ESA: Extreme habitable worlds

Origin of life on earth by RNA and viruses

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Origin of life on earth by RNA and viruses

magnified virus

HGT

„I am a .... Virus"

Are viruses our oldest ancestors?

What contemporary viruses tell us about evolution

Viruses more friends than foes (2017)

Viruses are ubiquitous

EM

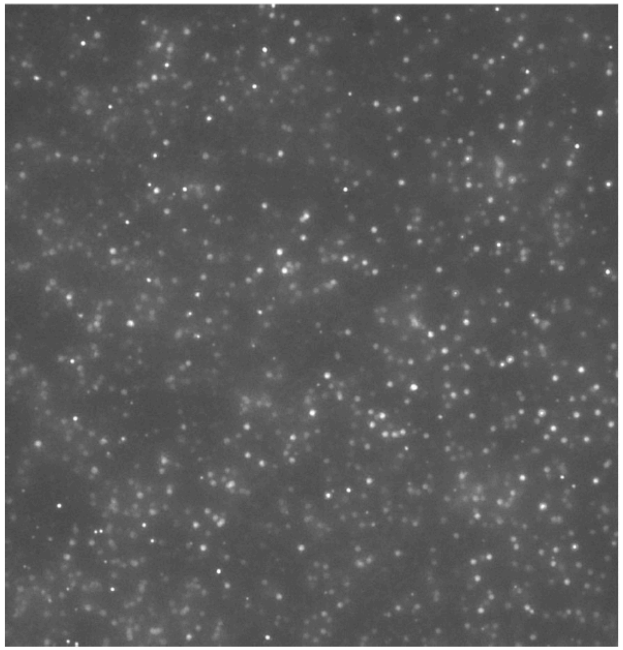


FIG. 1. SYBR Gold-stained human fecal viral concentrate under epifluorescent microscopy. No contaminating microbial cells were observed.

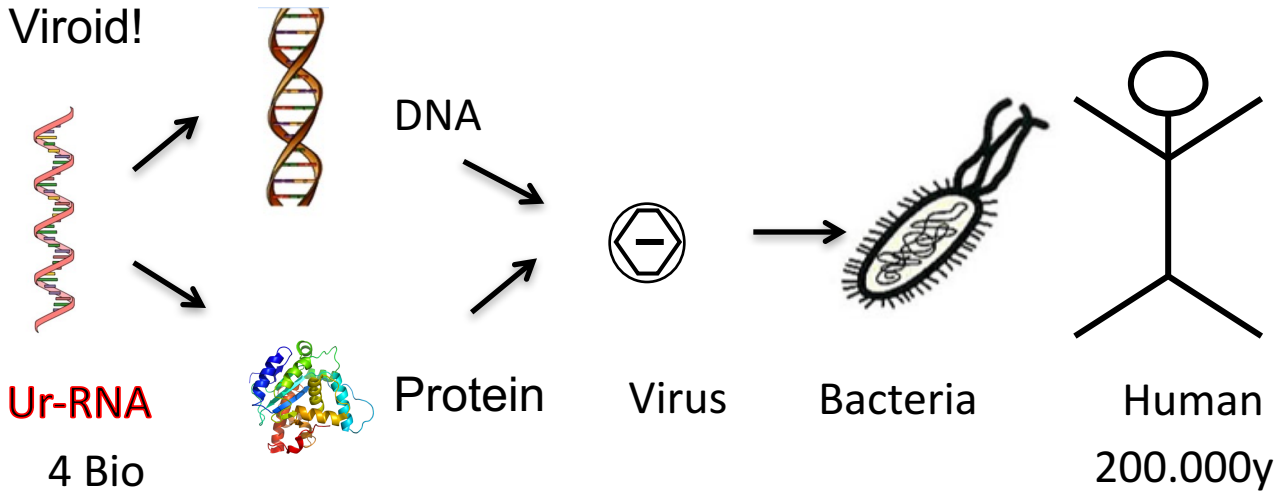
Viruses: 10^{33}

Atoms 10^{80}

Stars: 10^{25}

Sand 10^{28}

Life: Replication und Evolution – viroids as MODEL
Def: Proteinsynthesis



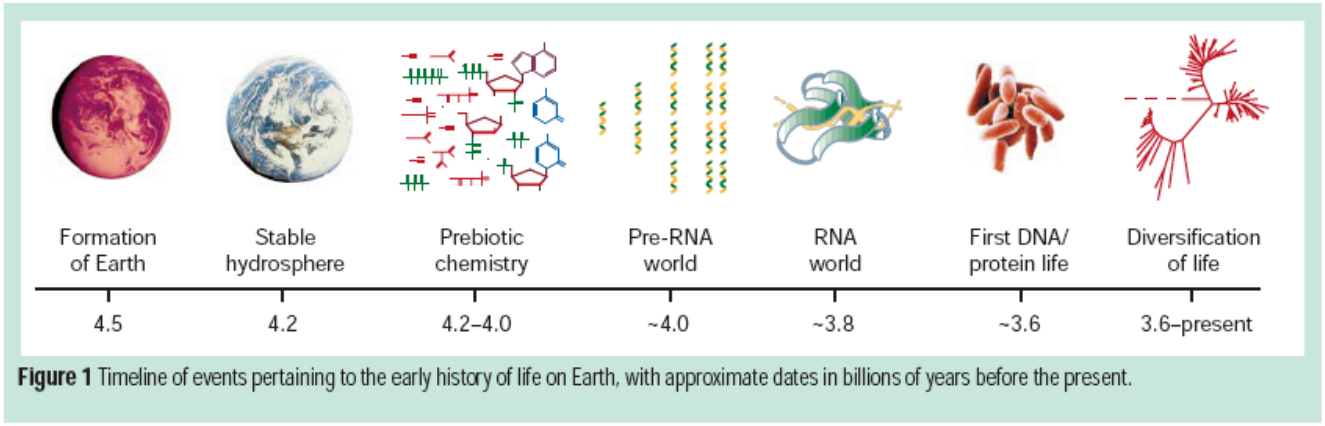


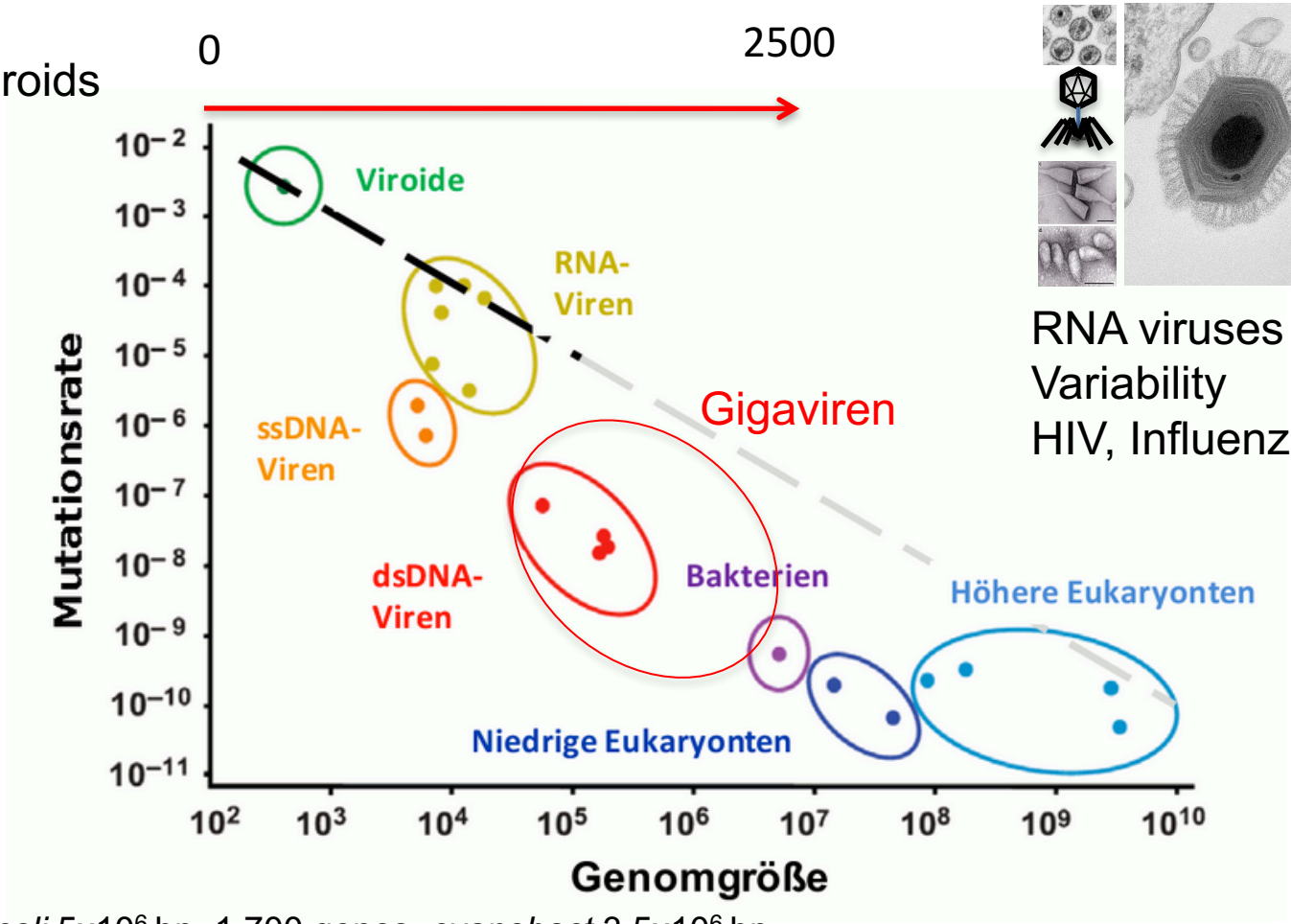
Figure 1 Timeline of events pertaining to the early history of life on Earth, with approximate dates in billions of years before the present.

