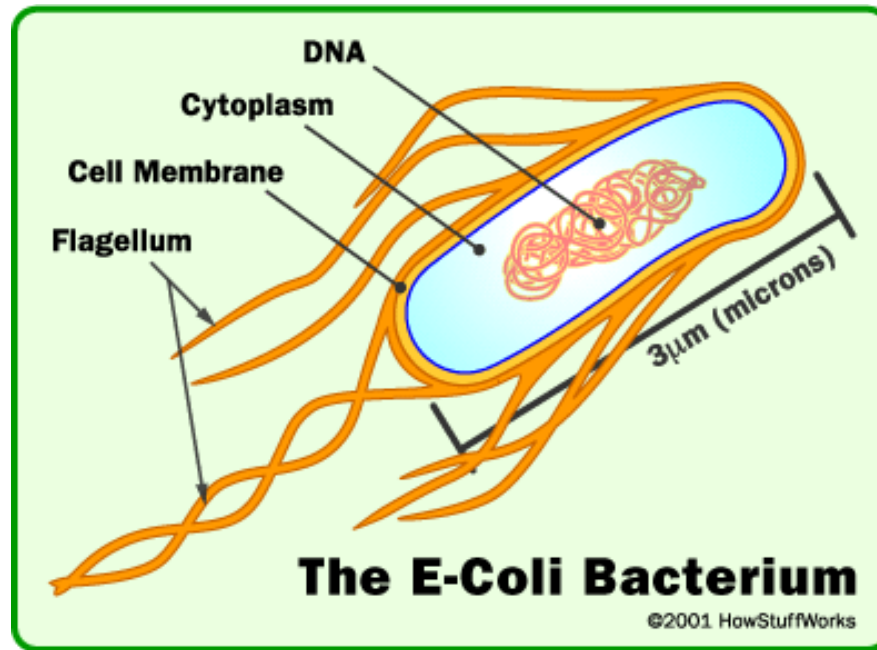


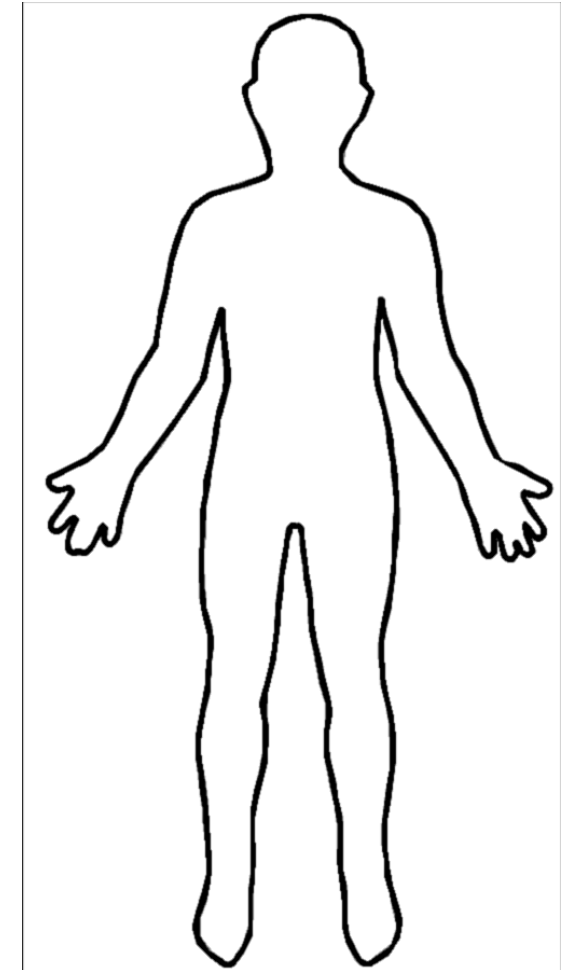
Universality:



