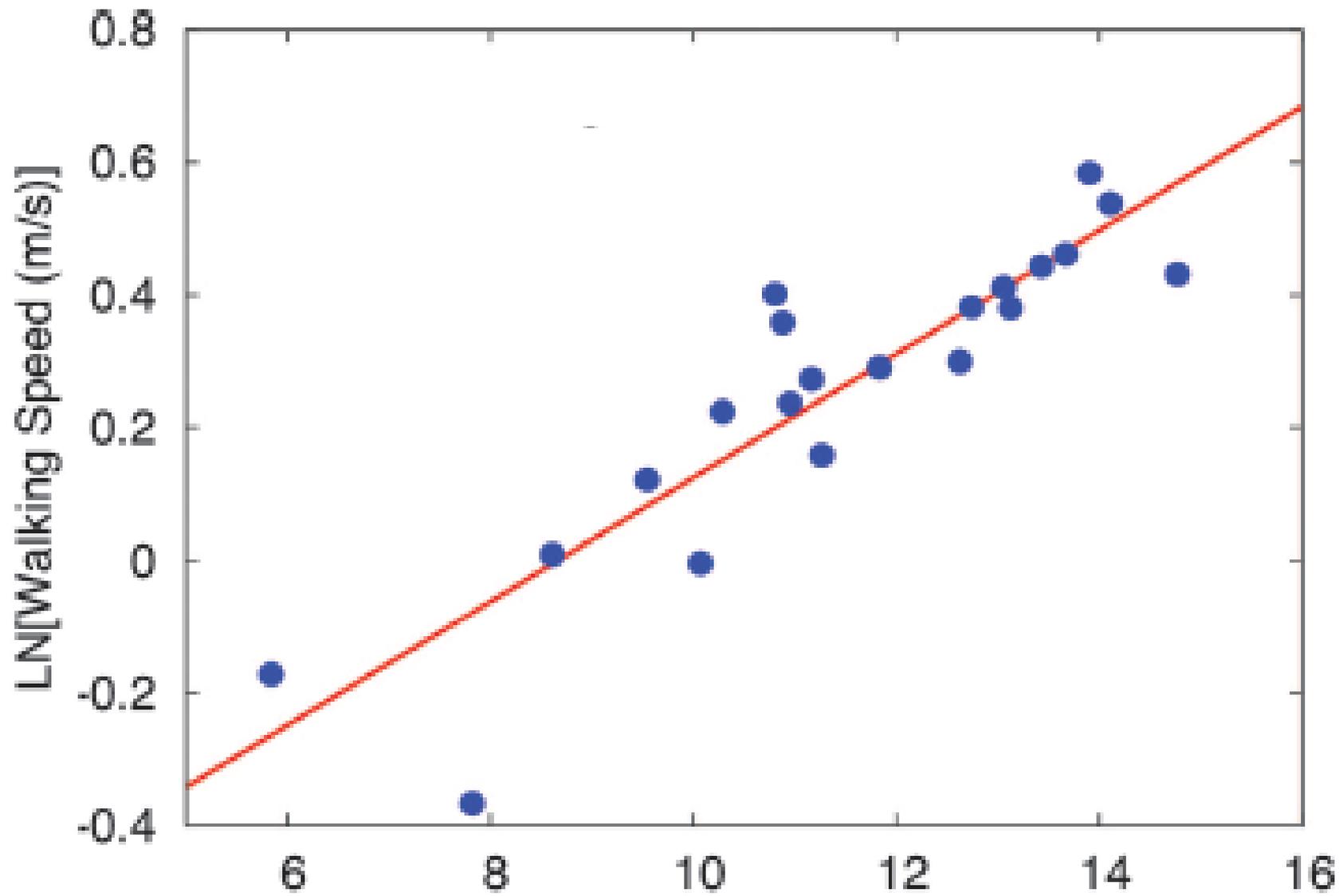
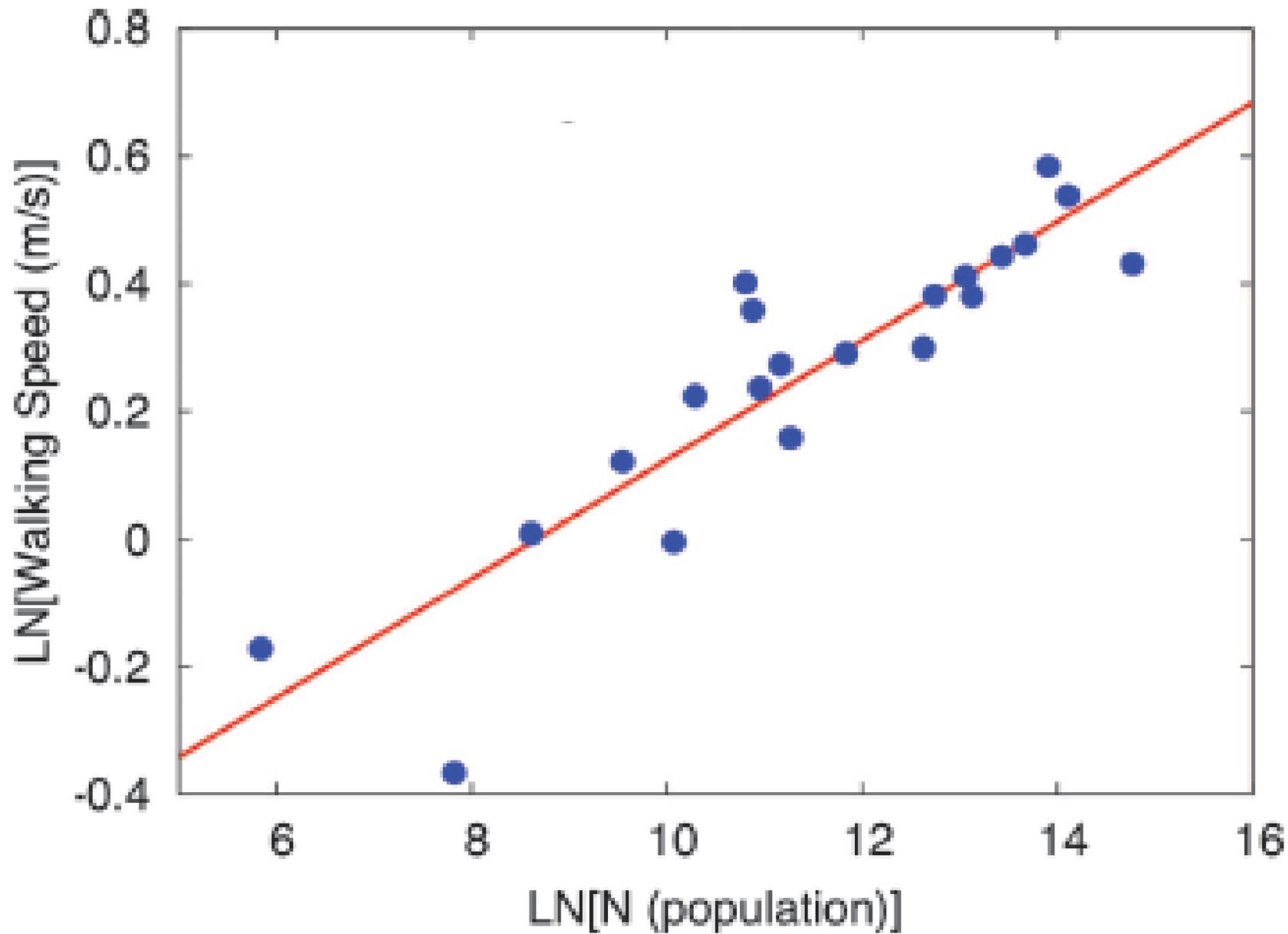


# Main Points

- 1) **Homo sapiens as just another mammal**
  - analogies between individuals and cities
  - metabolism, allometry, and life histories revisited
  - the production of extra-metabolic energy
  - energy consumption as a predictor of life histories
  
- 2) **The appealing oxymoron of sustainable development**
  - Brown et al: wealth as a predictor of energy consumption
  - the Malthusian-Darwinian dynamic, failed societies, and alternatives to technological bail-outs for the third chimpanzee
  
- 3) **Traditional versus modern conflicts**
  - predictors of armed conflict in the third chimpanzee
  - the phenomenon of genocide in Class Mammalia
  - xenophobia, and why we should not try to solve one of the biggest mysteries in biology
  
- 4) **Cumulative final: Wednesday 16 December at 115pm in this room. Study session for final is Wednesday 9 December.**
  
- 5) **Monday and Wednesday 7 and 9 Dec = optional test 3. If you are in Monday's lab and opt to take test 3, you are free to take test 3 between the hours of 2-5pm on Wednesday. Email Anne-Marie about when you will take the final. If you are in Wednesday's lab and opt to take test 3, you will take test 3 Monday at 110pm. This test will cover material through 2 December.**
  