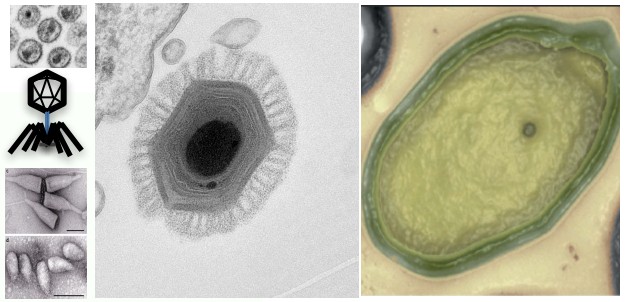
NATURE | VOL 418 | 11 JULY 2002 | www.nature.com/nature

Nature 418,214(2002)

Viruses zero genes (0-2500 genes)!

viroids





RNA viruses
Variability
HIV, Influenza

Gant viruses
„mimiviruses“

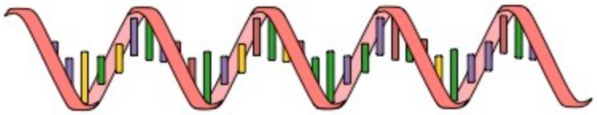
nt

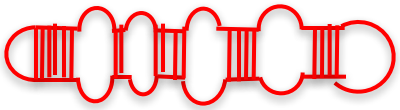
E. coli 5x10^6 bp, 1.700 genes, *cyanobact* 3.5x10^6 bp, 3.000 genes, O_2 producers, giant viruses 2.500 genes
Humans have 3.2x10^9 bp, 20.000 genes

1 Gene = 1000 nt

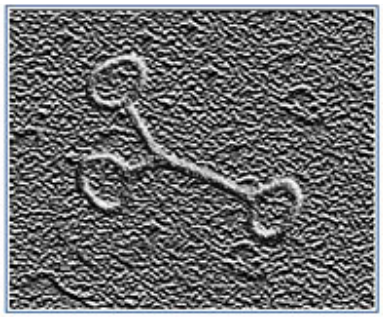
Mod nach EC Holmes Virology 2011

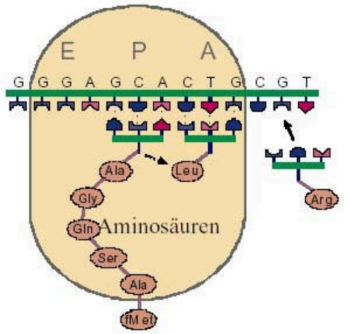
Ribozyme/Viroid, smallest Virus:





Ur-RNA





ribosome

pluripotent:closed circles, cleave, join, replicate, mutate, evolve, nc, structural info, can gain or lose catalytic activity peptide bond formation

„Ribosomes are ribozymes“ (Steitz, Yonath), NP

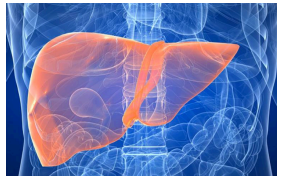
Plant pathogen

Humans: Hepatits Delta Virus (HBV as helper)

Gene regulators (98% hu genome reg 2% proteins)

CircRNA "sponge“ today 25.000 miR per cell, regualtors of regulators

ncRNA, miR, siRNA, lncRNA, circRNA, mRNA, tRNA, piRNA (transgenerational genetics in semen transmitted),



HDV code and coat!

Lincoln&Joyce, Science 323,1229(2009)
T.Taylor,T.Cech, F.Dyson
T.Diener, H. Sänger Giessen

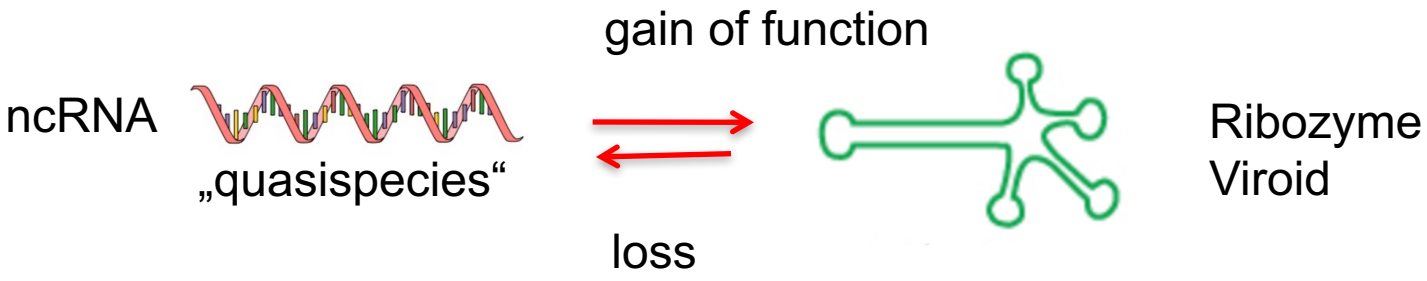
RNA world: anaerobic, no lights, chemotrophic, biologial activity, evolution, no protein synthesis

test tube!

-One pot synthesis: H,C,N,O, P: nucleotide, amino acid, lipid

-Polymerization

- non-coding (nc)RNA to Ribozyme/viroid



Random RNA (aptamrter) to ribozyme on Malachit Green induced by electrostatic field

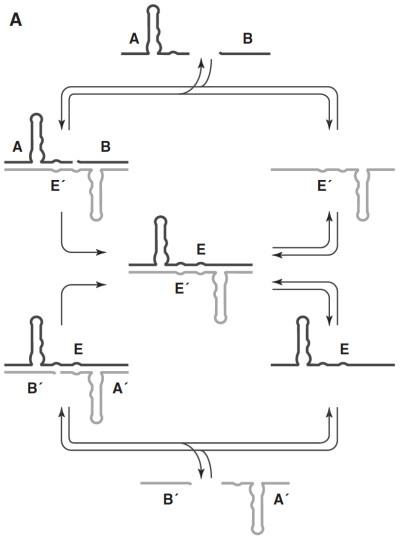
chemical evolution

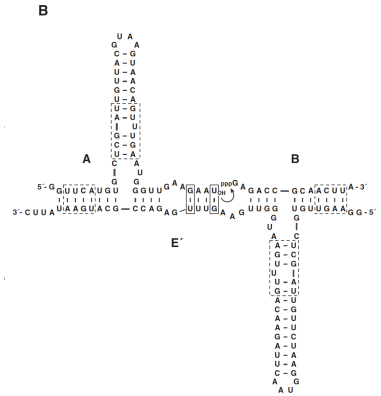
Patel et al Sutherland 2015
Brackett and Dieckmann,Chembiochem7,839 (2006)
Wlson and Szostak AnnRevBiochem1999

