



Bakteriofagen – det mest dødbringende væsen på Jorden, der kan redde dit liv!

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Globe Institute

UNIVERSITY OF COPENHAGEN

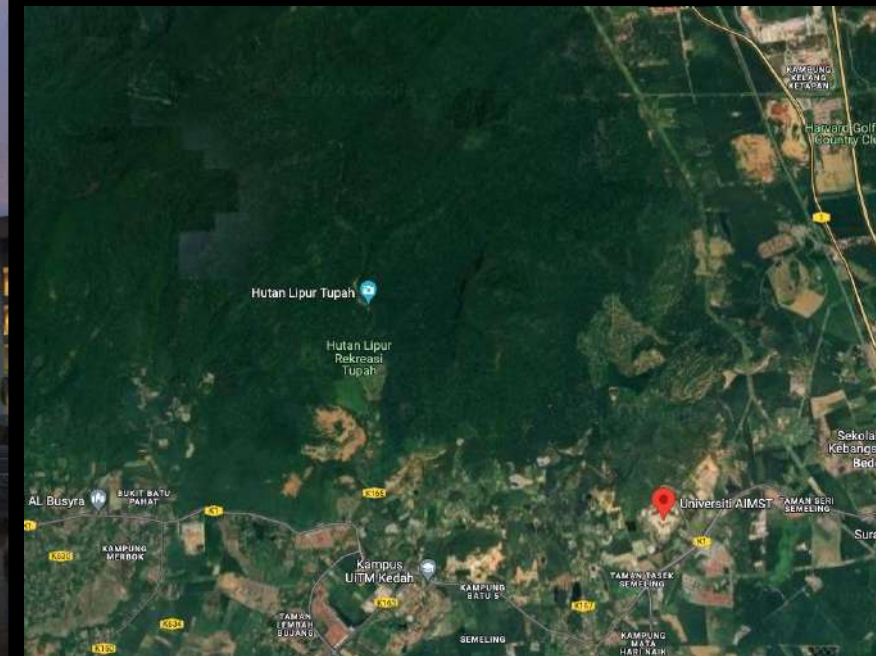




Senior forsker (lektor)
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AIMST University, Malaysia



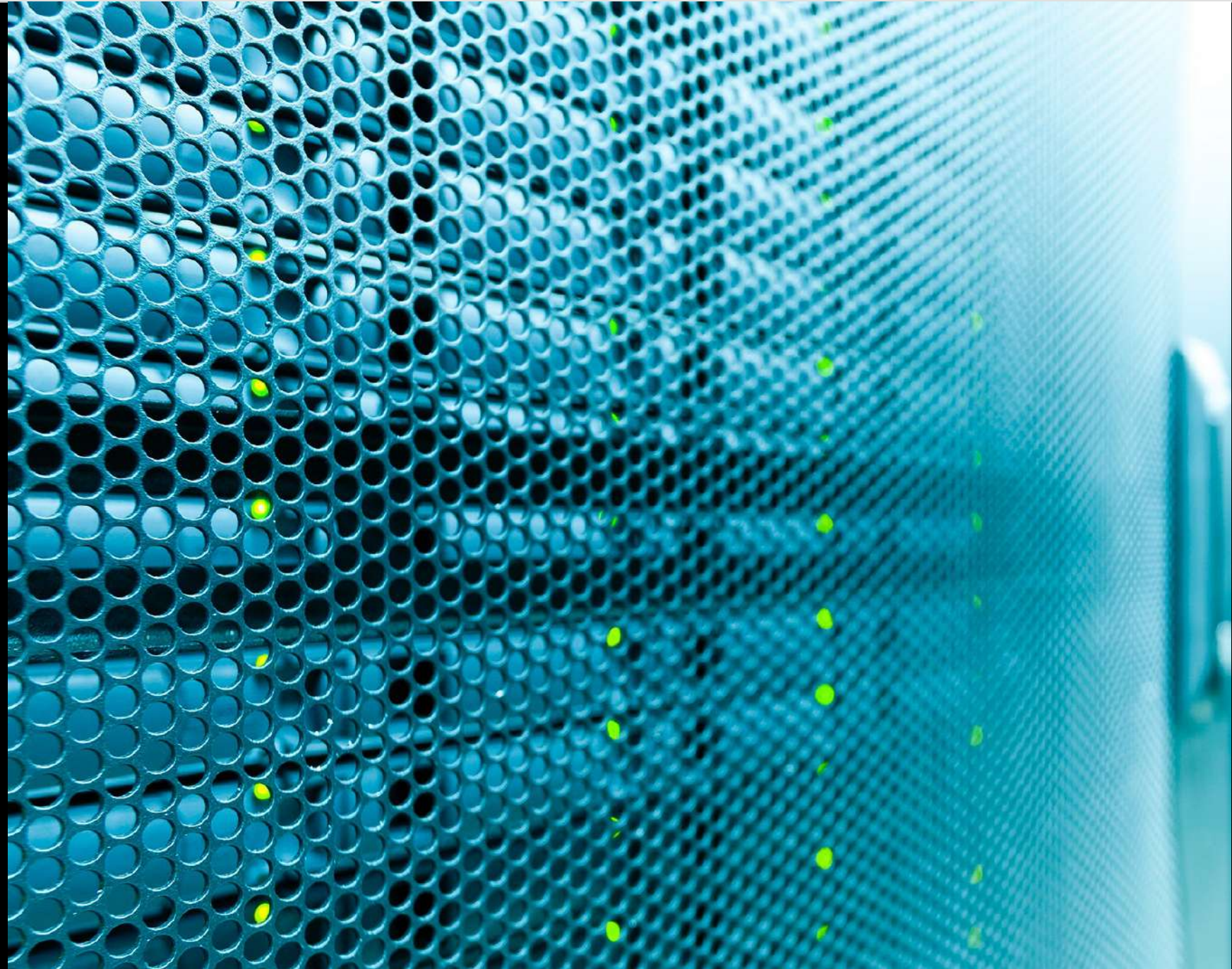
Hvad er bioinformatik?

“Bioinformatik er et tværfagligt felt, der udvikler metoder og softwareværktøjer til at forstå og fortolke biologisk data.”

Biologi

Big Data

Super computere



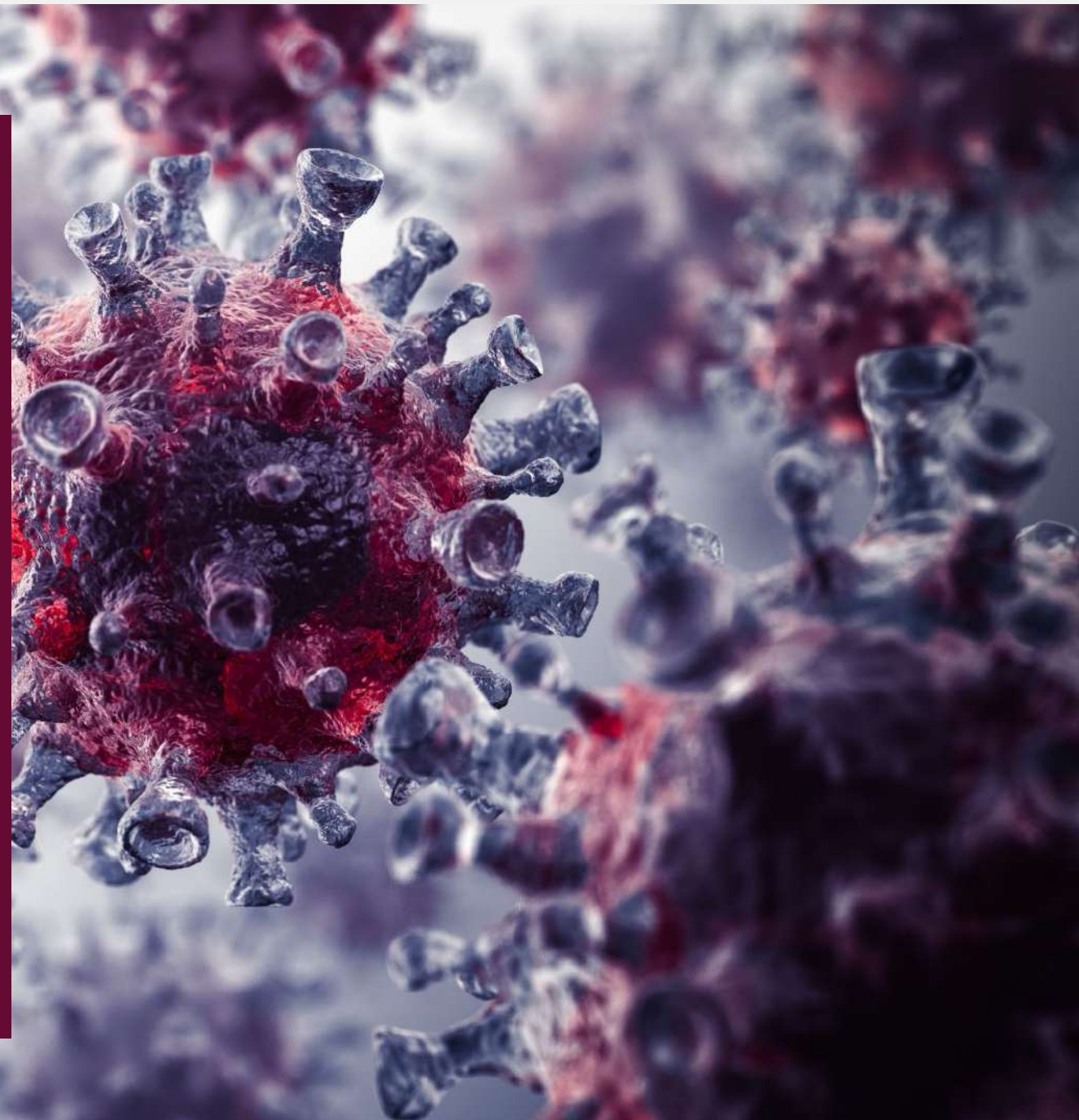


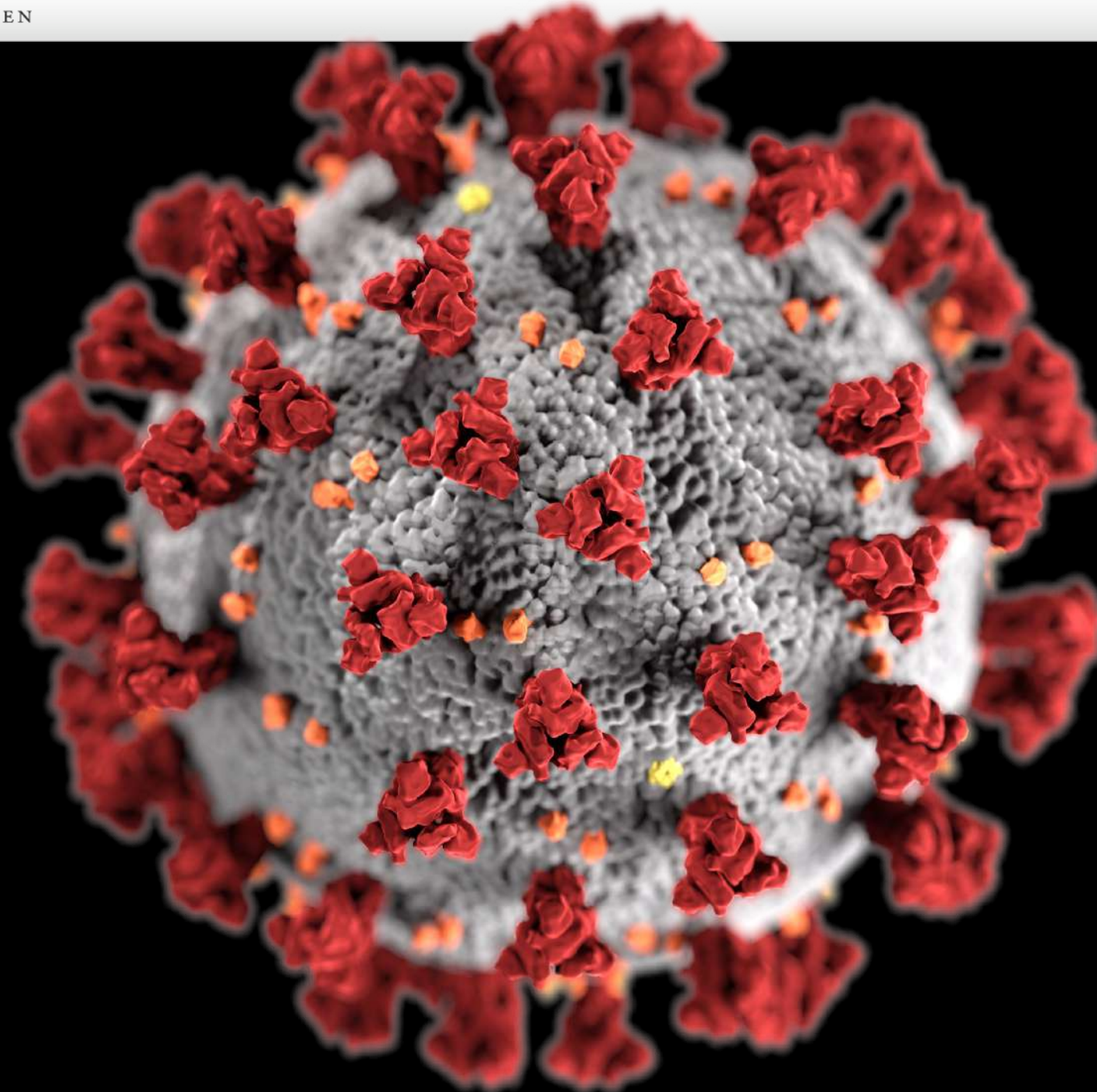


Regnskove er ikke kun planter og insekter... De er også fyldt med vira

Hvad er en virus?

