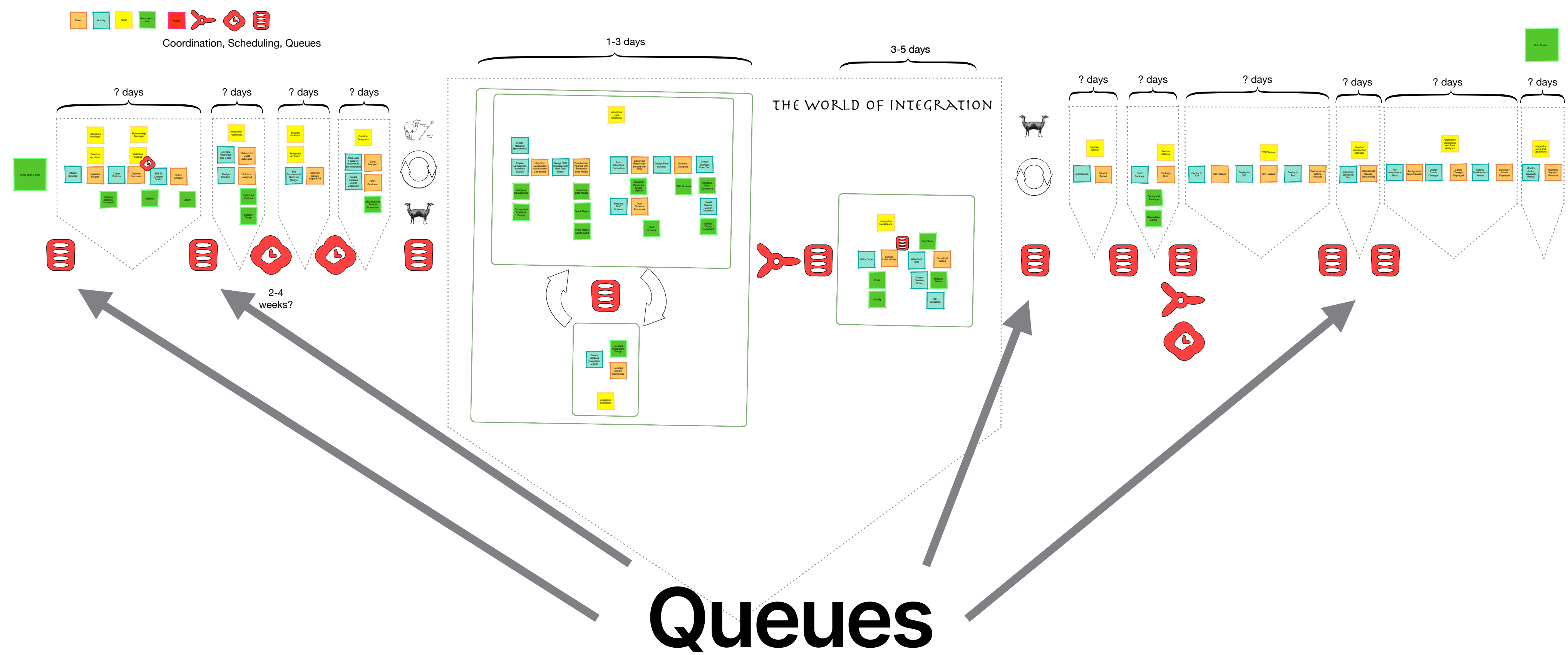


# Value stream maps





# Value stream maps





# Corporate metabolism

**As companies scale they add more  
processes and hierarchy**

**Therefore things slow down**

**...but we also deliberately  
block our corporate arteries.**





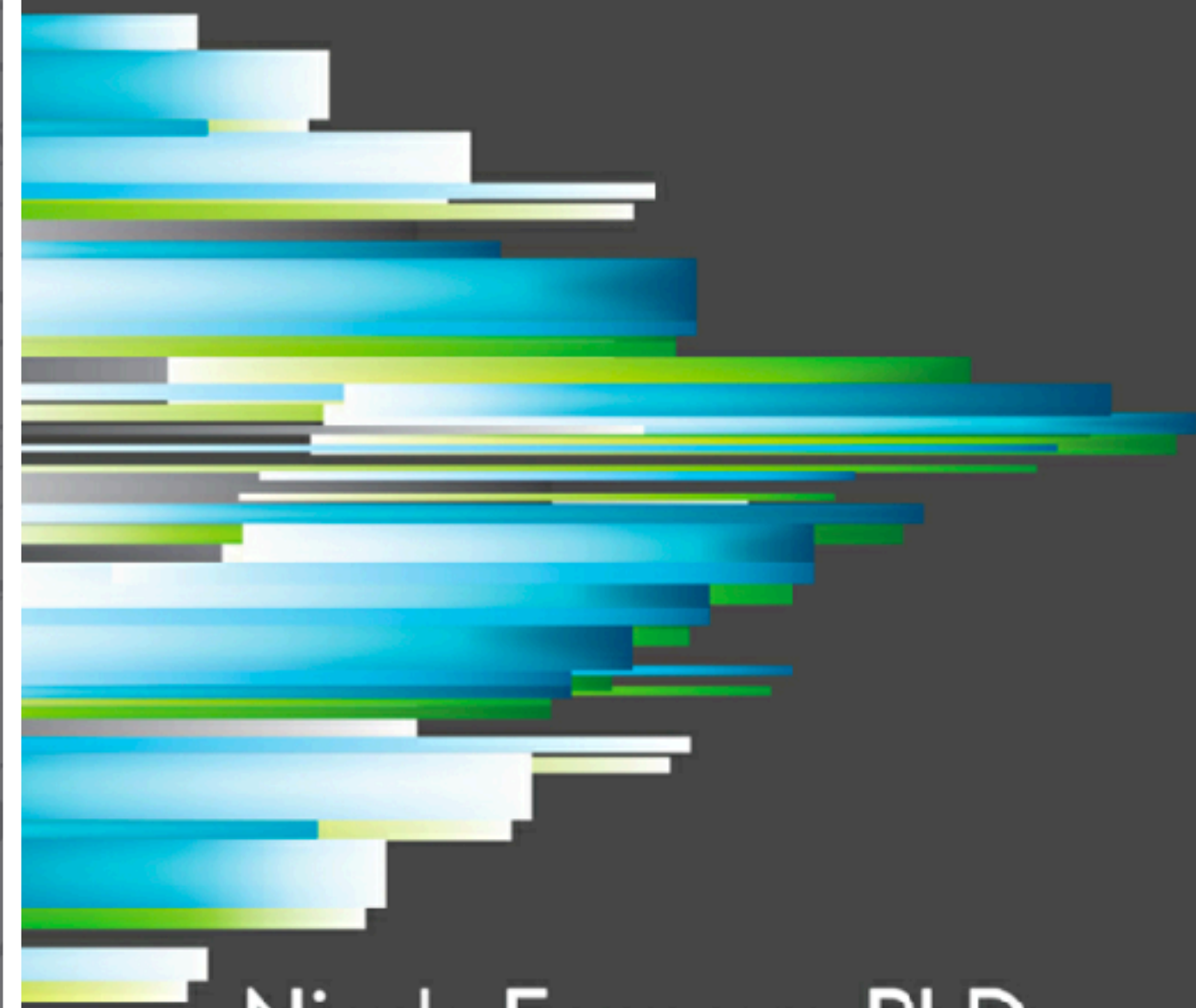
# Sidebar: Identifying the signs of ageing



THE SCIENCE OF LEAN SOFTWARE AND DEVOPS

# ACCELERATE

Building and Scaling High Performing  
Technology Organizations



Nicole Forsgren, PhD  
Jez Humble, *and* Gene Kim

*with forewords by Martin Fowler and Courtney Kissler  
and a case study contributed by Steve Bell and Karen Whitley Bell*



**Fun Fact:**

**Change Request Boards**



# Monitoring org. health

**MTTR**

**Cycle time**

**Change  
failure rate**

**Number  
of deploys**



# Identifying the signs of ageing

**4 key metrics are leading  
indicators org. health**

**Like monitoring heart  
rate & blood pressure**

**Improvement limited by  
hierarchy and scaling laws**

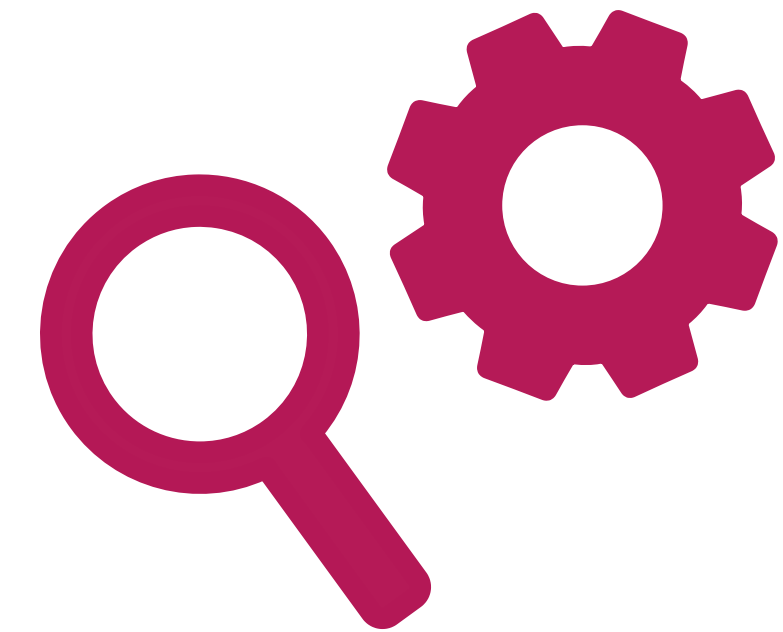
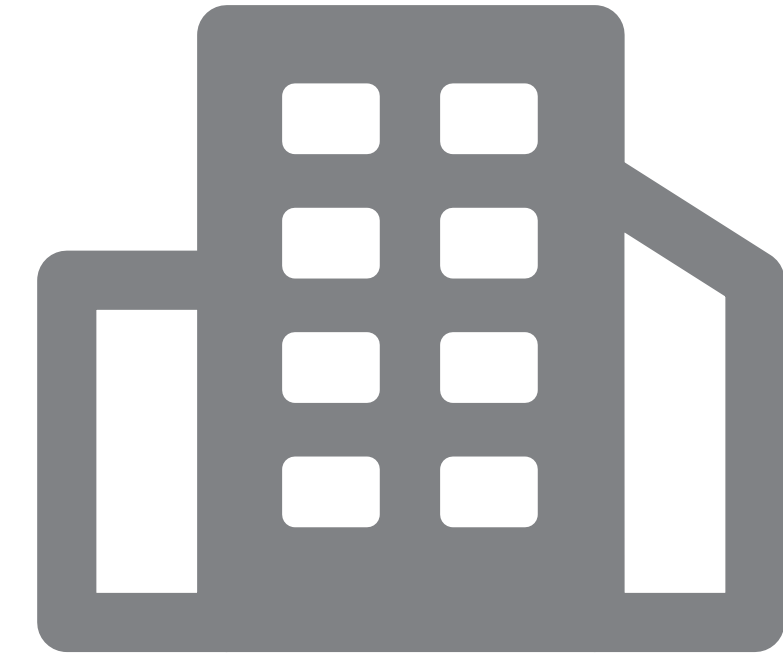