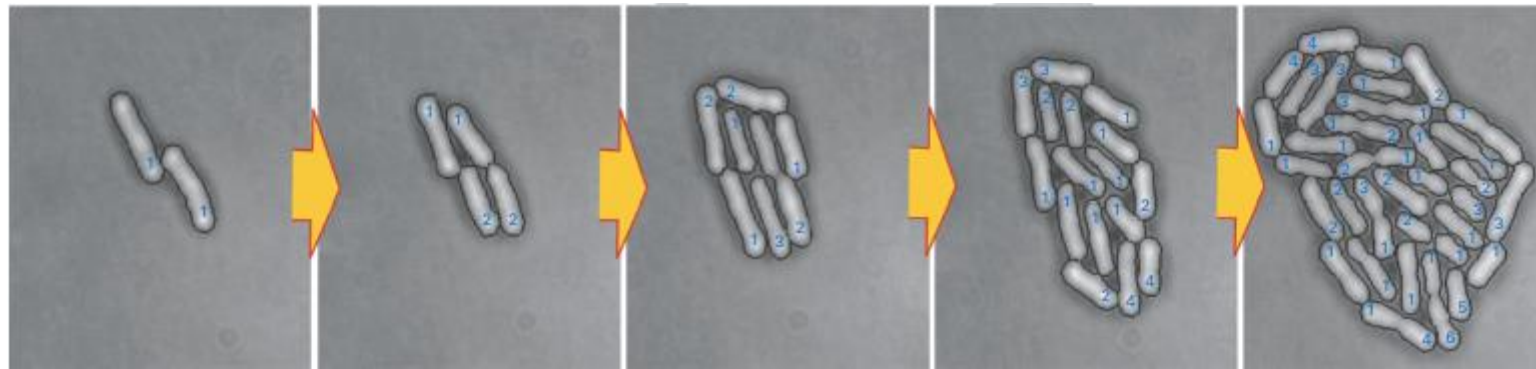
≠



≈



Life copies:



→ copy, copy, and copy...
1..2..4..8..16..32...



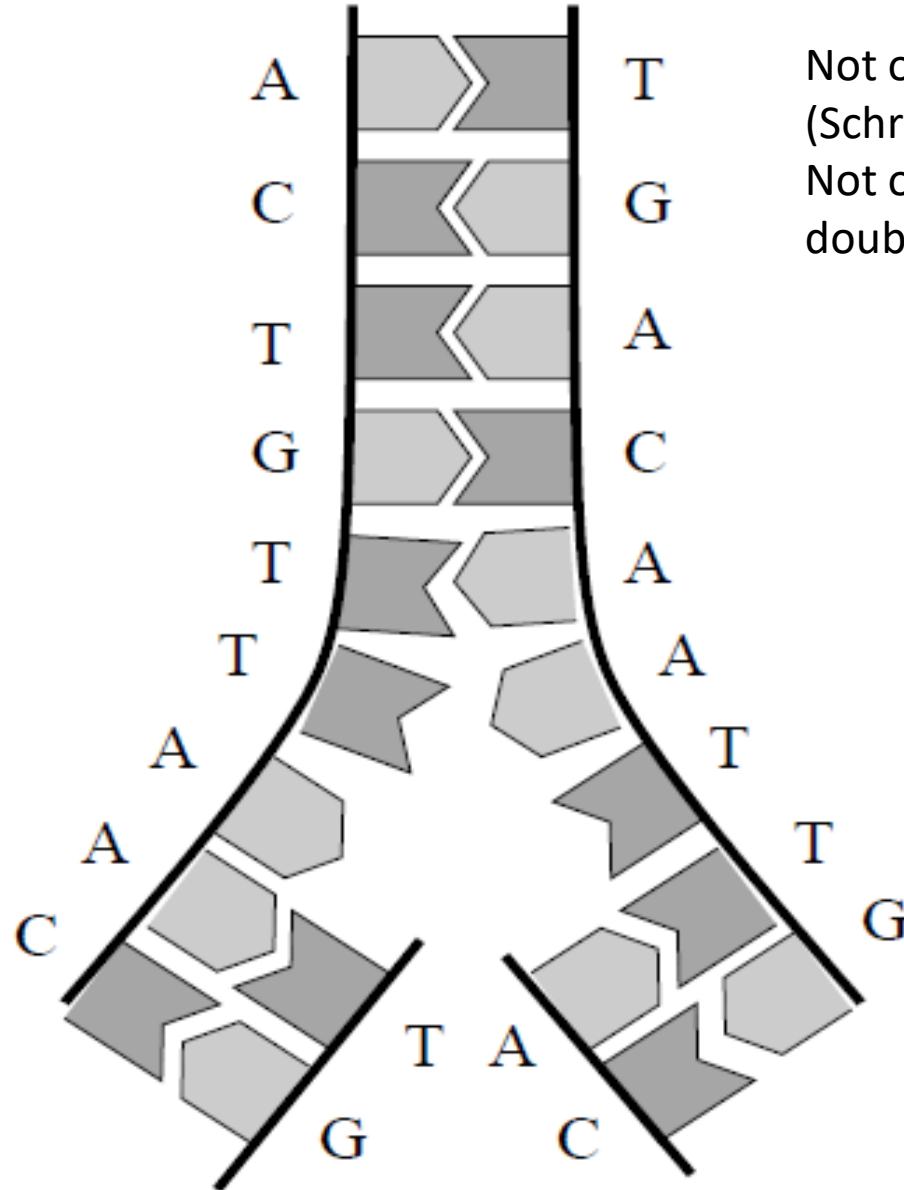
Number of humans 6,000,000,000
Number of bacteria 5,000,000,000,000,000,
000,000,000,000,000