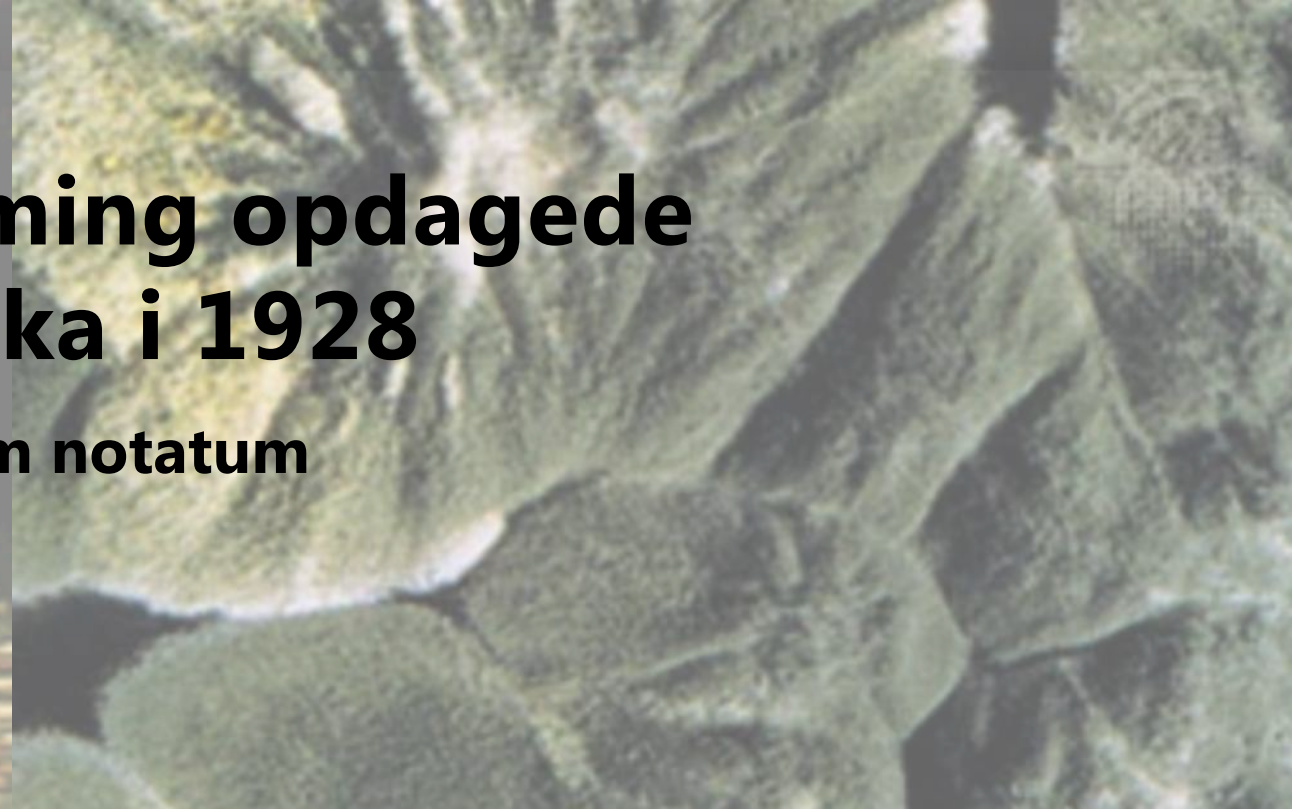
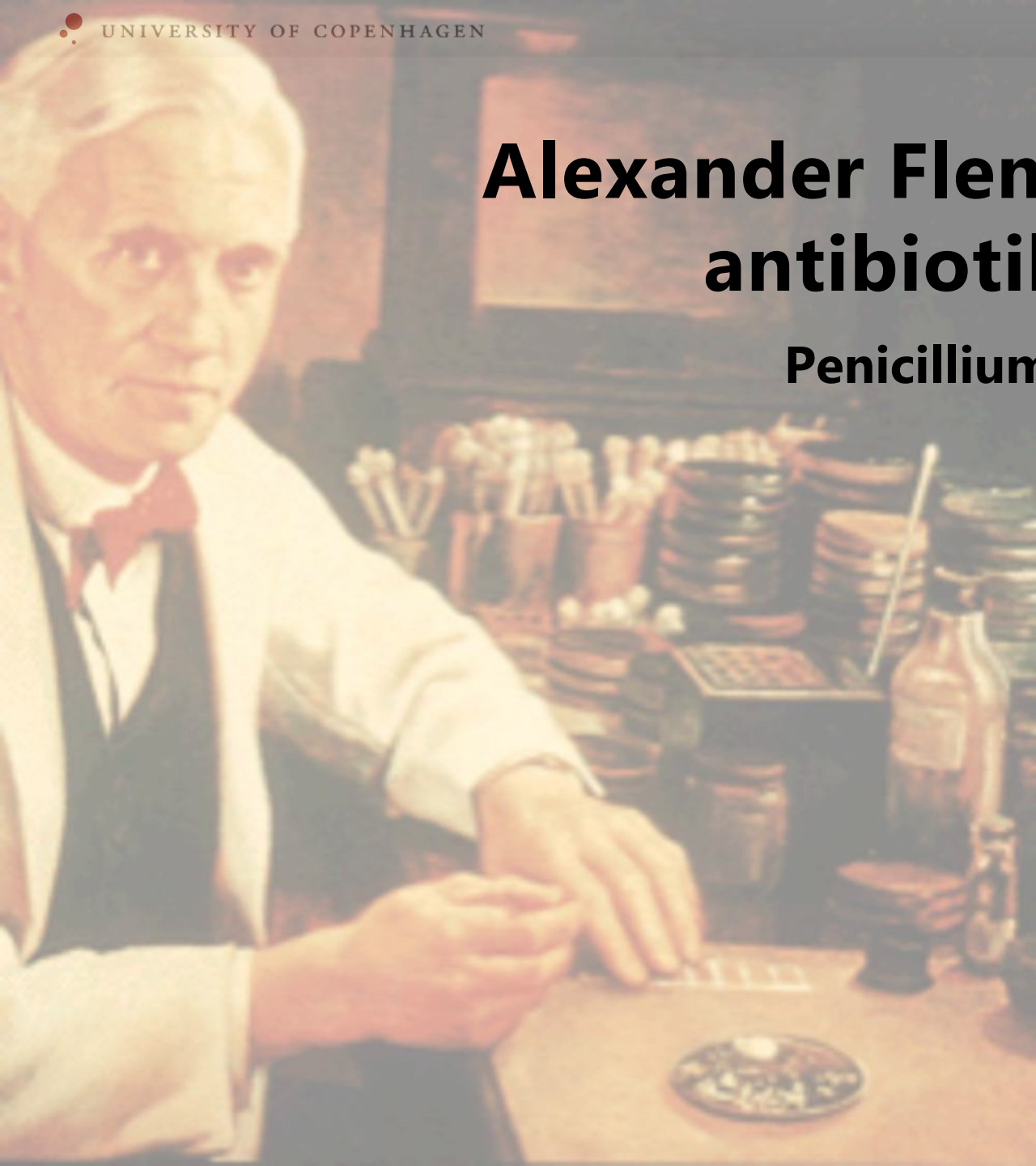
- Mikroskopisk – kan kun replikere inde i værtscellernes levende celler
- Genetisk materiale – DNA eller RNA omsluttet af en protein kappe kaldet en kapsid
- Værtsspecifikke - inficerer forskellige livsformer, fra planter og dyr til bakterier (bakteriofager)
- Sygdomsfremkaldende - varierer fra milde til livstruende, som for eksempel forkølelse, influenza, HIV, og Ebola





Alexander Fleming opdagede antibiotika i 1928

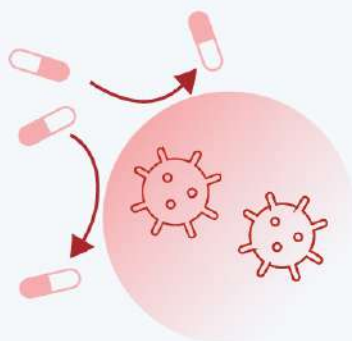
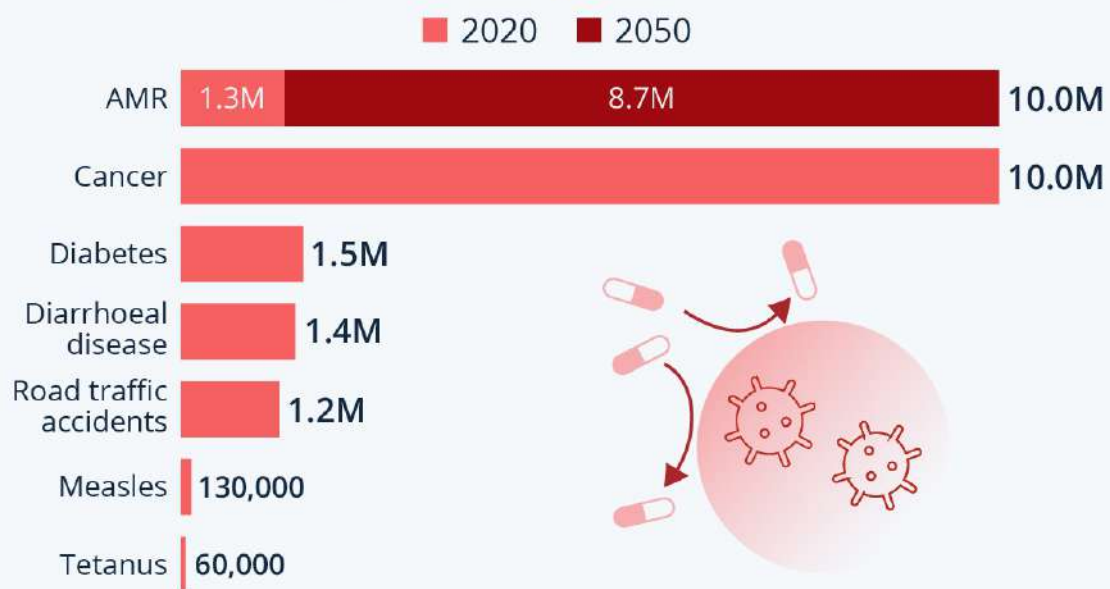
Penicillium notatum



Årlige dødsfald på grund af antibiotikaresistente bakterier

Deaths From Drug-Resistant Infections Set To Skyrocket

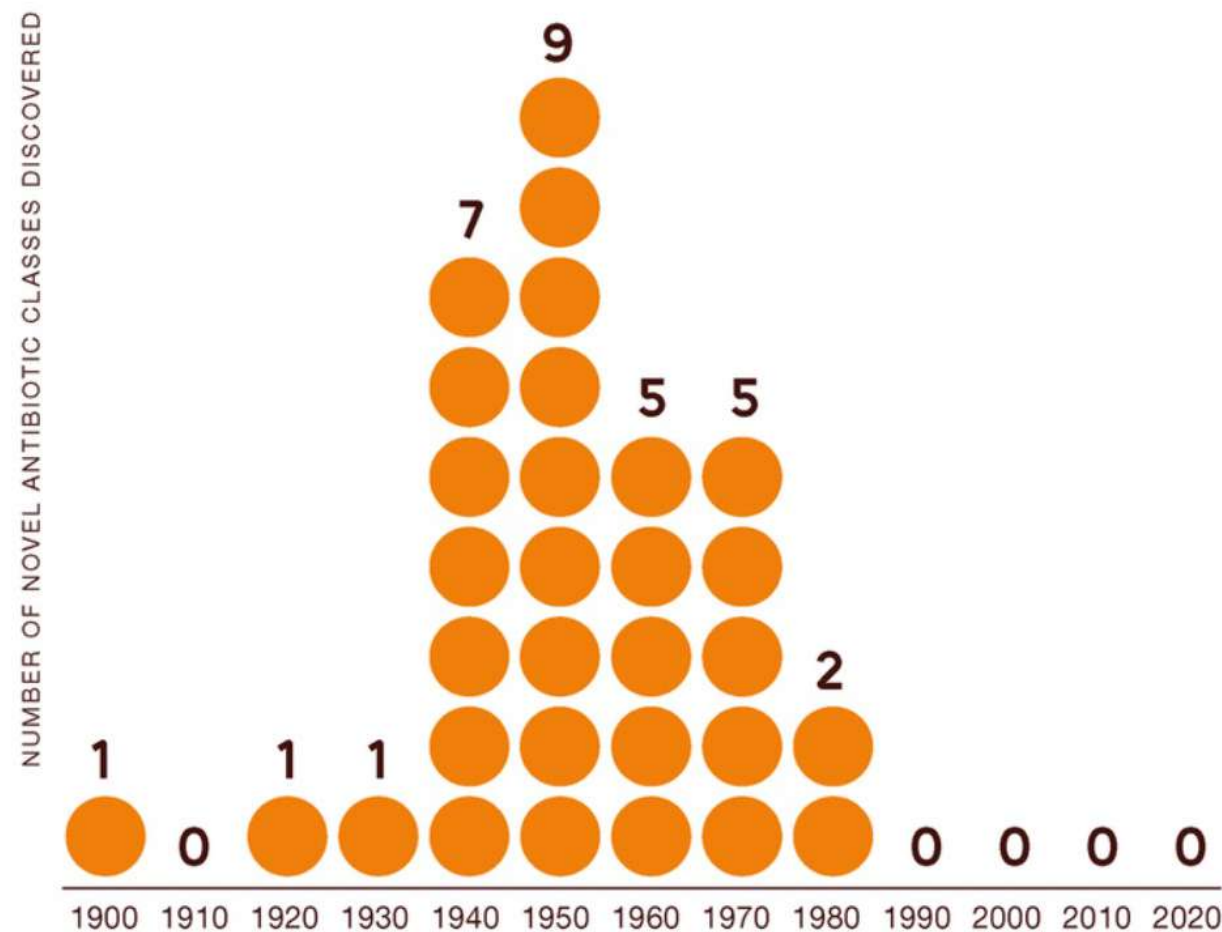
Predicted mortality from antimicrobial-resistant* infections (AMR) versus today's common causes of deaths



