

Lecture 8

Comparing to other Complex Systems. Benchmarking Cities

8.2 Comparisons between Cities and Other Complex Systems

Four Principles of Urban Scaling Theory

- 1) Cities are mixing populations over built space and time **Jacobs, Wirth, Burgess**
- 2) City infrastructure as decentralized but hierarchical networks **Alexander**
- 3) Personal effort is limited **Park, Milgram**
- 4) Socioeconomic products of cities are the result of interactions,
subject to spatial costs **Jacobs**
Alonso

Are cities like ***other*** complex systems? Or are they an entirely different thing?

Urban Metaphors

Cities are not **organisms**, any more than they are **machines**, and perhaps even less so. They do not grow or change of themselves, or reproduce or repair themselves. They are not autonomous entities, nor do they run through life cycles, or become infected. [...]

But it is more difficult, and more important, to see the fundamental ineptness of the metaphor and how it leads us unthinkingly to cut out slums to prevent their “infectious” spread, to search for an optimum size, to block continuous growth, to separate uses, to struggle to maintain greenbelts, to suppress competing centers, to prevent “shapeless sprawl”, and so on.

-Kevin A. Lynch, Good City Form (1984).

This matters a lot actually !

Organisms and “vascular systems”

Huawei unveils smart city “nervous system”

[News](#) 15 Nov 2017 by SmartCitiesWorld news team



Lida: "Huawei is committed to creating a strong nervous system that powers smart cities"

Huawei is demonstrating joint ICT solutions to connect the digital and physical worlds across city administration, public services, and industrial economies



EAST RIVER

WILLIAMSBURG BRIDGE

MANHATTAN BRIDGE

CROSS MANHATTAN ARTERIALS AND RELATED IMPROVEMENTS

LOWER MANHATTAN EXPRESSWAY
MID MANHATTAN EXPRESSWAY

DOWNTOWN REDEVELOPMENT
THE CENTRAL CITY
POST OFFICE
THE NEW EAST SIDE

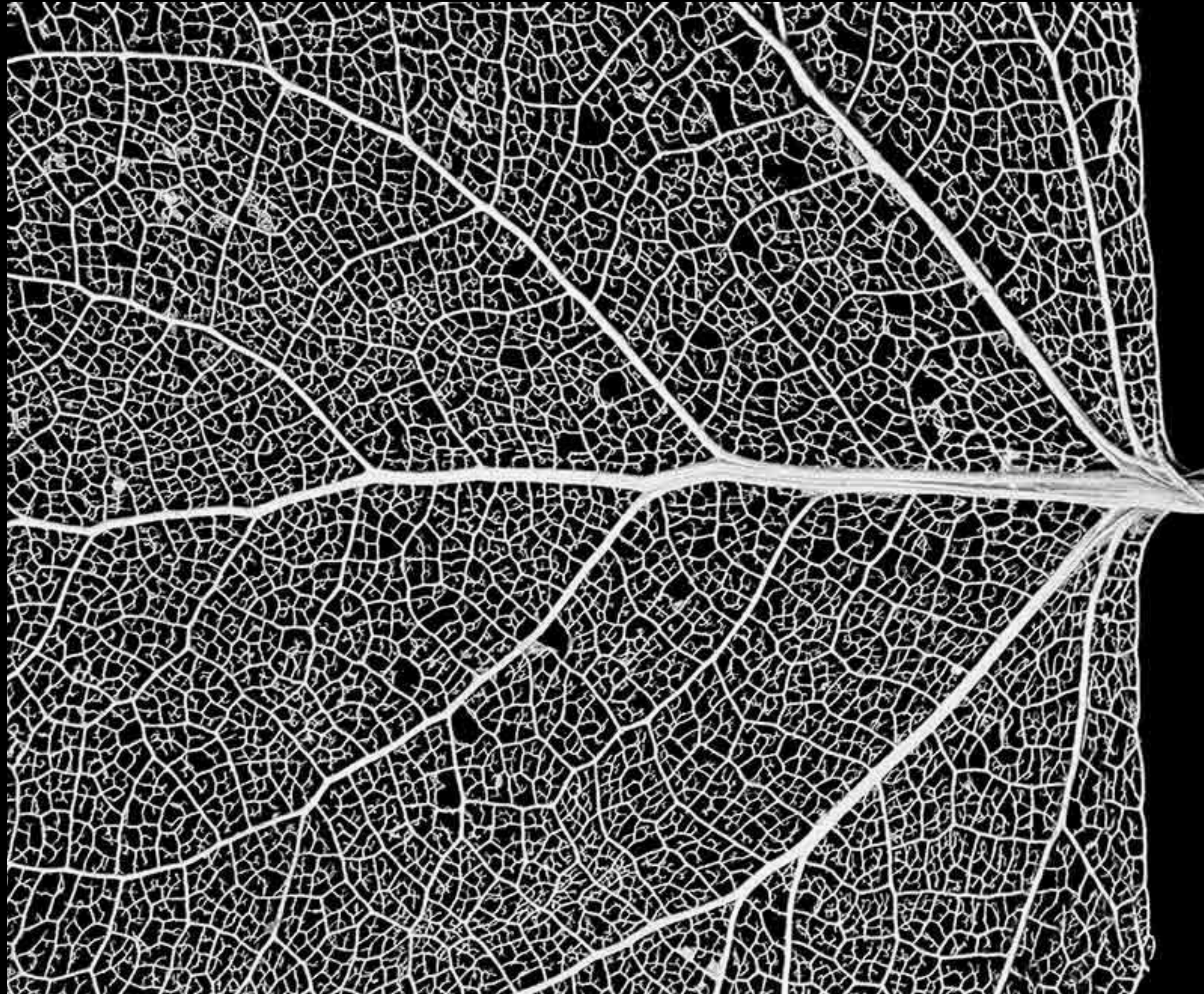
Looking east along route
of Lower Manhattan
Expressway from Hudson
River to East River