- 6) **Yet again, an opportunity for extra credit in this class**

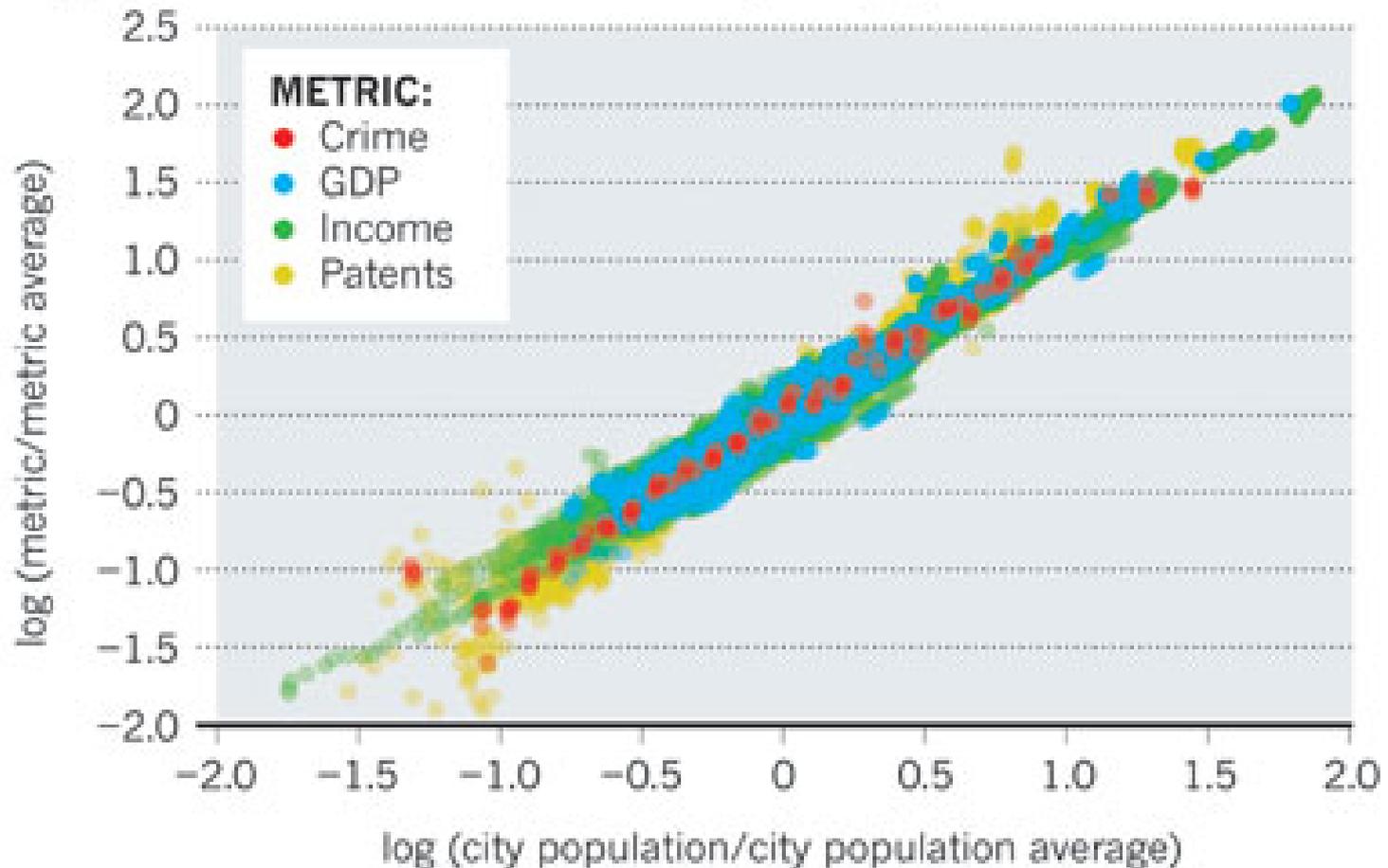


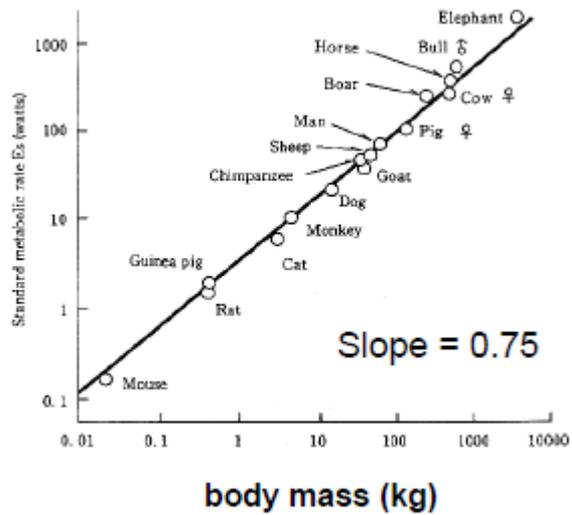
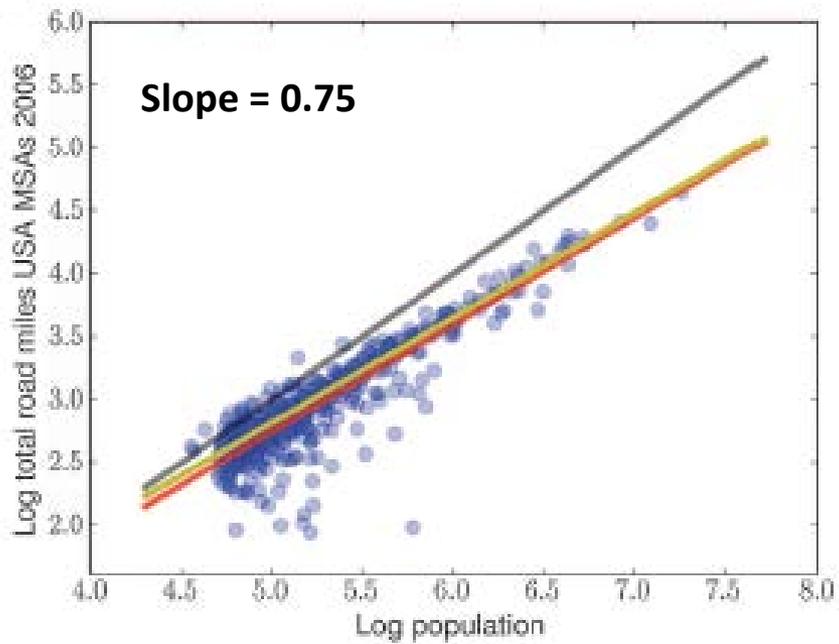


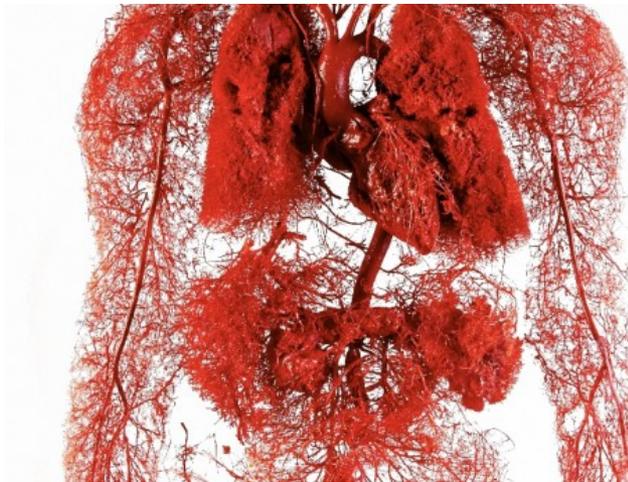
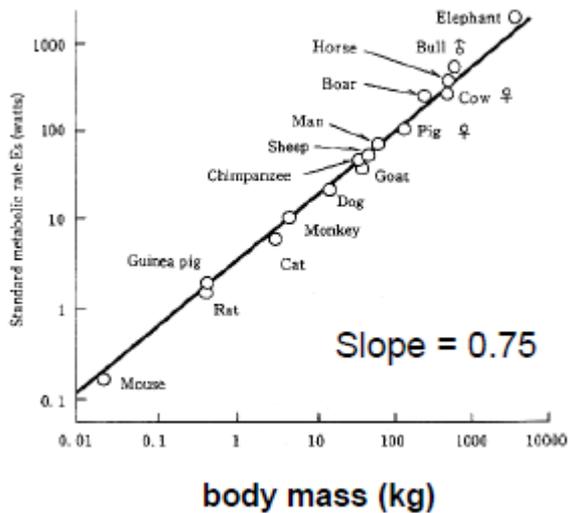
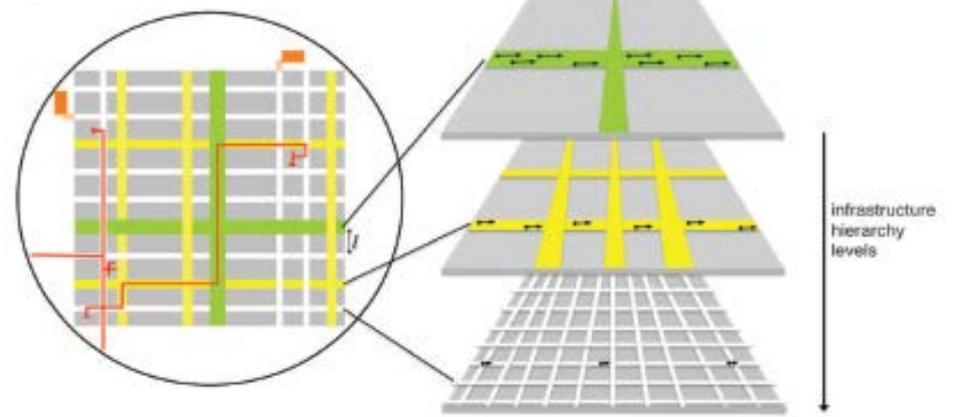
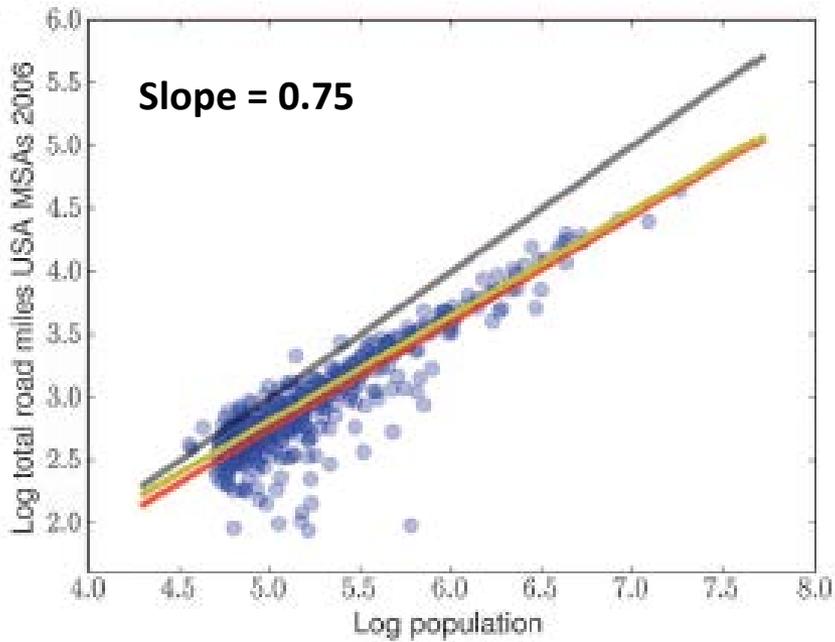
# Shifts toward cities

## PREDICTABLE CITIES

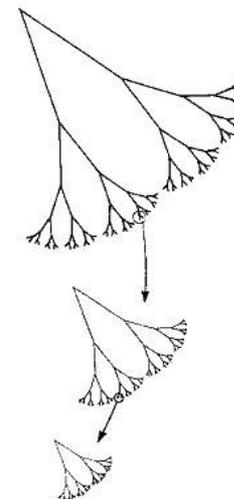
Data from 360 US metropolitan areas show that metrics such as wages and crime scale in the same way with population size.







Self-Similar Structure (Fractal)



**The Networks**

CIRCULATORY SYSTEM

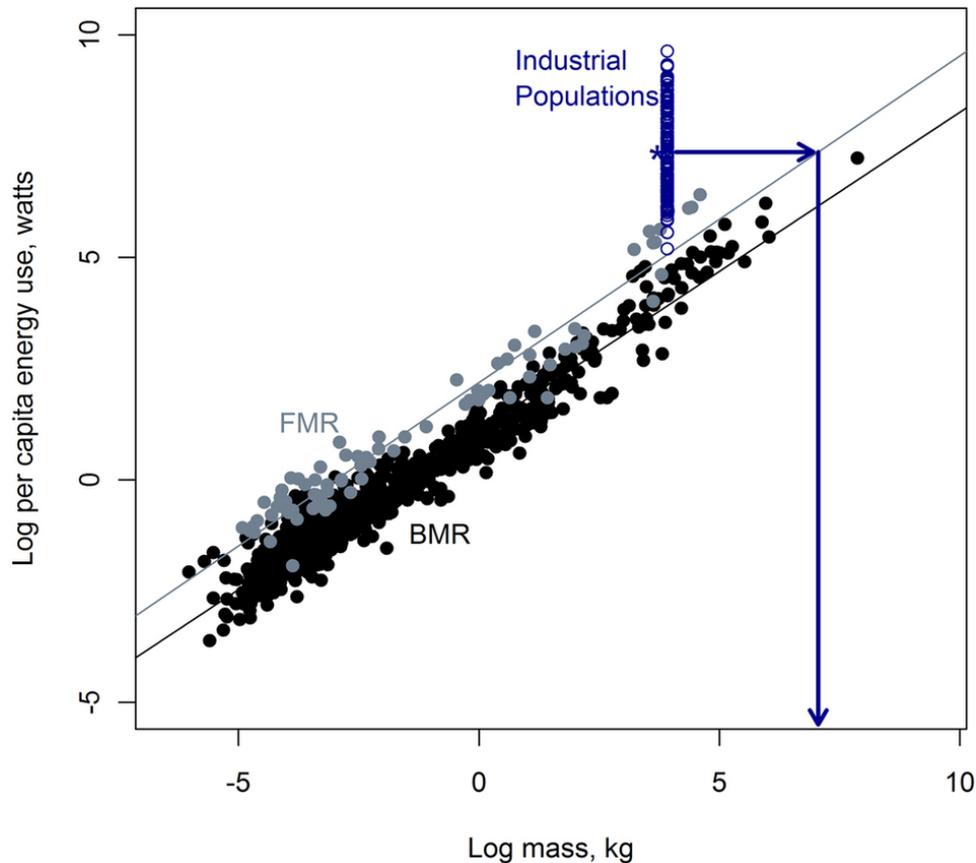
LUNGS

TREE BRANCHES

The scientists who developed the scaling theory took clues from naturally occurring networks that carry life-sustaining fluids in organisms in which each small part is a replica of the whole. No matter how big the organism, the ends of these fractal networks are always the same size, since individual cells are of similar size in all organisms.