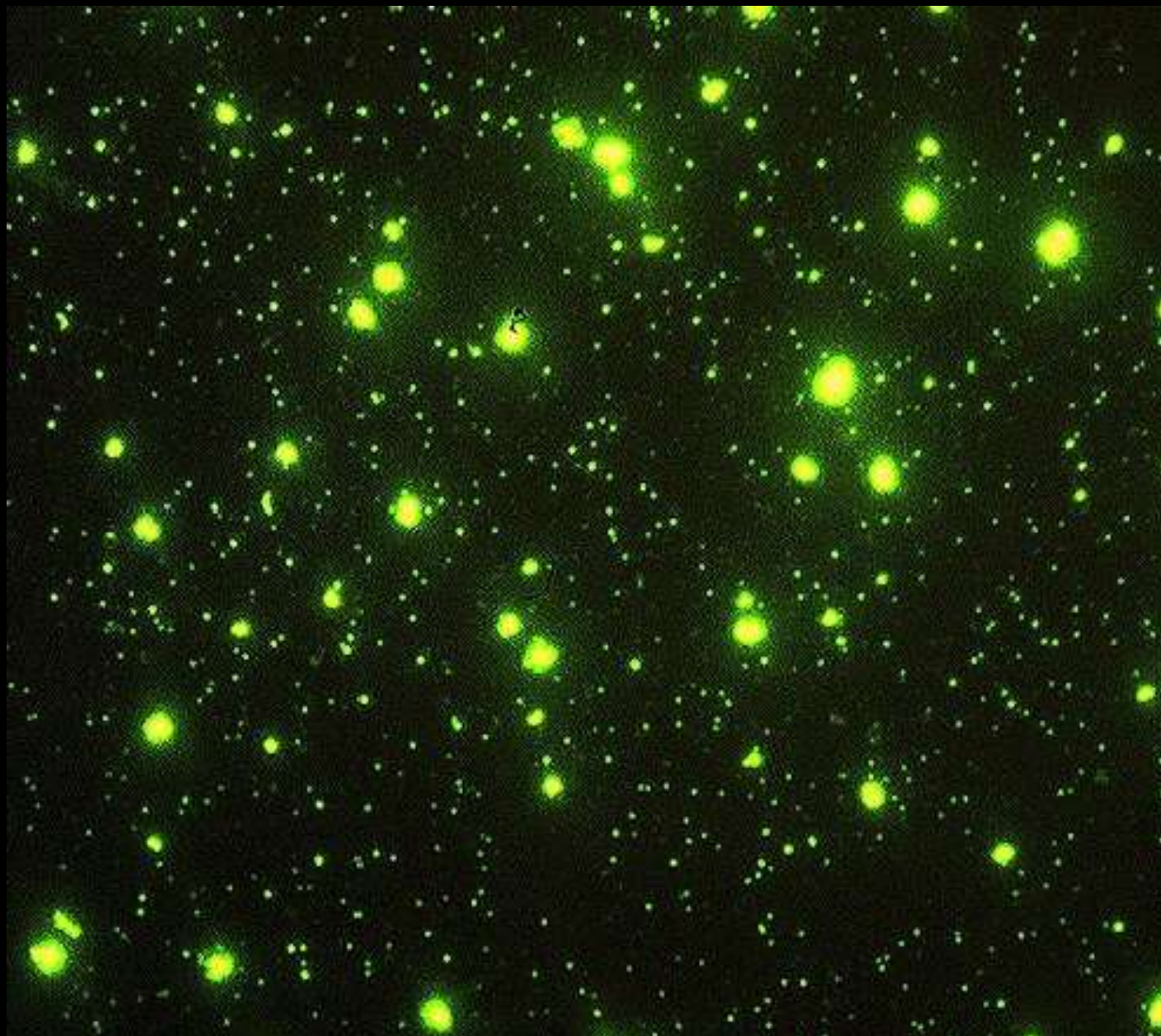
* resistant to antibiotics, antivirals, antifungals and antiparasitics
 Source: Bracing for Superbugs 2023 (UN Environmental Programme)



Antibiotic discovery has been in decline for decades

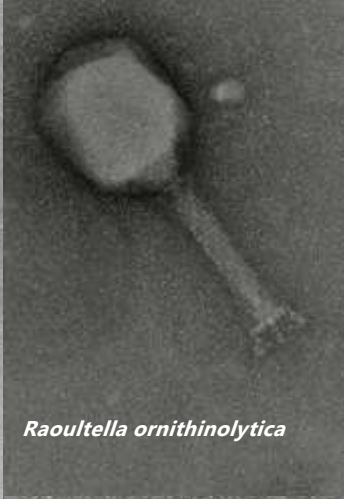


Forudsagte tal for antimikrobiel resistens i 2050
 Tackling a Crisis for the Health and Wealth of Nations. 2014