Cech and Altman NP: Ribozyme
T Diener and Sänger: viroid

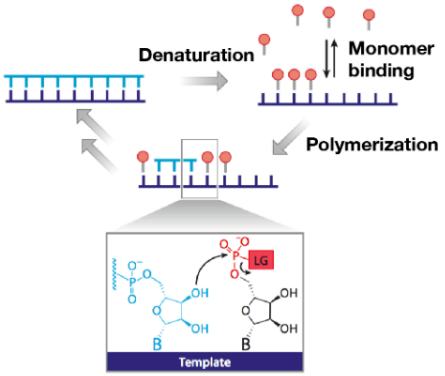
Self-sustained replication of ribozyme

J.Joyce



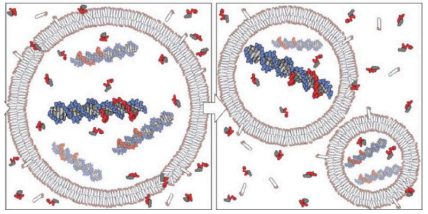


J.Szostak

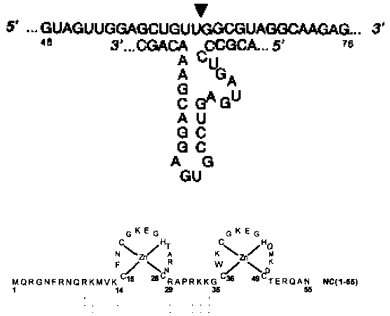


Chemical replication of RNA

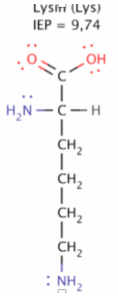
98% of human genome is for ncRNA

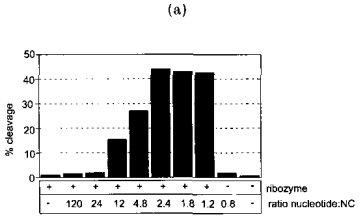


liposomes

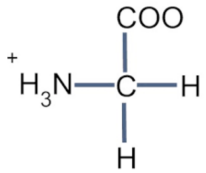


NC HIV





Ribozymes activated with AA, chaperone



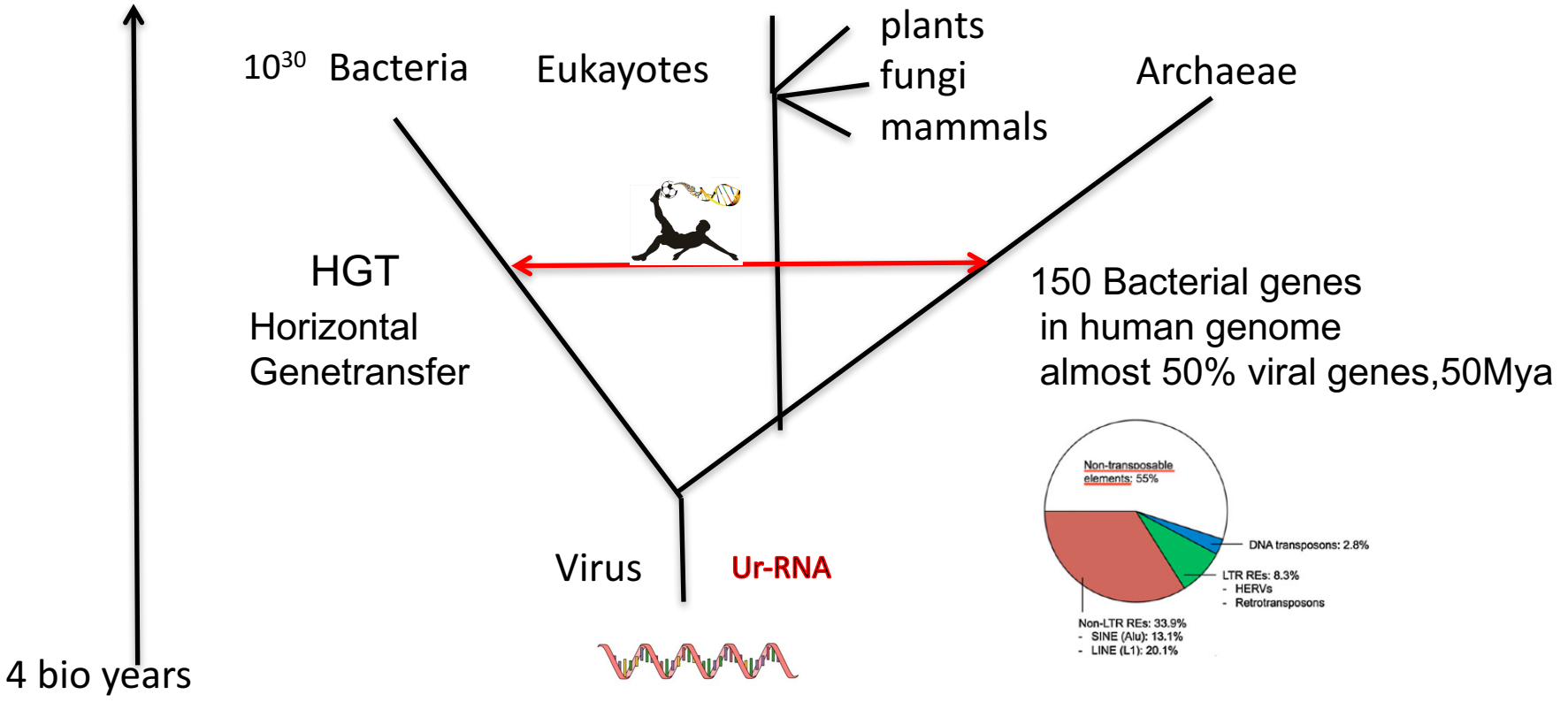
glycine (Mars Rosetta)

Müller et al Moelling.JBC 242,422(1994)

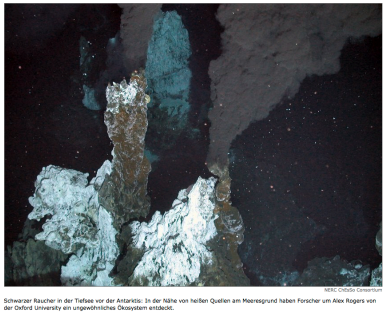
Lincoln and J.Joyce Science 323,1229 (2009).

We are all related!

10^{33} viruses in all three kingdoms (most successful)



"warm little pond"
Ch. Darwin
HCNOPS



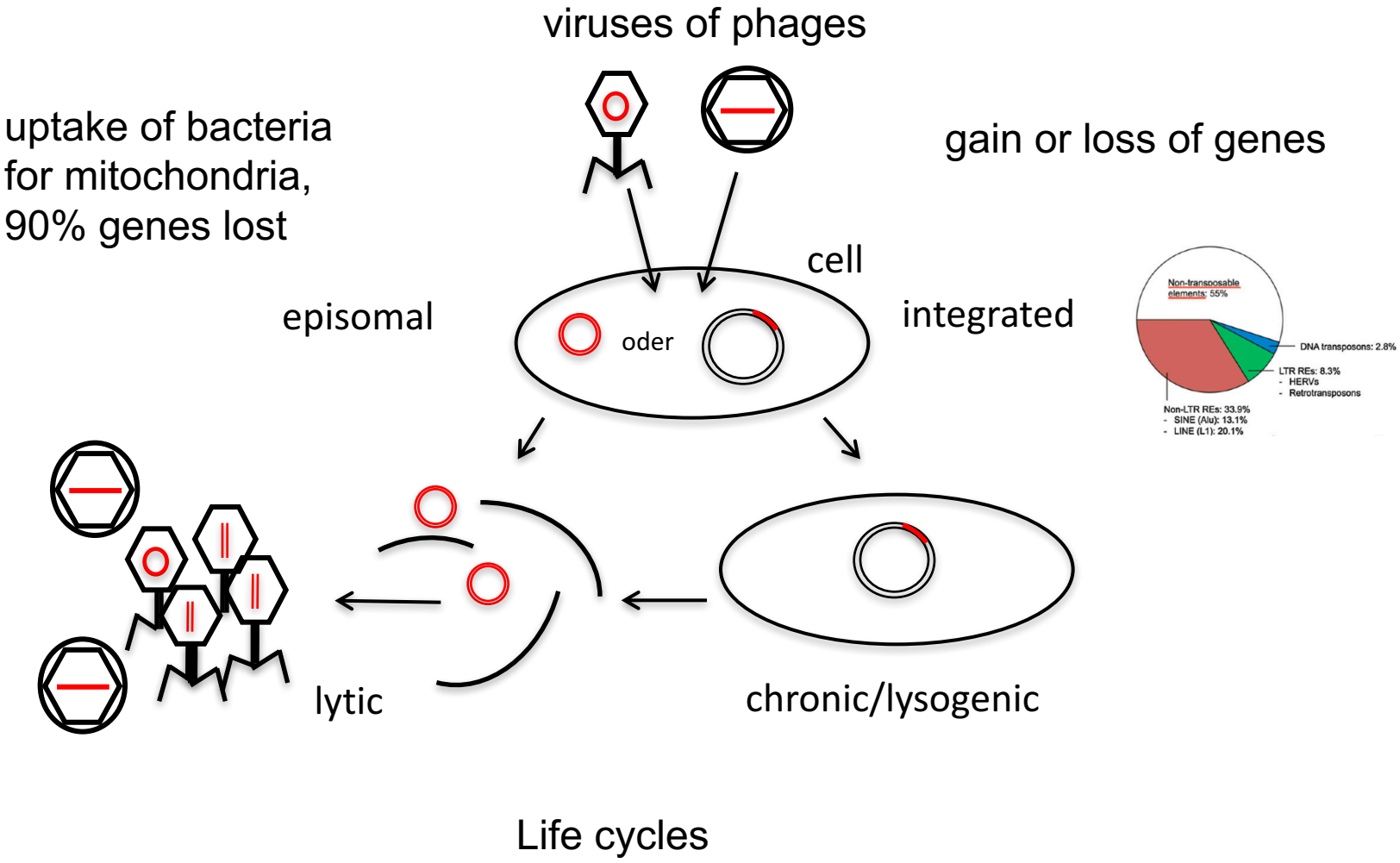
Schwarzer Raucher in der Tiefsee vor der Antarktis: In der Nähe von heißen Quellen am Meeresgrund haben Forscher um Alex Rogers von der Oxford University ein ungewöhnliches Ökosystem entdeckt.

