Stillehavslaksen har løsningen, hvordan kan vi gi den videre til Atlantisk laks?

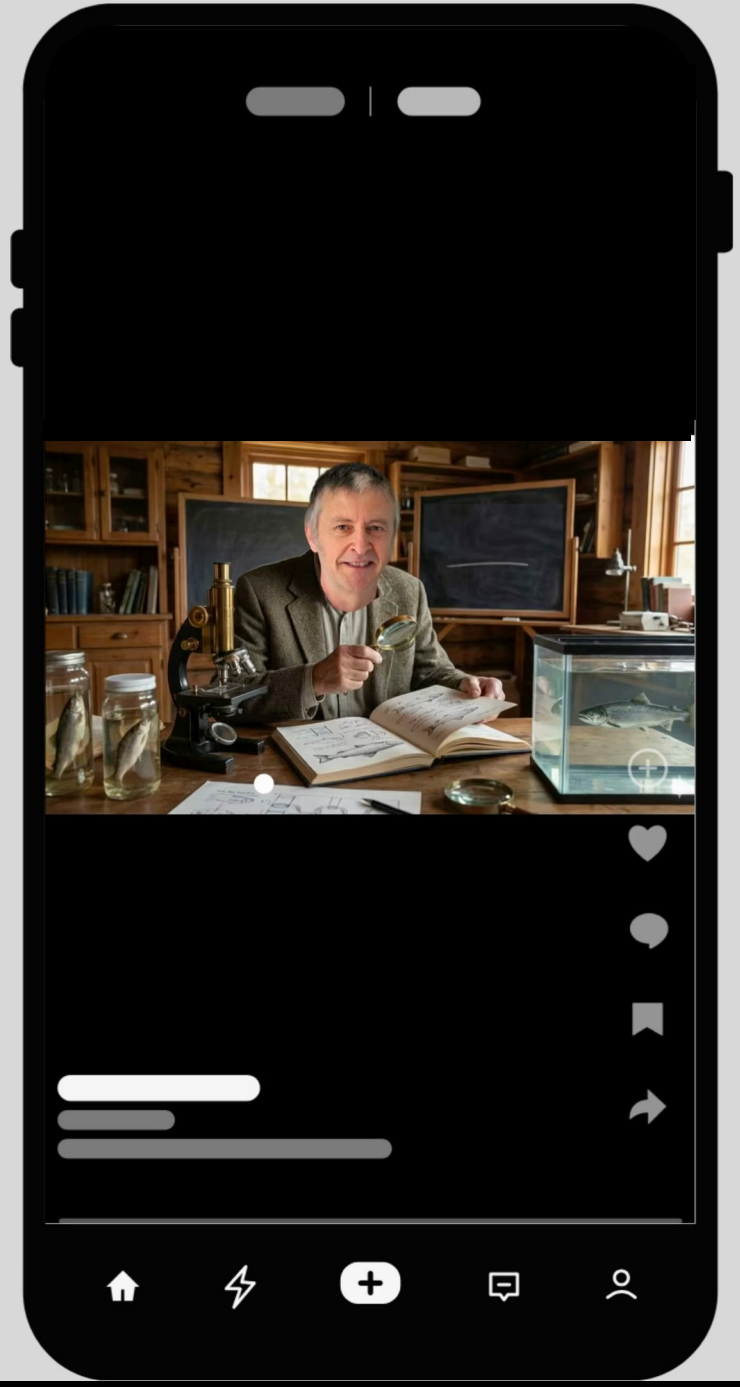
Crisp ResisT et FHF finansiert prosjekt

Lene Sveen, Mark D. Fast, Torstein Tengs, Rachel A. Kline, Judit Aguilar Marti, Dominic Kurian, Gerrit Timmerhaus, Marianne Vaadal, Ross D. Houston, James E. Bron, Sean J. Monaghan, Haitham H. Mohammed, Rose Ruiz Daniels, Sarah Salisbury, Diego Robledo, Mark Braceland, Miroslava Hansen, Anne Wargelius, Teshome Tilahun, Ajna Ødegård, Tone Kari Knudsdatter, Matt Watsmuth, Nicholas Robinson

Nofima

Nofima

Alle prosjekter starter med en idè….