# Organisational mortality

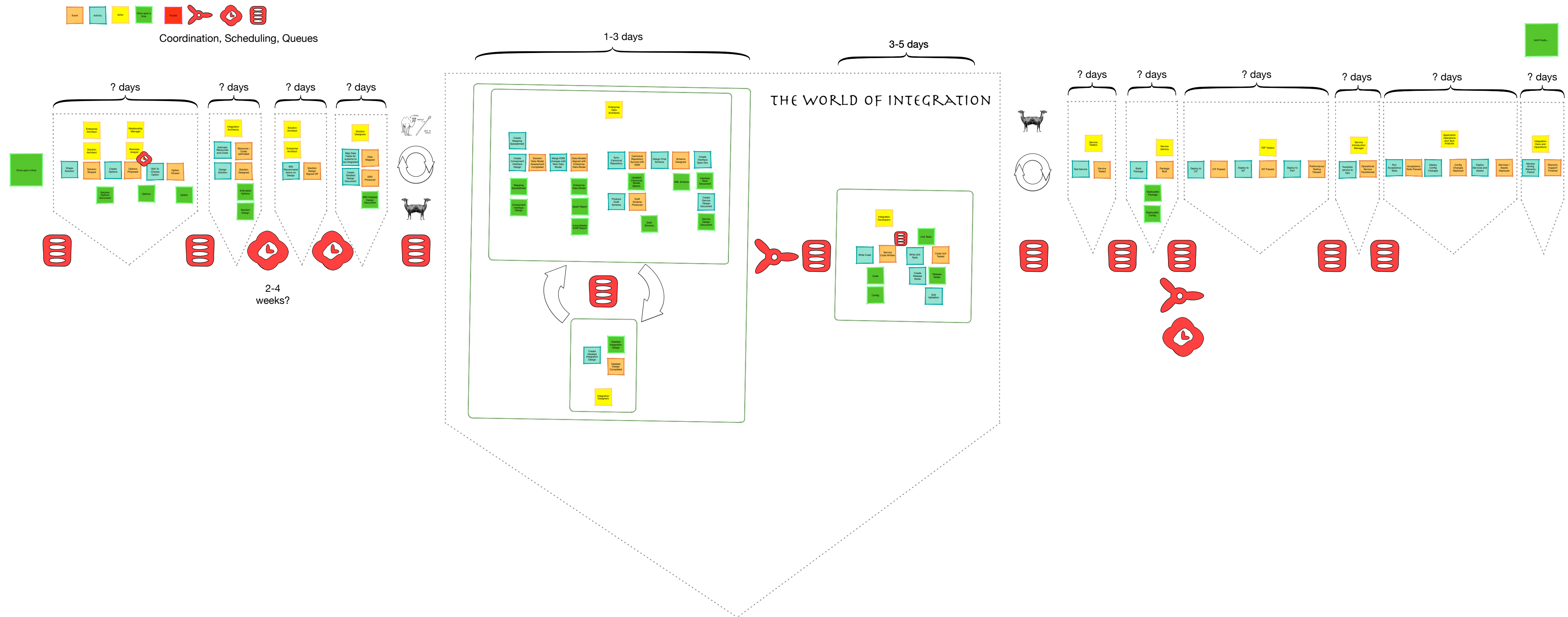


**Larger organisations  
spend less of their  
revenue on R&D.**



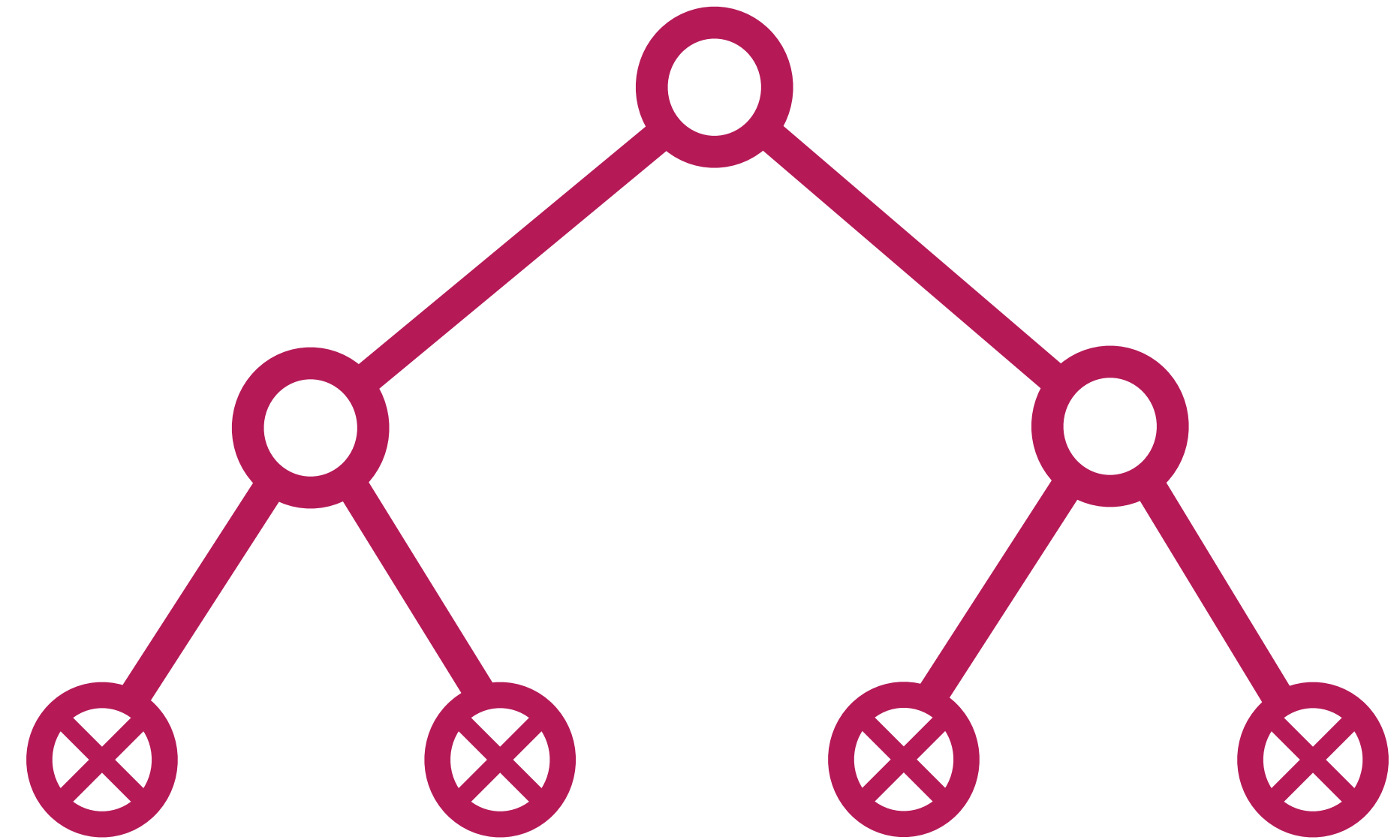


# + more and more process & constraints





# Hierarchies grow and grow...





# **Hierarchical organisations:**

**Gain economies of scale  
for infrastructure ( $\sim 0.85$ )**

**Achieve sub-linear  
growth in revenue ( $\sim 0.85$ )**

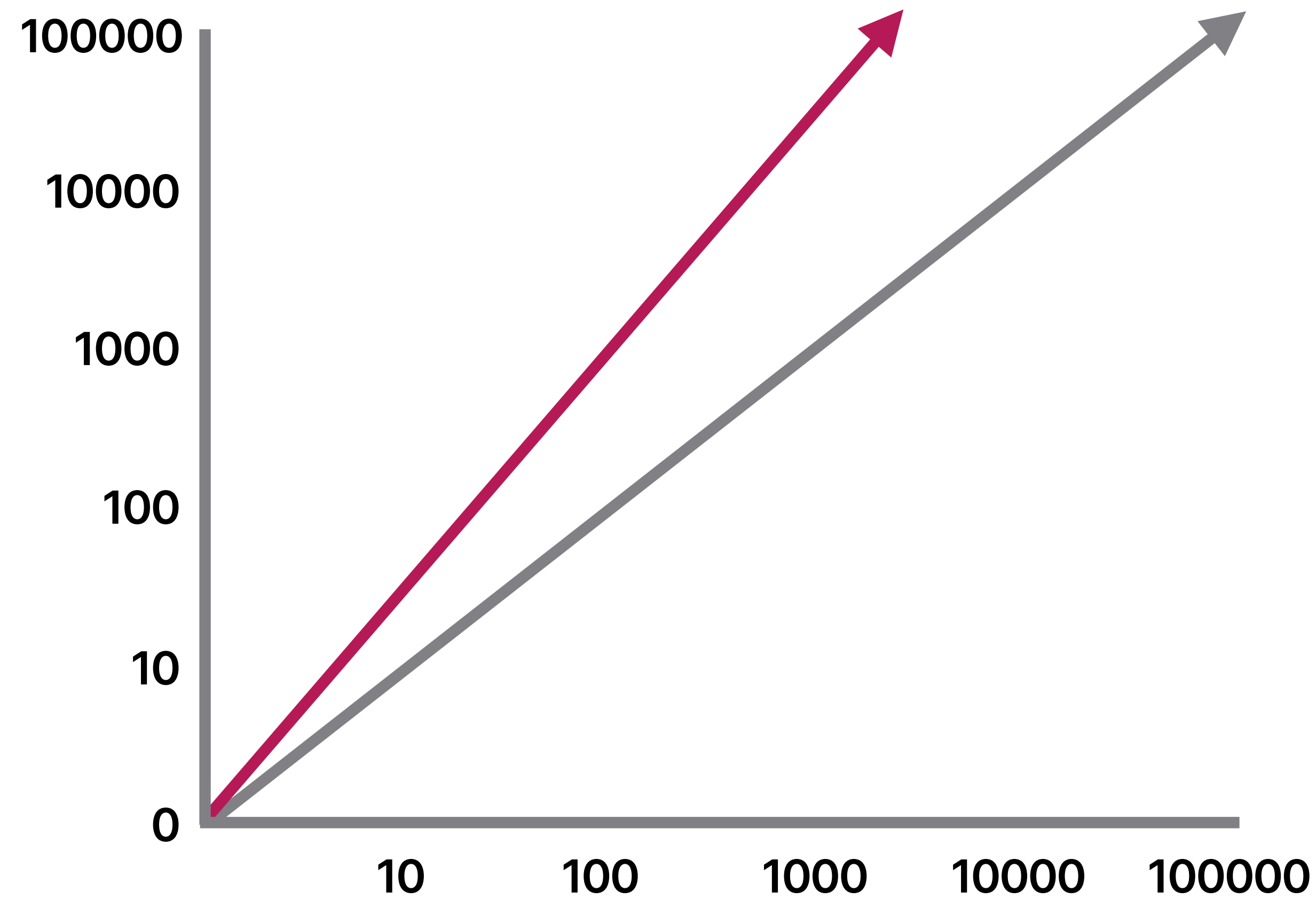