HOLLAND TUNNEL

WEST SIDE ELEVATED HIGHWAY

HUDSON RIVER

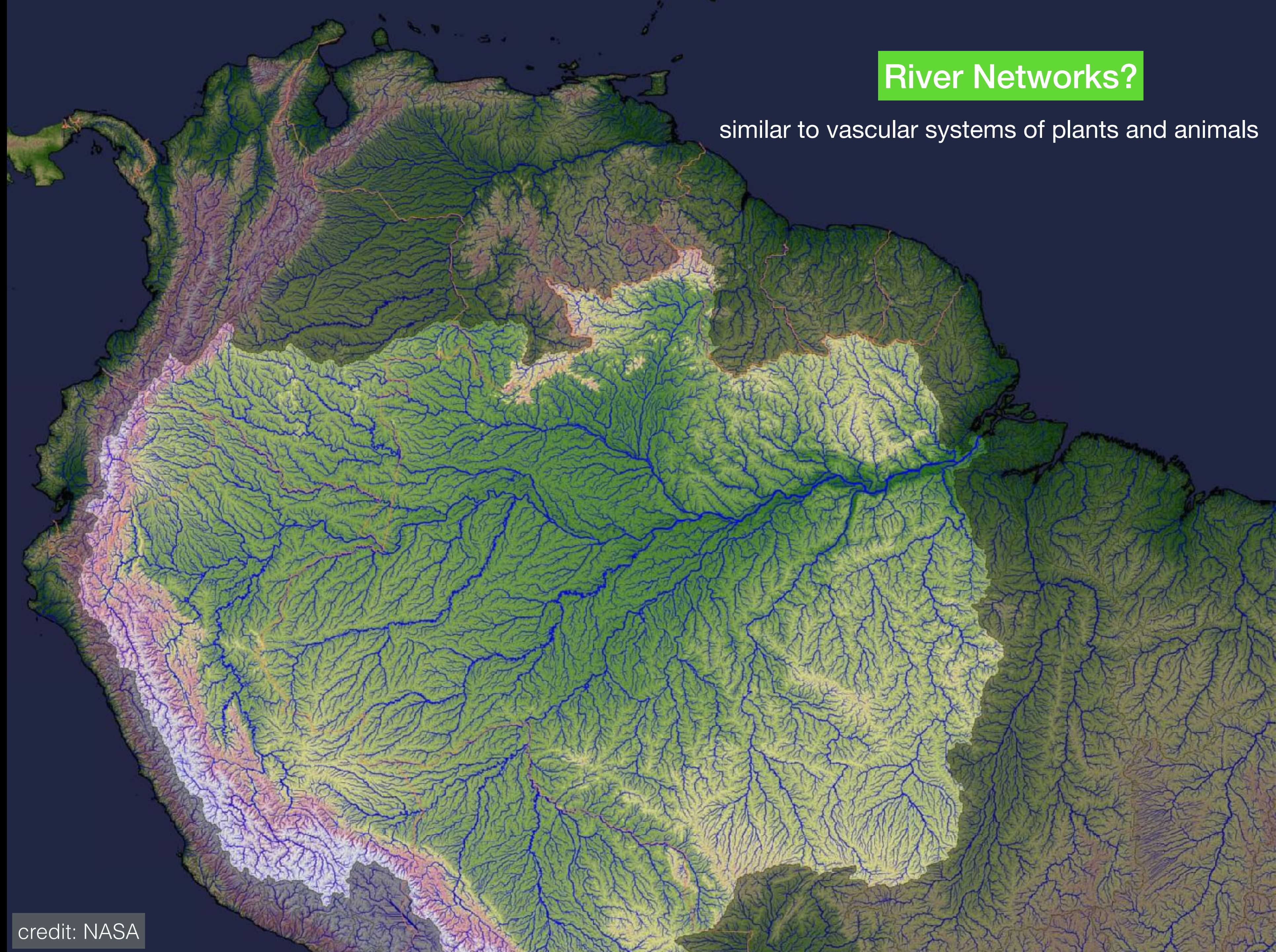
Biological Organisms?



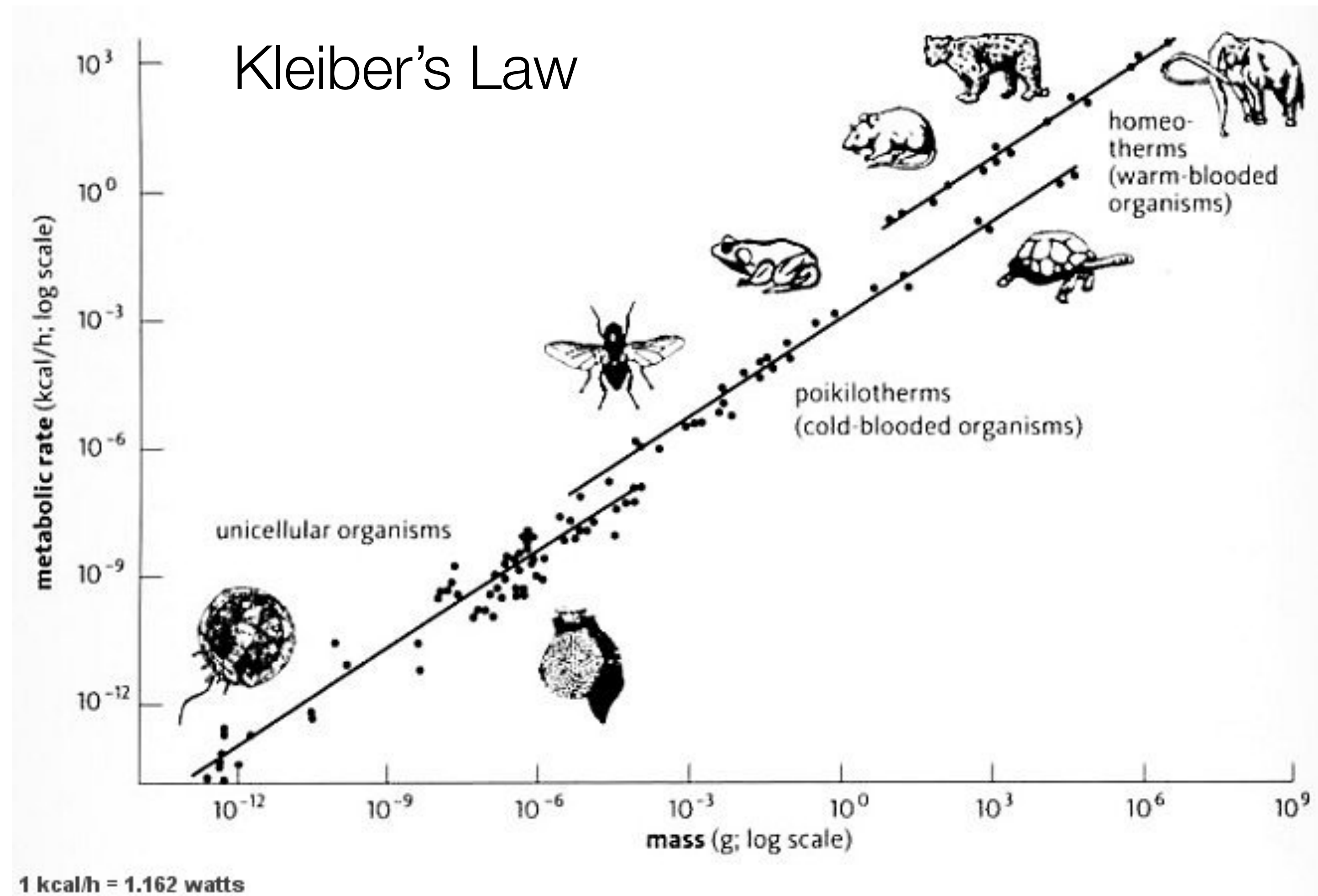
credit: Royce Bair

River Networks?