Human biomass	0.3 G tons
Ant biomass	1.0 G tons
Fish biomass	1.0 G tons
Bacterial biomass	500.0 G tons!!
	=1/2 total biomass on earth

1,000,000,000 bacteria per liter ocean water
20,000,000,000 phage per liter ocean water

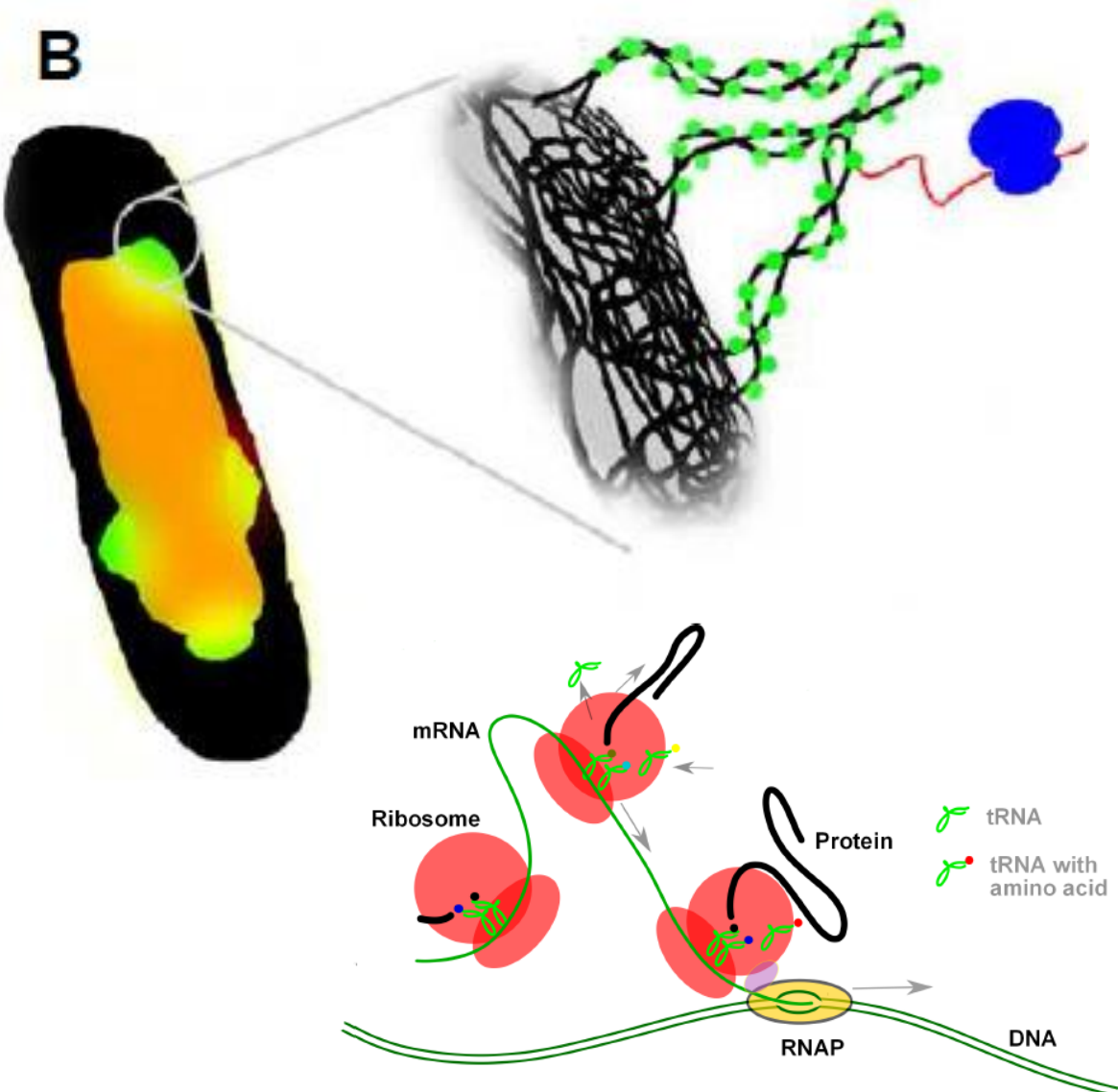
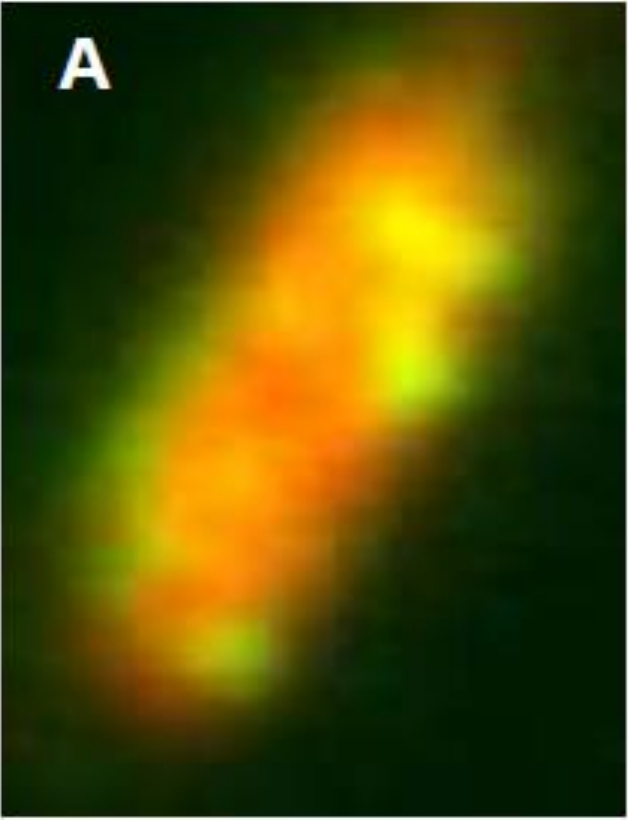
Bacteria can double each 0.5 hour. How soon can one bacteria grow to fill earth?