**reduce their metabolic rate... and  
eventually die.**





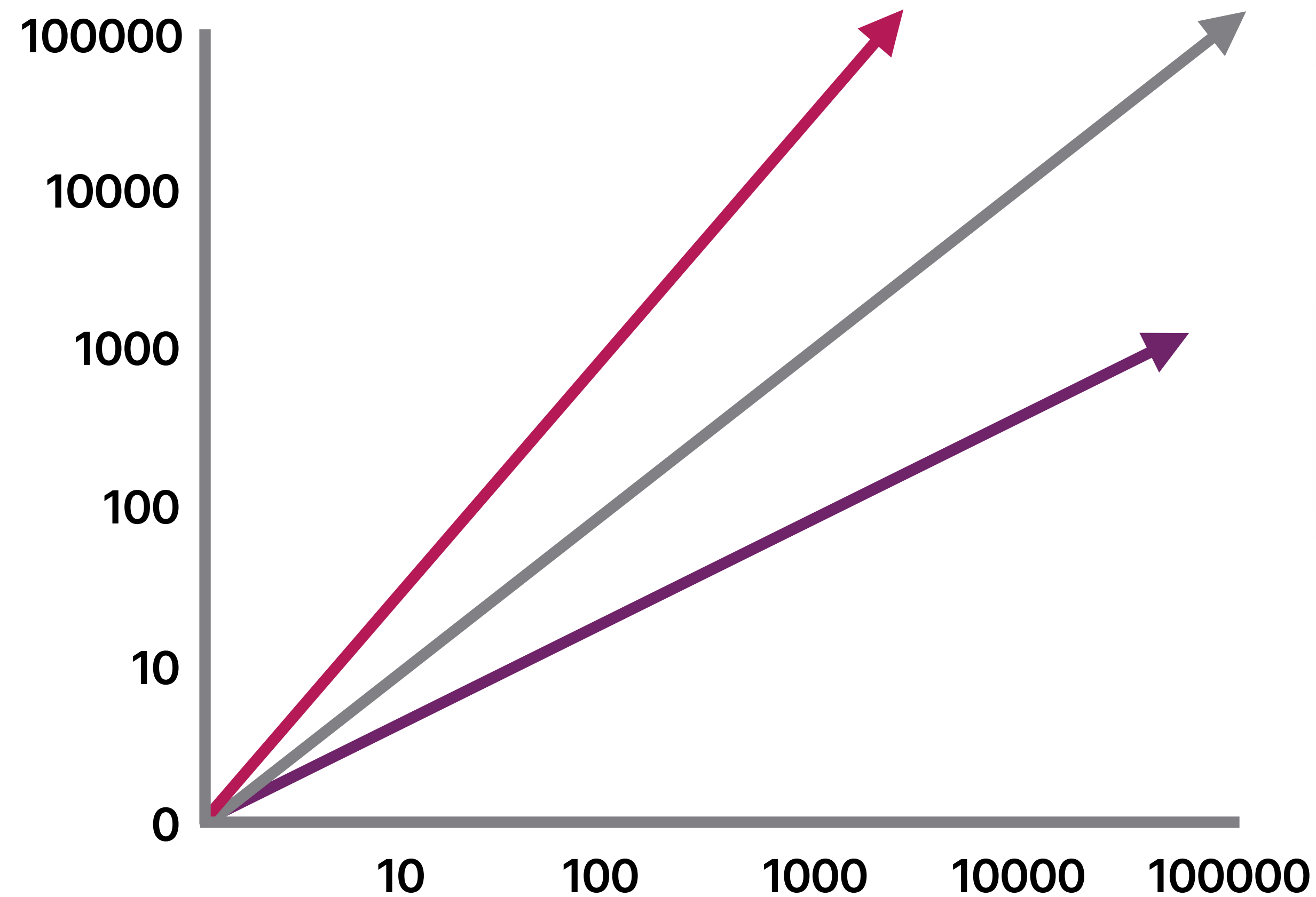
# Scaling Complex Adaptive Systems





**Super-linear scaling:**  
As x doubles, y increases  
by more than double

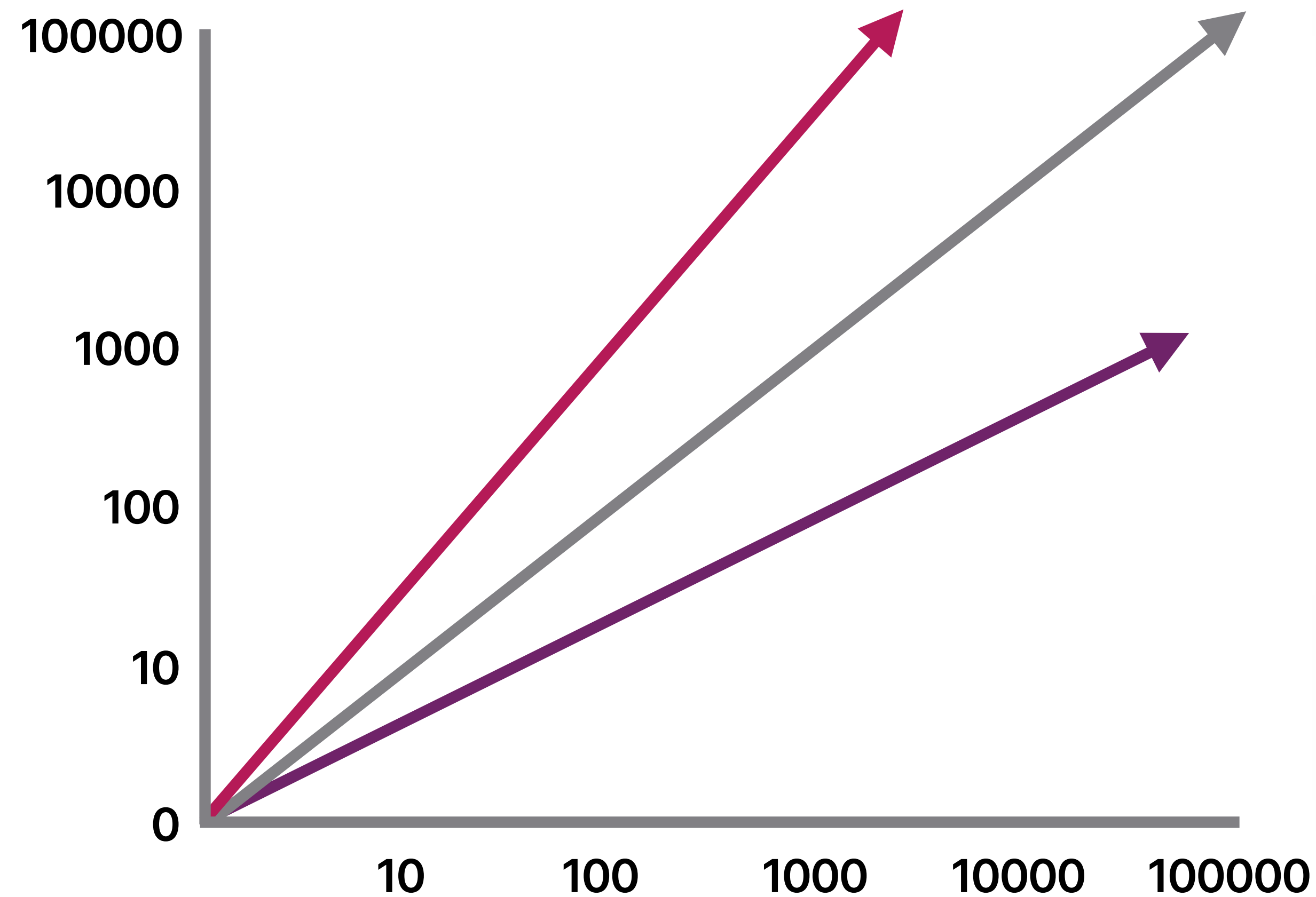




Innovation, wages,  
# professionals, crime,  
disease, pollution **(1.15)**

Road length, # petrol stations  
& restaurants, water pipes,  
electricity cables **(0.85)**