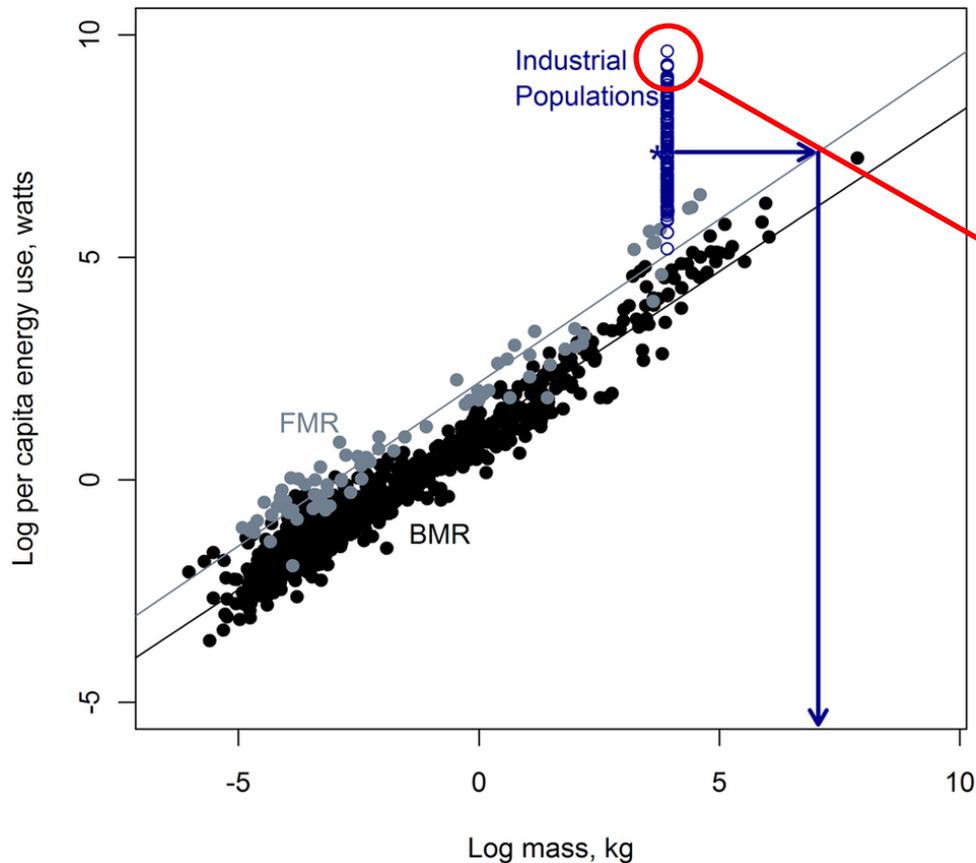
# Metabolism and body size

- Median energy consumption of industrialized H. sapiens is roughly 10x the expectation for a non-human mammal of the same size



# Metabolism and body size

- **Magnitude and pace of this increase is unprecedented, because it occurred without an increase in human body mass**

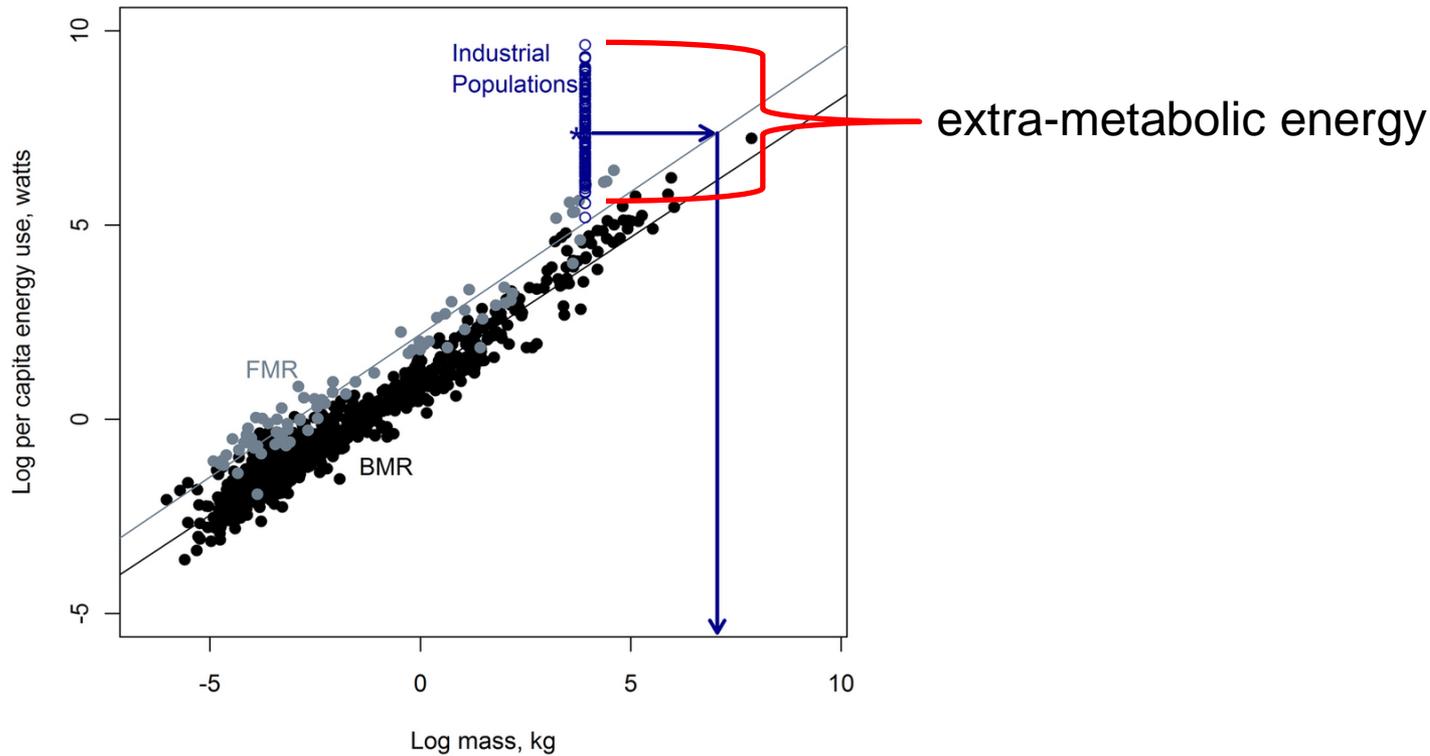


two sperm whales (92,500 kg)



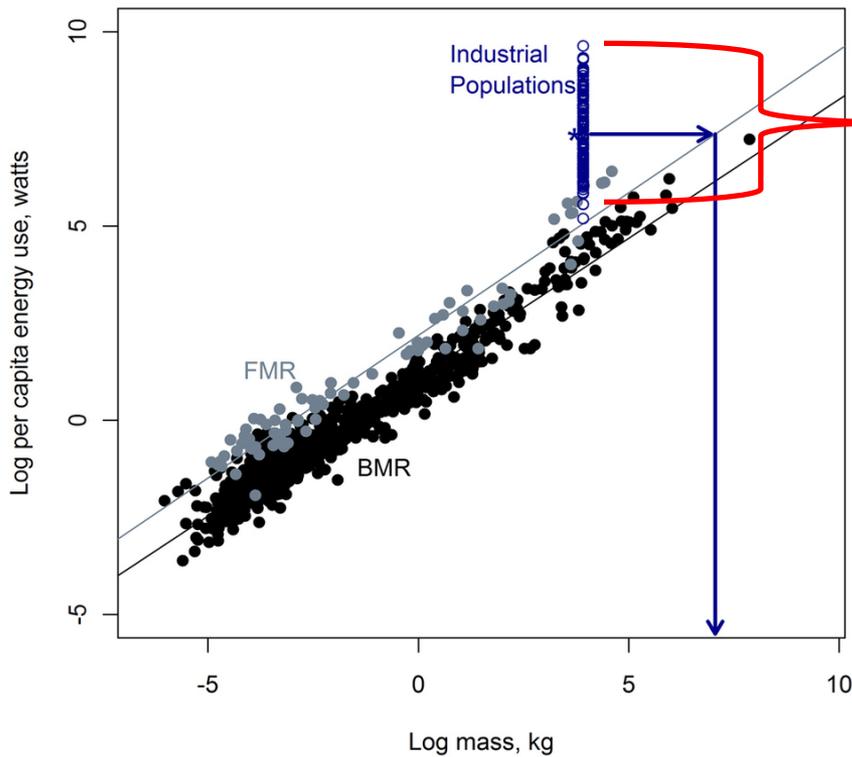
# Metabolism fuels life history and demography

- for non-human mammals, energy use approximates caloric intake and digestion (i.e., metabolism)

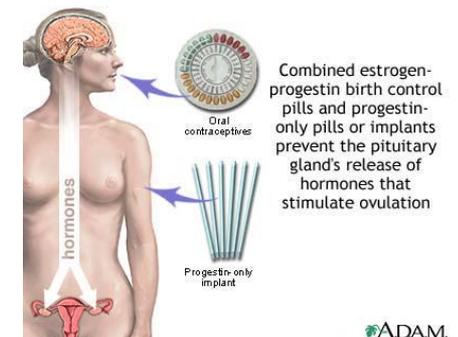


# Metabolism fuels life history and demography

- for non-human mammals, energy use approximates caloric intake and digestion (i.e., metabolism)
- industrial environments provide goods and services that alter demography without changing metabolism (i.e., extra-metabolic energy)

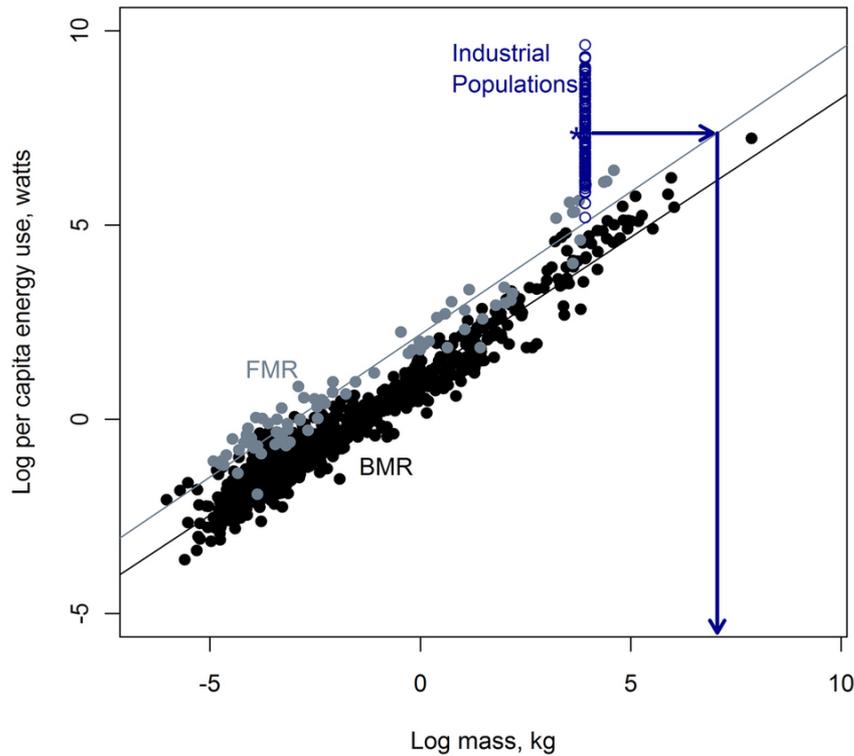


extra-metabolic energy



# Body size, wealth, and life histories

- energy use is a function of body size for non-human mammals, so demographics and life histories are constrained by body size in non-human mammals



# Body size, wealth, and life histories

- any trait that scales with body size can be expressed as a function of energy use
- for humans, can energy use (both metabolic and extra-metabolic combined) predict life history variables?