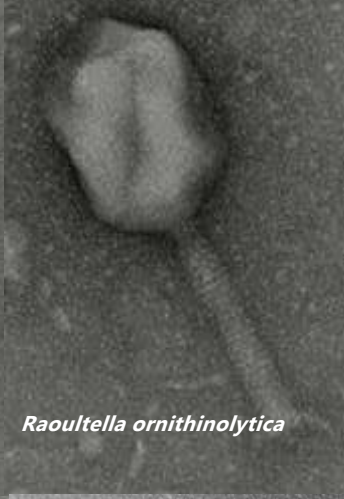




Raoultella ornithinolytica



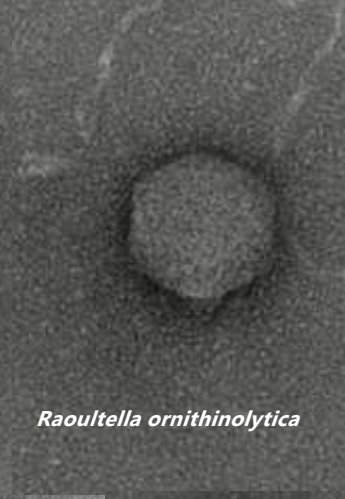
Raoultella ornithinolytica



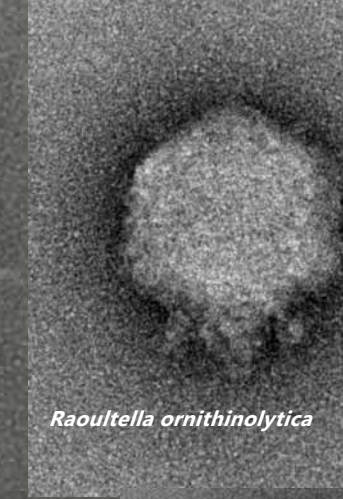
Raoultella ornithinolytica



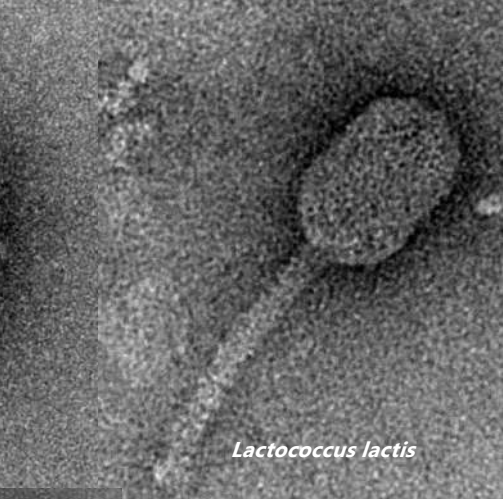
Raoultella ornithinolytica



Raoultella ornithinolytica



Raoultella ornithinolytica



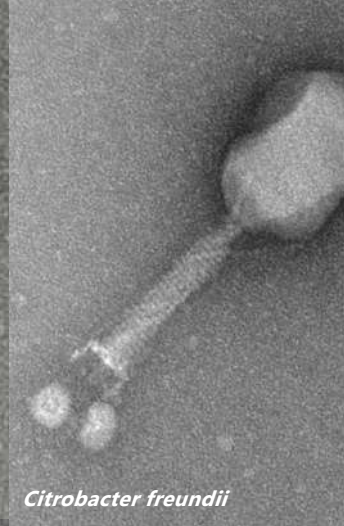
Lactococcus lactis



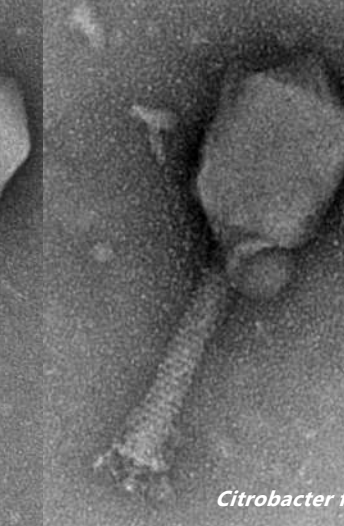
Enterococcus faecalis



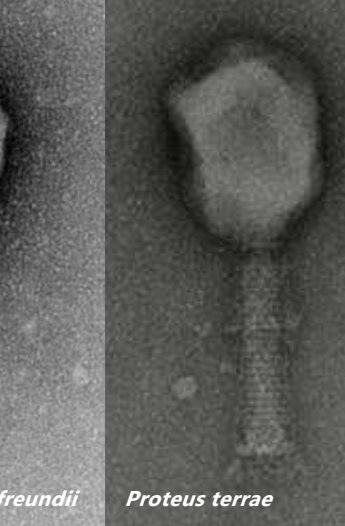
Enterococcus faecalis



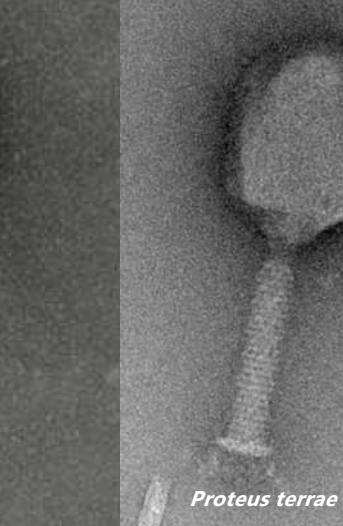
Citrobacter freundii



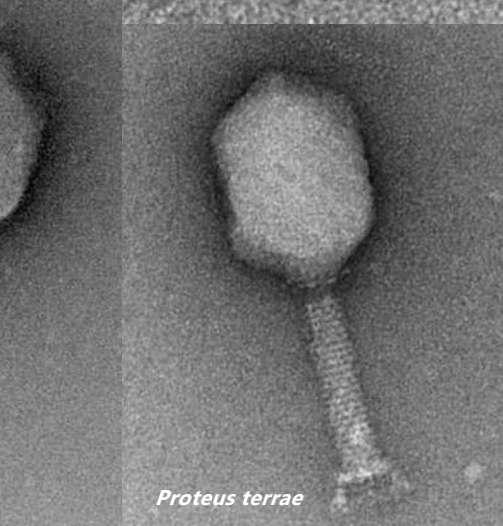
Citrobacter freundii



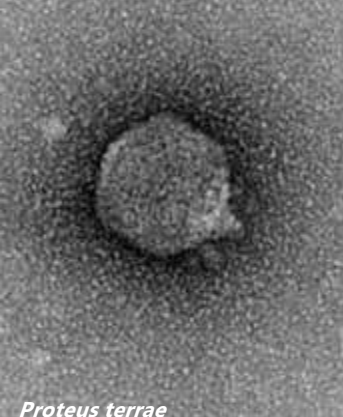
Proteus terrae



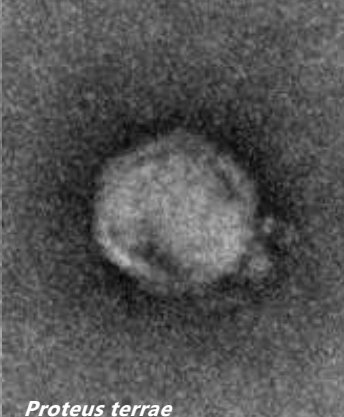
Proteus terrae



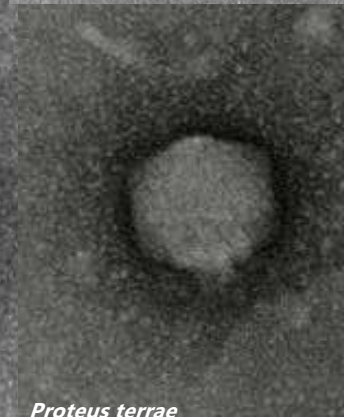
Proteus terrae



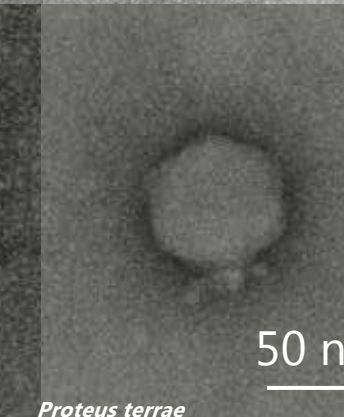
Proteus terrae



Proteus terrae

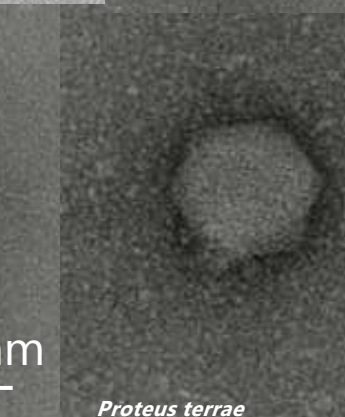


Proteus terrae

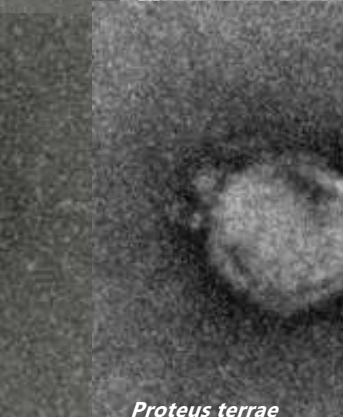


Proteus terrae

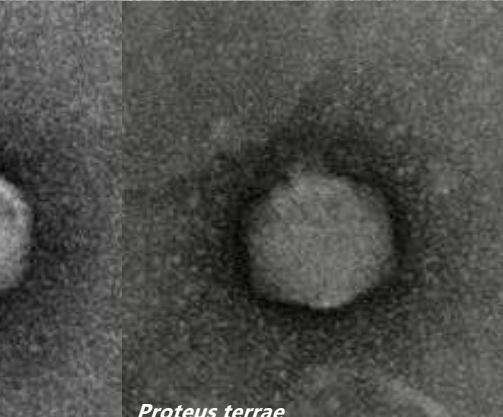
50 nm



Proteus terrae

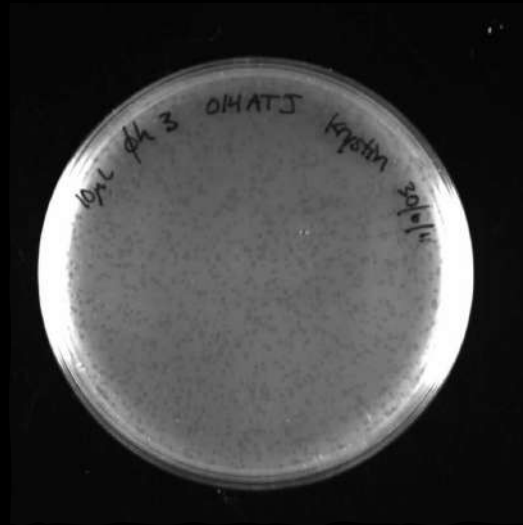
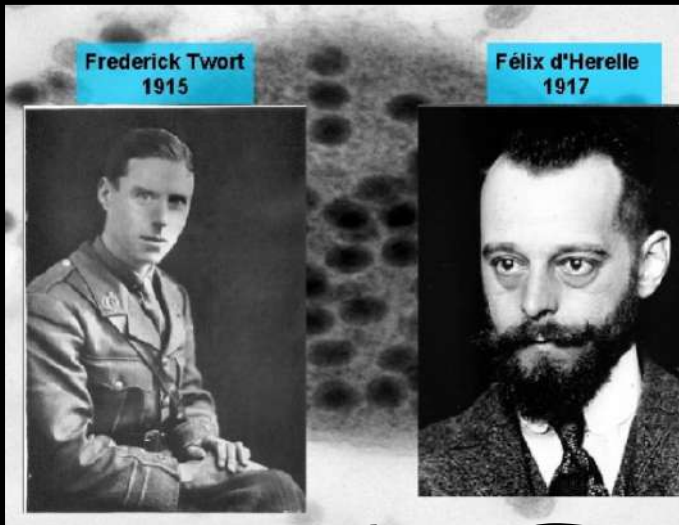


Proteus terrae



Proteus terrae

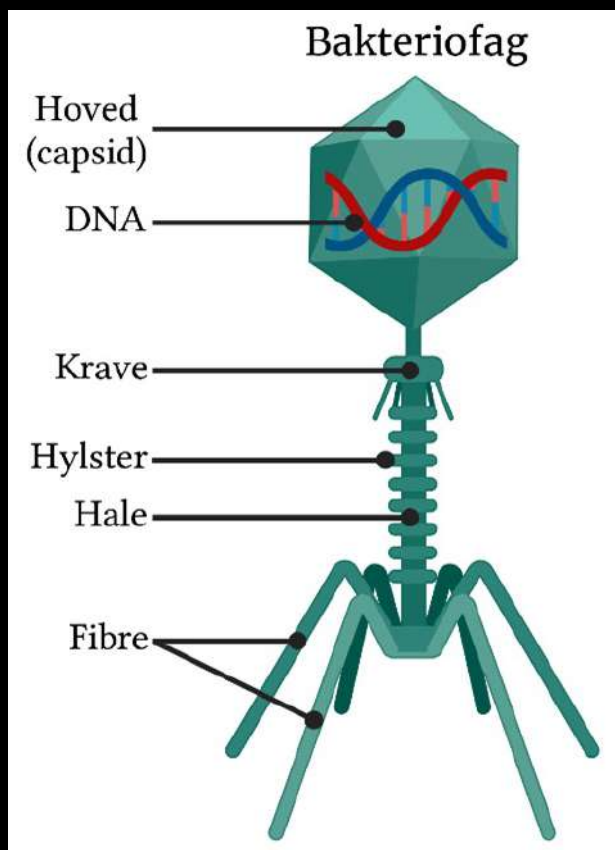
Bakteriofagens opdagelse og historie



- D'Herelles monografi, 1921
"bakteriofagen: dens rolle i immunitet"
- Efter at antibiotika blev opdaget i 1940'erne, blev fager som antimikrobielle stoffer kun lidt undersøgt
- Pasteur institute forberedte fager indtil 1978

- George Eliava etablerede Eliava Institute i Tbilisi, Georgia i 1923
- I 1980'erne forberedte 100 forskere tonsvis af fager hvert år (hovedsageligt diarré og koldbrand)

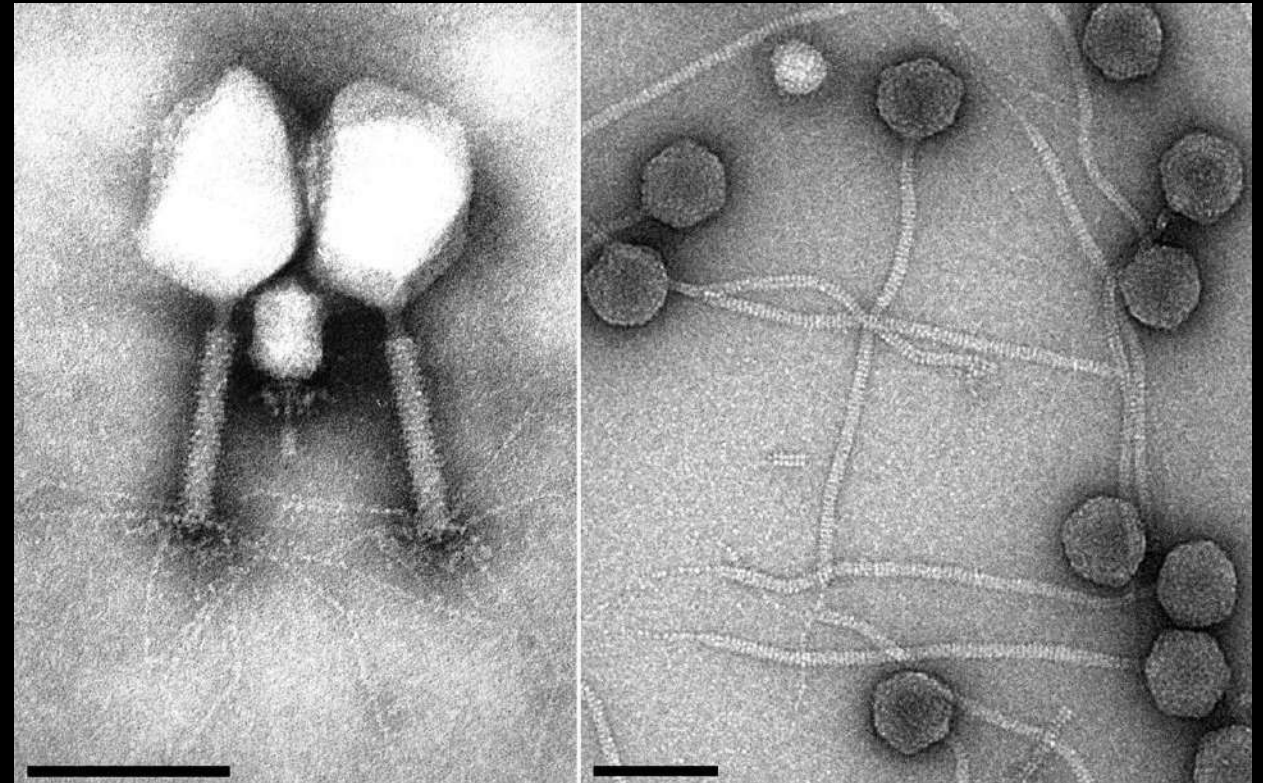
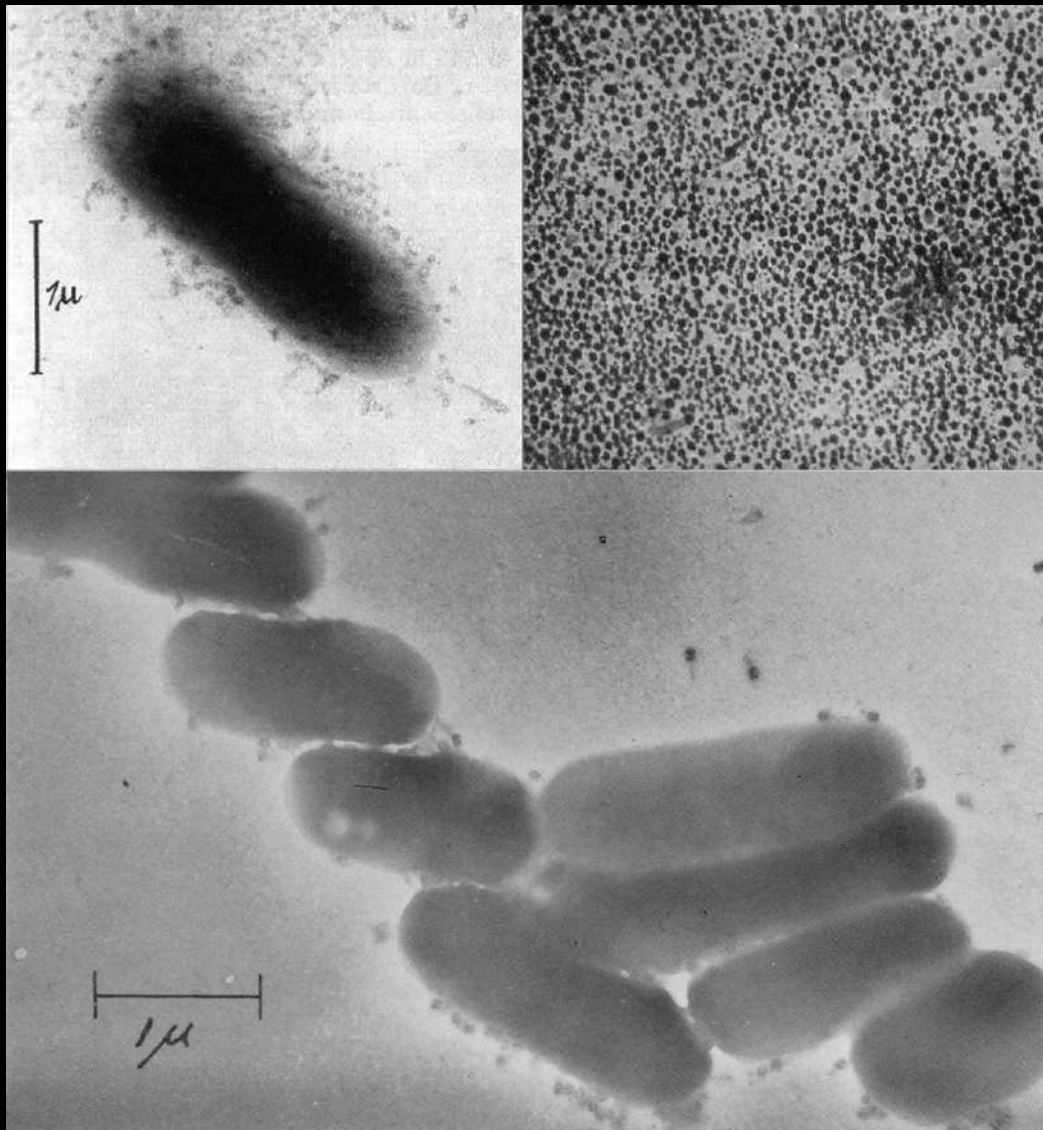
Hvordan virker en bakteriofag?