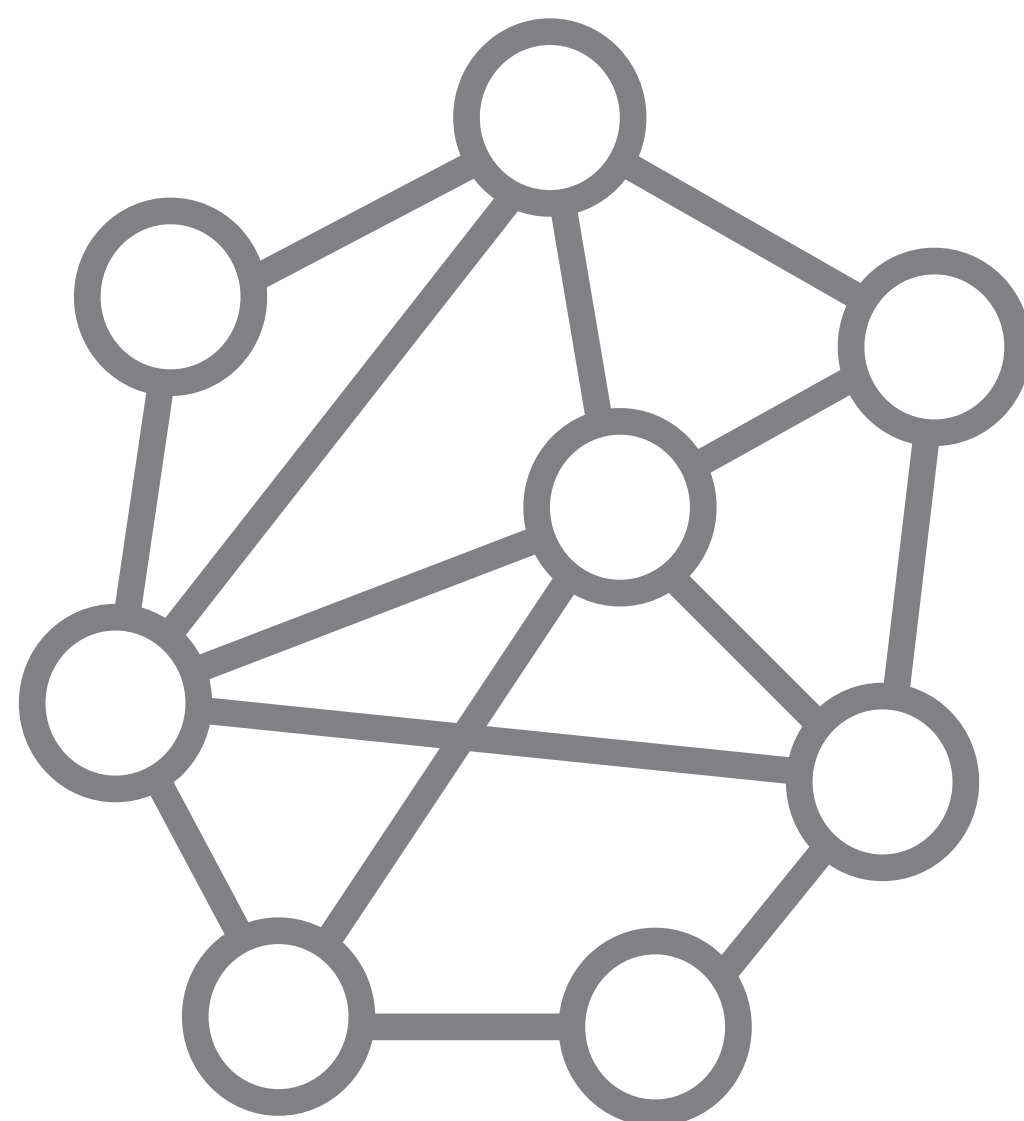


Innovation, wages,  
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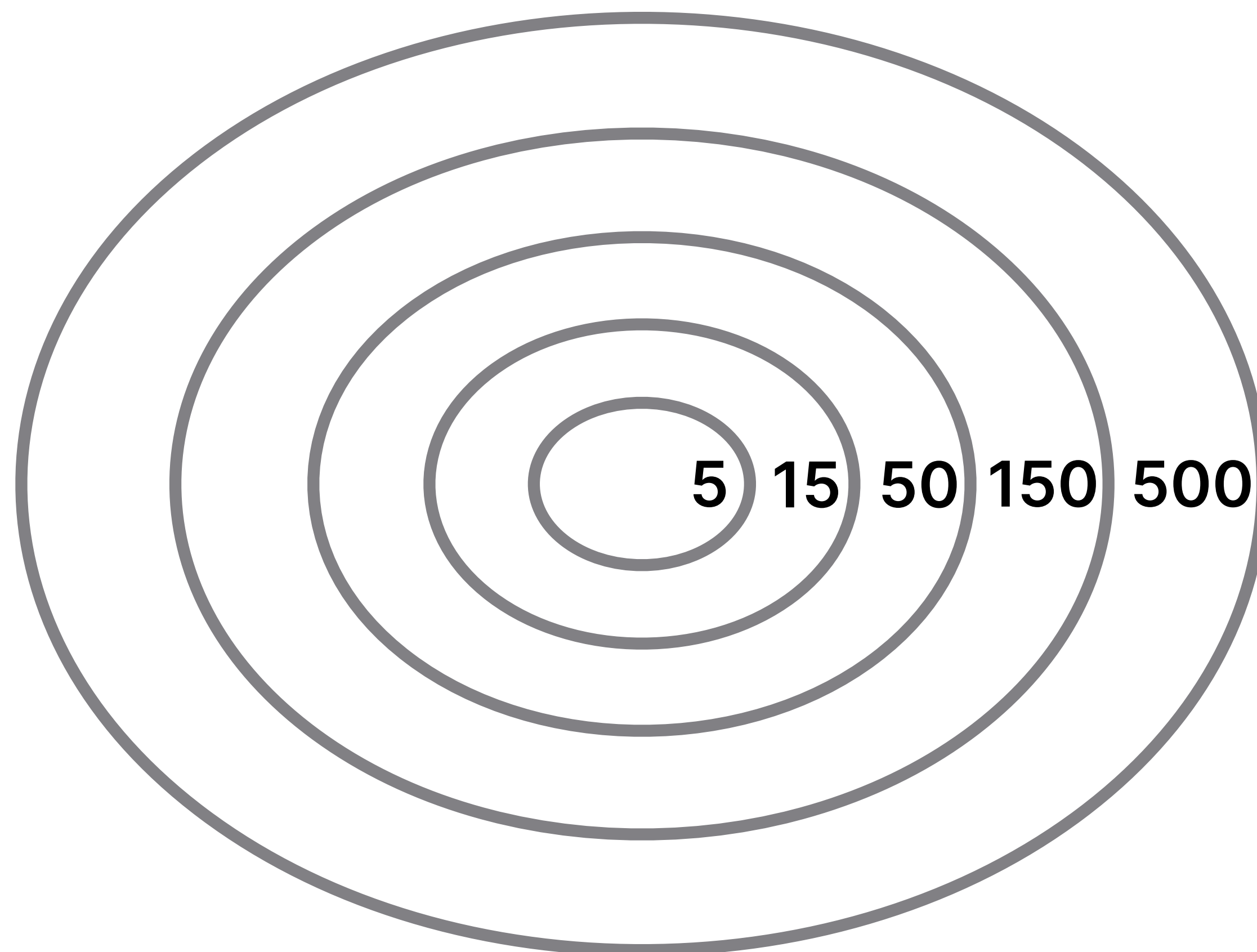
Walking speed **(1.10)**

Road length, # petrol stations  
& restaurants, water pipes,  
electricity cables **(0.85)**