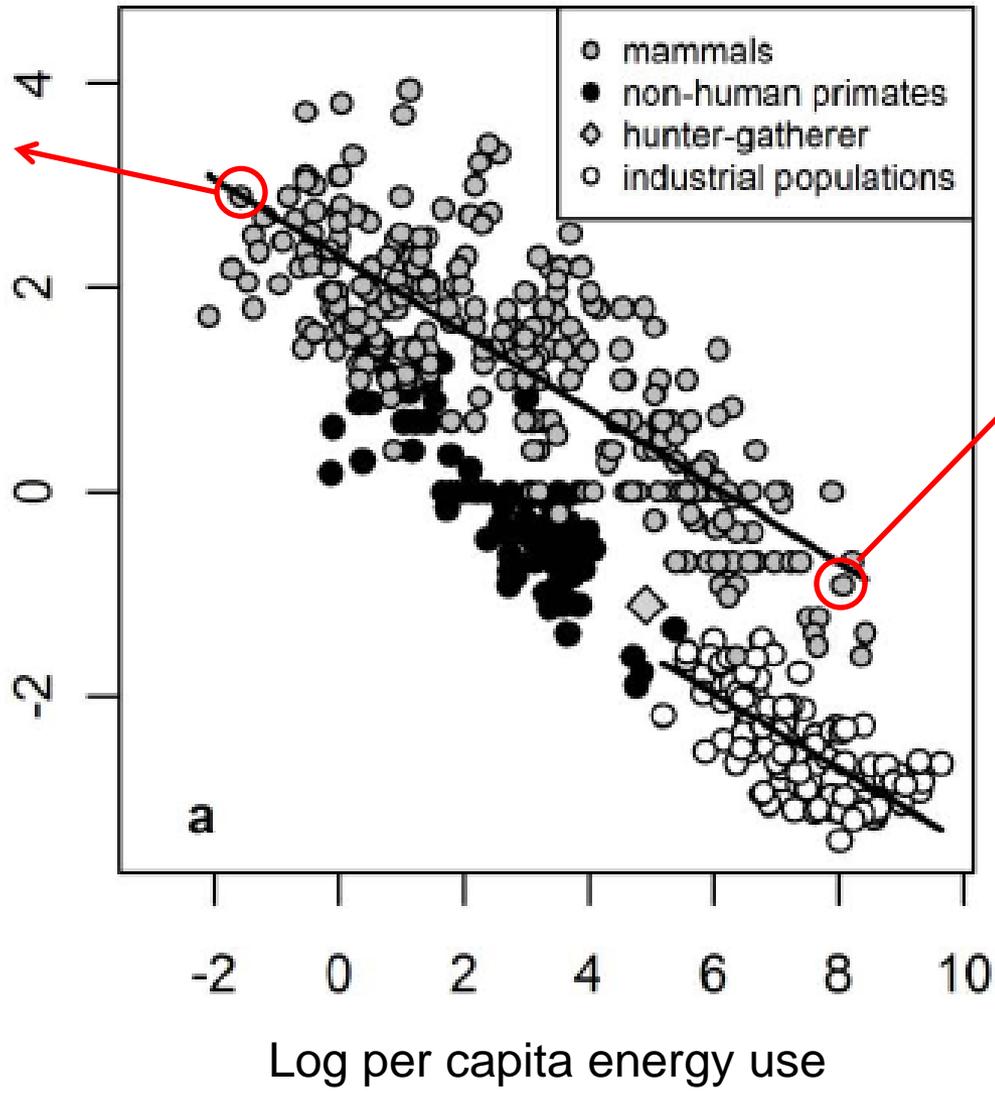
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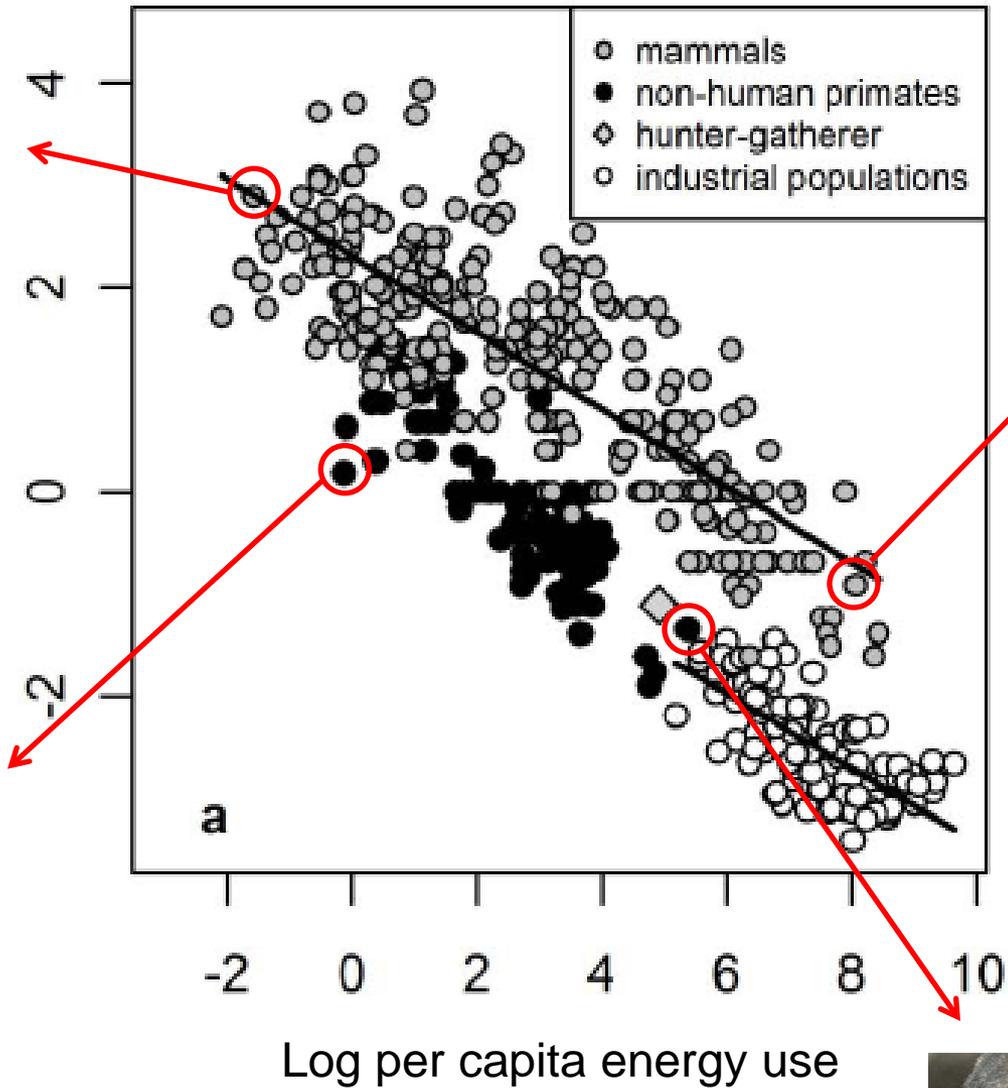


Log births per year



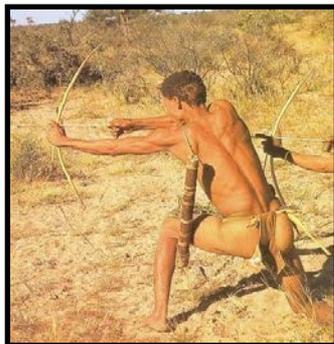
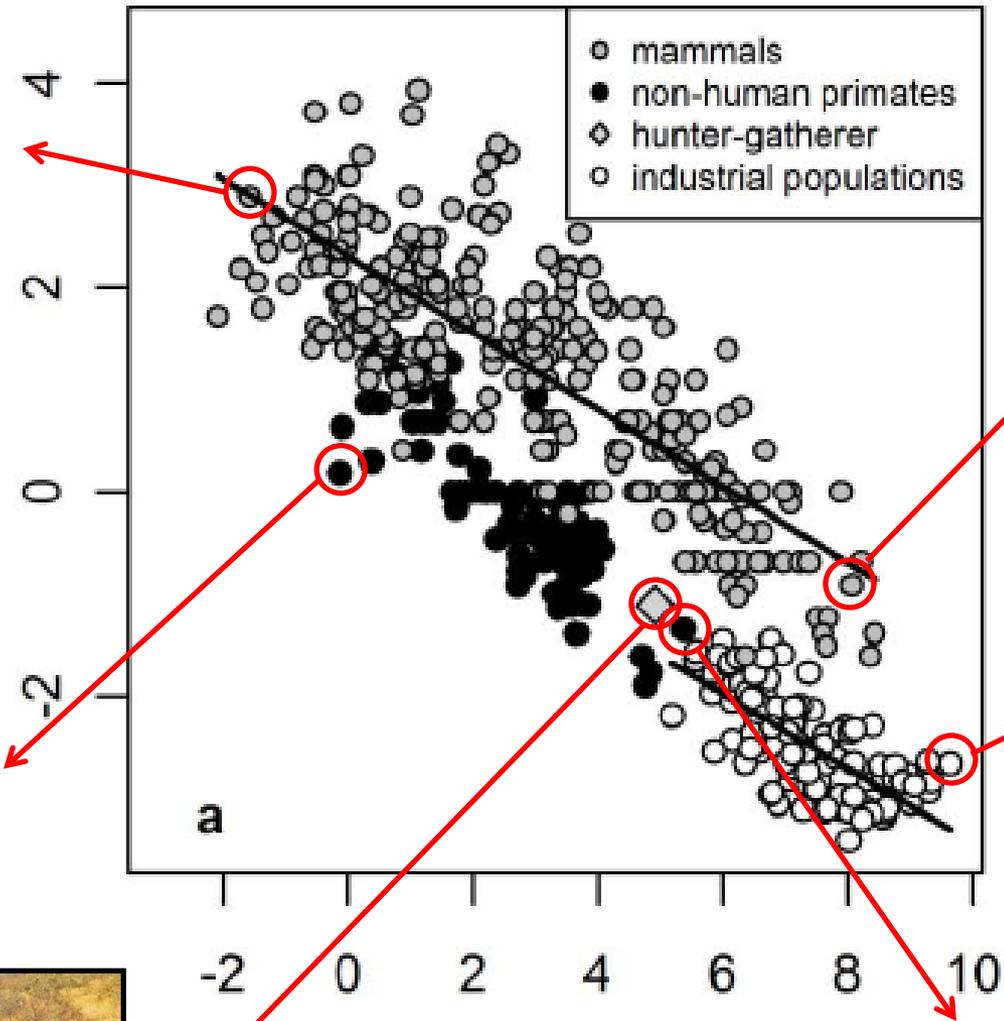