Copying \leftrightarrow Strings \leftrightarrow Double stranded



Not obvious that one should strings...
(Schrödinger got that wrong.. Turing got it right)
Not obvious that one should use
double string (L.Pauling got that wrong)

Within 0.001mm:



Quite large diversity of tools within a E-coli:

- About 20% proteins and 3% DNA, 15% RNA (95% are stable)
- About 1000 different proteins to live in given environment; i.e. that is the number of different tools to live and compete on today's earth...
?maybe similar on early earth
- Each of these proteins is a machine/enzyme/building block in the cell.
- Their relative abundancies are regulated by each other, and they self assemble to allow the cell to replicate itself.

→ Multicellular life?

Archea → Procaryotes → Eucaryotes → Multicellular life

Oxygen needed before eucaryotes, but eucaryotes may have been a freak accident (A merging of two divergent beings)

Many freak accident afterwards:

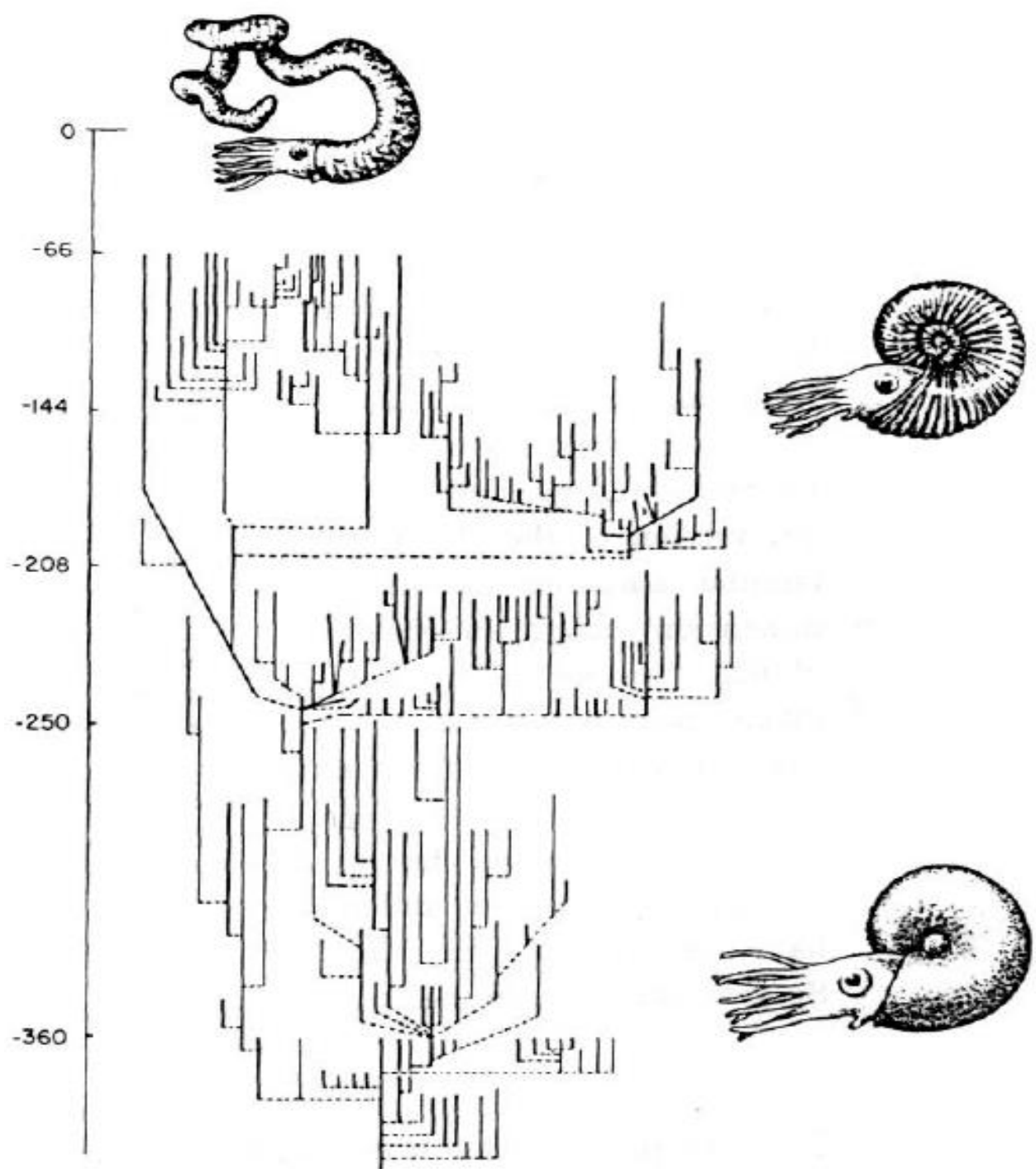
Fractal evolution..

.....