Meteorites (stardust)
Vulkanoes: black smokers
(hydrothermal or cycling terrestrial)
or ice

Eme Nat Rev Micro. 2017

Moelling EMBO Rep.2012, Archives Virol 2013

Endosymbiosis pox viruses for nuclei?



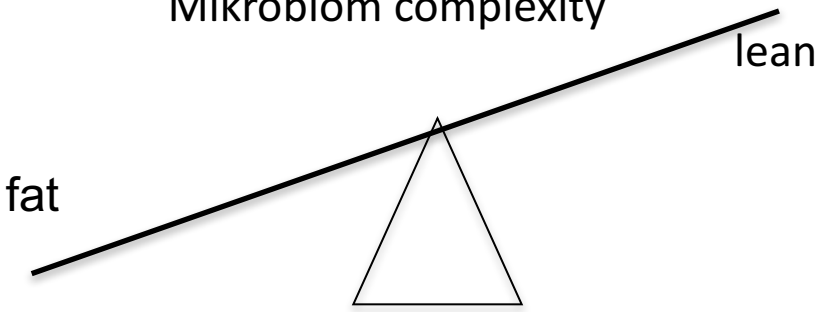
Viruses not only parasites

Rich environment makes lazy – ribozyme, viruses

Loss of gene count in obese guts
Delegated functions
cyanobacteria to mitochondria

loss or gain of function
ribozyme dep.on environment

Mikrobiom complexity



200.000 genecounts

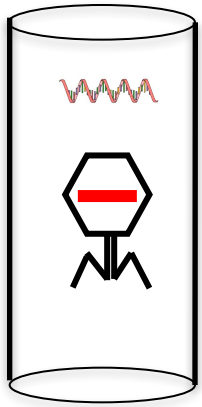
800.000

Decrease/loss of complexity

RNA can „de-evolve“ to ncRNA

rich milieu makes „lazy“ loss of genes

ncUr-RNA/Rz



"Spiegelman`s Monster"

Qbeta Phage

RNA Phage in capillary 40 years ago

bacteria endosymbiont in
eukatryotic cells 90% gene loss intracllular RZ lose activity!

Eigen: From simplicity to complexity, Oxf Univ P(2015)
Chemical evolution

Aptamer to ribozyme Brackett and Dieckmann, Chembiochem7,839 (2006)
(Malachit Green induces electrostatic field

Model for early life forms
Viroids (naked viruses), Ribozymes

Summary:

RNA: non-coding, no protein, 0 to 300 bases, quasispecies
structural information, respond to environment,
cleave and join, replicate, mutate, evolve – this is“alive“
loss and gain of functions
„ribosomes are ribozmes“
sequence space gigantic (4^{50} corr to 10^{30})
Influenza or HIV, RNA primary genetic information, is highly variable
range from Nanoparticles to Mimiviruses, ie.
„Mimicking bacteria“ with components for protein synthesis
RNA invents, DNA stabilizes
TODAY: obligatory parasites!
Consequence of rich environment
Most successful species on our planet 10^{33}

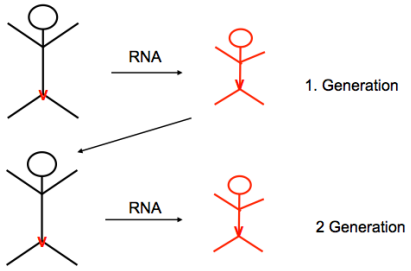
Future:

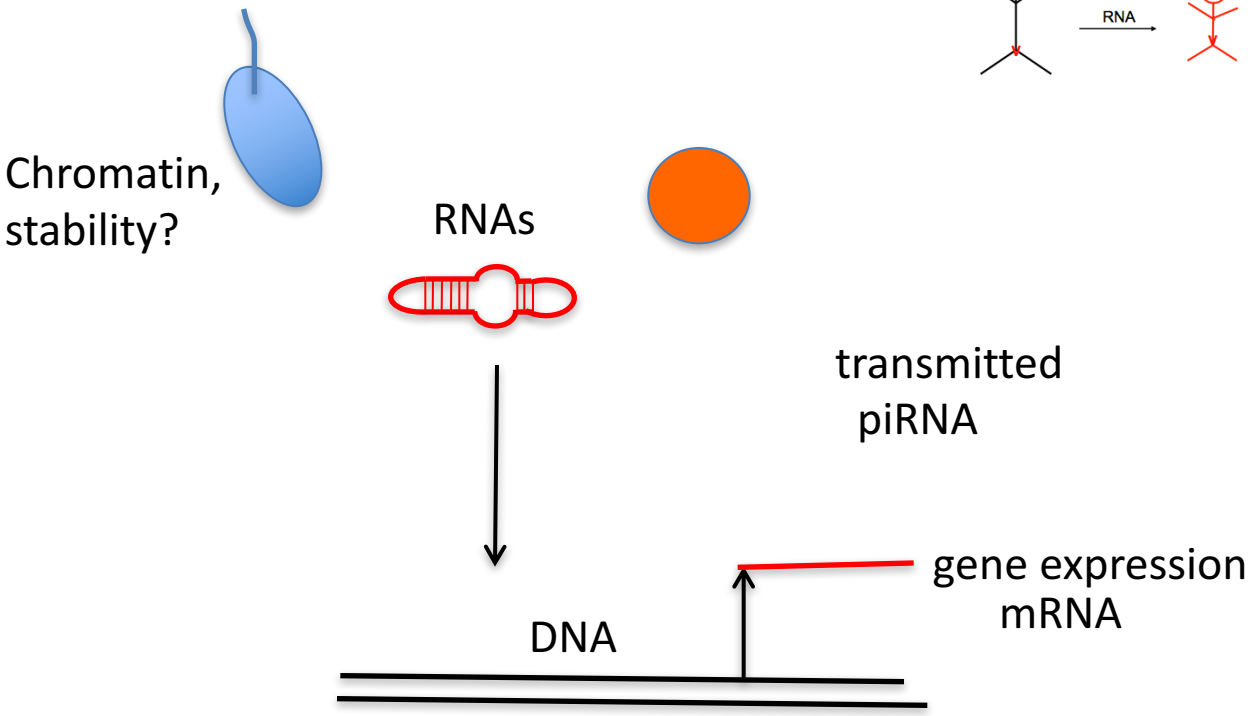
Samples with virome, microbiome, PCR,
ndicator gene with color emission after cleavage
Astronaute analysis –piRNA etc

Patel and Sutherland 2015

RNAs as transgenerational regulator

stable many generations





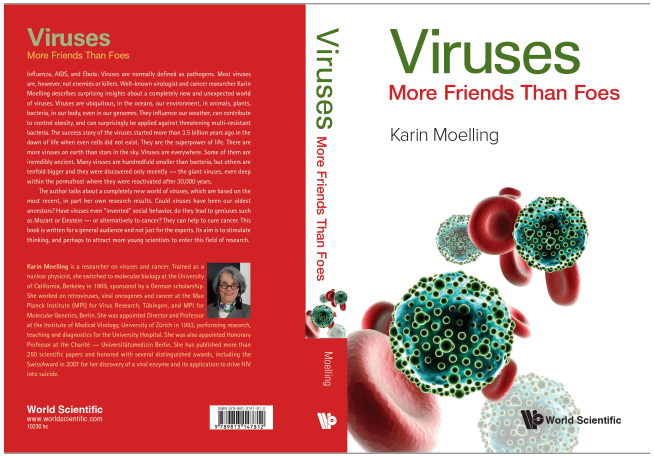
not only transient epigenetics by methylation and acetylation for one generation bit many!