Log births per year





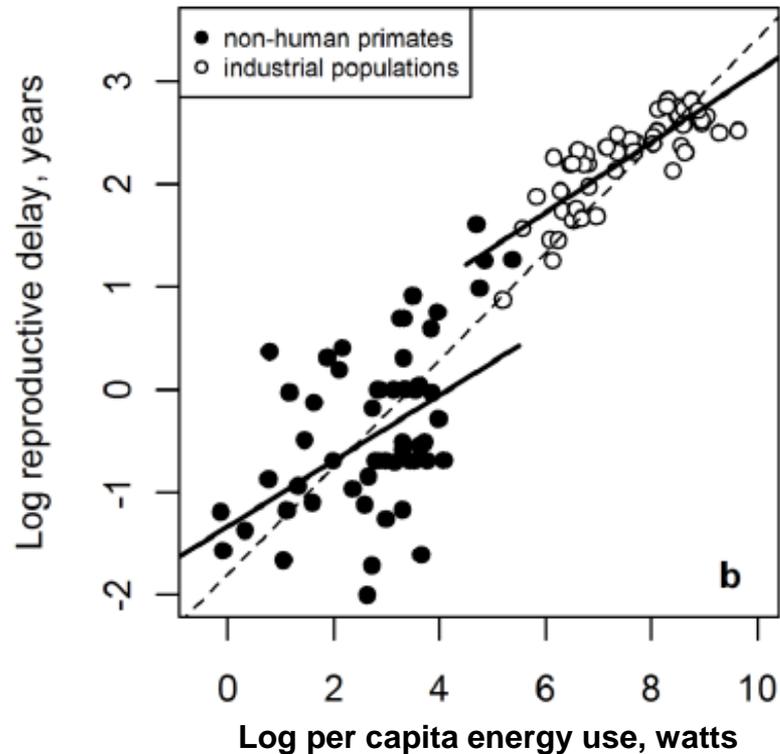
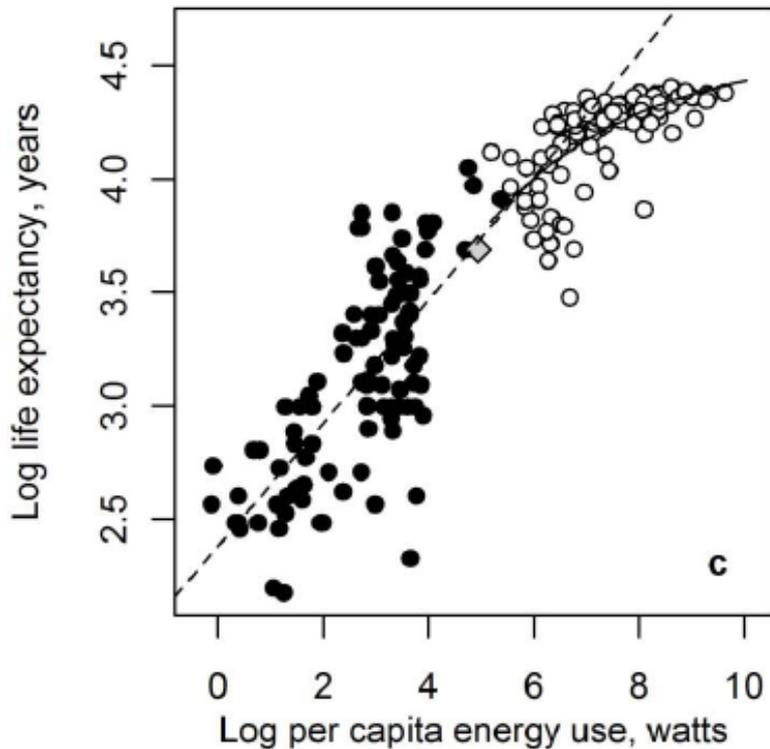
Log births per year