Bad luck

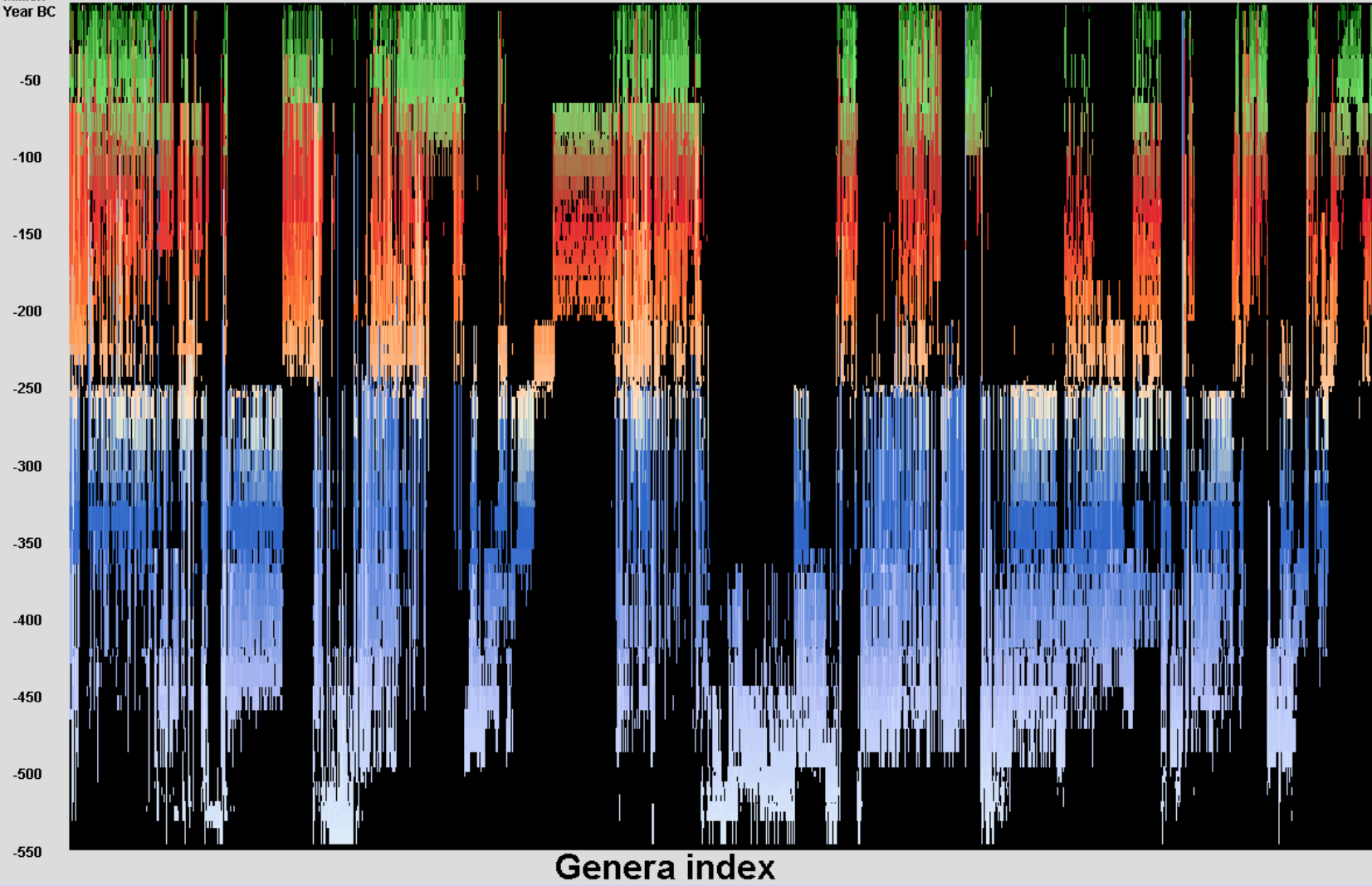
.....

(D. Raup,
figure from
N.Eldredge,
``*Life pulse*'')



Existence periods of genera:

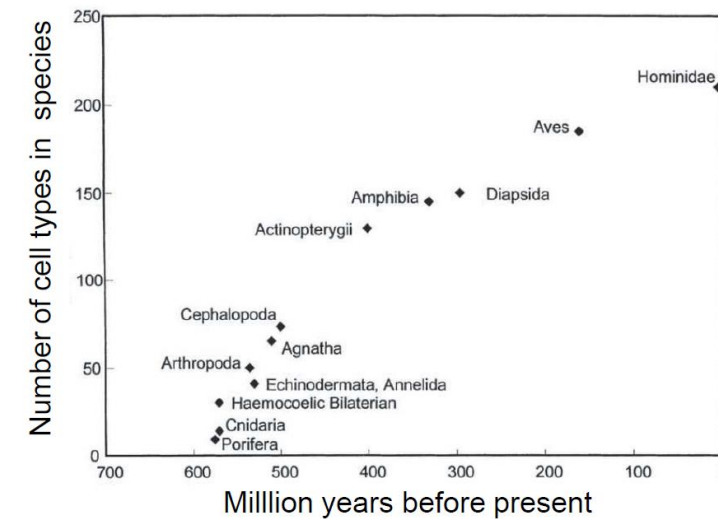
From gen. index: 0
 Plot type: 1
 Number of gen.: 31363
 Color code: 6
 Step
 Alternating color: 0