T4 bakteriofag



Kilde: NASA - Neil Armstrong

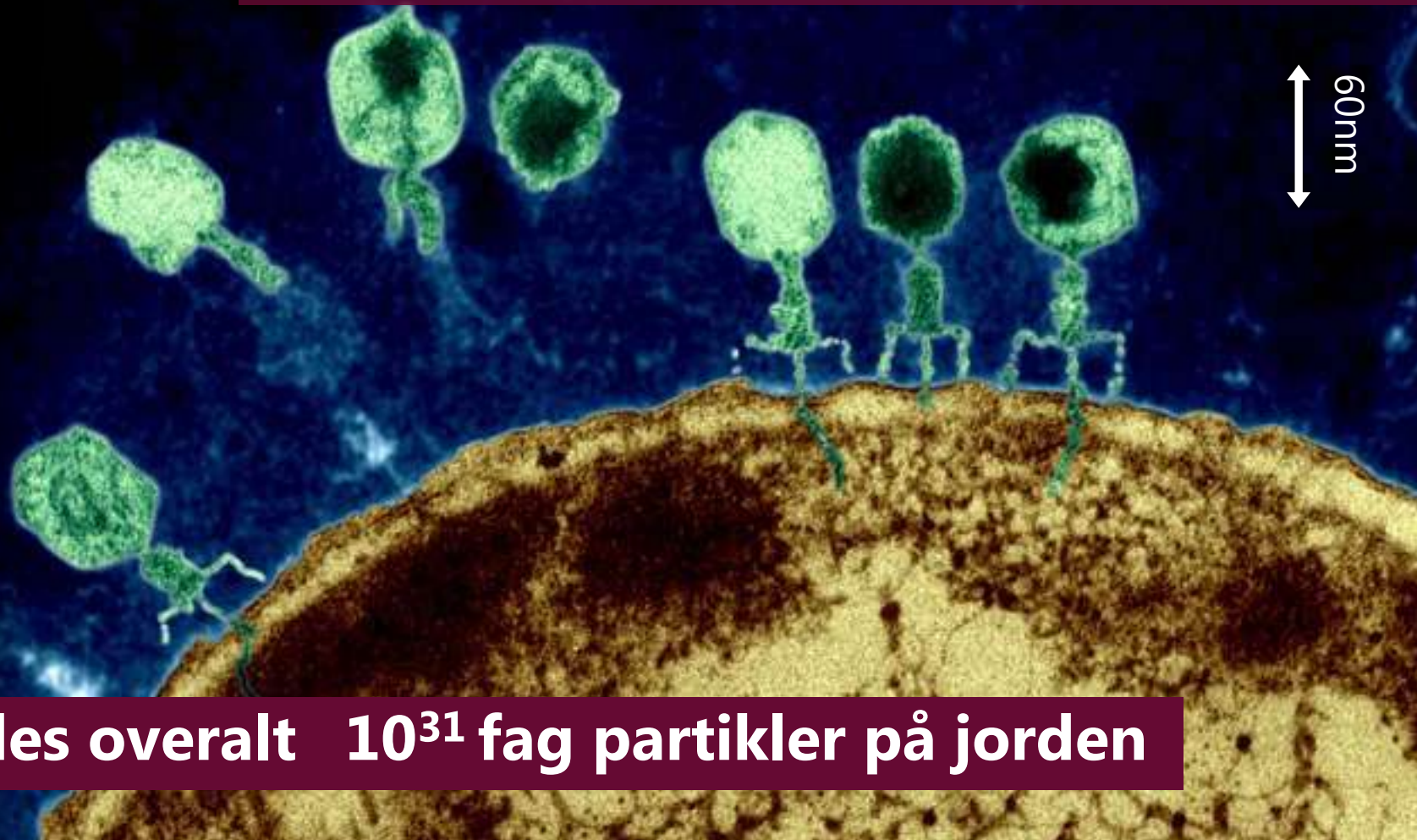
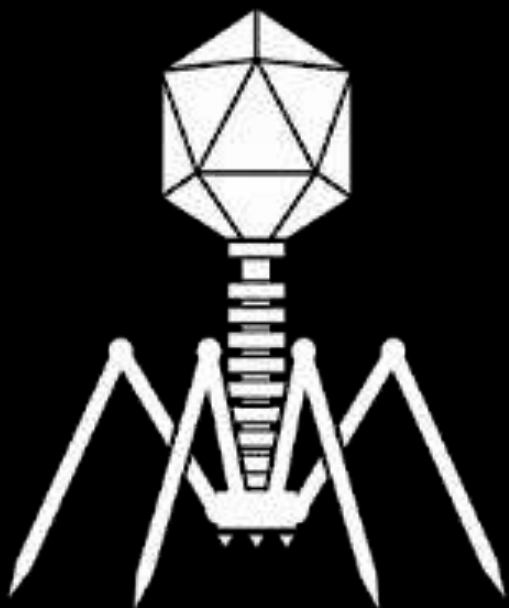


2 myovira og 1 podovirus - siphovirus

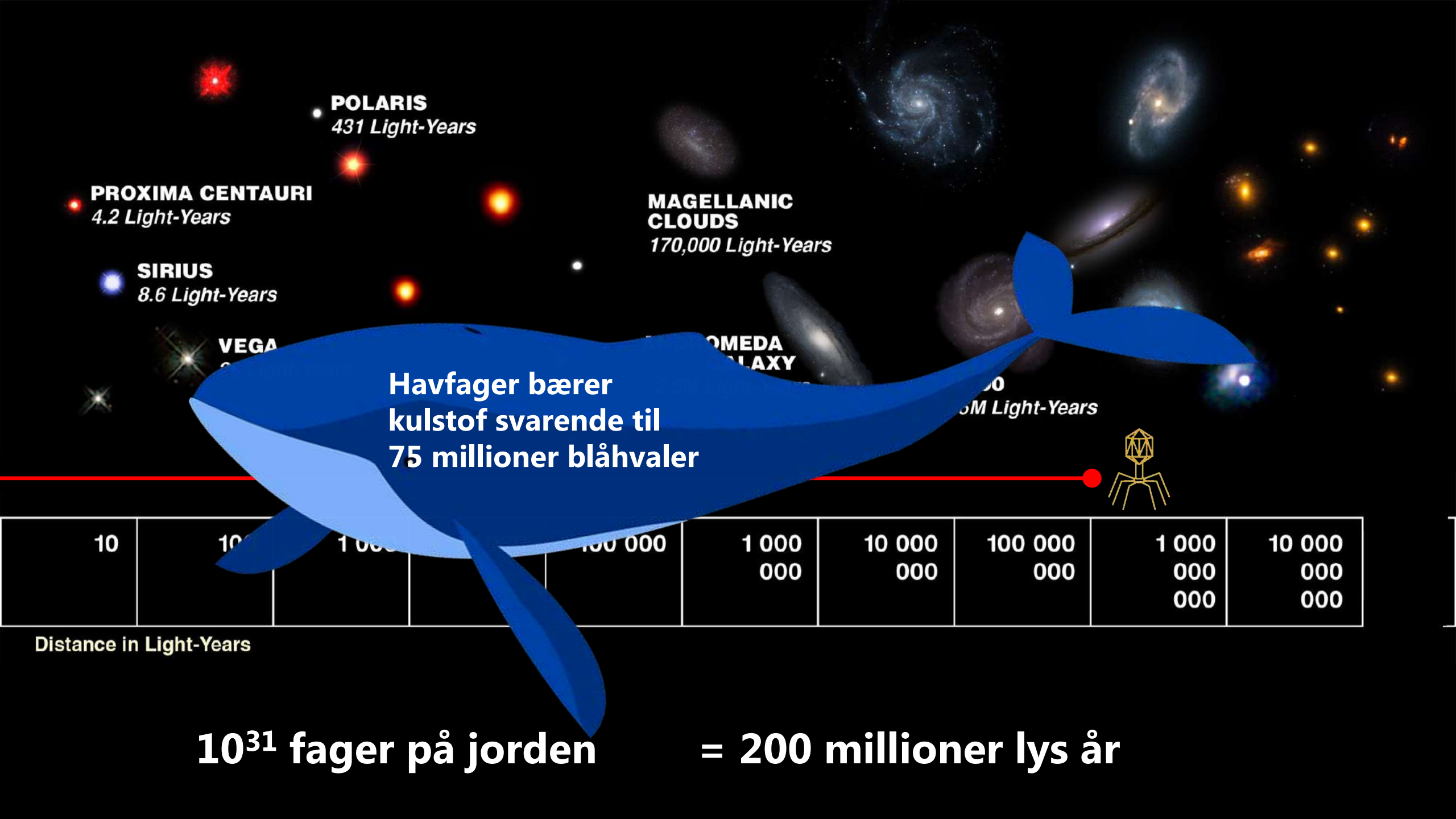
Bakteriofager er vira der kun angriber bakterier

Nøglen til at vedligeholde mikrobiel balance

Løsningen til multiresistente bakterier



Fager er ancient og findes overalt 10^{31} fag partikler på jorden



POLARIS
431 Light-Years

PROXIMA CENTAURI
4.2 Light-Years

SIRIUS
8.6 Light-Years

VEGA

MAGELLANIC CLOUDS
170,000 Light-Years

OMEGA GALAXY

50
5M Light-Years

Havfager bærer
kulstof svarende til
75 millioner blåhvaler

| | | | | | | | | |
|----|----|-----|---------|-----------|------------|-------------|---------------|----------------|
| 10 | 10 | 100 | 100 000 | 1 000 000 | 10 000 000 | 100 000 000 | 1 000 000 000 | 10 000 000 000 |
|----|----|-----|---------|-----------|------------|-------------|---------------|----------------|

Distance in Light-Years

10³¹ fager på jorden

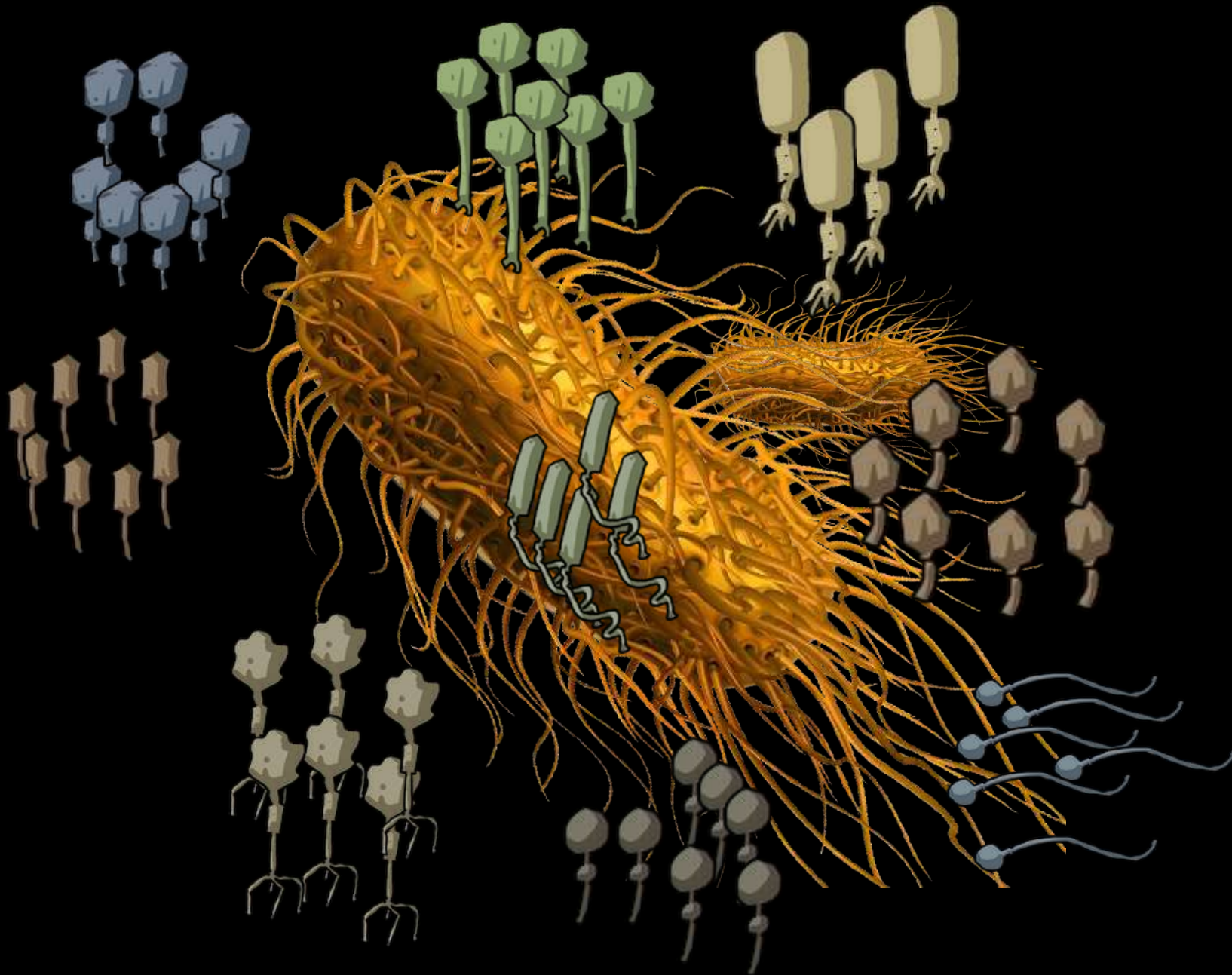
= 200 millioner lys år

Genetisk afstand mellem **bakterielle genomer (19% ukendte gener)**

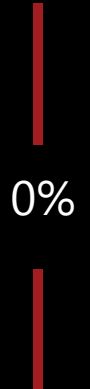
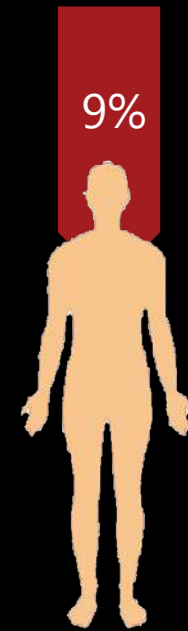
Genetisk afstand mellem **bakteriofag genomer (64% ukendte gener)**