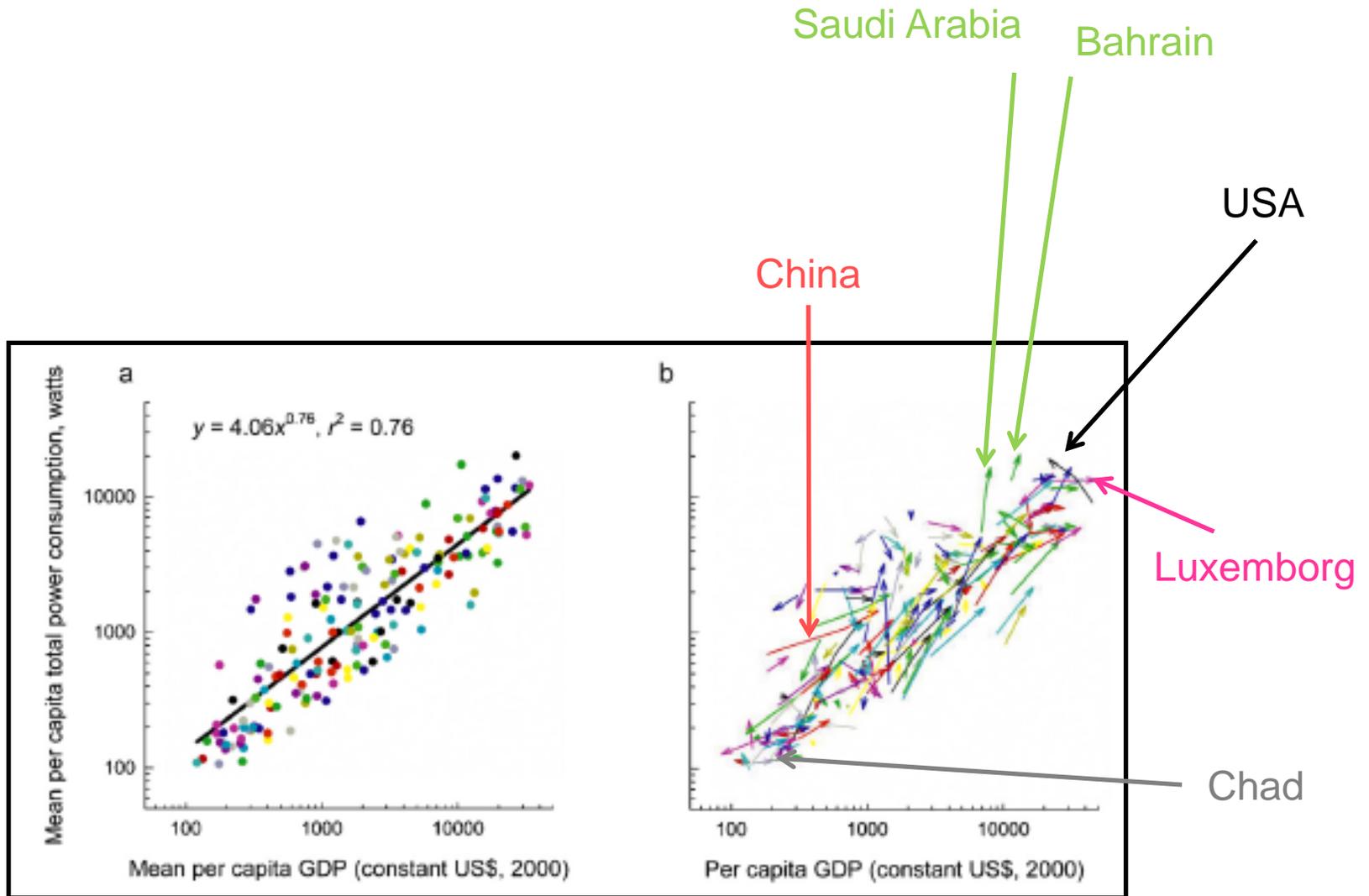
Log per capita energy use

# Body size, wealth, and life histories

- life expectancy and reproductive delay are strongly related to energy use

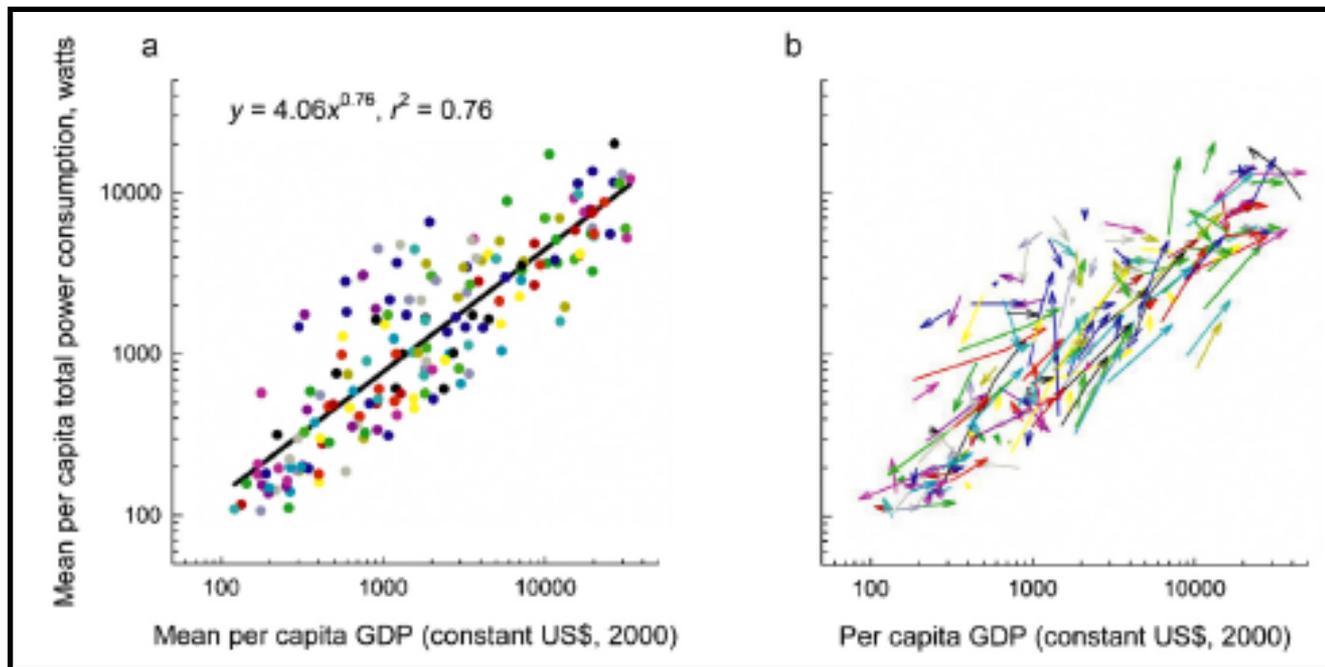


# Body size, wealth, and life histories

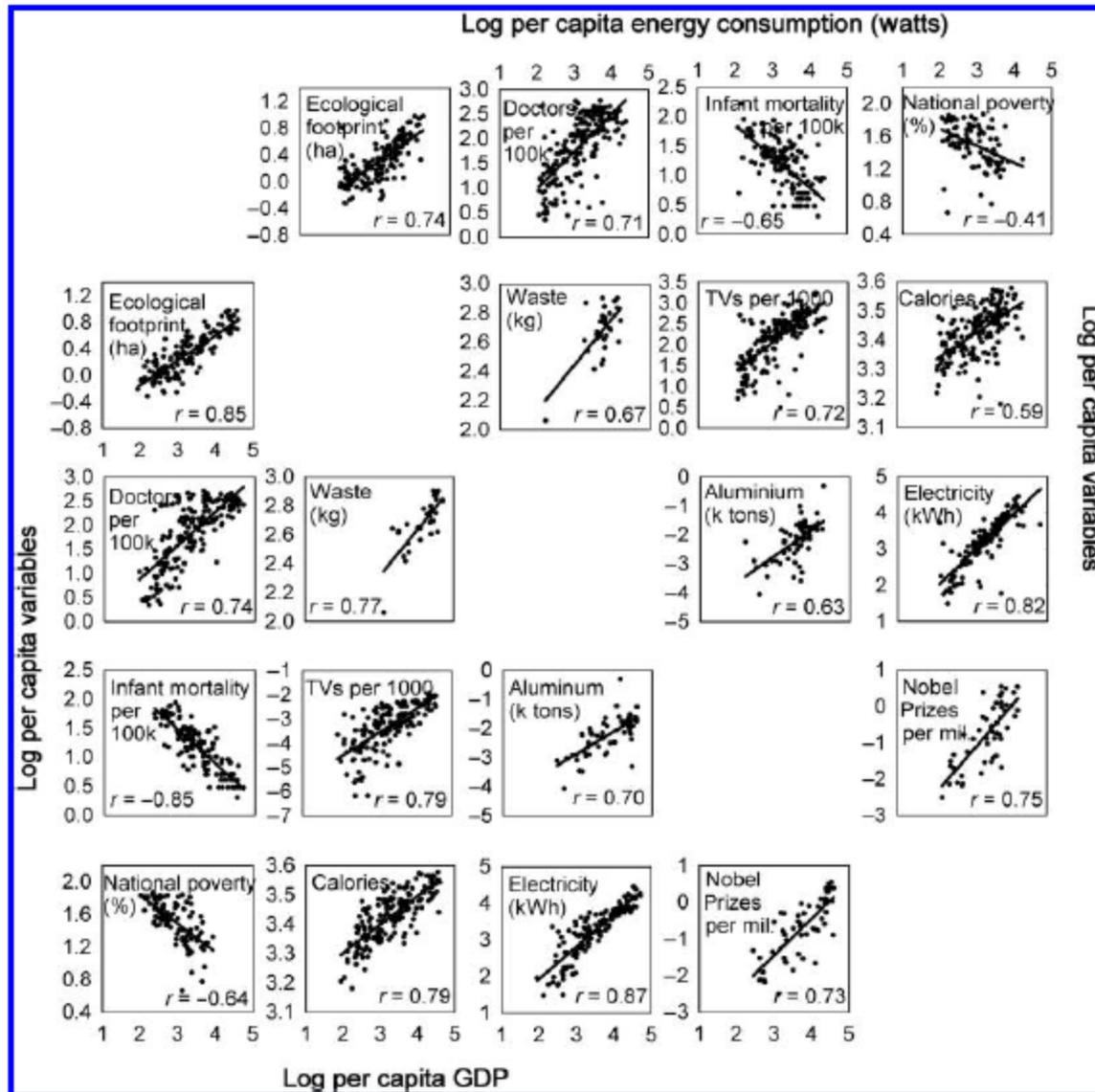


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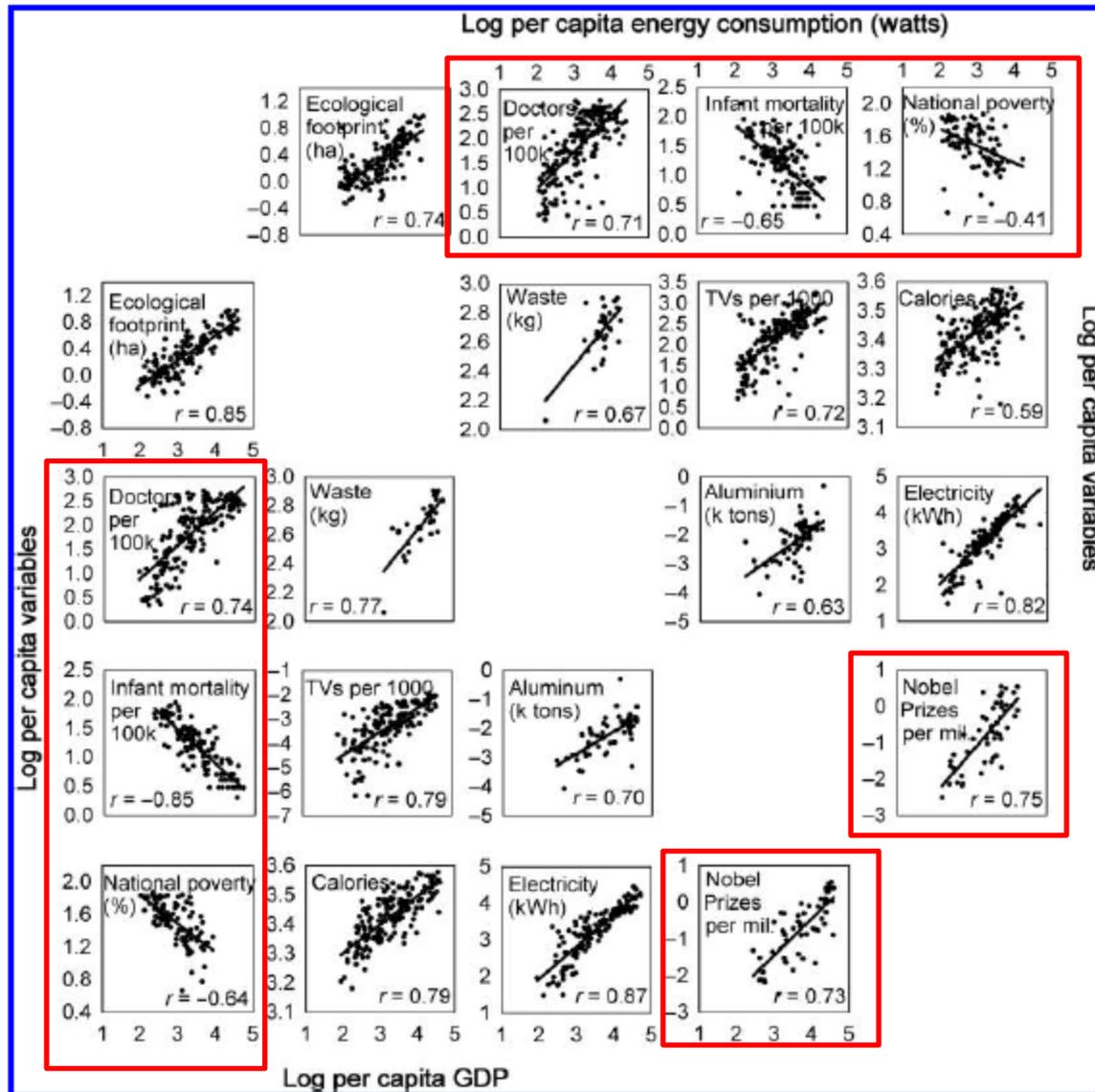
Discussion Q: why did Brown et al plot energy consumption as a function of GDP, as opposed to the other way around? Do you agree with this?



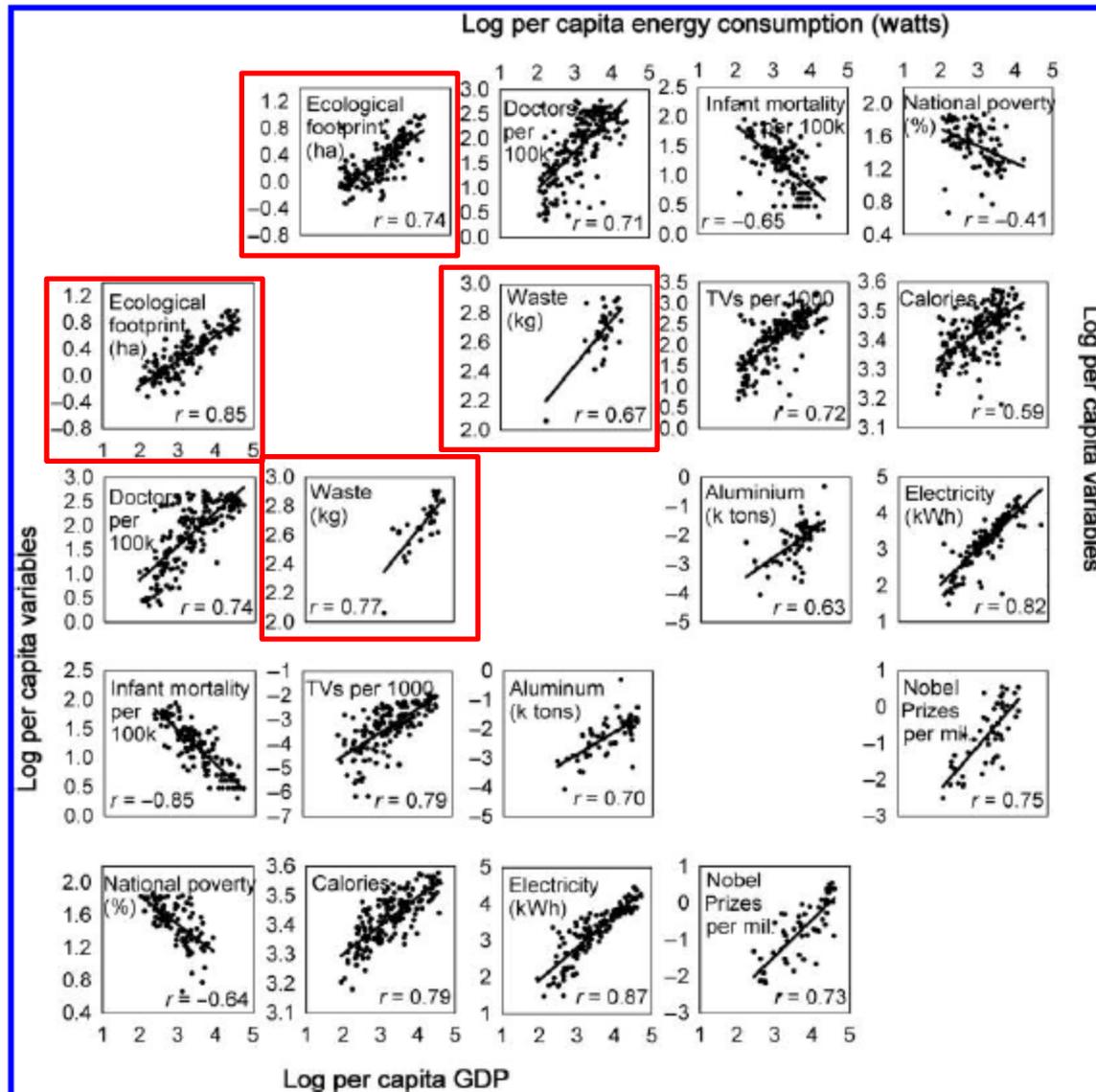
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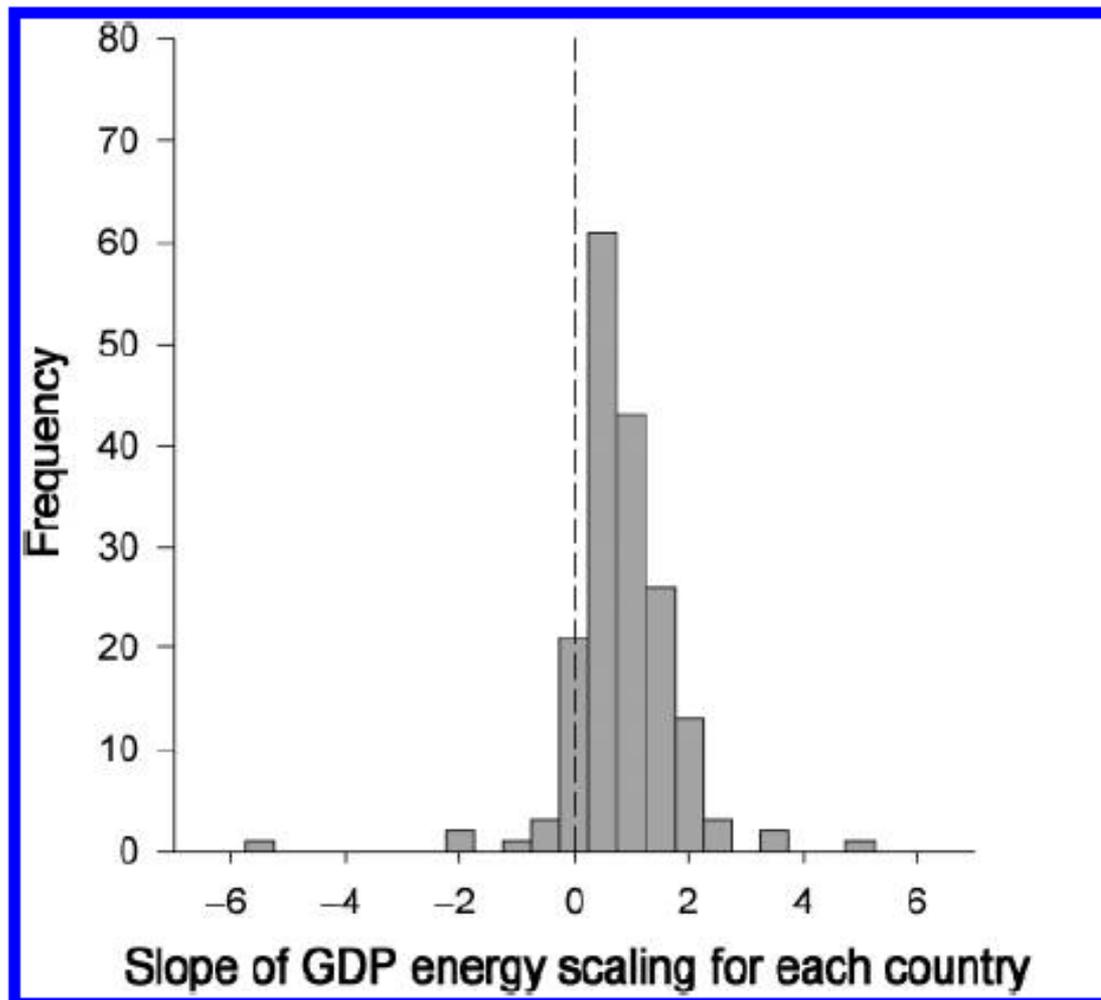