Rassoulzadegan M et al.
Nature 441,469 (2006)

Thanks!

Most viruses do not cause disease
viruses are the inventors, drivers of evolution, recycle nutrients
„endosymbionts“
not obligatory parasites, beginning of life – survivors

Detection by PCR, 98^0 C, minilab, fossils, quasi-fossils, chirality(Quack)?



WSP 2017

Moelling: **What contemporary viruses tell us about evolution**
Arch Virol 158,1833 (2013)

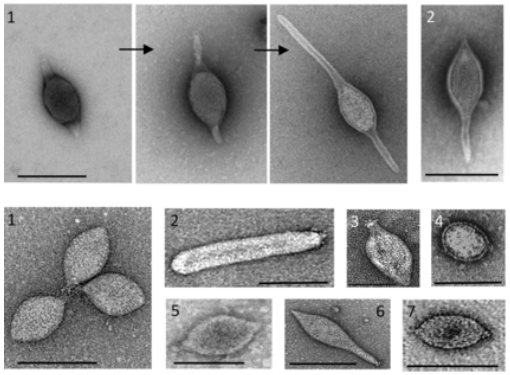
Edit a booklet – give e mails

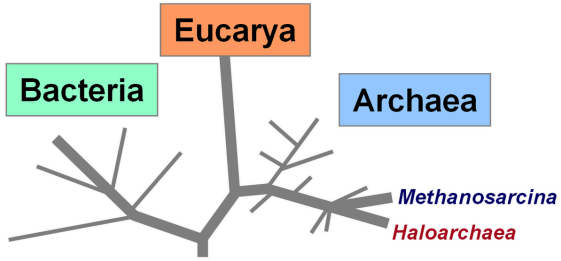
Cyano bact and phages, Uv
Bärtierchen

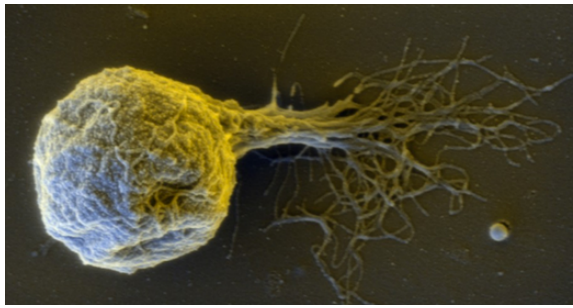
Viruses in Archaea (Extremophiles)

Extremophile

98 oC 13.000 Years
Georgia Prangishvili



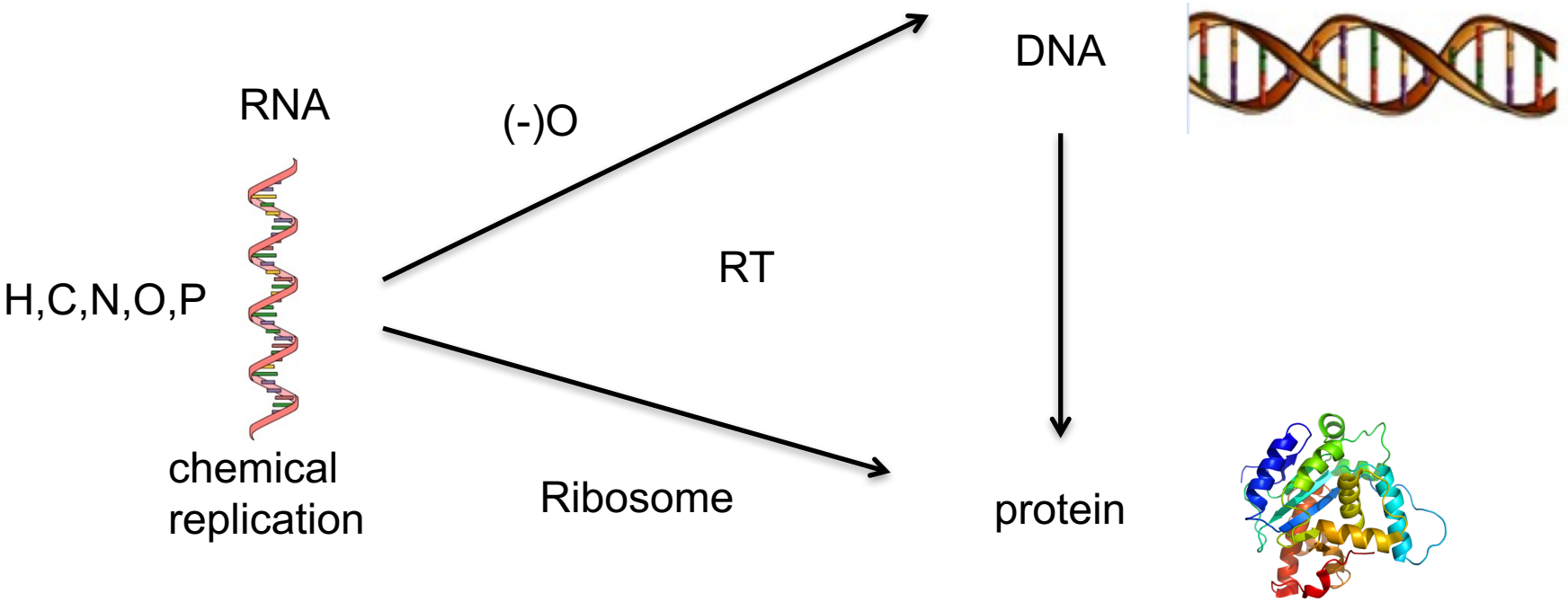


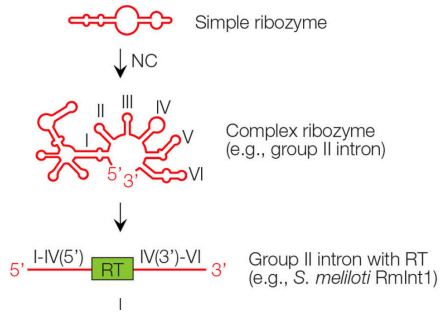


archaea are slow developers

Prangishvili 2006

RNA is unique: hardware and software



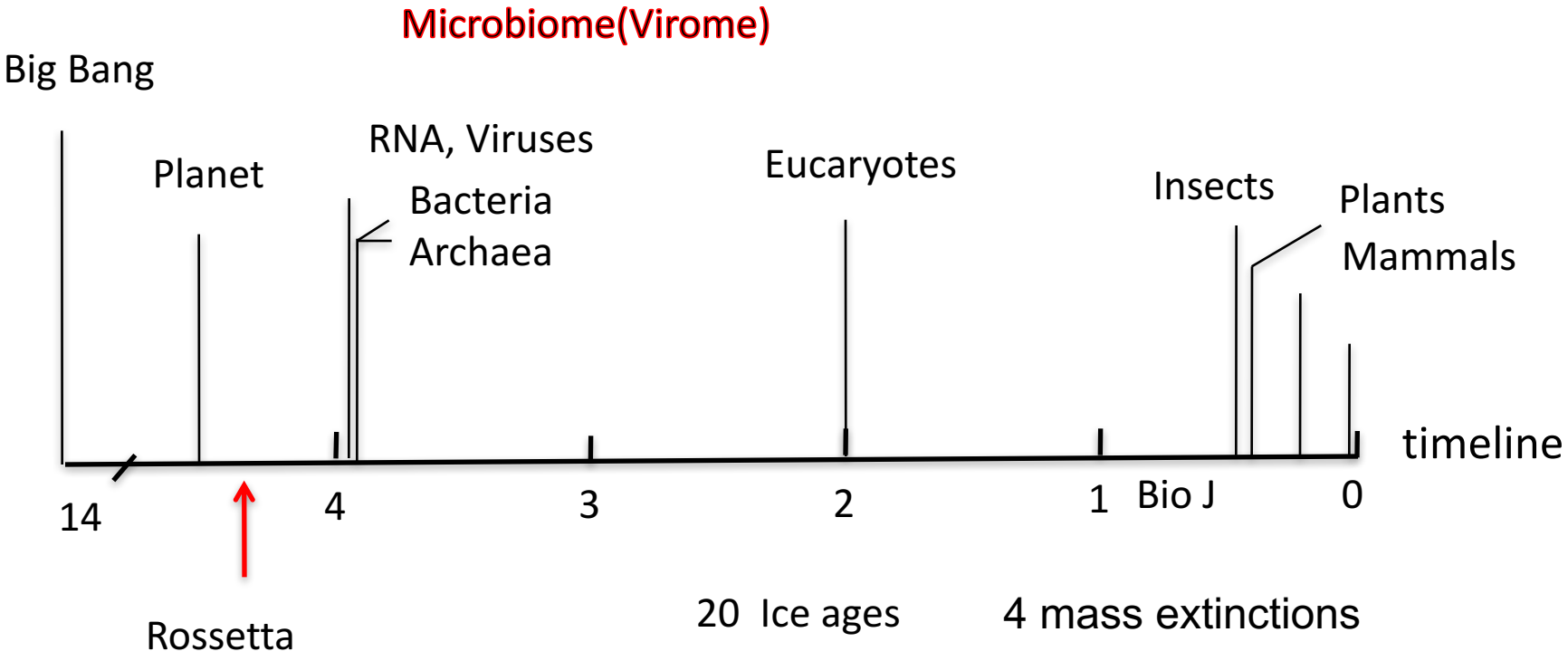


Moelling et al. Frontiers 2017

John von Neumann

F.Dysons: 2 origins of life

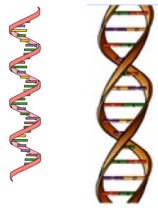
"Virosphere“: from the beginning...