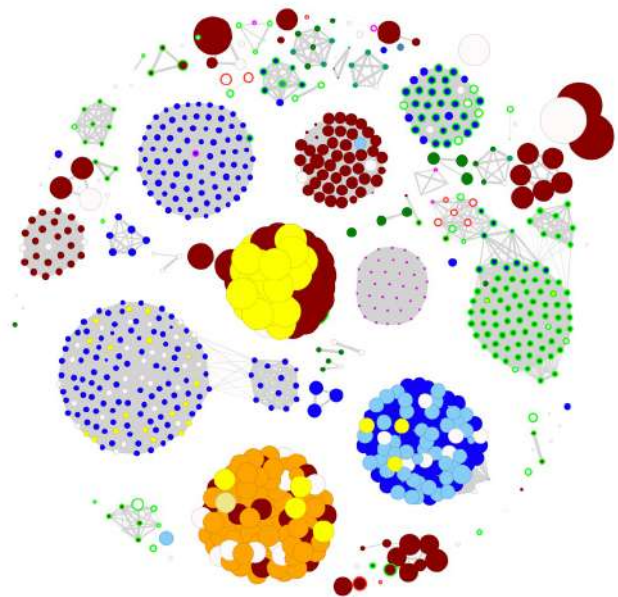


Enorm genetisk diversitet

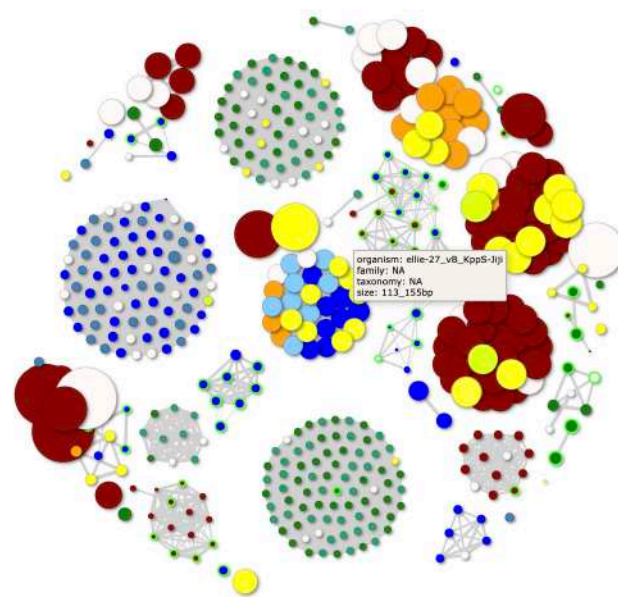


Salmonella

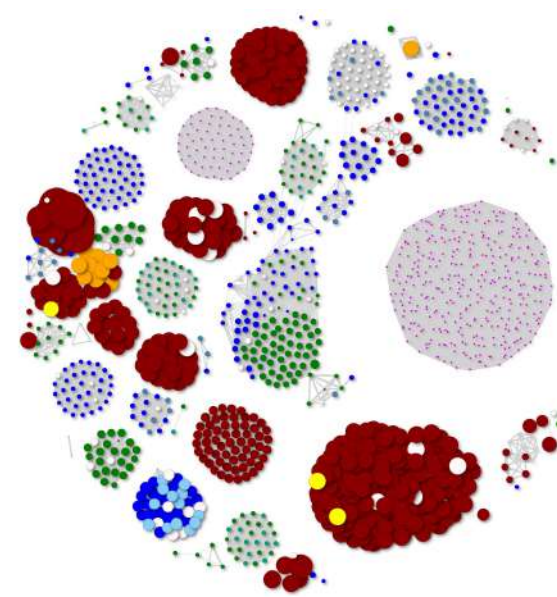




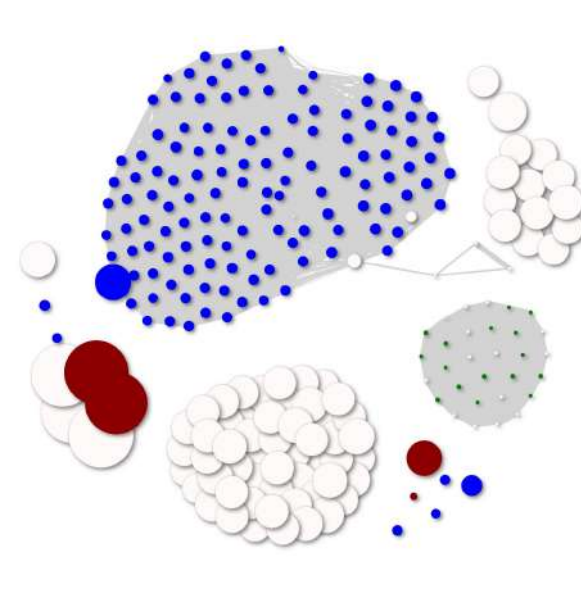
Salmonella



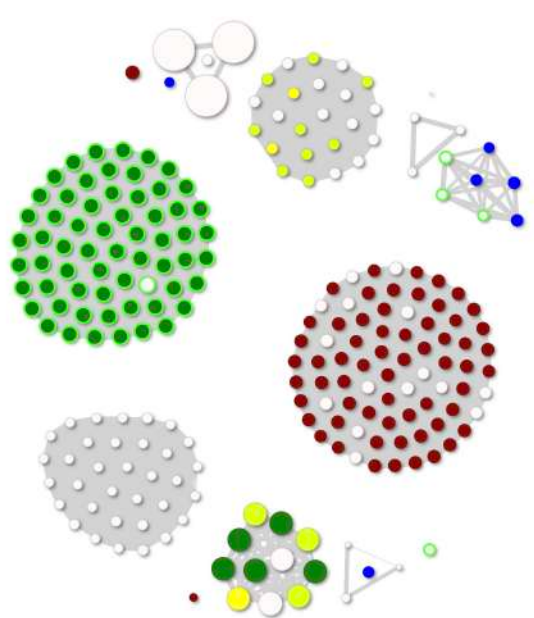
Klebsiella



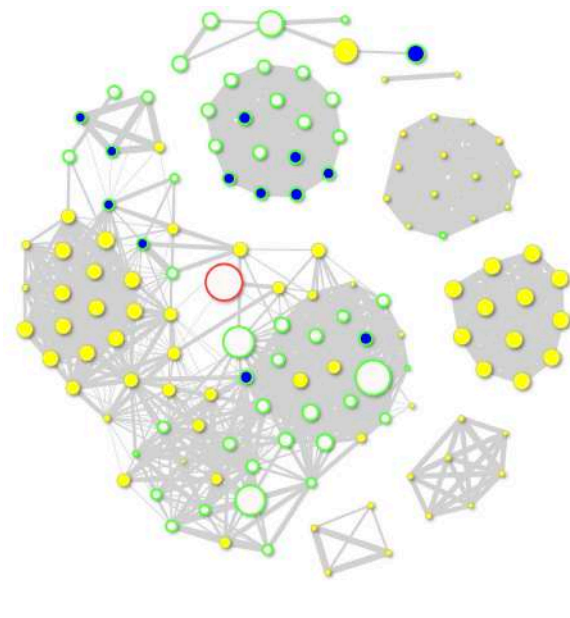
E.coli



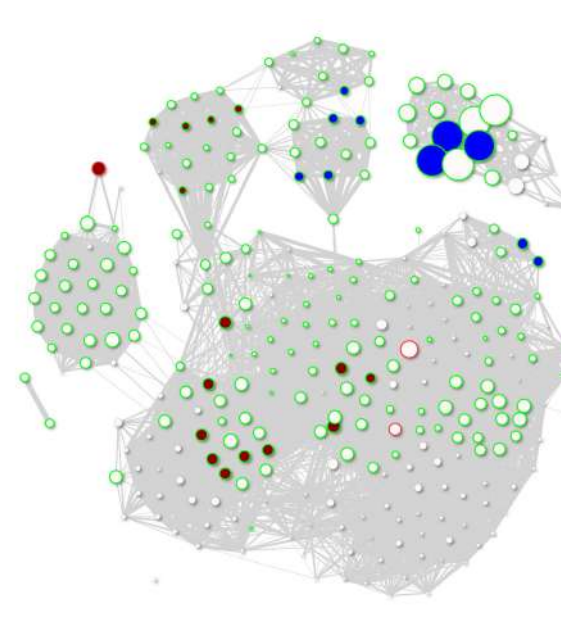
Staphylococcus aureus



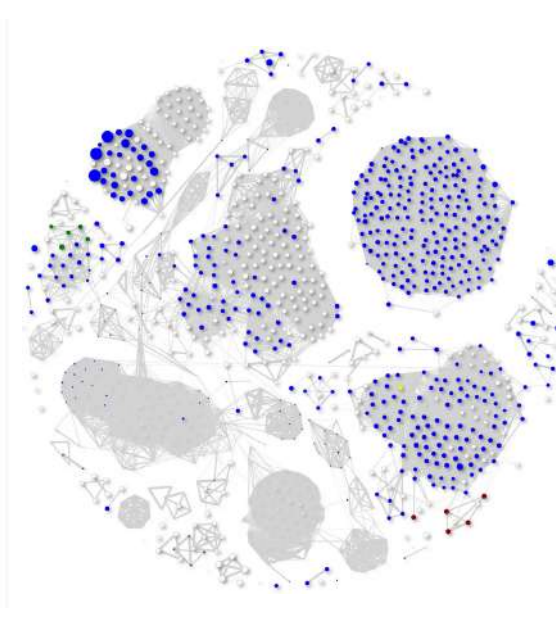
Flavobacterium



Clostridium perfringens



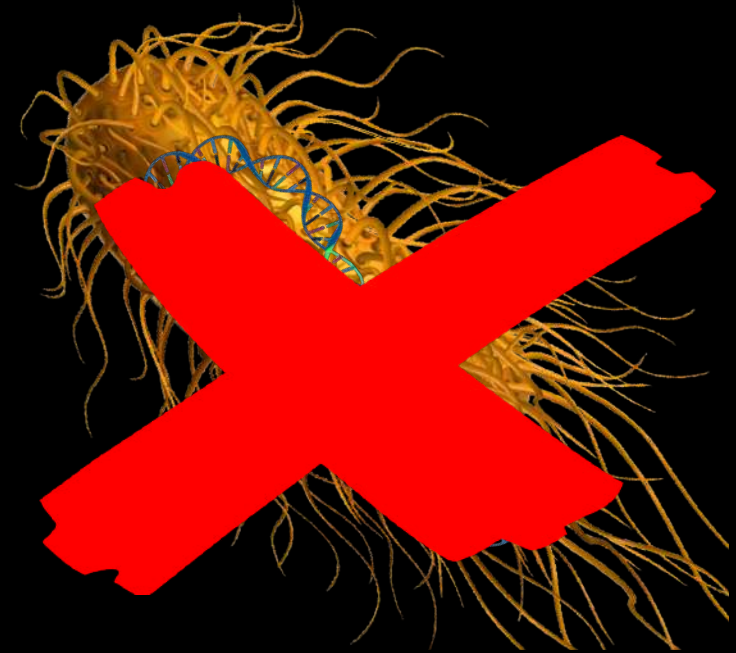
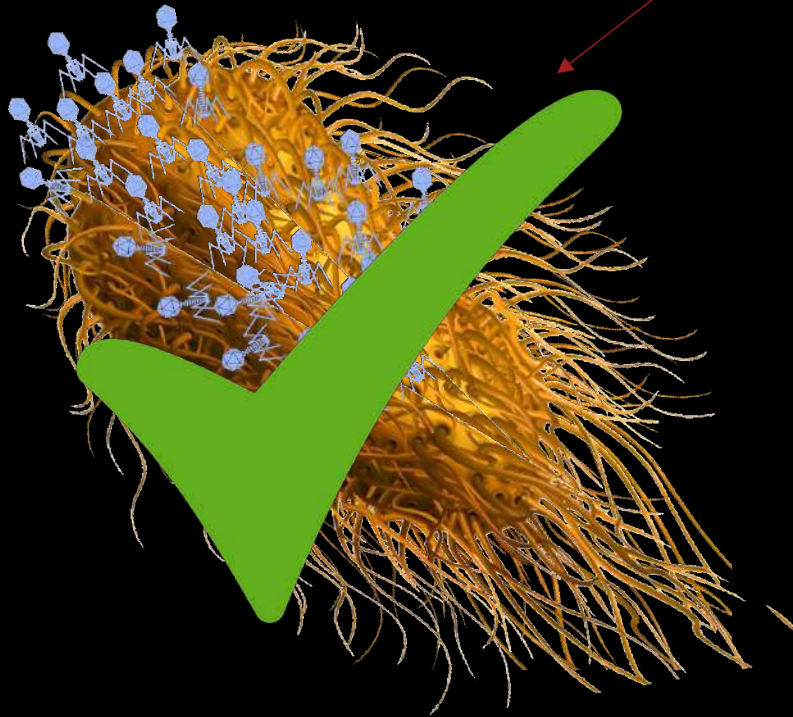
Clostridium difficile



Streptococcus



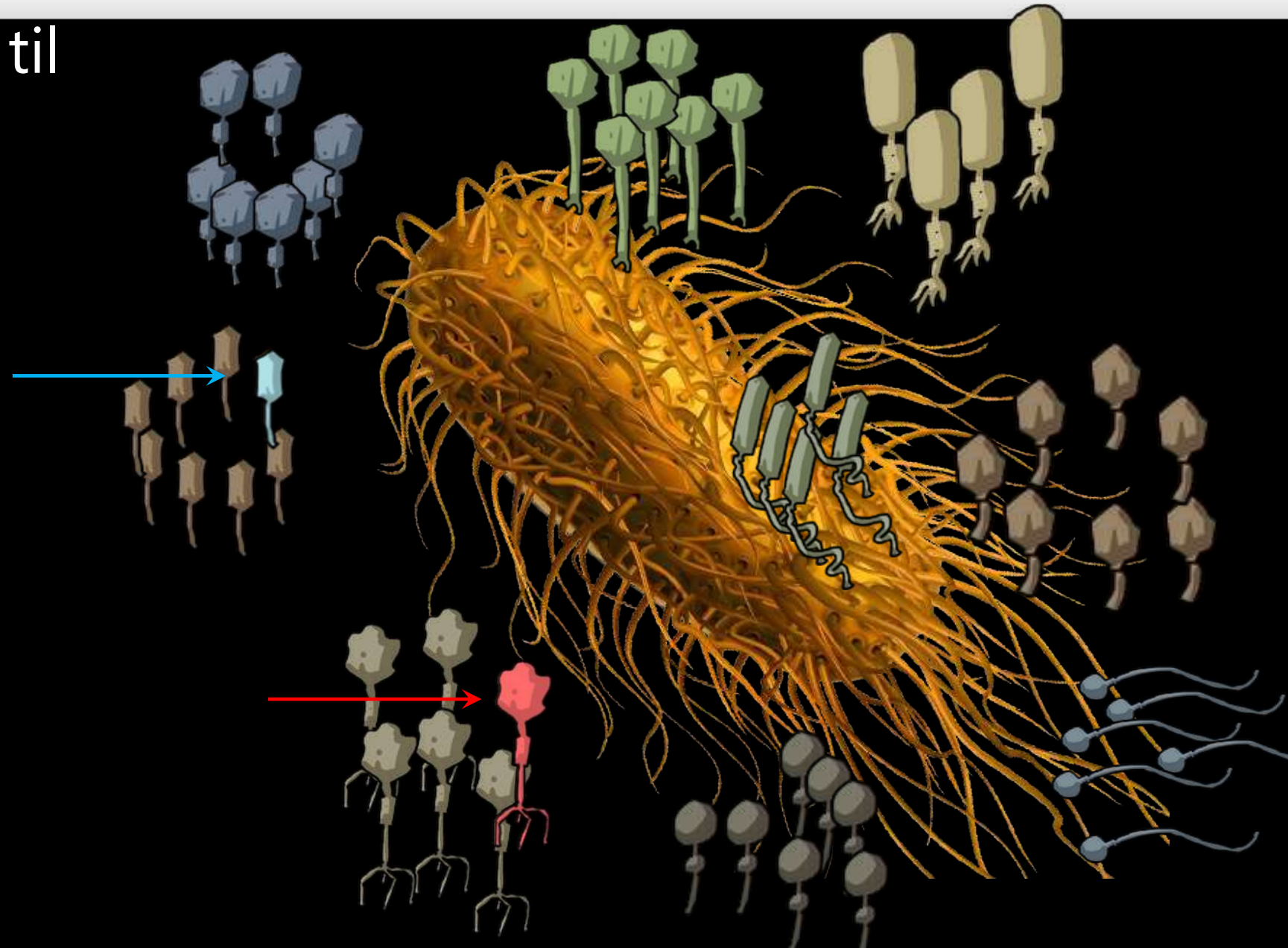
virulent lysogen



Er alle fager egnede til terapeutisk brug?