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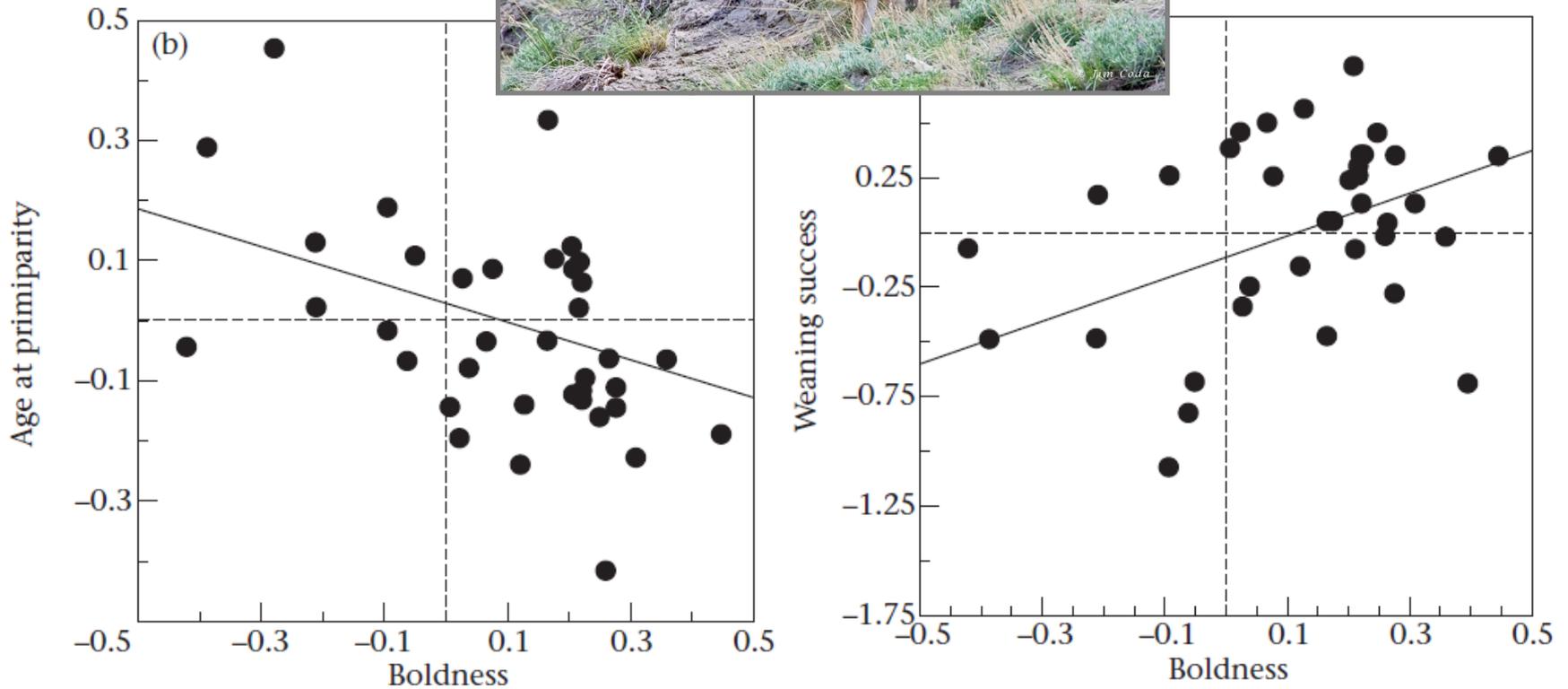


# Energetic limitations to economic growth

- standards of living (as indexed by GDP) are increasing through time



# Bold/aggressive personalities and fitness



# Bold/aggressive personalities and fitness



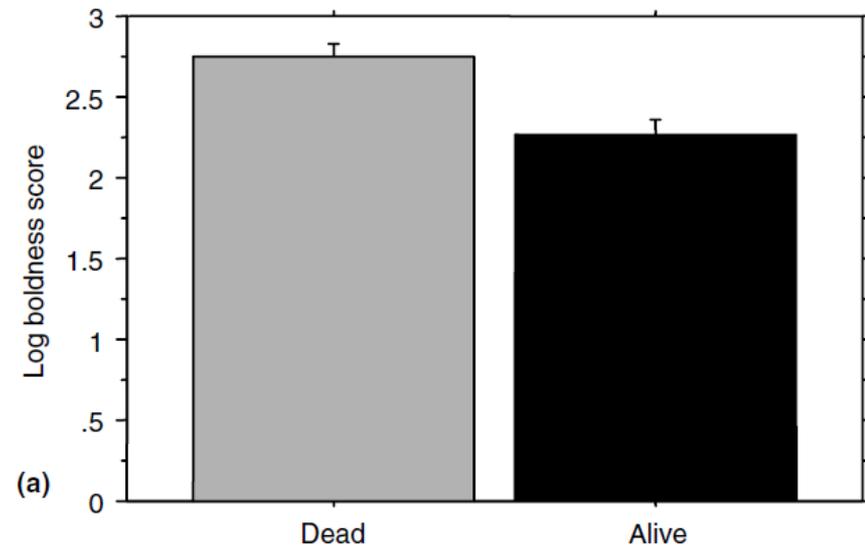
**Table 2.** Behavioural activities reflecting personality types

Bold	Cautious
2. Resting relaxed	3. Resting alert
13. Investigating	16. Hesitant approach (object)
14. Bold approach (object)	17. Hesitant approach (conspecific)
15. Bold approach (conspecific)	19. Fleeing
18. Chasing conspecific	20. Fleeing conspecific
21. Following conspecific	28. Submission
23. Pouncing on object	48. Watching conspecific
24. Pouncing on conspecific	51. Warning bark
27. Discipline	56. Watching person
29. Play chase	
30. Play flee	
31. Play fight	
32. Play stalk	
33. Playing with object	
55. Following person	

# Bold/aggressive personalities and fitness

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# **Bold/aggressive personalities and fitness**

SOME GENOCIDES, 1950-1990



Figure 13

DEATHS	VICTIMS	KILLERS	PLACE	DATE
1. xx	Indians	Brazilians	Brazil	1957-1968
2. x	Aché Indians	Paraguayans	Paraguay	1970s
3. xx	Argentine civilians	Argentine army	Argentina	1976-1983
4. xx	Moslems, Christians	Christians, Moslems	Lebanon	1975-1990
5. x	Ibos	North Nigerians	Nigeria	1966
6. xx	Opponents	Dictator	Equatorial Guinea	1977-1979
7. x	Opponents	Emperor Bokassa	Central African Republic	1978-1979
8. xxx	South Sudanese	North Sudanese	Sudan	1955-1972
9. xxx	Ugandans	Idi Amin	Uganda	1971-1979
10. xx	Tutsi	Hutu	Rwanda	1962-1963
11. xxx	Hutu	Tutsi	Burundi	1972-1973
12. x	Arabs	Blacks	Zanzibar	1964
13. x	Tamils, Sinhalese	Sinhalese, Tamils	Sri Lanka	1985
14. xxxx	Bengalis	Pakistani army	Bangladesh	1971
15. xxxx	Cambodians	Khmer Rouge	Cambodia	1975-1979
16. xxx	Communists and Chinese	Indonesians	Indonesia	1965-1967
17. xx	Timorese	Indonesians	East Timor	1975-1976

x = less than 10,000; xx = 10,000 or more; xxx = 100,000 or more; xxxx = 1,000,000 or more

SOME GENOCIDES, 1900-1950

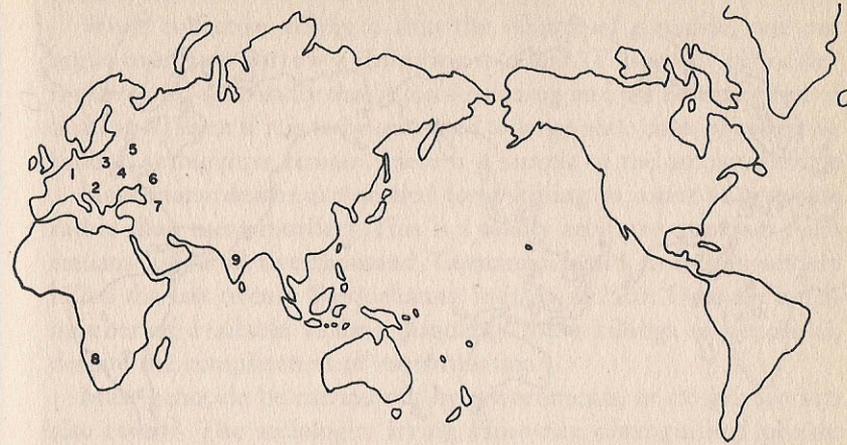


Figure 12

DEATHS	VICTIMS	KILLERS	PLACE	DATE
1. xxxxx	Jews, Gypsies, Poles, Russians	Nazis	Occupied Europe	1939-1945
2. xxx	Serbs	Croats	Yugoslavia	1941-1945
3. xx	Polish officers	Russians	Katyn	1940
4. xx	Jews	Ukrainians	Ukraine	1917-1920
5. xxxxx	Political opponents	Russians	Russia	1929-1939
6. xxx	Ethnic minorities	Russians	Russia	1943-1946
7. xxxx	Armenians	Turks	Armenia	1915
8. xx	Hereros	Germans	Southwest Africa	1904
9. xxx	Hindus, Moslems	Moslems, Hindus	India, Pakistan	1947

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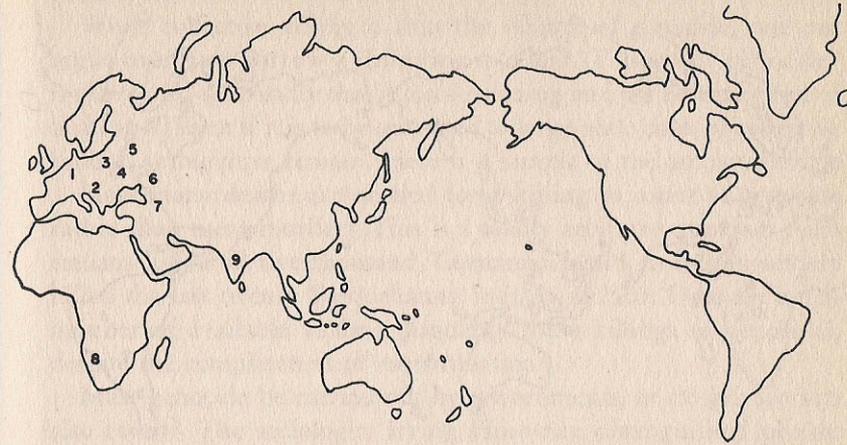


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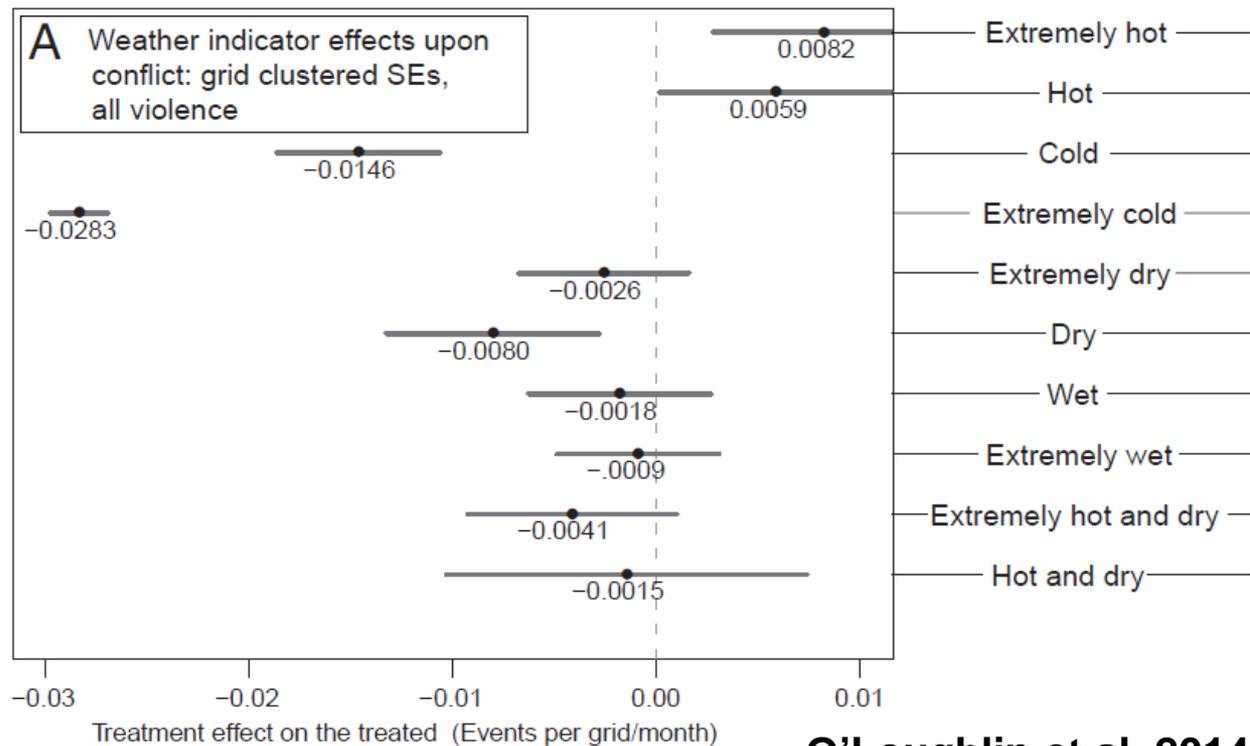