similar to vascular systems of plants and animals



The Energy Use of Biological Organisms

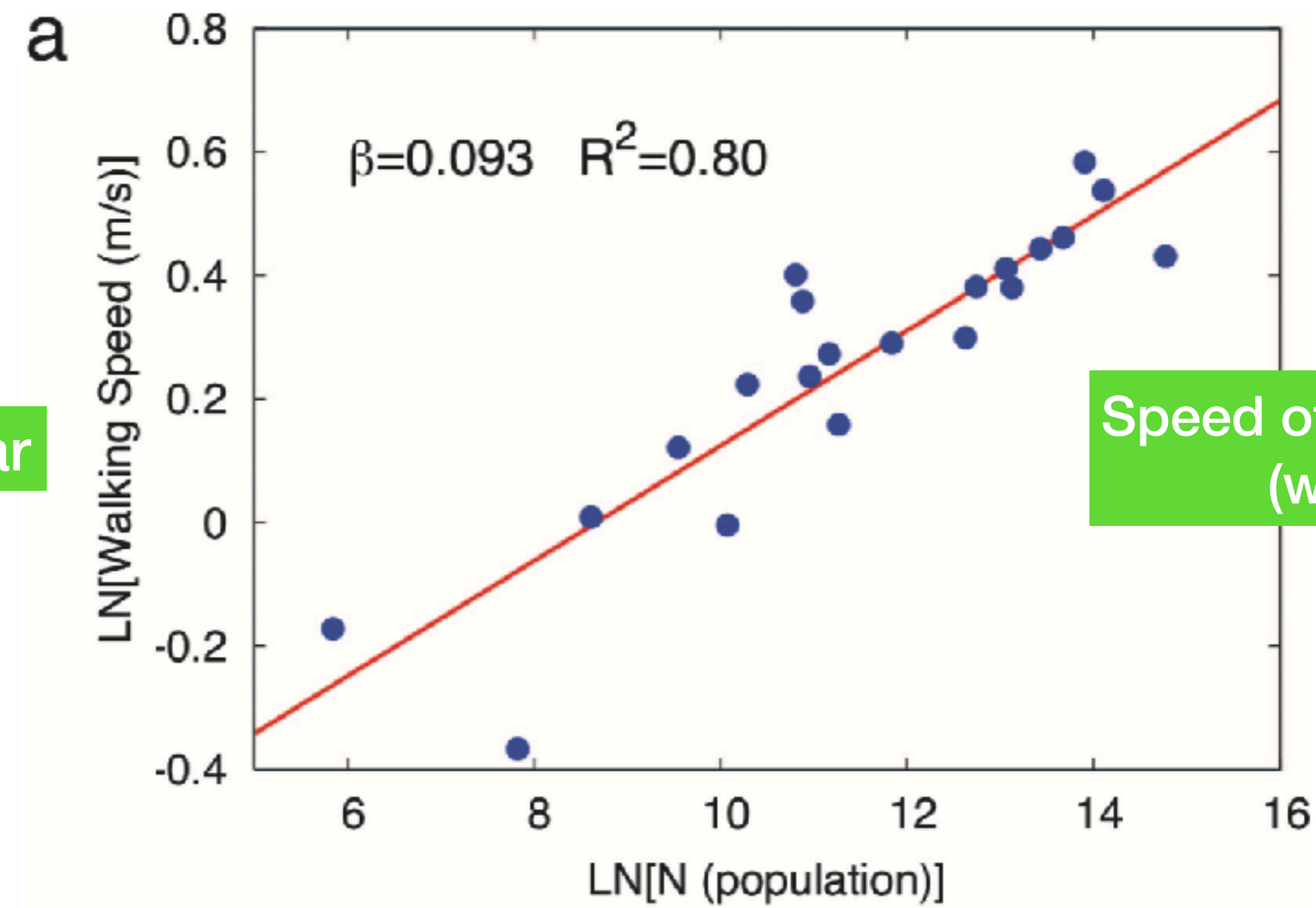


Energy/time \sim Mass $^{3/4}$ **sublinear**

Power or Metabolism

West, Brown, Enquist 1997, ..

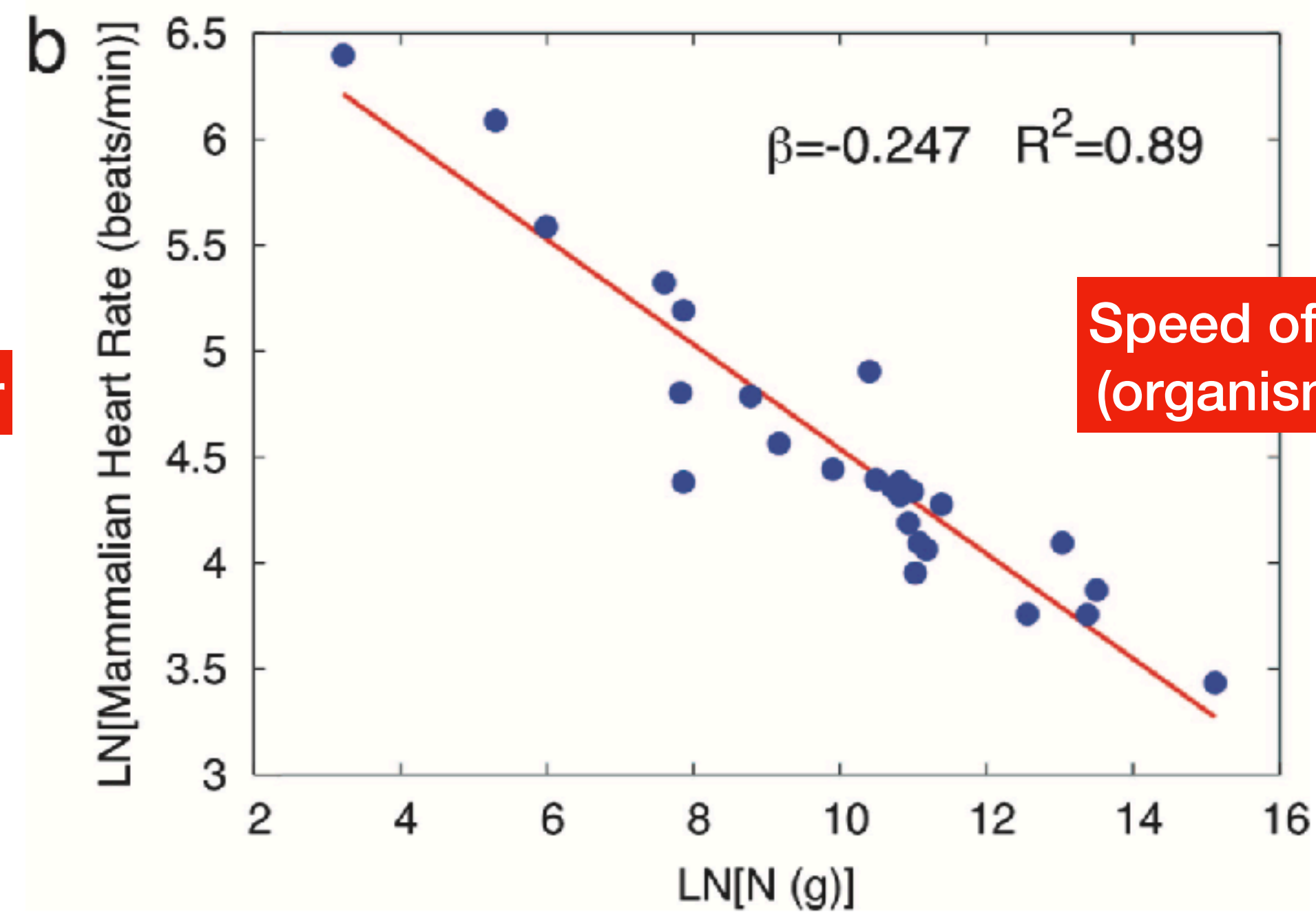
superlinear



Speed of Life in Cities
(walking)