Leben: Erbgut mit Verpackung (Protein) und Replikation
Einfachster Fall: Viren

Parasites

RNA/DNA

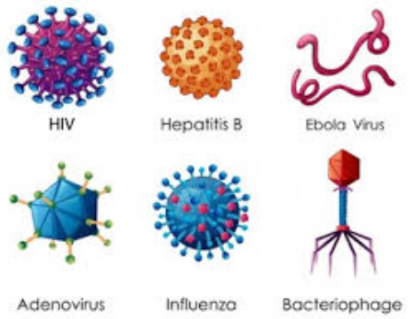


+

Protein

=

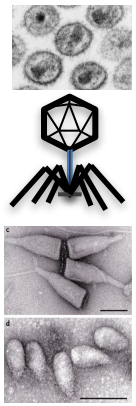
Viren

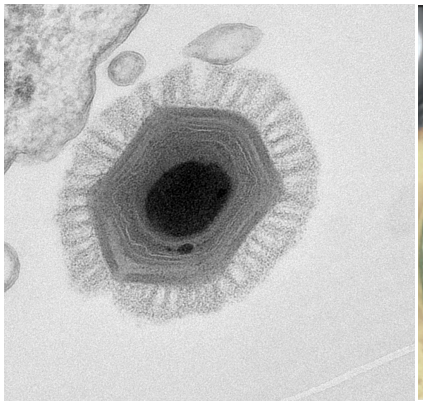


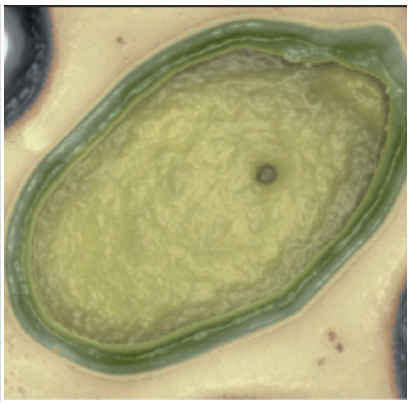
HIV

Phage

Archaea





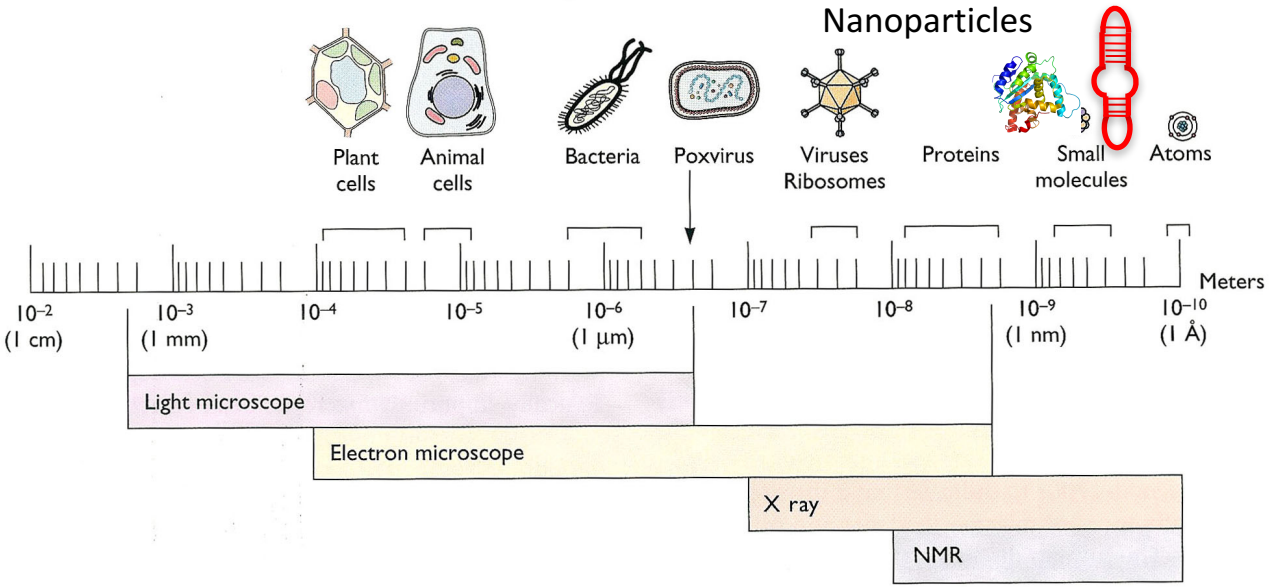


Giga Viren

1500-3000 Virustypen?

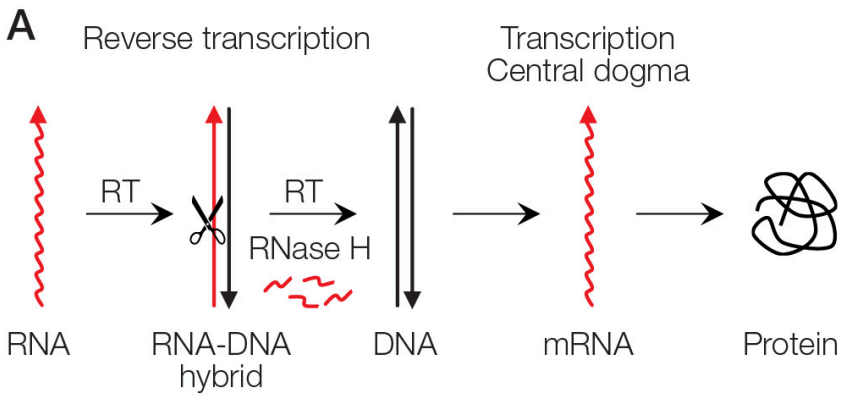
Viruses size range 4 logs

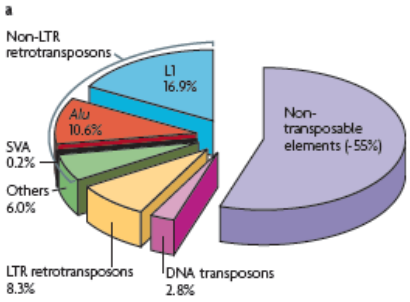
giant viruses

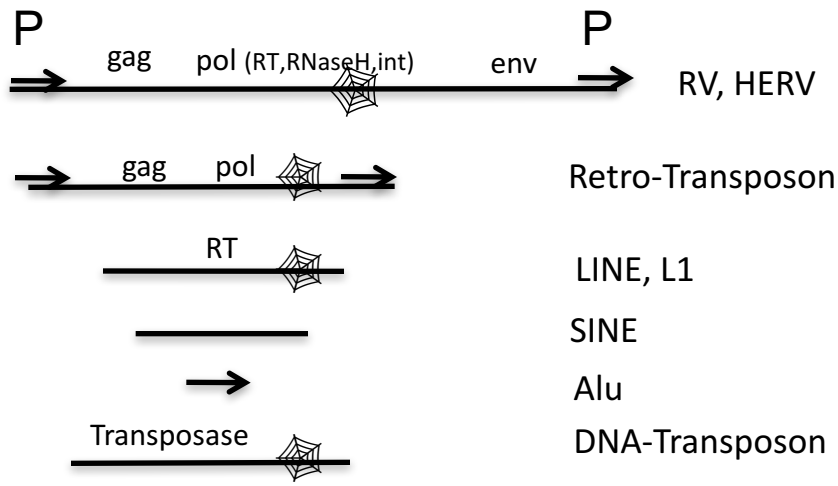


size and evolution?