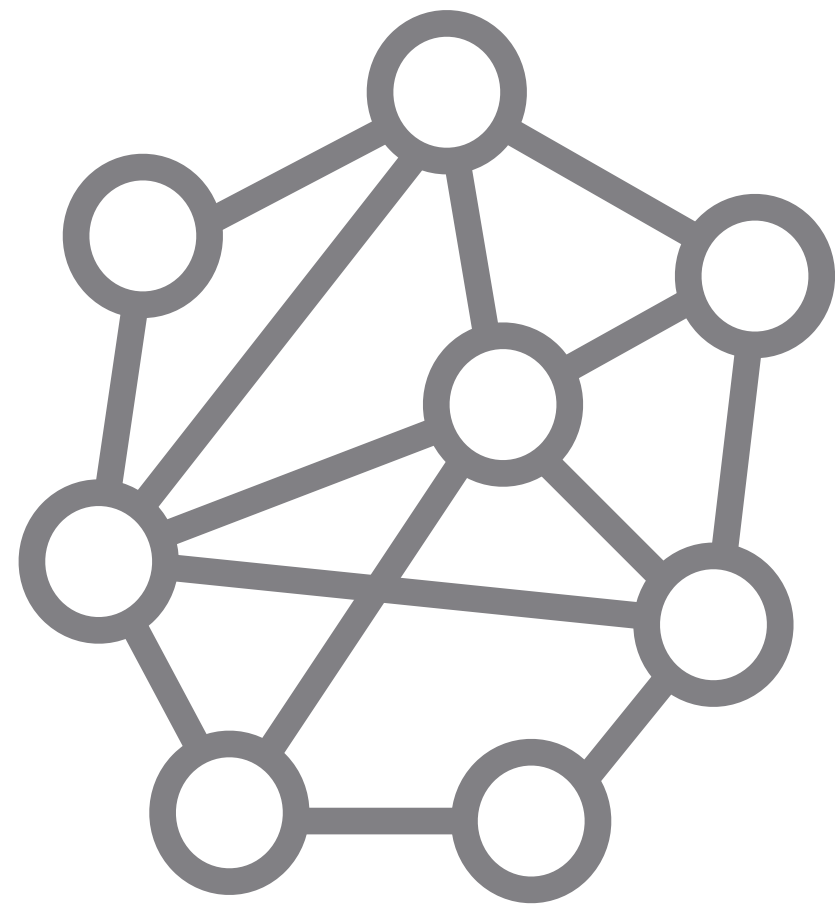




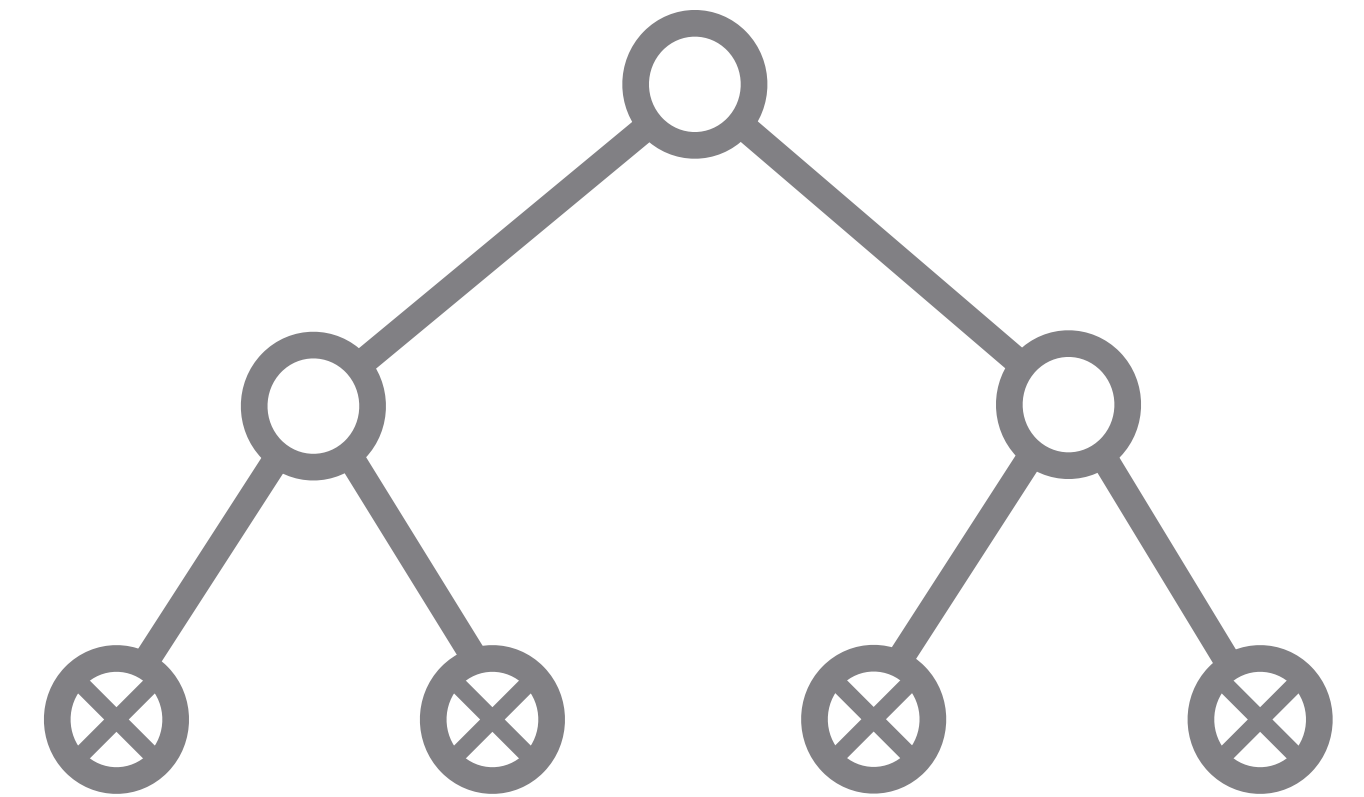
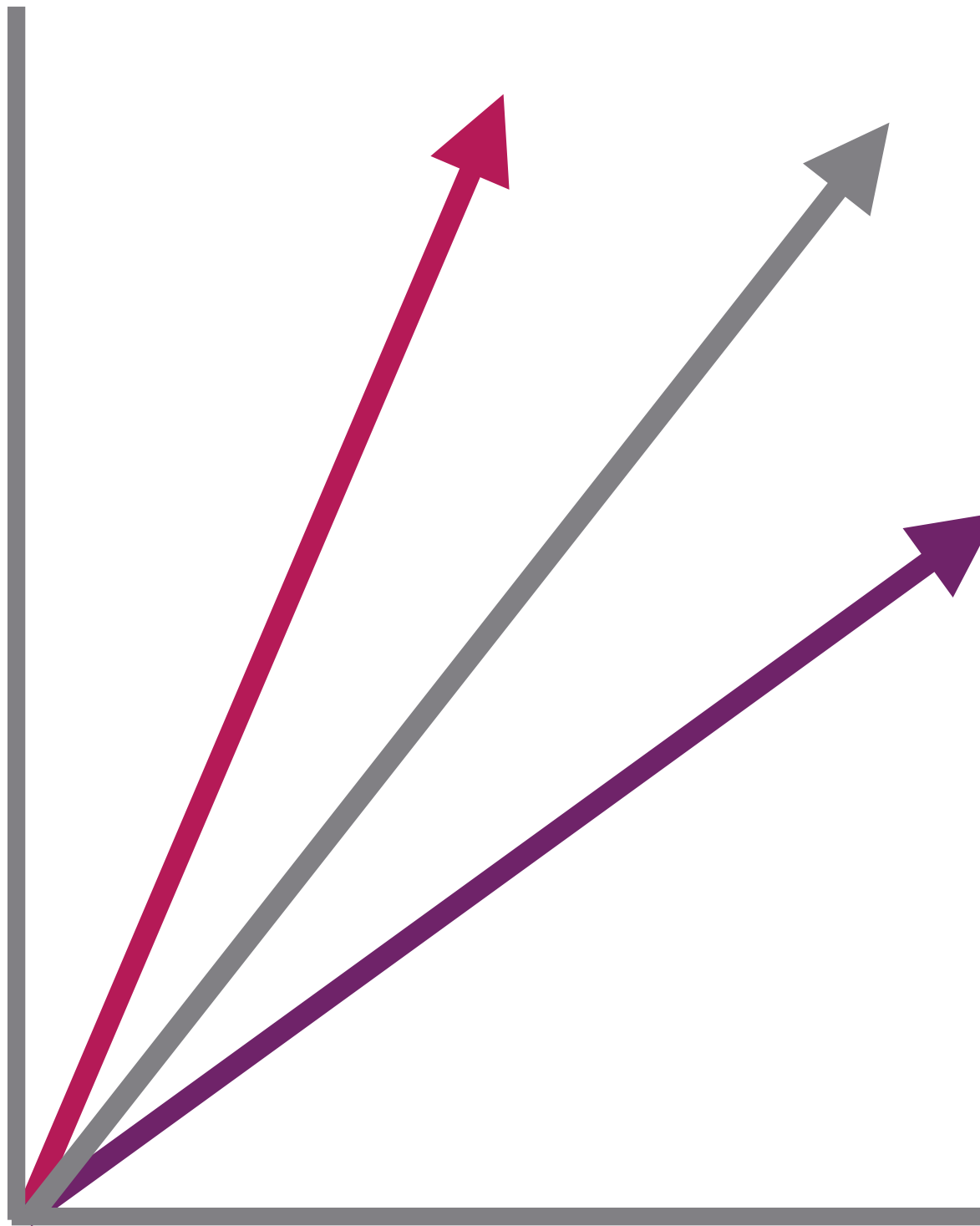
**Small world fractal space  
filling network**