- increases with scale
- strong heterogeneity
- innovation and change

sublinear



Speed of Life in Nature
(organism's heart rate)

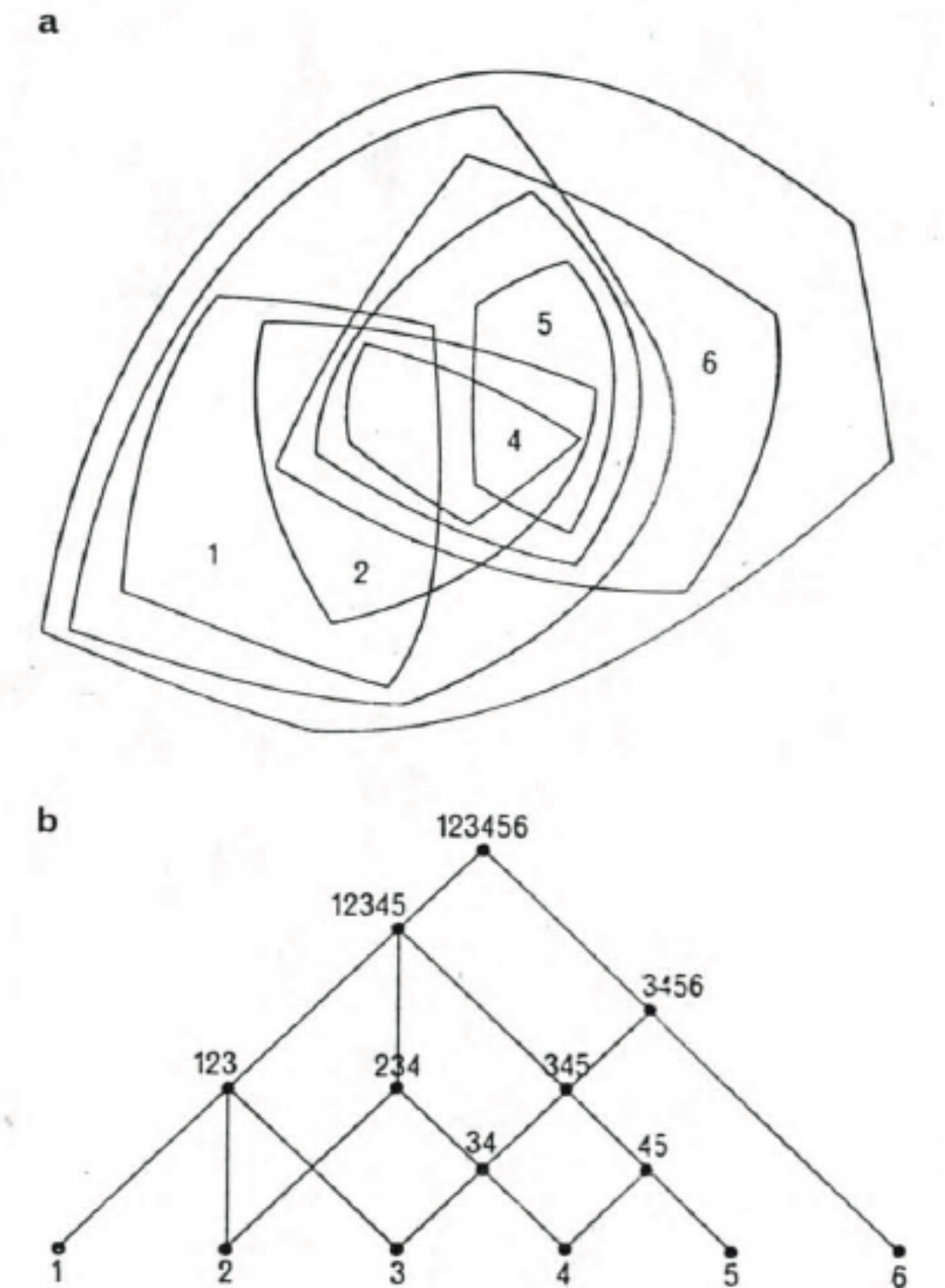
- decreases with scale
- no diversity
- energy efficiency

But cities are actually *decentralized* networks

You don't have to go through Times Square, to go from Chinatown to Wall Street ...



Las Vegas NM
credit: Christa Brelsford



C. Alexander
The city is not a tree

Cities are NOT driven by energy efficiency !!

What are cities driven by, if not energy efficiency?

Ecosystems?