Lysogen ~~X~~ bliver i bakterier ~~X~~ i stedet for at dræbe den ~~X~~

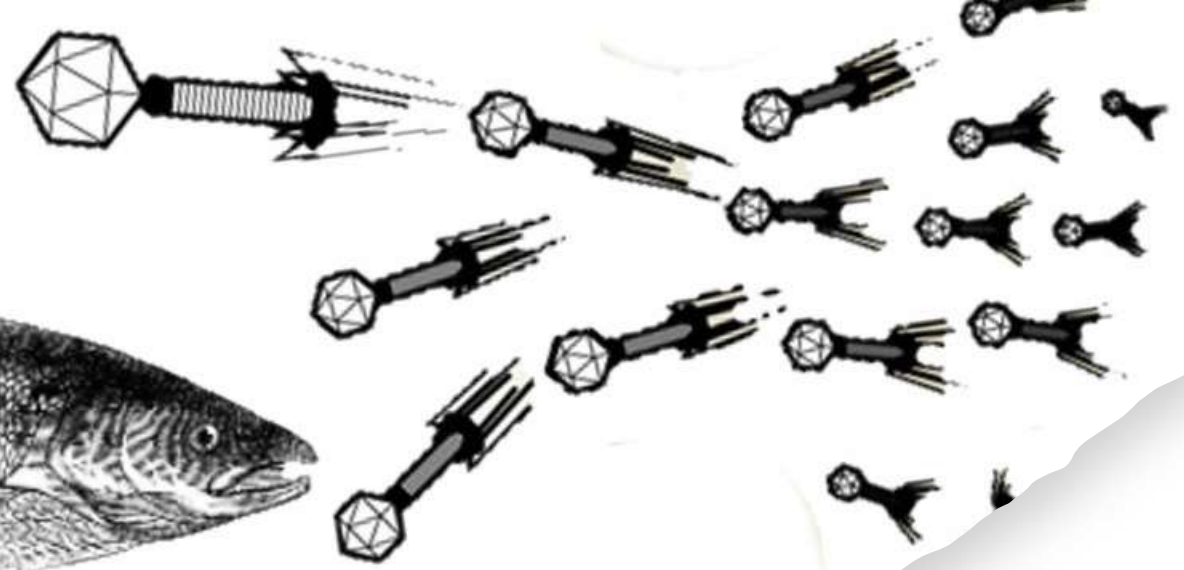
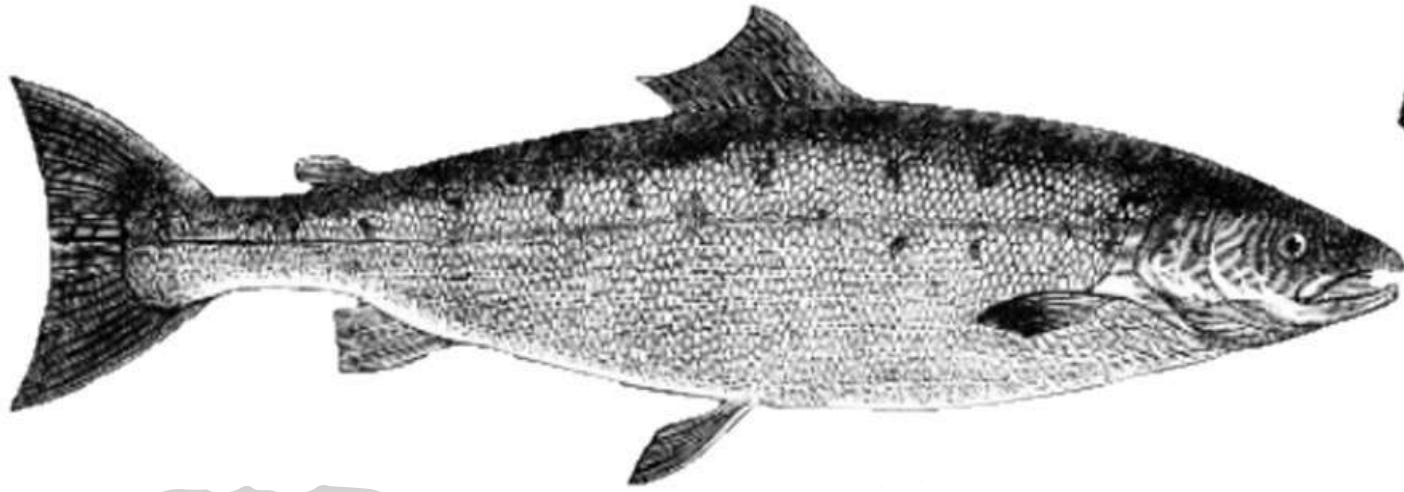
Bærer toksiner eller antibiotikaresistens ~~X~~ gener ~~X~~



Regnskoven, planter og bakteriofager

Gratis online
Undervisnings-materiale





Fager kan redde lakseindustrien

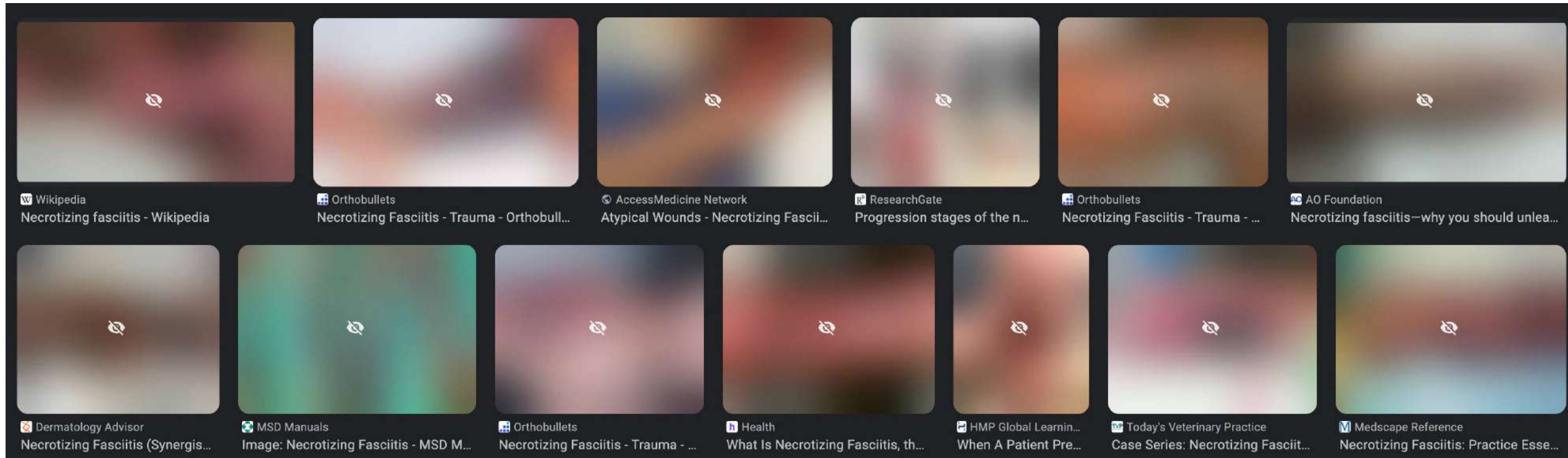
Bakterien *Pasteurella skyensis* stigende trussel mod laksefarme, forårsager pasterioulosis

Mulige løsninger:

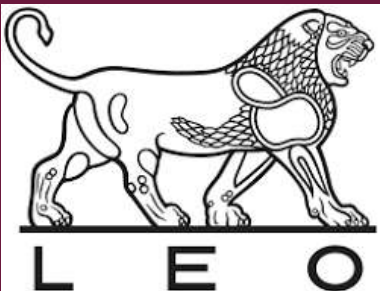
- Antibiotika (ikke ønsket behandling)
- Vacciner (tidligt stadie under udvikling)

Vores løsning:

- Bakteriofager (99,9 % sikker løsning)



Fagterapi til behandling af kødædende bakterier



- Nekrotiserende blødt vævsinfektioner (NSTI) (kødædende sygdom)
- Forårsaget af Streptococcus A bakterier => 10 cm i timen
- Eskalerer hurtigt globalt og udgør en dødelig bakteriel trussel
- 20% ender med amputation, 25% resulterer i dødsfald.

Første eksempel på en britisk patient, der behandles ved hjælp af fager

Brief Communication | Published: 08 May 2019

Engineered bacteriophages for treatment of a patient with a disseminated drug-resistant *Mycobacterium abscessus*

Rebekah M. Dedrick, Carlos A. Guerrero-Bustamante, Rebecca A. Garlena, Daniel A. Russell, Katrina Ford, Kathryn Harris, Kimberly C. Gilmour, James Soothill, Deborah Jacobs-Sera, Robert T. Schooley, Graham F. Hatfull & Helen Spencer

Nature Medicine 25, 730–733 (2019) | [Cite this article](#)

55k Accesses | 731 Citations | 2494 Altmetric | [Metrics](#)

Abstract

A 15-year-old patient with cystic fibrosis with a disseminated *Mycobacterium abscessus* infection was treated with a three-phage cocktail following bilateral lung transplantation. Effective lytic phage derivatives that efficiently kill the infectious *M. abscessus* strain were developed by genome engineering and forward genetics. Intravenous phage treatment was well tolerated and associated with objective clinical improvement, including sternal wound closure, improved liver function, and substantial resolution of infected skin nodules.



A tailor-made treatment combined three phages. THE HATFULL LABORATORY

health Life, But Better Fitness Food Sleep Mindfulness Relationships

Genetically modified virus saves teen's life, offers hope in fight against antibiotic resistance

By Nina Awanawa and Susan Scott, CNN
6 minute read - Updated 7:27 PM EDT, Fri May 10, 2019