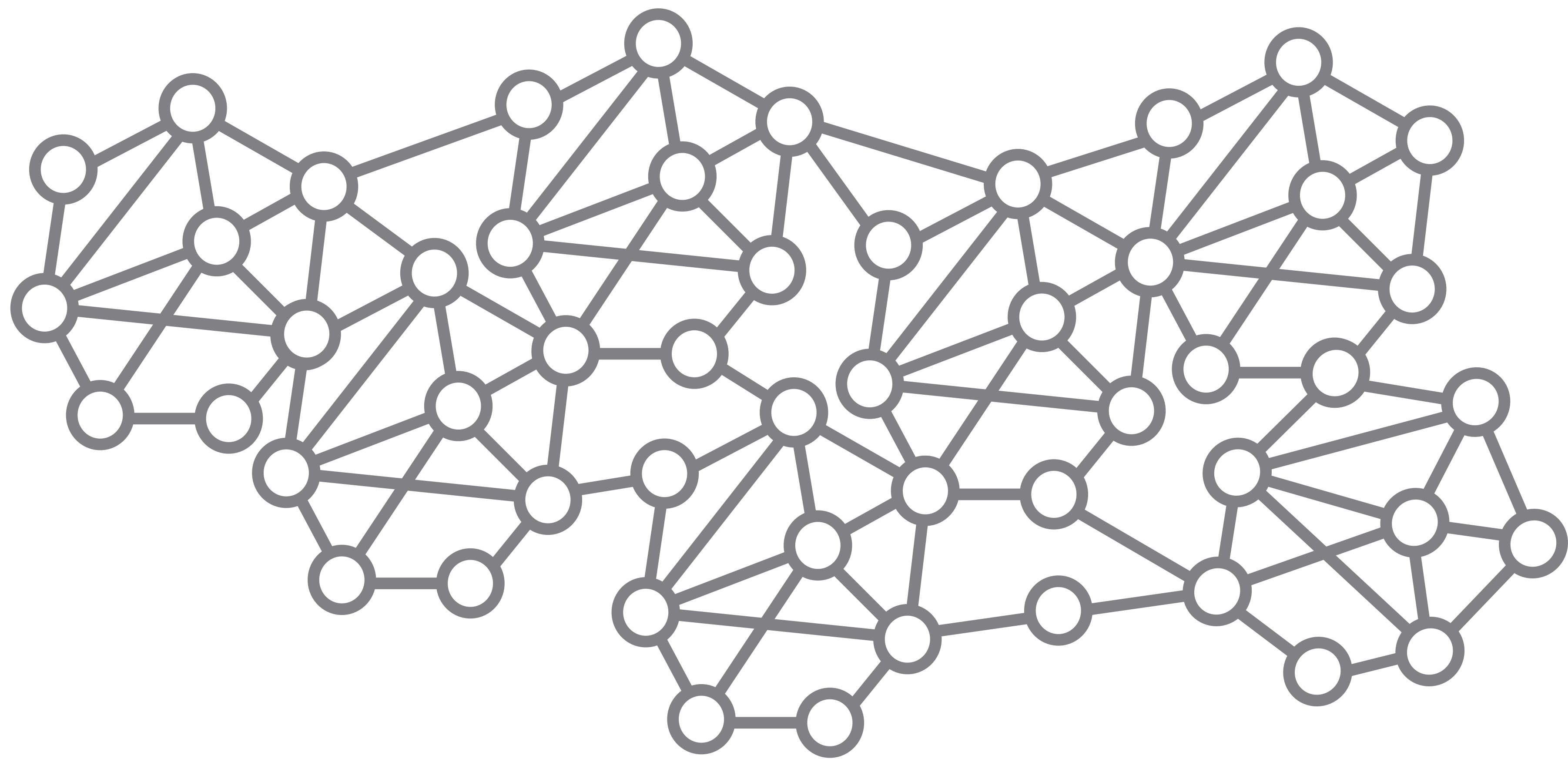


**Small world fractal  
space filling network**



**Hierarchical fractal space  
filling network**









# **As cities grow they**

**Gain economies  
of scale for  
infrastructure**

**Gain returns to  
scale for socio-  
economic factors**

**Rarely die**

**Get 115% more  
stuff for 85% of  
the cost!**





**/thoughtworks**

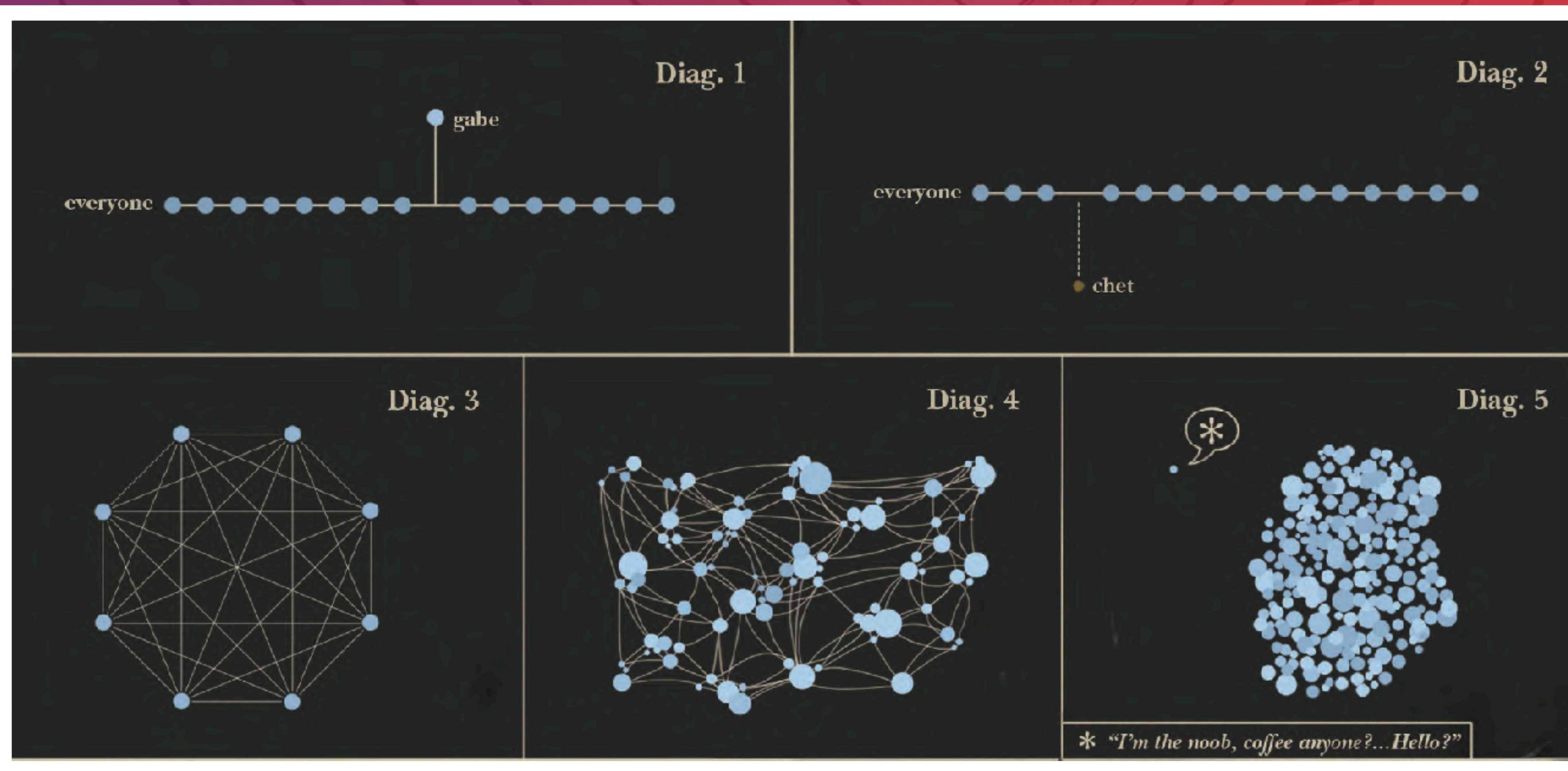




**VALVE**



# VALVE

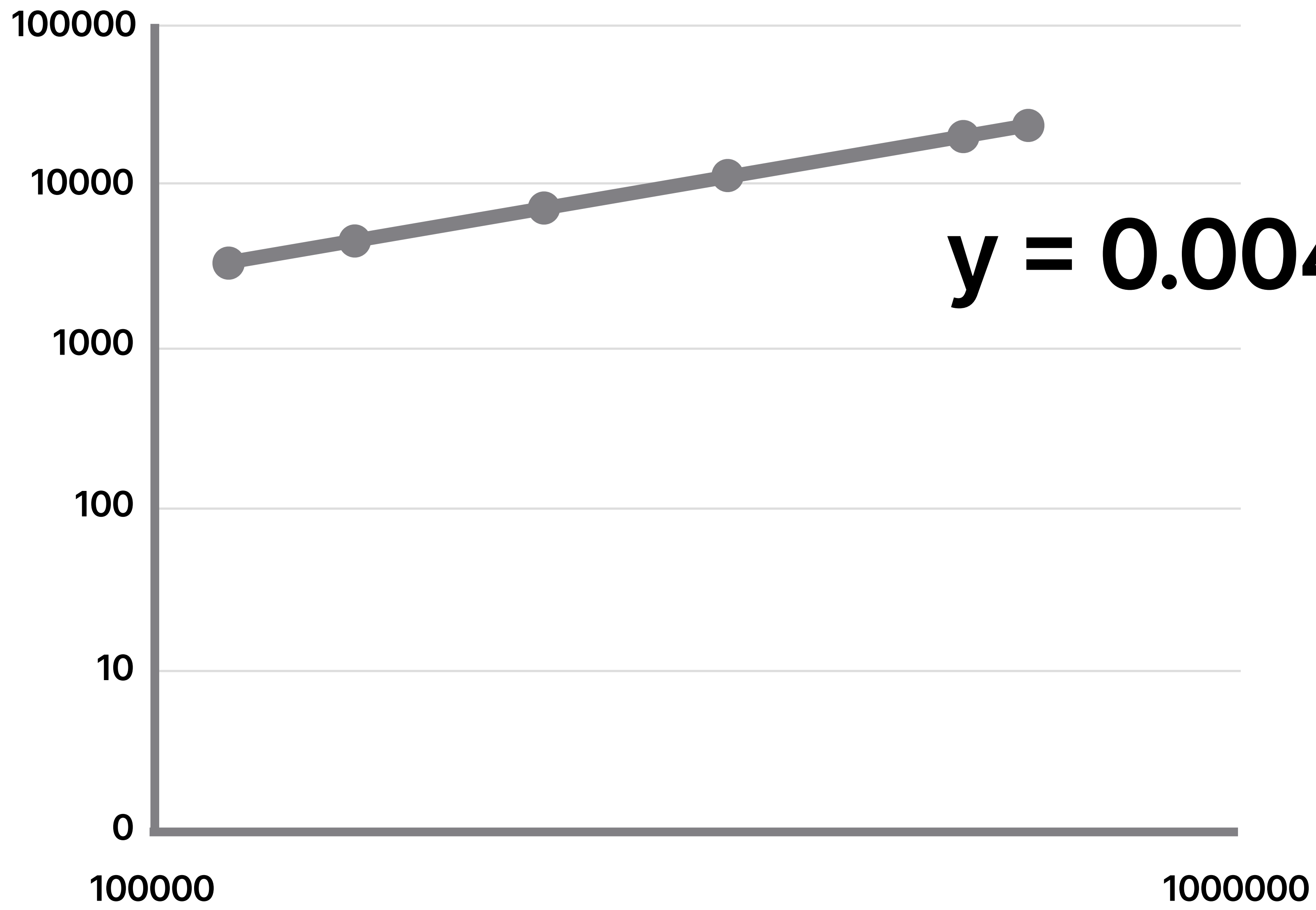




amazon

The Amazon logo is centered on a background with a purple-to-red gradient and a hexagonal pattern. The word "amazon" is in a white, lowercase, sans-serif font. Below the text is a white curved arrow pointing from the 'a' to the 'n', which is the iconic Amazon smile logo.