No particular progress,
 Just life
 Replaced by
 Other life
 On million years scales

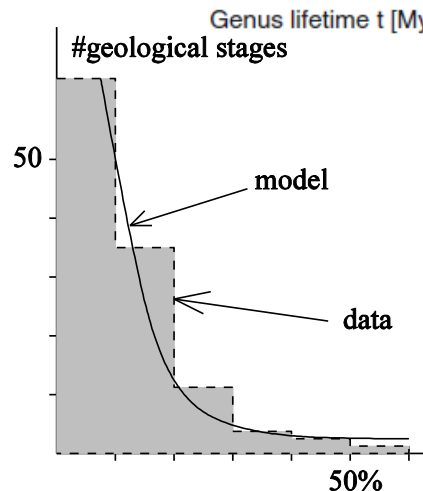
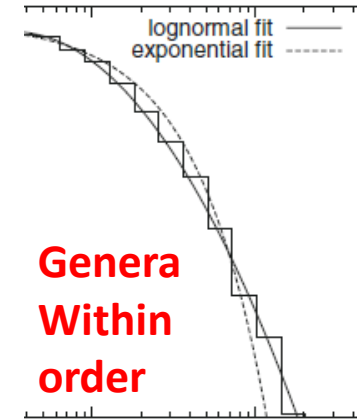
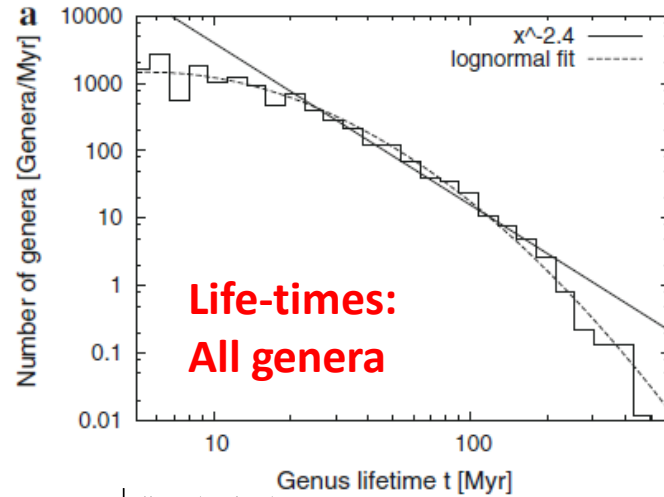
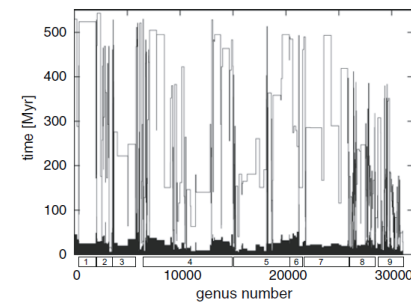
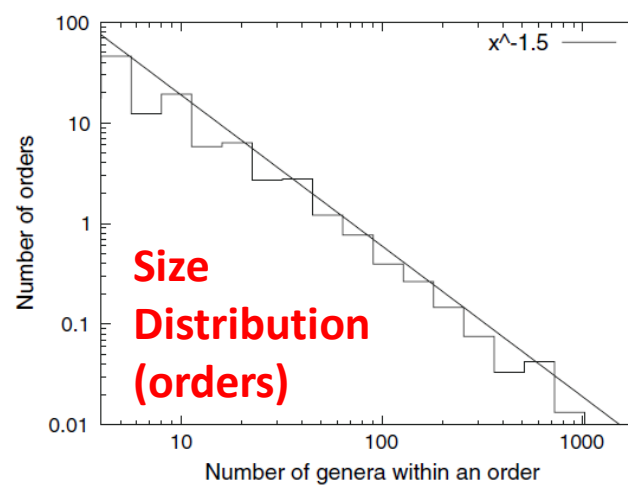
...