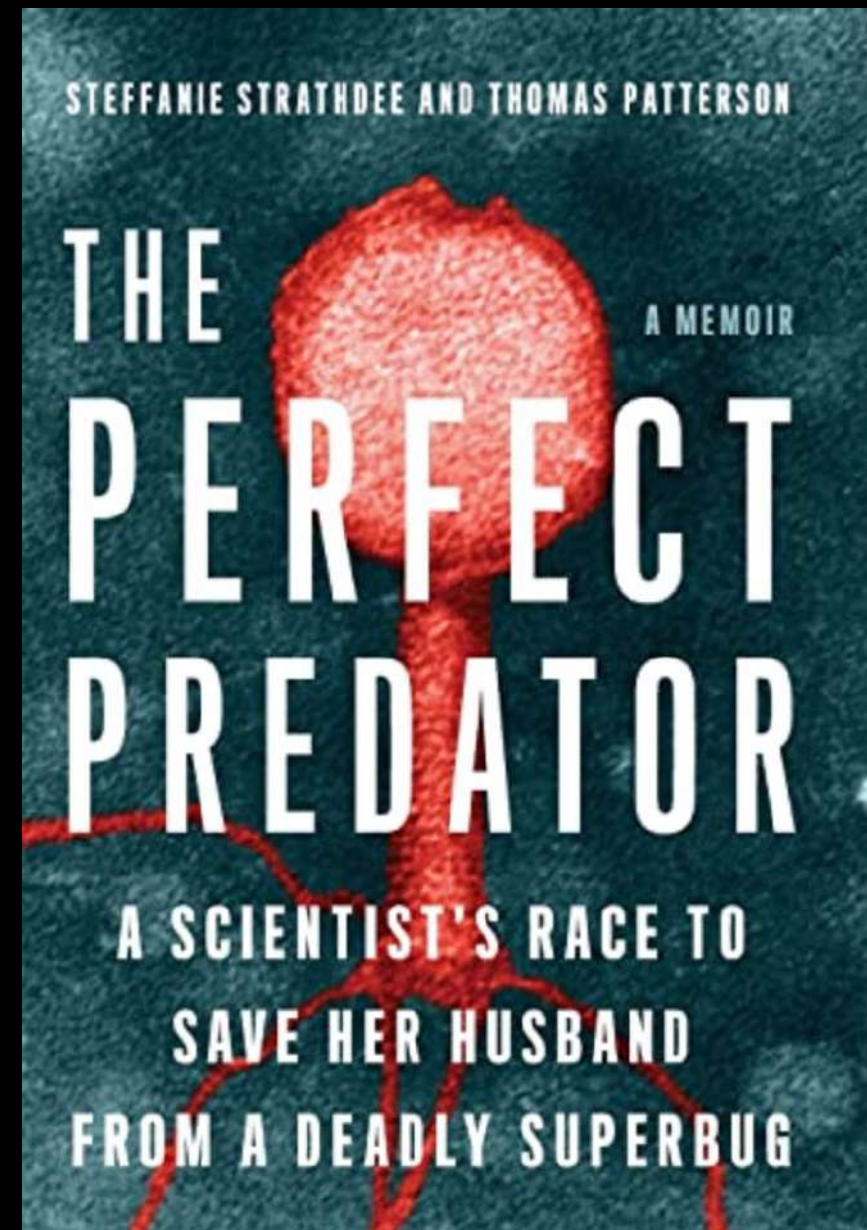
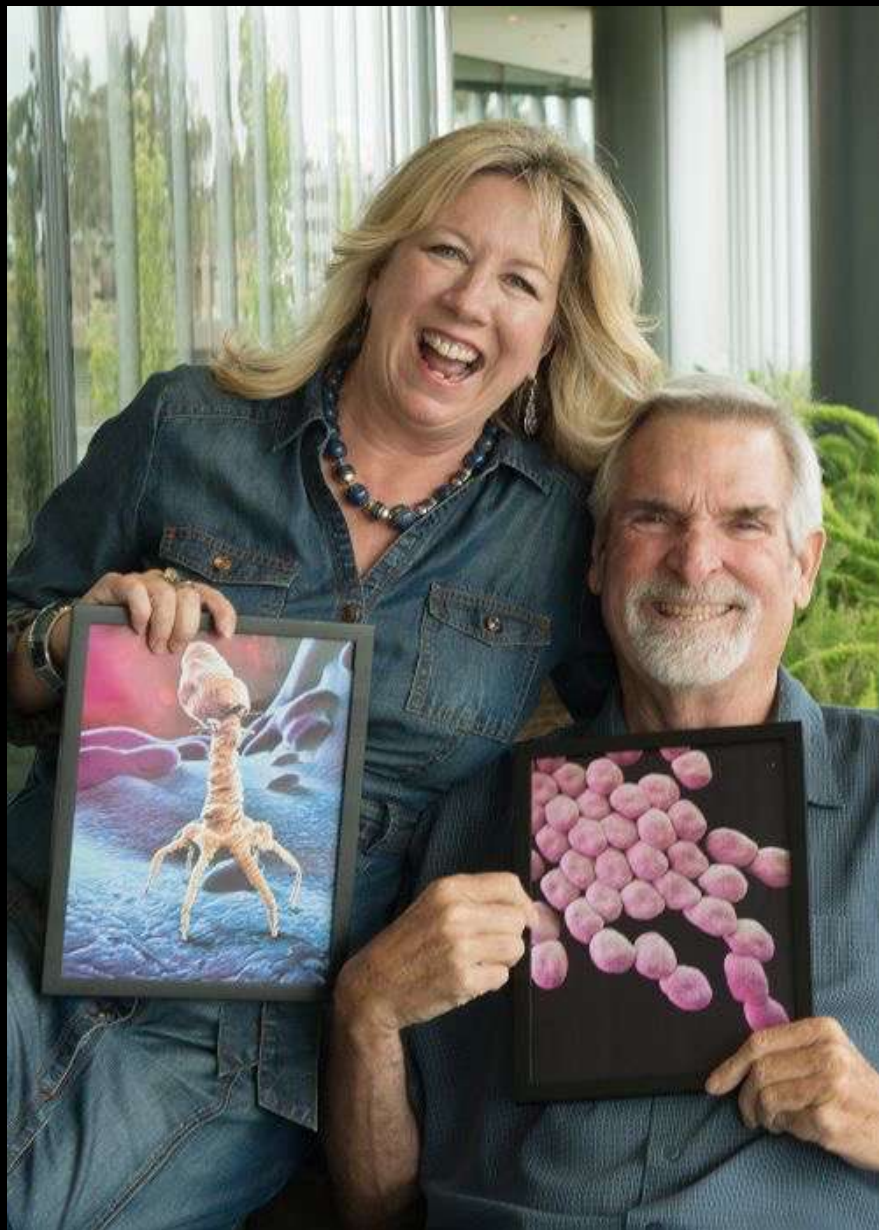
Virus helps teen in life-threatening battle

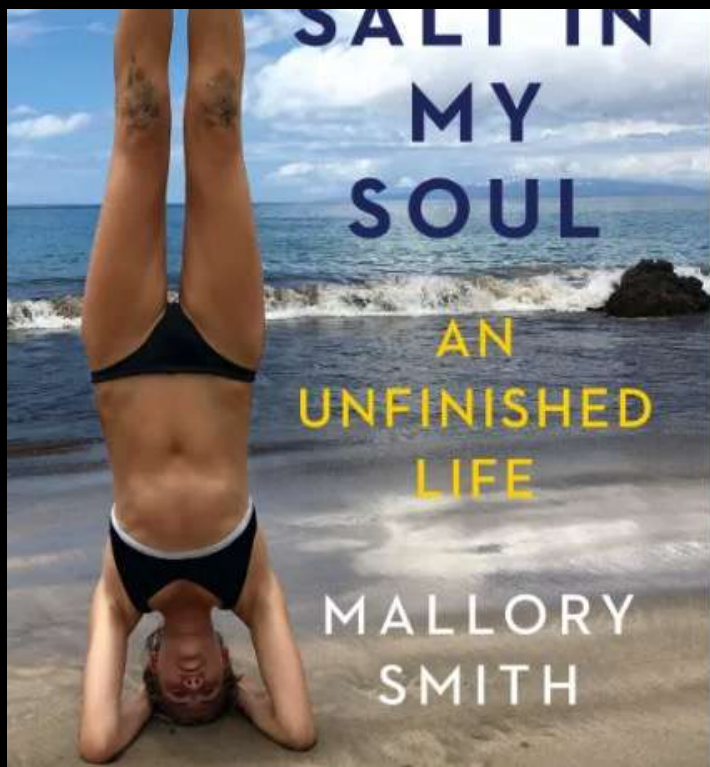
Tribute to Isabelle Carnell-Holdawa

Dedicated to the memory of Isabelle Carnell-Holdaway

This site is a tribute to Isabelle. She is much loved and will always be remembered.

They defeated 'the world's worst bacteria' with phages





Diane Shader Smith @dianeshadersmith · Jan 3, 2023 ...

Many of the brightest minds working to solve the global health crisis of AMR were part of the campaign featured below. It was an honor to contribute on behalf of the many millions who have died - or will die. Losing Mallory/ #health #share #media sharing...



Diane Shader Smith on LinkedIn: Antibiotic Resistance Archives - Future of Pers...

From linkedin.com





Bacteriophage

The Deadliest Being on Planet Earth
Kurzgesagt



The war is fought by the single deadliest entity on our planet:



© Illustration: Alinea/Pernille Sihm

Hologenomik

Indhold Kapitler

Du er aldrig alene! For skjult for det blotte øje er alle de mikroskopiske bakterier, som lever på, i og omkring kroppen.

I disse år er forskere ved at undersøge, hvordan samarbejdet med de mange bakterier er med til at holde os sunde og raske, og det er det samarbejde, som *hologenomik* handler om.

Når du er færdig med forløbet:

- kan du give eksempler på, hvordan forskellige organismer samarbejder med bakterier
- kan du forklare, hvad hologenomik er
- kan du argumentere for, hvordan hologenomik kan påvirke fremtiden.

Fag Klassestrin Varighed
 Biologi 8. kl. • 9. kl. Ca. 6,5 Lektioner

Danmarks
 Grundforskningsfond
 Danish National
 Research Foundation

CEH

CENTER FOR
 EVOLUTIONARY
 HOLOGENOMICS



UNIVERSITY OF
 COPENHAGEN

Undersøg bakterierne i din armhule *



Kapitel 1 Du er ikke alene

Vidste du, at der er lige så mange mikroorganismer, som der er menneskeceller i din krop? Man kan ikke se dem, men der er flere tusinde milliarder, og de er så mikroskopiske, at de samlet ikke fylder mere end en bagekartoffel! I dette kapitel skal du opleve, hvordan bakterier og andre mikroorganismer er vigtige for alt liv på Jorden. Du skal bl.a. lave en tidslinje, læse fagtekster og lave en undersøgelse.



Kapitel 2 Bliv ekspert

Takket være den nyeste forskning i hologenomi sammen med, og er afhængige af, vores mikroorganismer tyder altså på, at vi ikke kan forstå, hvordan vi fungerer på vores mikroorganismer. I dette kapitel får du en introduktion til om hologenomi. Du bliver guidet godt igennem, og du skal præsentere for din gruppe.



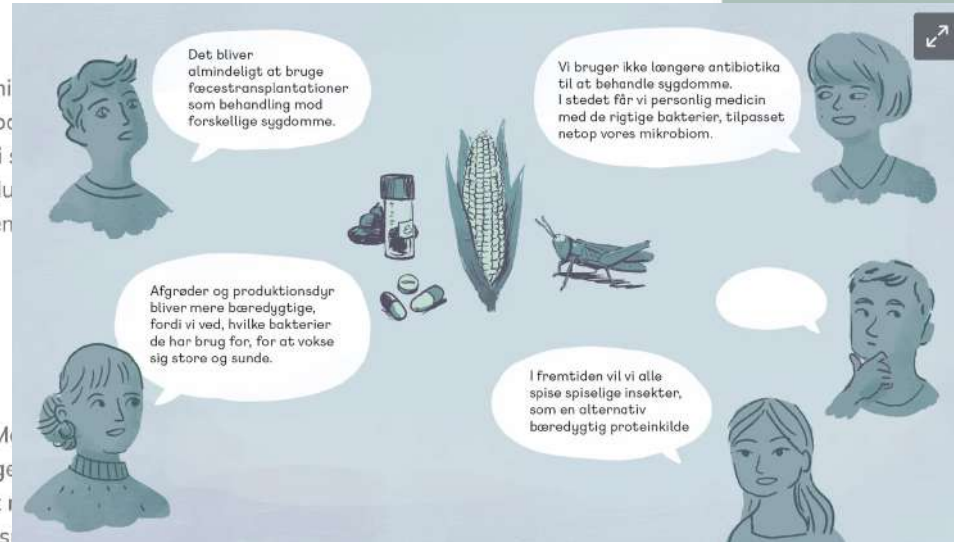
Kapitel 3 Gå i forskernes fodspor

Har du tænkt over, at forskere ofte laver fejl? Måske er det nysgerrighed og undren. Når de skal undersøge noget, spørger de "hvordan er gribben i stand til at leve af giftigt mad?" En hypotese eller mulig forklaring på deres spørgsmål. Men hvis forklaringen ikke er rigtig. Men det betyder ikke, at forskerne ikke har lært noget. Tværtimod! For nu ved de, at det, de troede var forklaringen, ikke var rigtigt, og så kan de lave en ny hypotese. I dette kapitel skal du gå i forskernes fodspor ved selv at undersøge bakterier.



Kapitel 4 Kig ind i fremtiden

Forskning i hologenomi er ny og spændende. Den nye viden om samarbejdet mellem mikroorganismer og værtsorganisme åbner op for mange nye løsninger på fremtidens udfordringer med fx sundhed, fødevarerproduktion og bæredygtighed. I dette kapitel skal du sammen med en forsker kigge ind i krystalkuglen og forestille dig, hvordan hologenomi kan bruges i fremtiden.



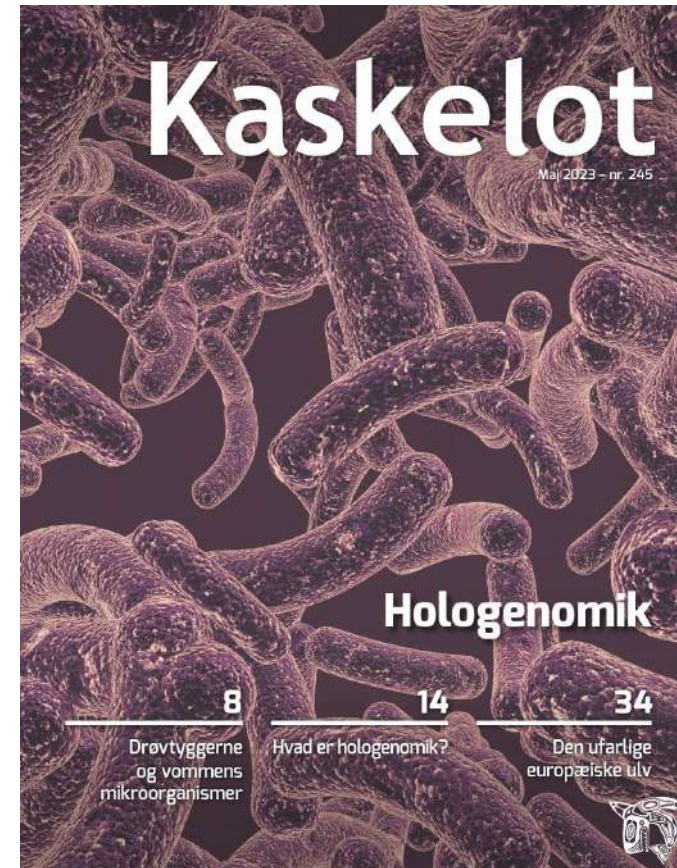


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HOLOGENOMICS

Find mere inspiration til undervisningen på vores hjemmeside her:
<https://ceh.ku.dk/communication-and-engagement/schools-in-focus/>



UNIVERSITY OF
COPENHAGEN

A microscopic image showing numerous green, stalked organisms, possibly algae or fungi, growing on a brown, textured surface. The organisms have a rounded, green head and a thin, green stalk. The background is dark blue.

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P.S. Jeg kommer gerne ud og taler på Jeres undervisningssteder