$$y = 0.0049x^{1.1515}$$

**amazon**



**Teams must  
communicate  
via interfaces**



**amazon**



**Teams must  
communicate  
via interfaces**

**All interfaces must  
be externalisable**

**amazon**



**Teams must  
communicate  
via interfaces**

**All interfaces must  
be externalisable**

**2 pizza  
(Dunbars #)  
teams**

**amazon**

The Amazon logo, featuring the word "amazon" in a white, lowercase, sans-serif font, with a white curved arrow underneath it pointing from the letter 'a' to the letter 'z'.





**Forcing  
functions for  
*flow***

**Limiting interaction to  
nearby teams**

**Team isolation**

**Scale by Dunbar's  
numbers**



The background is a grayscale abstract composition. The left half features a dense, repeating pattern of hexagons, similar to a honeycomb or stone tile texture. The right half shows a perspective view of a road or a series of parallel lines receding into the distance, creating a sense of depth and movement. The text is centered across the middle of the image, spanning both patterns.

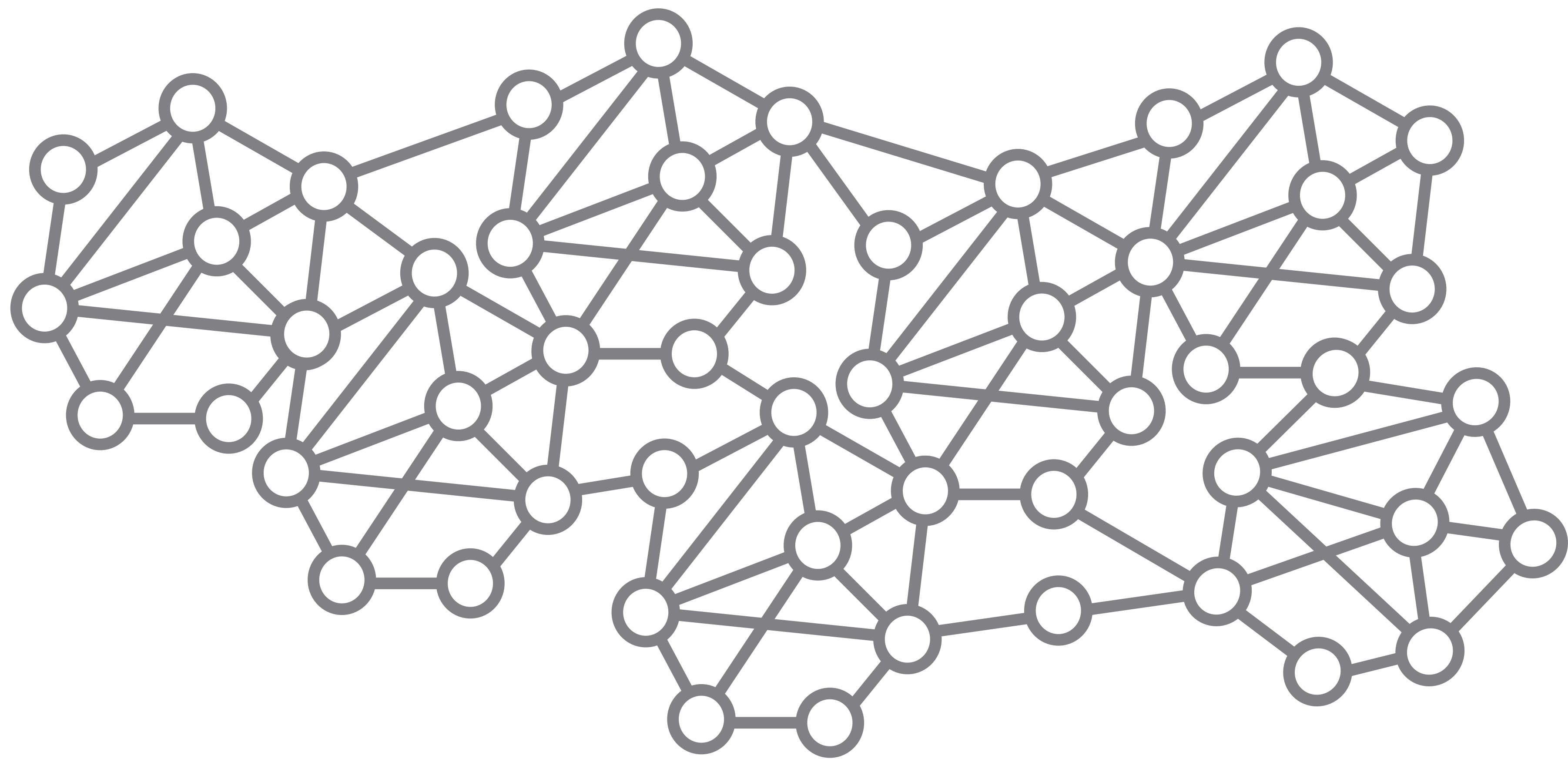
**As most companies get bigger,  
it gets harder to get bigger.**