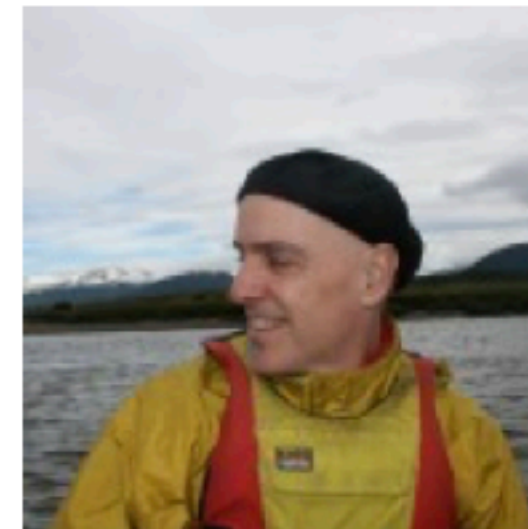
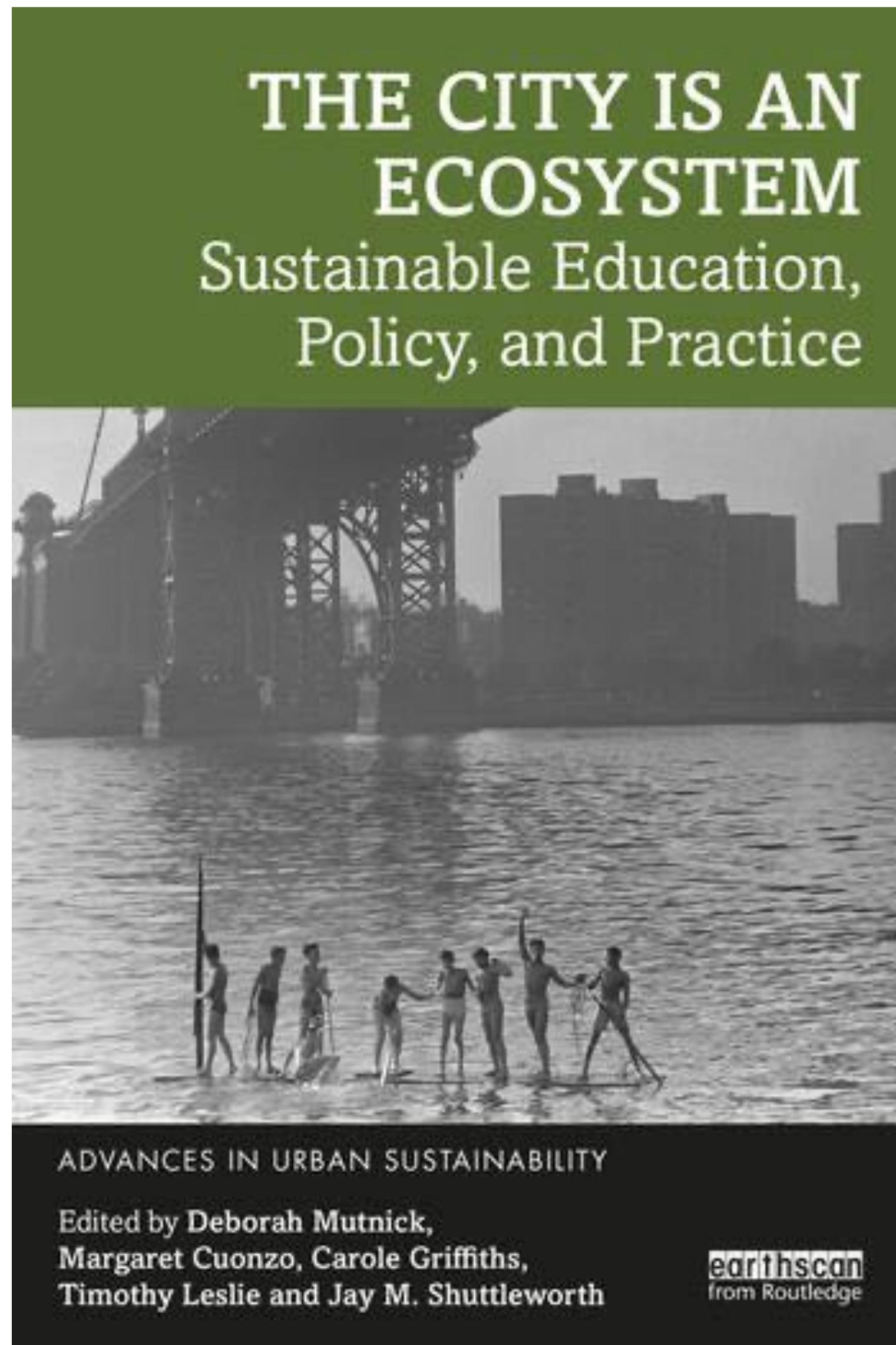
A Jane Jacobs favorite

driven by increased fitness
~growth rates of populations



credit: www.mostbeautifulthings.net

Ecosystems?



About the Writer:

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David loves urban spaces and nature. He loves creativity and collaboration. He loves theatre and music. In his life and work he has practiced in all of these.

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Introduction

Are cities *ecosystems* in the senses in which we think of classic natural and ecological areas outside of cities? After all, urban spaces are connected mosaics of green space, biodiversity (including people), non-biological structure, biophysical processes, energy flows, and so on. That sounds a lot like a natural ecosystem.

For example, here is one definition of a natural ecosystem (from [sciencing.com](#)):