Aus: Flint et al., 2000

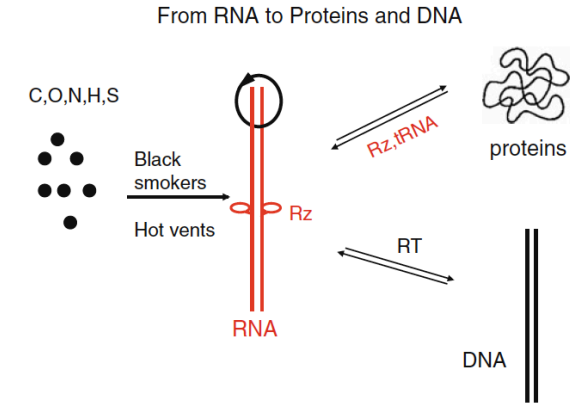


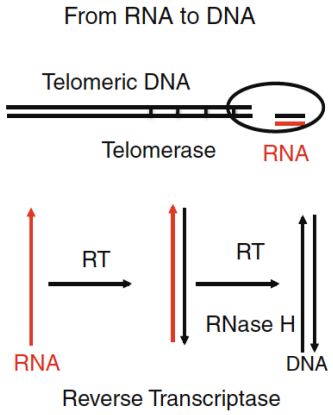


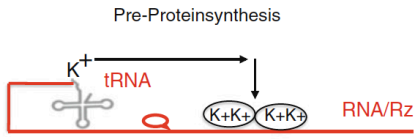


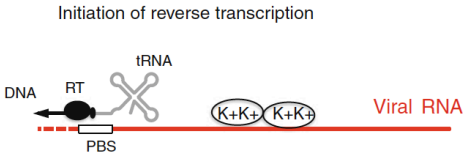
50% endogenous viruses

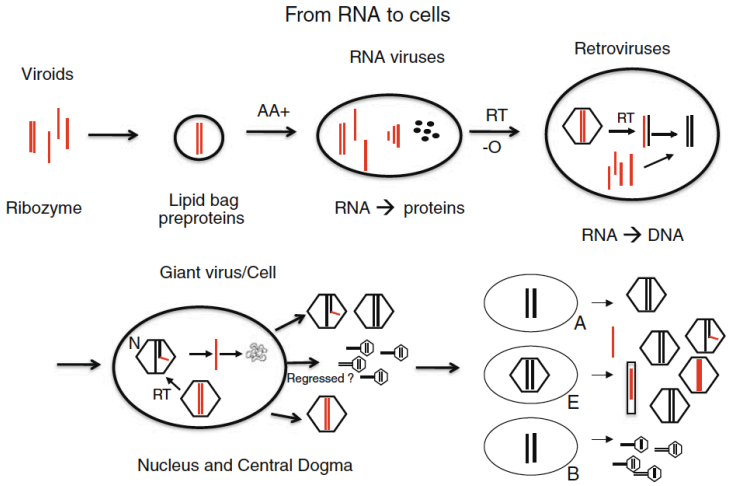
nach Cordaux ,Batzer 2009

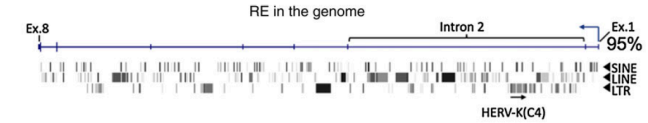


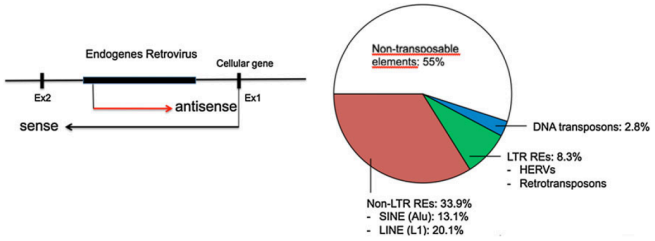




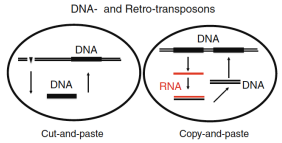








sequence space of $50^4 = 10^{30}$



98%ncRNA Stozak Aptamr o rz

PMC full text: Science. Author manuscript; available in PMC 2009 Aug 27.
Published in final edited form as:
Science. 2009 Feb 27; 323(5918): 1229–1232.
Published online 2009 Jan 8. doi: 10.1126/science.1167856
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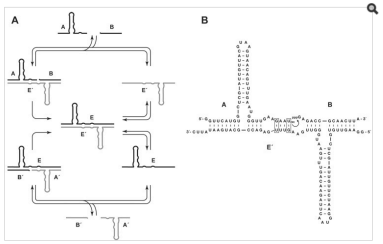
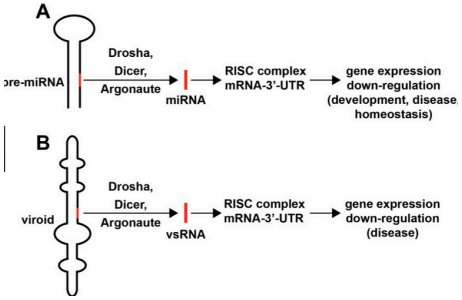
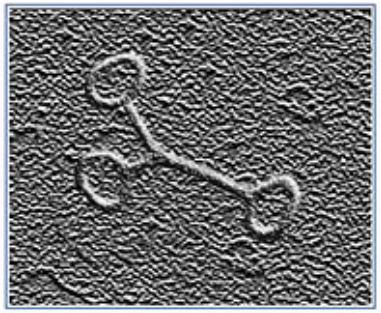
Fig. 1

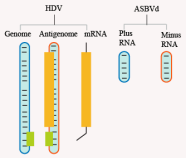


Scheme for cross-catalytic replication of RNA enzymes. (**A**) The enzyme E′ (gray) catalyzes ligation of substrates A and B (black) to form the enzyme E, while E catalyzes ligation of A′ and B′ to form E′. The two enzymes dissociate to provide copies of both E and E′ that each can catalyze another reaction. (**B**) Sequence and secondary structure of the complex formed between the cross-replicating RNA enzyme and its two substrates (E′, A, and B are shown; E, A′, and B′ are the reciprocal). Curved arrow indicates the site of ligation. Boxed residues indicate the sites of critical wobble pairs that provide enhanced catalytic activity compared to the parental R3C ligase.





without undies). The big difference between viroids and virusoids is that virusoids cannot cause disease without a helper virus, while viroids can infect by themselves. Also, virusoids cause distinct disease from their helper virus, though typically do not affect helper virus replication.



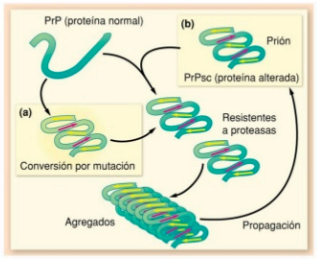
Virusoid and Viroid Genome Structure

The differences between viroids and virusoids can be seen in the table below:

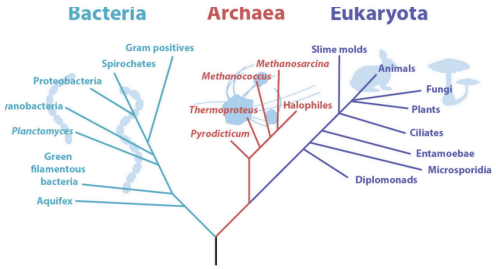
	Viroids	Virusoids (Satellites)
Genome Size	200-400 bases	500-2000 bases
Requires helper virus for replication?	No	Yes
Encodes proteins?	No	Yes
Replication Mediator	Host RNA Pol II	Helper virus polymerase
Site of Replication	Nucleus	Where helper virus replicates
Example	Potato spindle	Tobacco rings