**As Amazon gets bigger,  
it gets easier to get bigger.**







# Software Architecture, Team Topologies and Complexity Science



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**Organised around  
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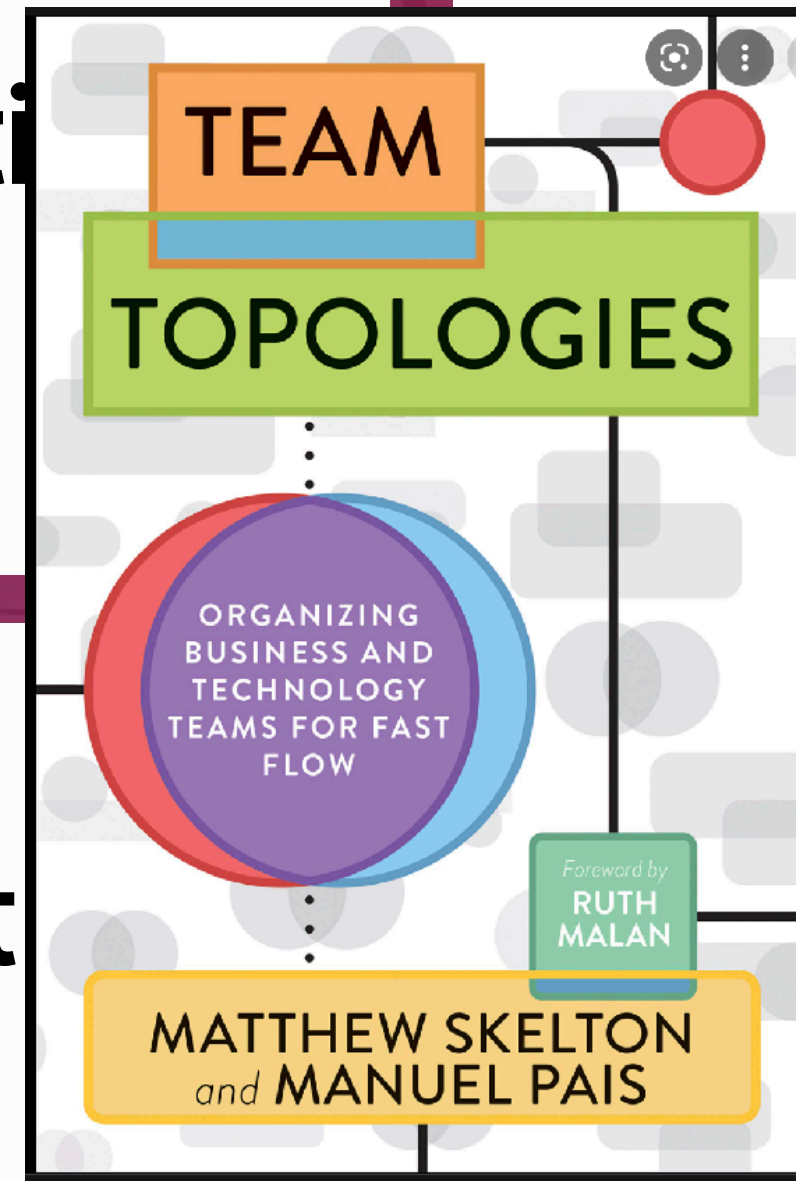
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Componentisation  
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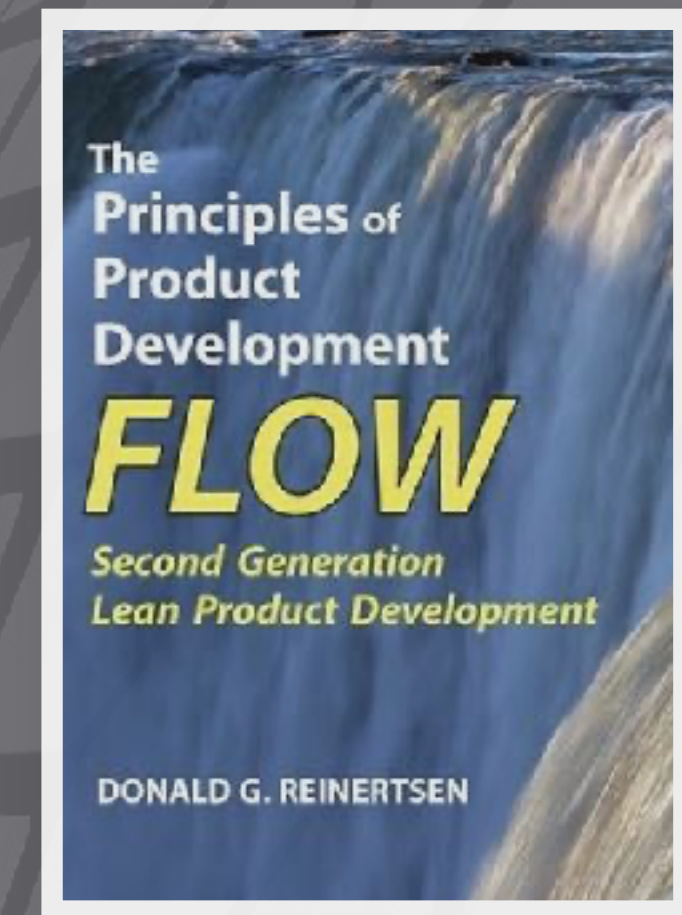
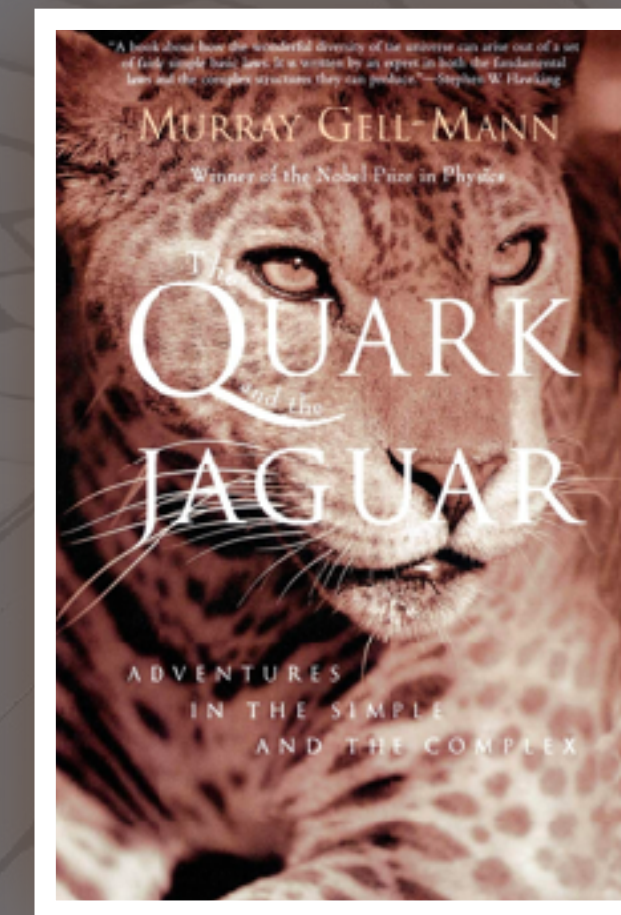
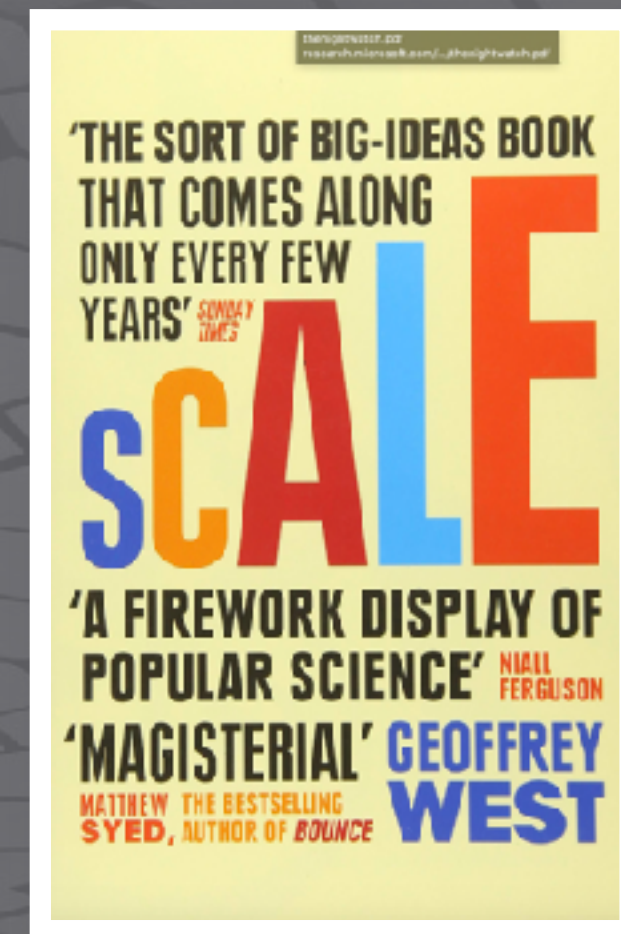
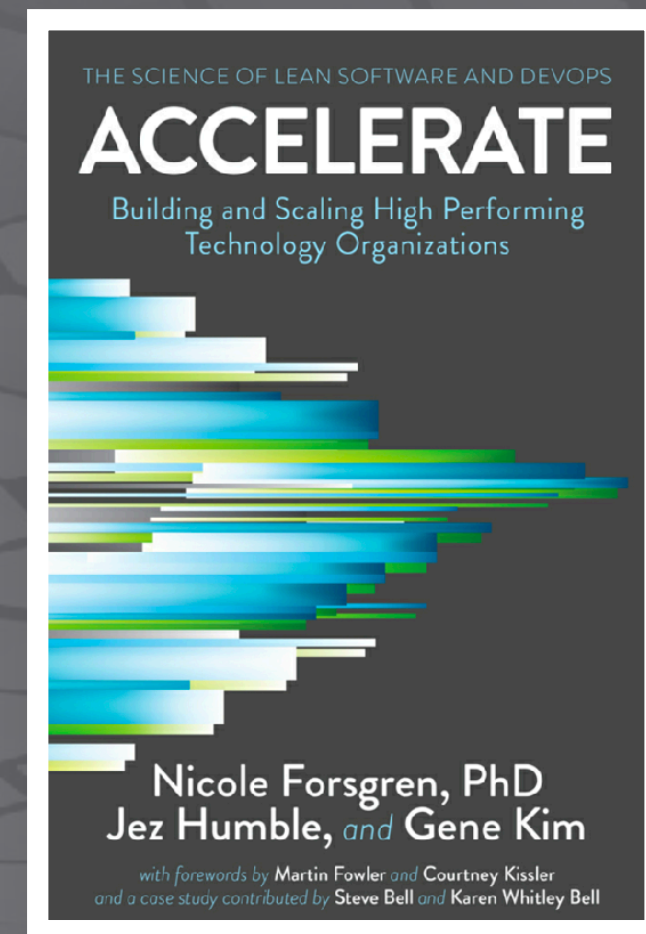
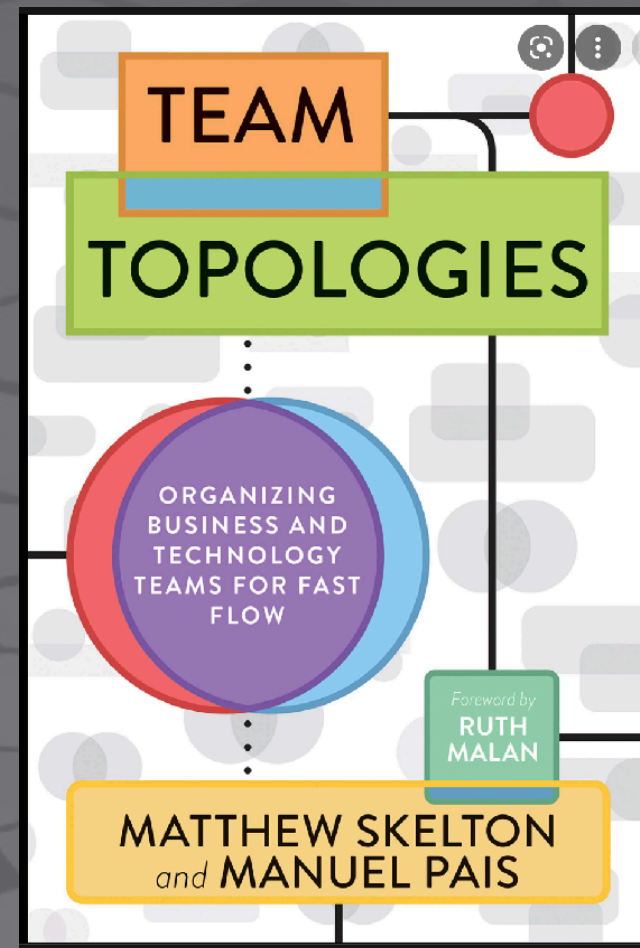
# Social network effects imply super-exponential growth

**Hierarchies slow  
metabolic rate**

**Team shapes for  
Flow**

**Forcing functions for  
Flow**





## A General Model for the Origin of Allometric Scaling Laws in Biology Geoffrey B. West, James H. Brown, Brian J. Enquist

Bettencourt, Luís M. A. 2013, The Origins of Scaling in Cities. Science 340: 1438-1441.

<https://protobi.com/post/revenue-per-employee-and-biologic-scaling-laws>

The origin of allometric scaling laws in biology from genomes to ecosystems:  
towards a quantitative unifying theory of biological structure and organization

Geoffrey B. West, James H. Brown. Journal of Experimental Biology 2005 208: 1575-1592; doi: 10.1242/jeb.01589