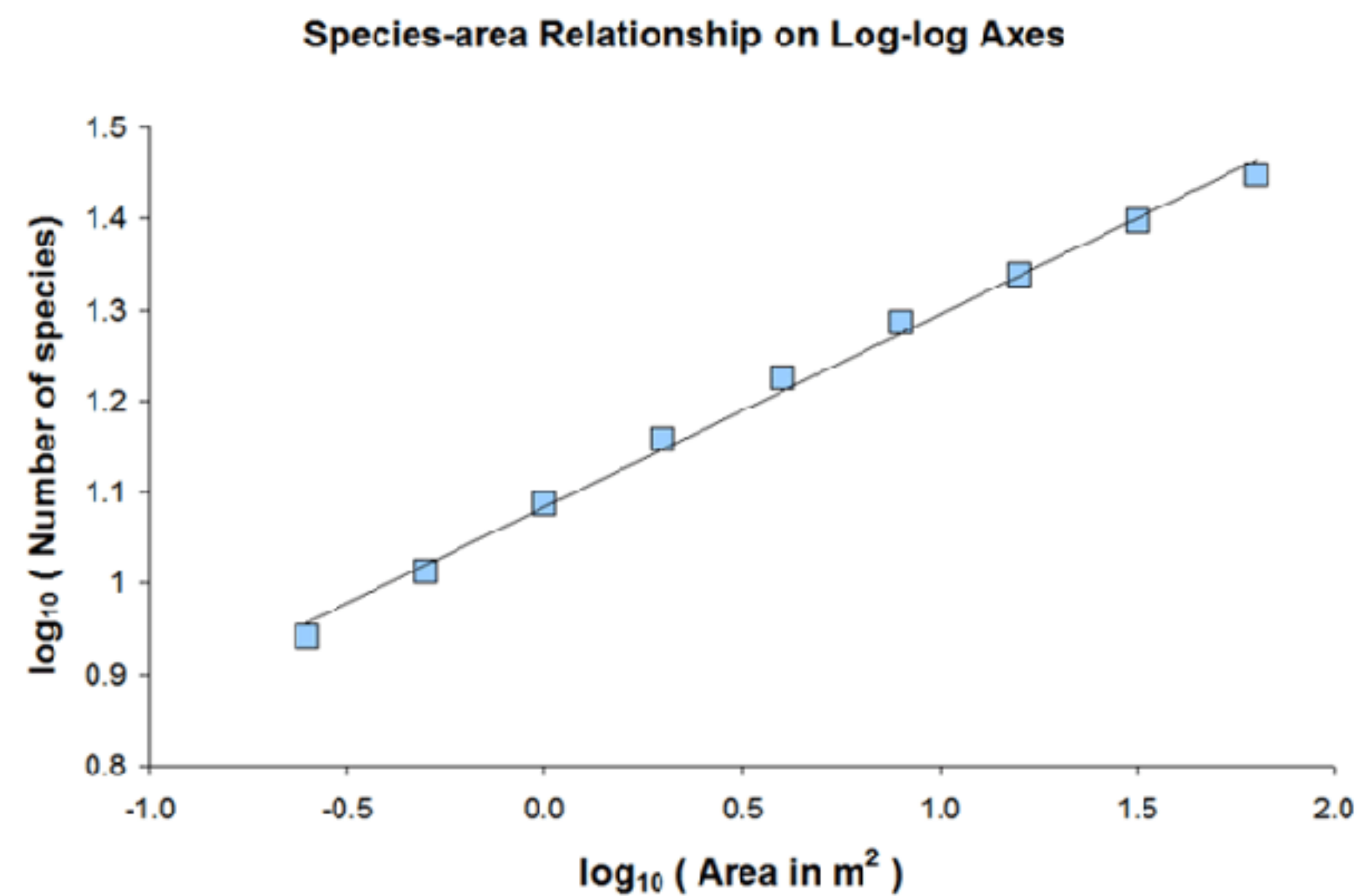
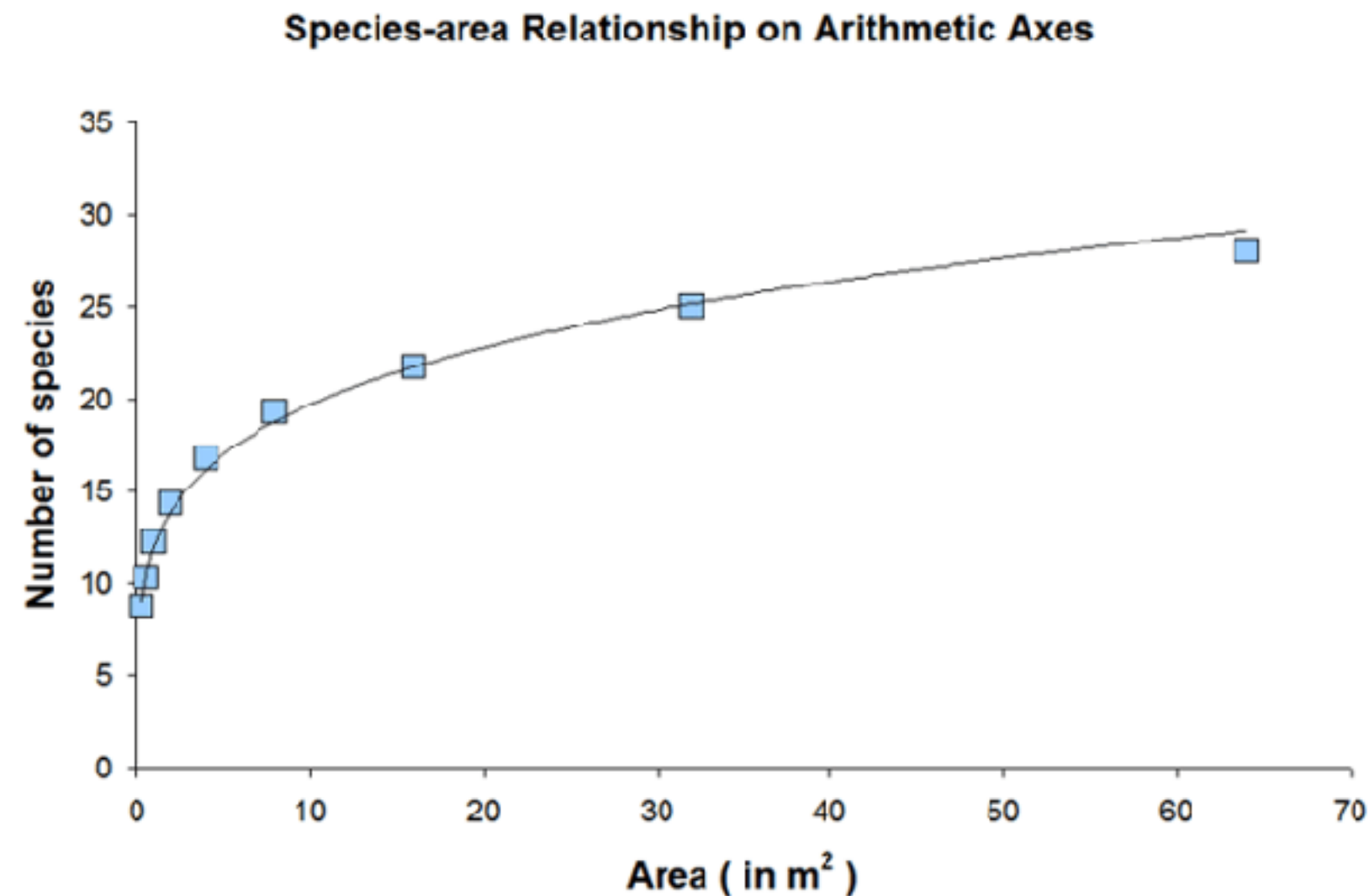
An ecosystem is comprised of all the non-living elements and living species in a specific local environment. Components of most ecosystems include water, air, sunlight, soil, plants, microorganisms, insects and animals.

That could be a description of a city. Or not (perhaps depending on the city).

But perhaps more importantly, does thinking explicitly about cities as ecosystems help us? Does it offer us any insight into urban design? For example, are our goals for cities—sustainability, resilience, livability, and justice—advanced by an urban ecosystem concept?

<https://www.thenatureofcities.com/2017/06/30/cities-ecosystems-analogous-natural-ones-nature-infrastructure-people-thinking-cities-way-help-us-think-urban-design/>