Viroides y Priones

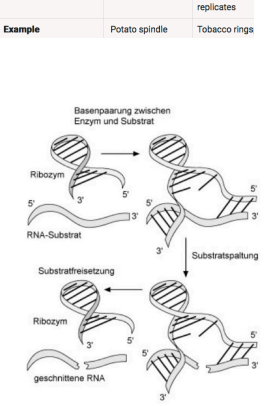
Esquema Viroide



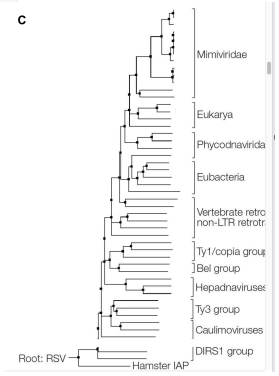
Esquema Prion

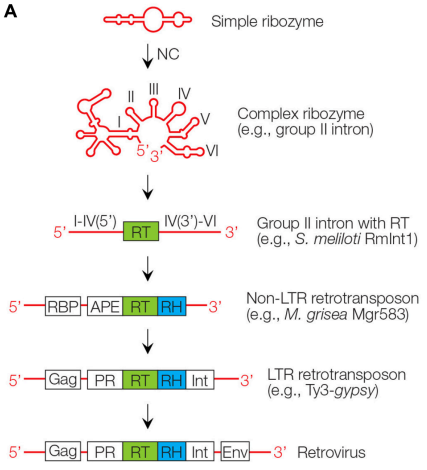


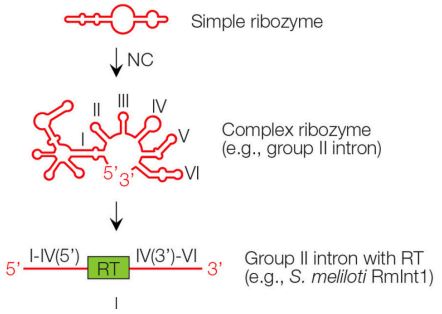
sequence space of $50^4 = 10^{30}$



ribozyme





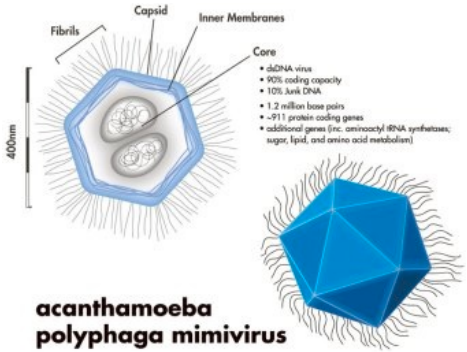


Rickettsien

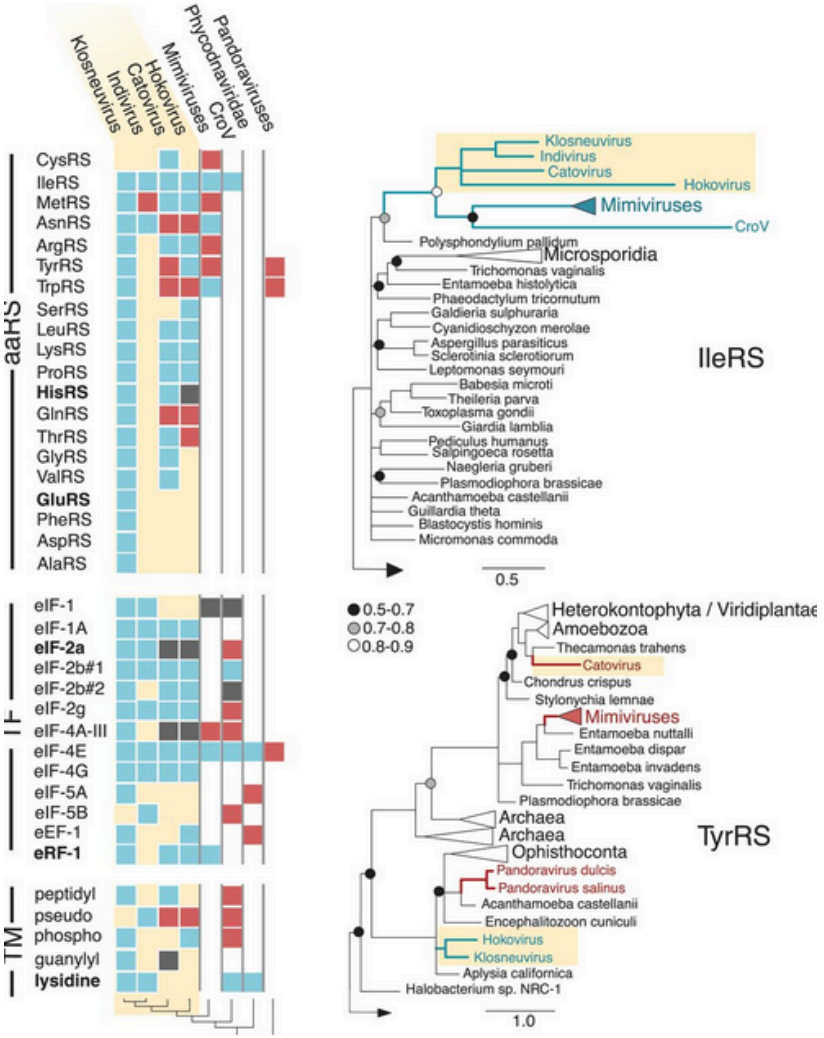
Rickettsia are obligatory intracellular parasites in eukaryotes,
may be large viruses, divide by fission
Aus dieases, sensitive to antibiotics, common relative ot mitochondria?

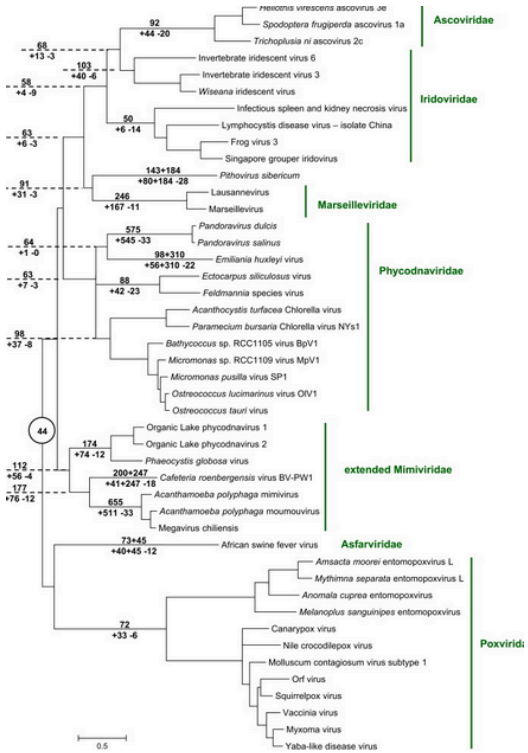
Obligatory inside cells:
Chlamydia trachomatis, Coxiella burnetii (Q fever)
Mycobacteria leprae, M tuberculosis

Trypanosoma, Toxoplamodia, Cryptosporidia



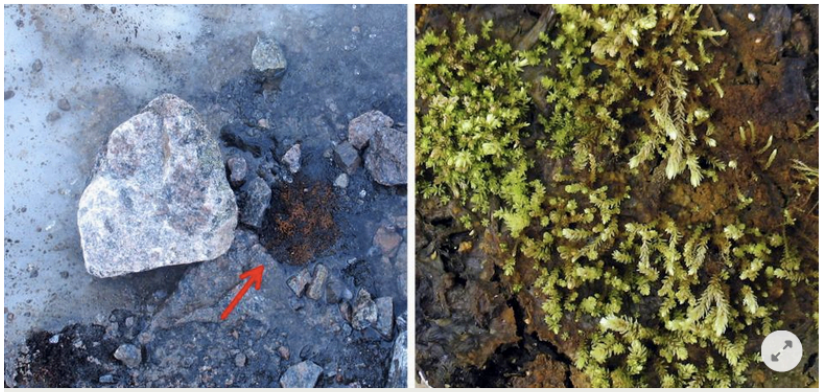
Klosneuvirus 20 AA transferases. Gain of host genes





Für Felix und Tim Aplysia!!!

Fungi 400 years in ice



Die Aufnahme links zeigt eine Moospflanze der Art Aulacomnium turgidum, die Jahrhunderte lang im Eis des Teardrop-Gletschers am Sverdrup Pass auf Ellesmere Island, eingefroren war. Kanadische Forscher haben herausgefunden, dass die Pflanzen (rechts in einer Petrischale) wieder zu wachsen beginnen, wenn sie durch den Rückzug des Gletschers ans Tageslicht kommen

Quelle: pa/pa

Dass Moospflanzen Überlebenskünstler sind, ist bekannt. Doch was Forscher jetzt berichten, klingt fast unglaublich: Moospflanzen, die 400 Jahre unter Gletschereis begraben waren, wachsen wieder.

Moospflanzen können einen jahrhundertelangen Schlaf unter einer dicken Schicht Gletschereis fast unbeschadet überstehen. Kanadische Forscher haben festgestellt, dass die Pflanzen wieder zu wachsen beginnen, wenn sie durch den Rückzug des Gletschers ans Tageslicht kommen.

Die Wissenschaftler zogen die Pflanzen dann auch im Labor heran. Die Moose verfügten über sehr widerstands- und wandlungsfähige Zellen, aus denen neue Pflanzen hervorgehen können, schreiben die Forscher in den „Proceedings“ der US-Nationalen Akademie der Wissenschaften.

Catherine La Farge und ihre Mitarbeiter von der Universität von Alberta (Edmonton/Kanada) hatten die Flora am Sverdrup Pass auf der Ellesmere-Insel des kanadisch-arktischen Archipels untersucht. Der dortige Teardrop-Gletscher hat sich