# Reasons for Genocides

- 1. Control of resources, particularly land**
- 2. Control of power**
- 3. Revenge**

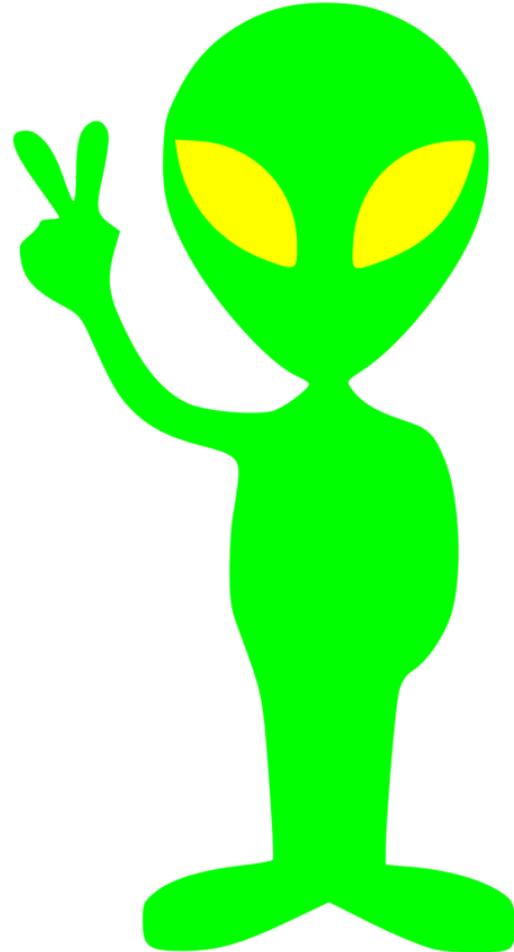
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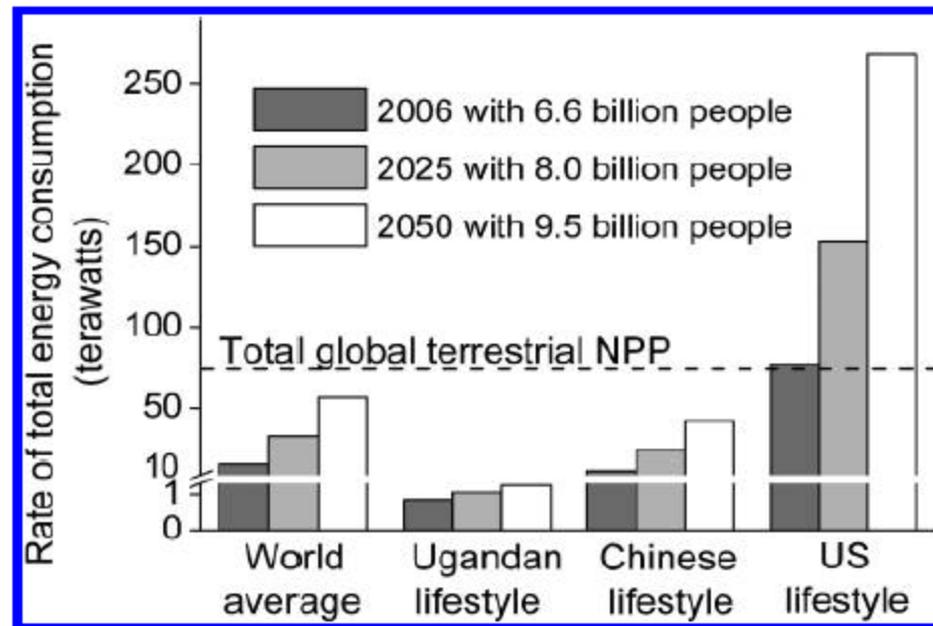
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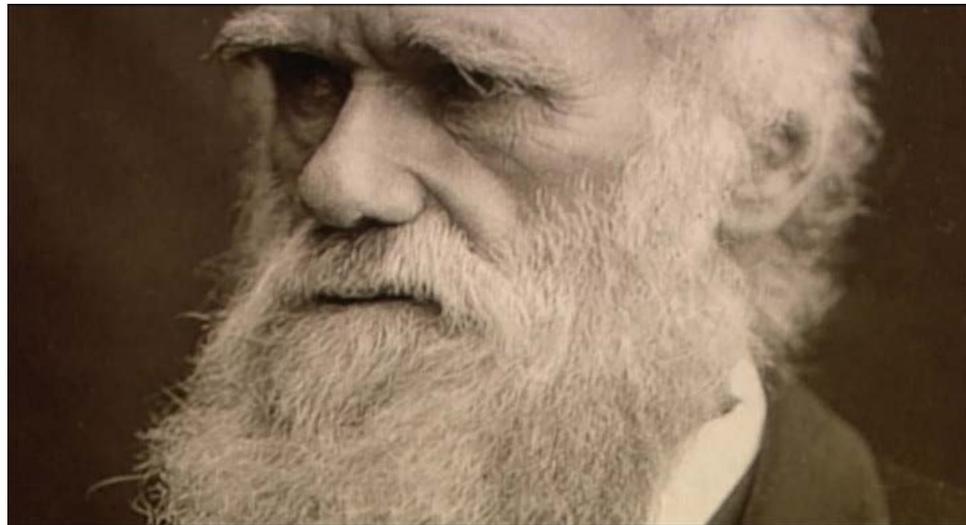
# Energetic limitations to economic growth

- **H. sapiens is projected (conservatively) to reach a global population size of 9-10 billion people by 2050**
- **Given this, there are three scenarios through which additional economic growth can be maintained**



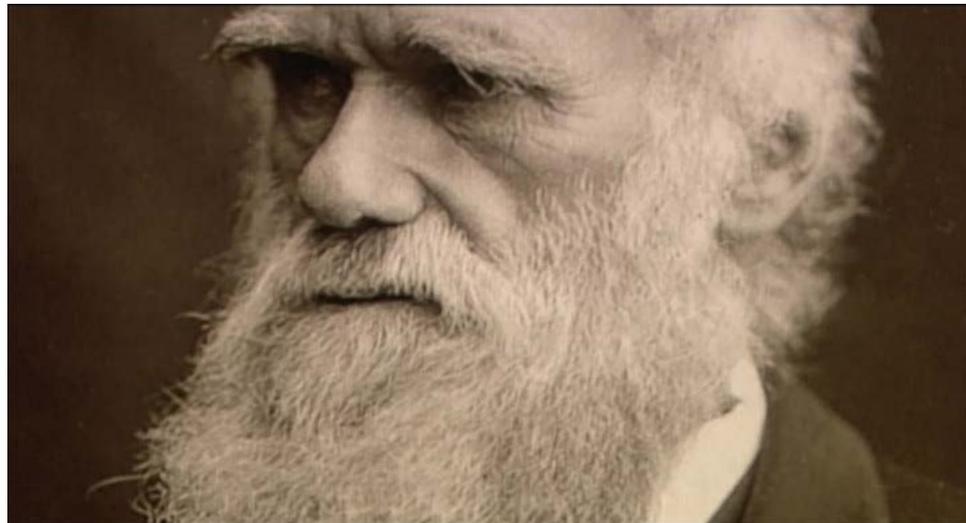
# The Malthusian-Darwinian Dynamic

- **Thomas Malthus: populations are capable of exponential growth until environmental (resource) limits are reached**
- **Charles Darwin: new adaptations (through biological and/or cultural evolution) push against these limits**



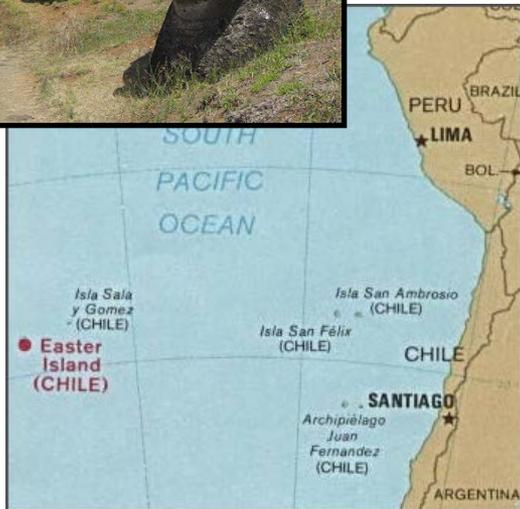
**Malthusian-Darwinian dynamic has created powerful tendencies for humans to reproduce and acquire wealth to enhance fitness and personal status.**

**Tragedy of the Commons = depletion of a shared resource by individuals that act in their own self-interests, despite their understanding that depleting the common resource is contrary to the group's long-term interests**



# 1) Technological bail-outs

Easter Island, Societal collapse ~1870



Cambodian Angkor, Societal collapse ~1400

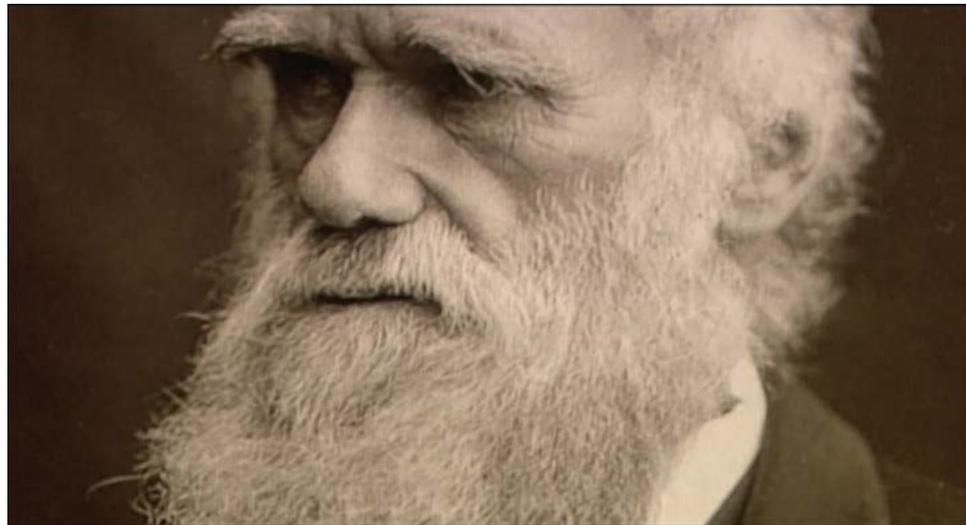


Yucatan Mayans Societal collapse ~1600



## 2) Voluntary reduction in energy use

**Malthusian-Darwinian dynamic has created powerful tendencies for humans to reproduce and acquire wealth to enhance fitness and personal status.**



### 3) Voluntary reduction in population size

**Malthusian-Darwinian dynamic has created powerful tendencies for humans to reproduce and acquire wealth to enhance fitness and personal status.**