We are freak
 Transient(?) events
 among multicellular
 Life forms



Observations:

- **Yule:**
(Yule distribution)
- **Van Valen:**
(Red Queen)
- **Raup/Sepkoski:**
(Fractal evolution & bad luck)



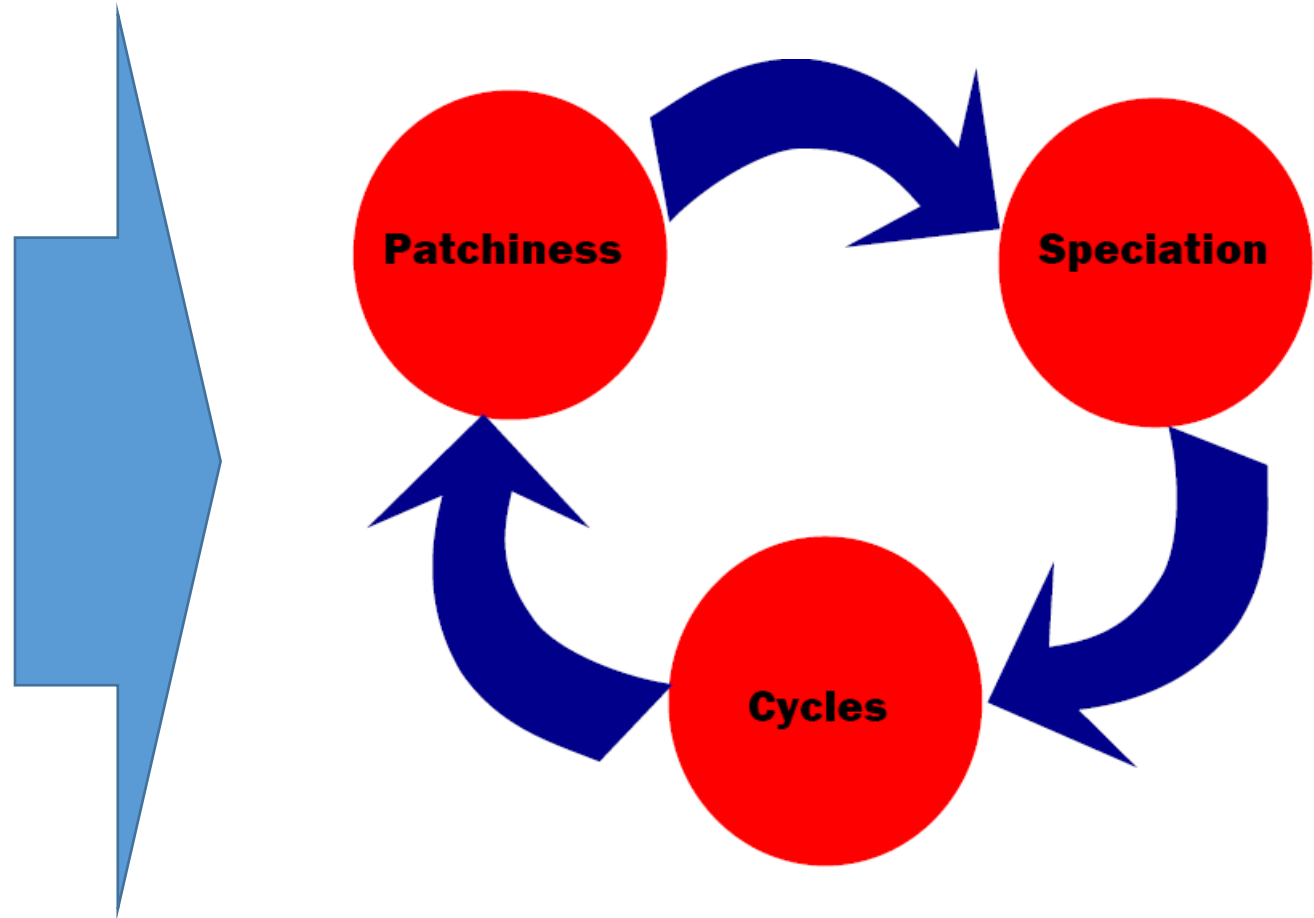
Average in the Taxonomic order

Bornholdt, S., Sneppen, K., & Westphal, H. (2009). Longevity of orders is related to the longevity of their constituent genera rather than genus richness. *Theory in Biosciences*, 128(2), 75-83.

Cyclic interactions → Diversity:



Fig. 1. Photograph of a crustose lichen community on a rock in an alpine environment (at 1300m altitude, Jotunheimen, Norway).



Overall Lesson:

• **Time \approx God**

**\approx Repetition of something
can make everything**