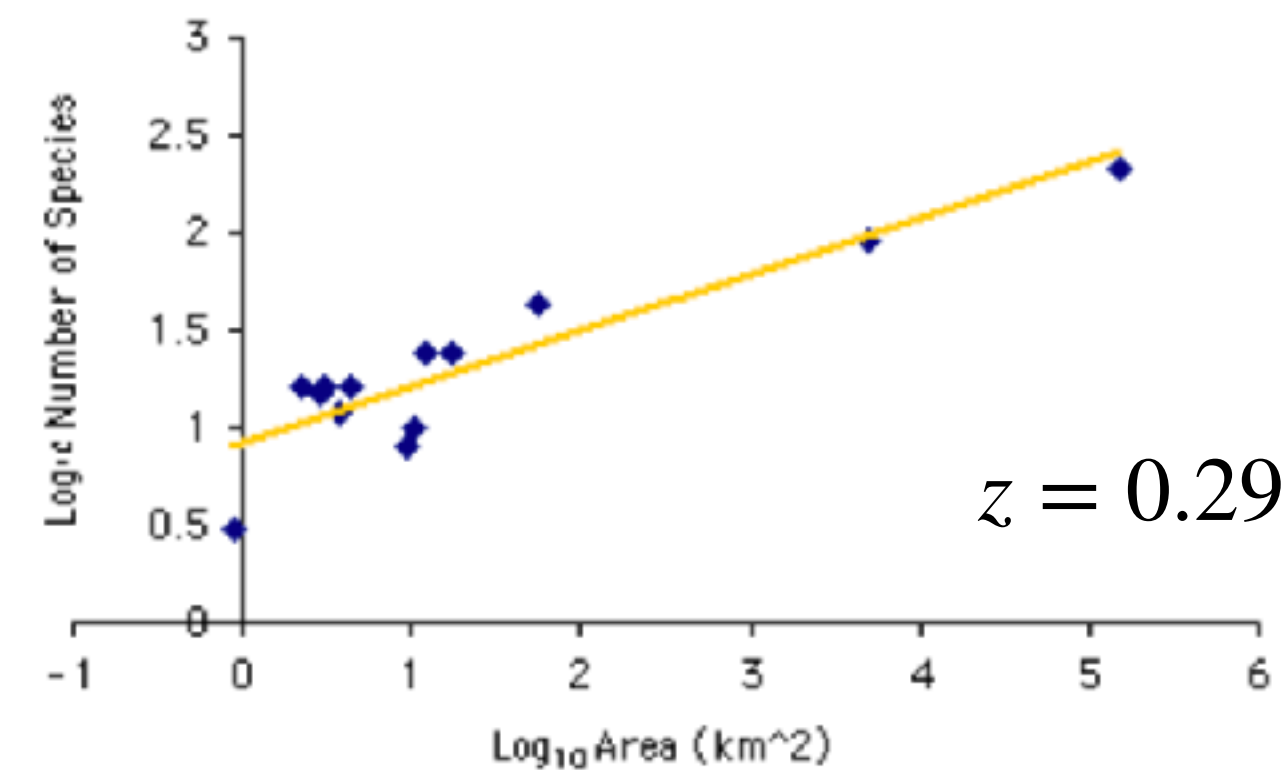
A law of diversity in nature



Species-Area Law

$$D = cA^z \quad z \sim 1/4$$

number of species vs.
habitat area

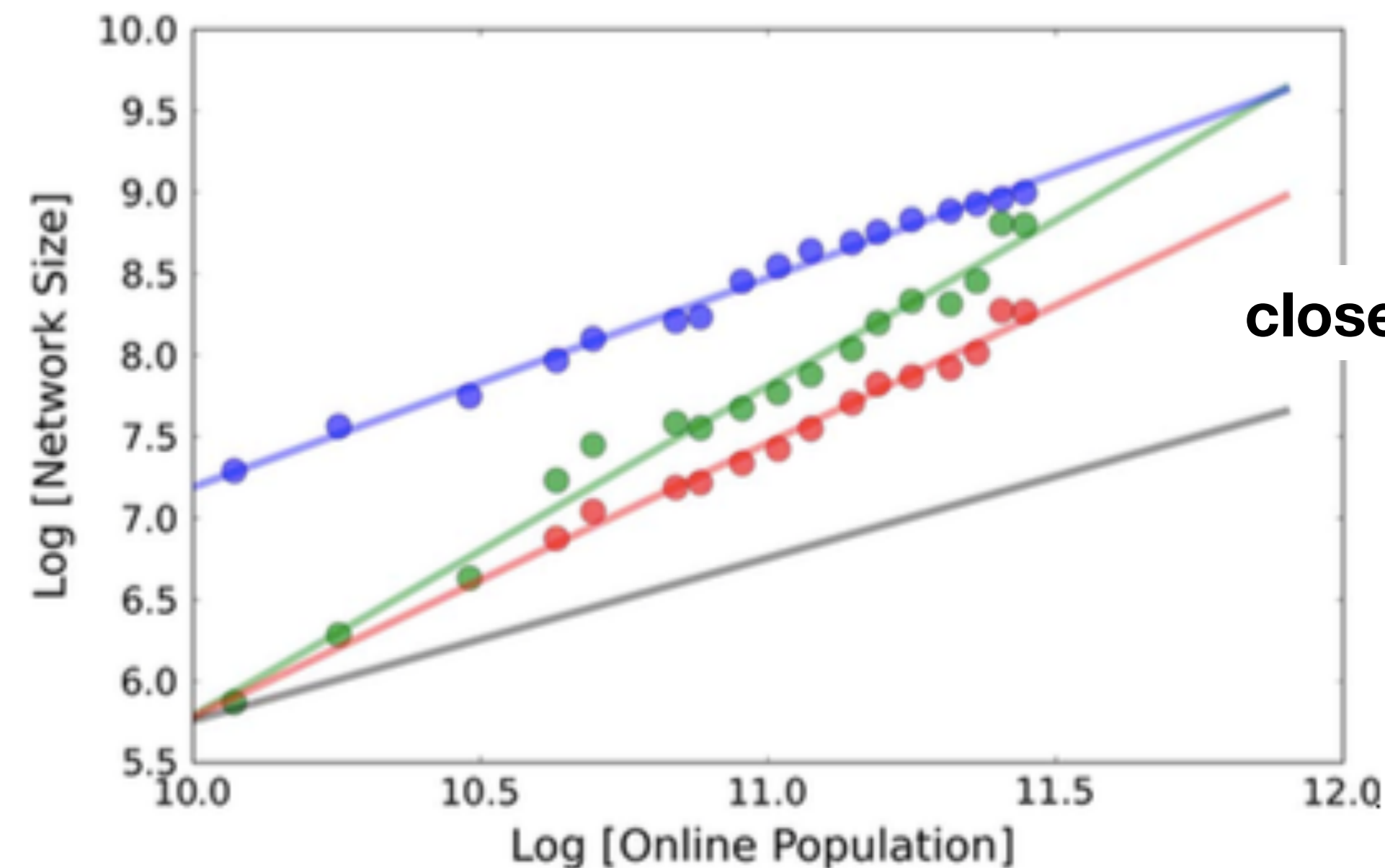


Browne and Peck 1996
credit: Louis J. Gross

Cities show much greater diversity and much greater power density (achievable by importing resources)

$$D = cN^{5/6}$$

Internet?

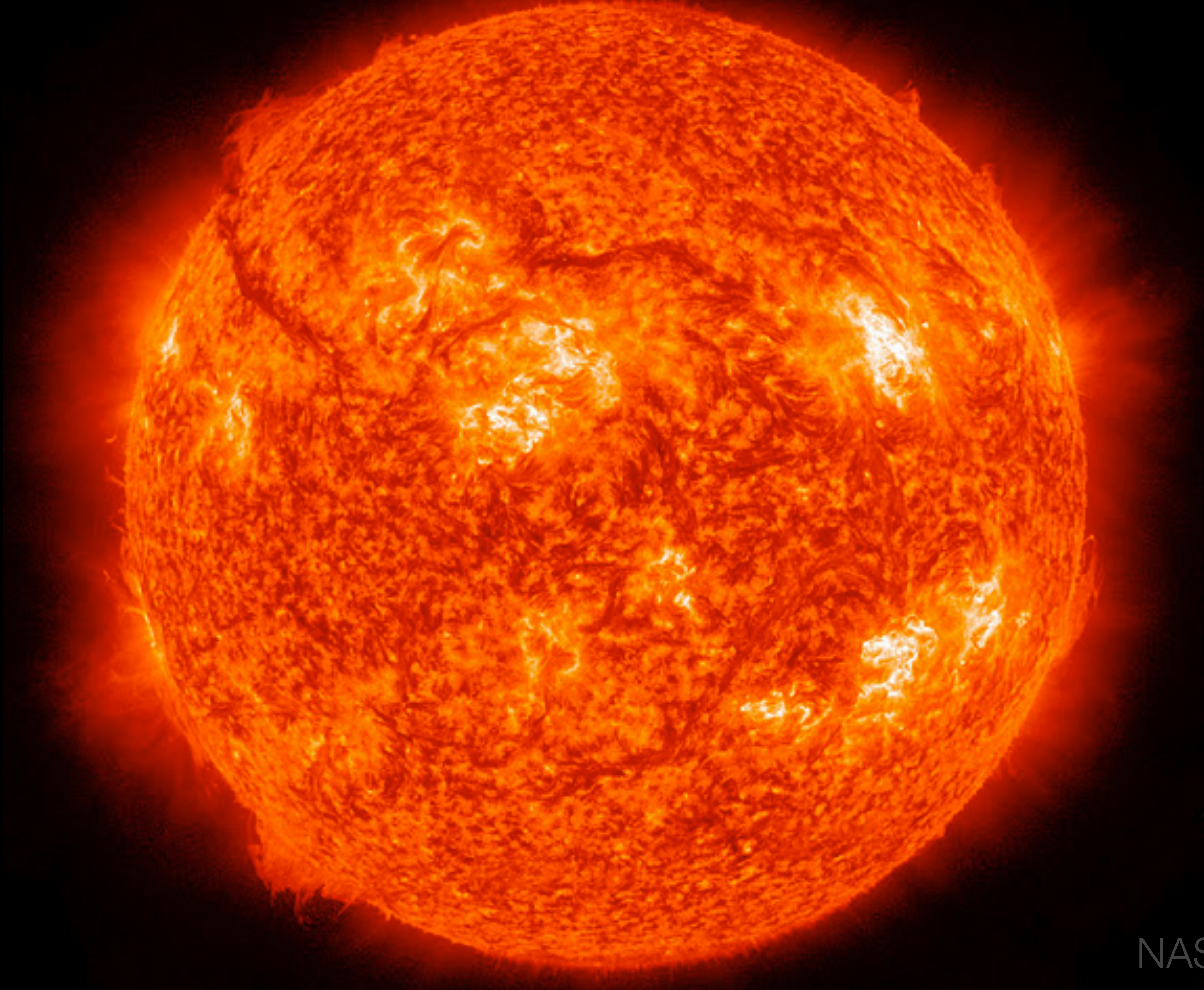


closer to Metcalfe's law

There is no physical space on the internet...

Fig. 3. *Scaling of global computer networks with online population size. The size of the Internet, measured in terms of DNS hosts (blue) is characterized by an exponent 1.28 (95% CI = [1.22, 1.34], $R^2 = 0.99$), while the growth of the WWW, in terms of an estimate of total webpages (green), is characterized by an exponent 2.03 (95% CI = [1.88, 2.17], $R^2 = 0.98$) and of active pages (red) by an exponent 1.68 (95% CI = [1.55, 1.82], $R^2 = 0.98$). In all cases, the size of online networks has been growing superlinearly with the number of Internet users, indicating that more pages and more computation is effectively used per capita as the network grows, much like in other open-ended social systems (e.g., cities). Exponents are manifestly different from those observed for cities.*

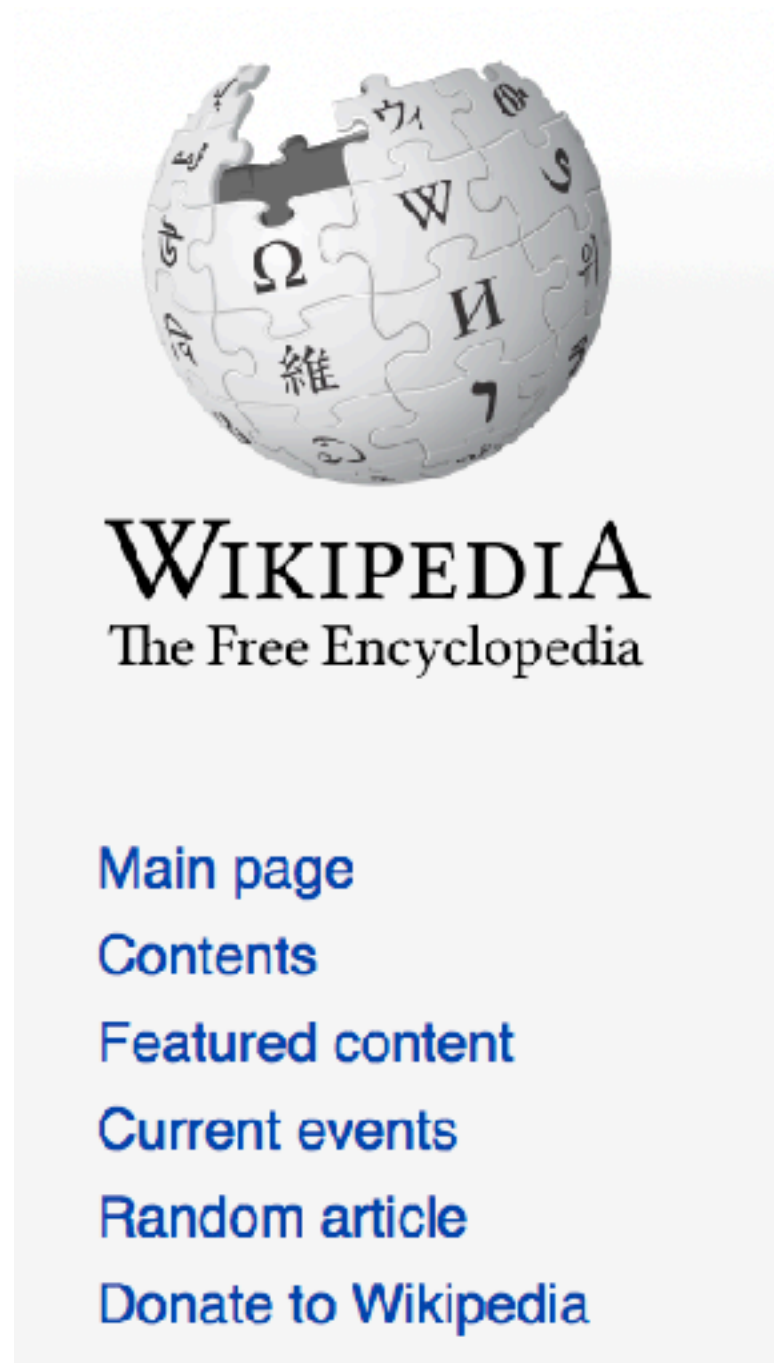
Stars?



NASA

For Stars

Light is Superlinear on Mass



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Mass–luminosity relation

From Wikipedia, the free encyclopedia

In [astrophysics](#), the **mass–luminosity relation** is an equation giving the relationship between a star's mass and its [luminosity](#), first noted by [Jakob Karl Ernst Halm](#).^[1] The relationship is represented by the equation:

$$\frac{L}{L_{\odot}} = \left(\frac{M}{M_{\odot}} \right)^a$$

where L_{\odot} and M_{\odot} are the luminosity and mass of the Sun and $1 < a < 6$.^[2] The value $a = 3.5$ is commonly used for [main-sequence stars](#).^[3]

different exponents !

More massive stars burn brighter per unit mass, live shorter lives.



networks that act “a bit” like stars

credit: NASA 2012

Cities are
general-purpose
“Social Reactors”

They intensify and sustain rates of large scale social interactions of all kinds

What for? Who benefits? What about inequality?



Shutterstock

Scientific Proof That Cities Are Like Nothing Else in Nature

EMILY BADGER JUN 20, 2013

<https://www.bloomberg.com/news/articles/2013-06-20/scientific-proof-that-cities-are-like-nothing-else-in-nature>