Nick Robinson

Nofima

Jeg har en drøm

1. Smitte naturlig luseresistente laksearter med lus
2. Identifisere genene som er involvert
3. Validere genene ved hjelp av genredigering
4. Bruke denne informasjonen til å gjøre Atlantisk laks mer lik stillehavslaks

Med målrettet **avl**, **vaksinering** eller **genredigering**

Nofima

CRISP RESIST

Nofima

CRISP RESIST

Nofima

BAKGRUNN

FORSØKSDESIGN

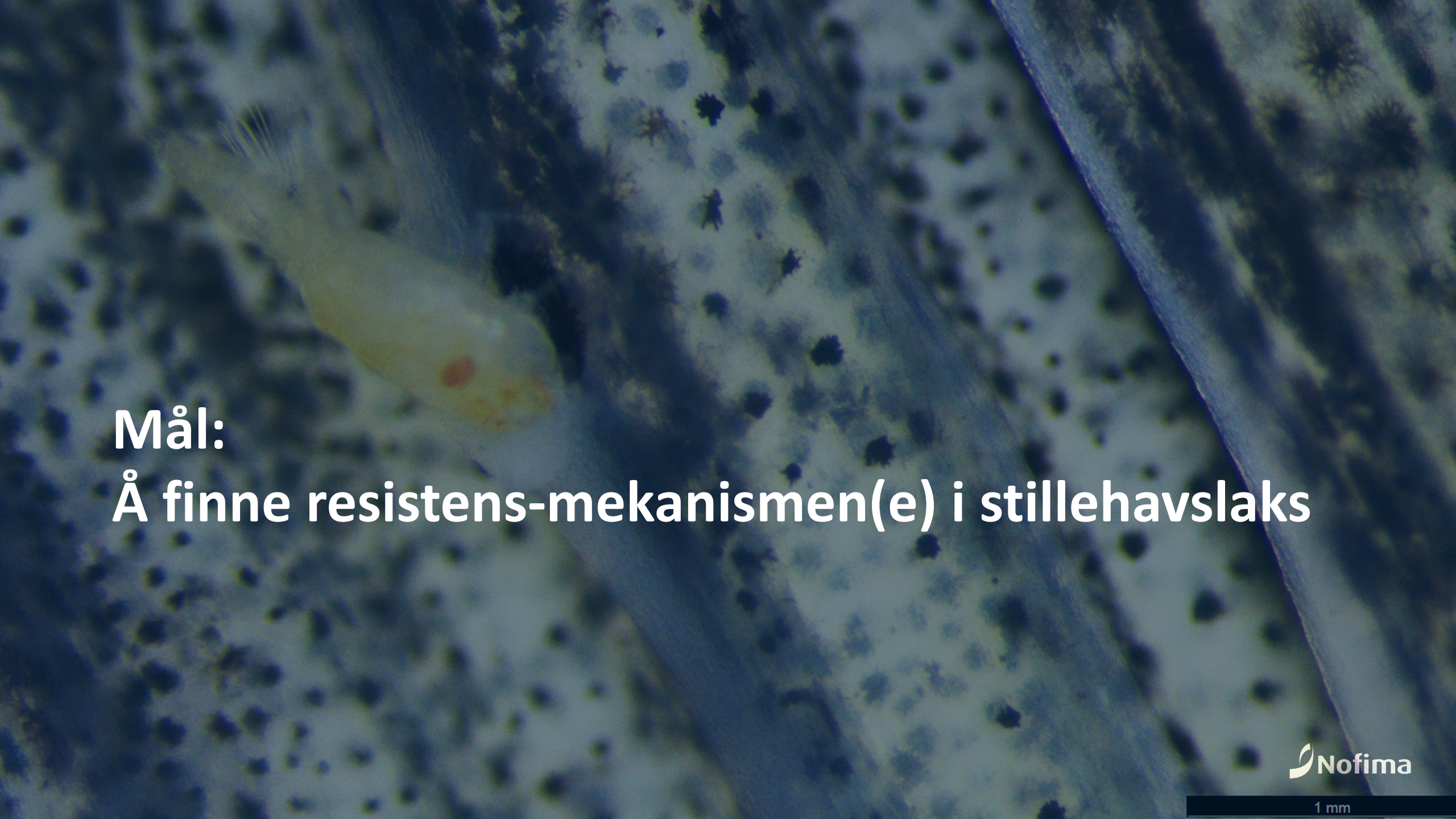
RESULTATER

GENREDIGERING

VEIEN VIDERE

Nofima

Nofima



Mål:
Å finne resistens-mekanismen(e) i stillehavslaks

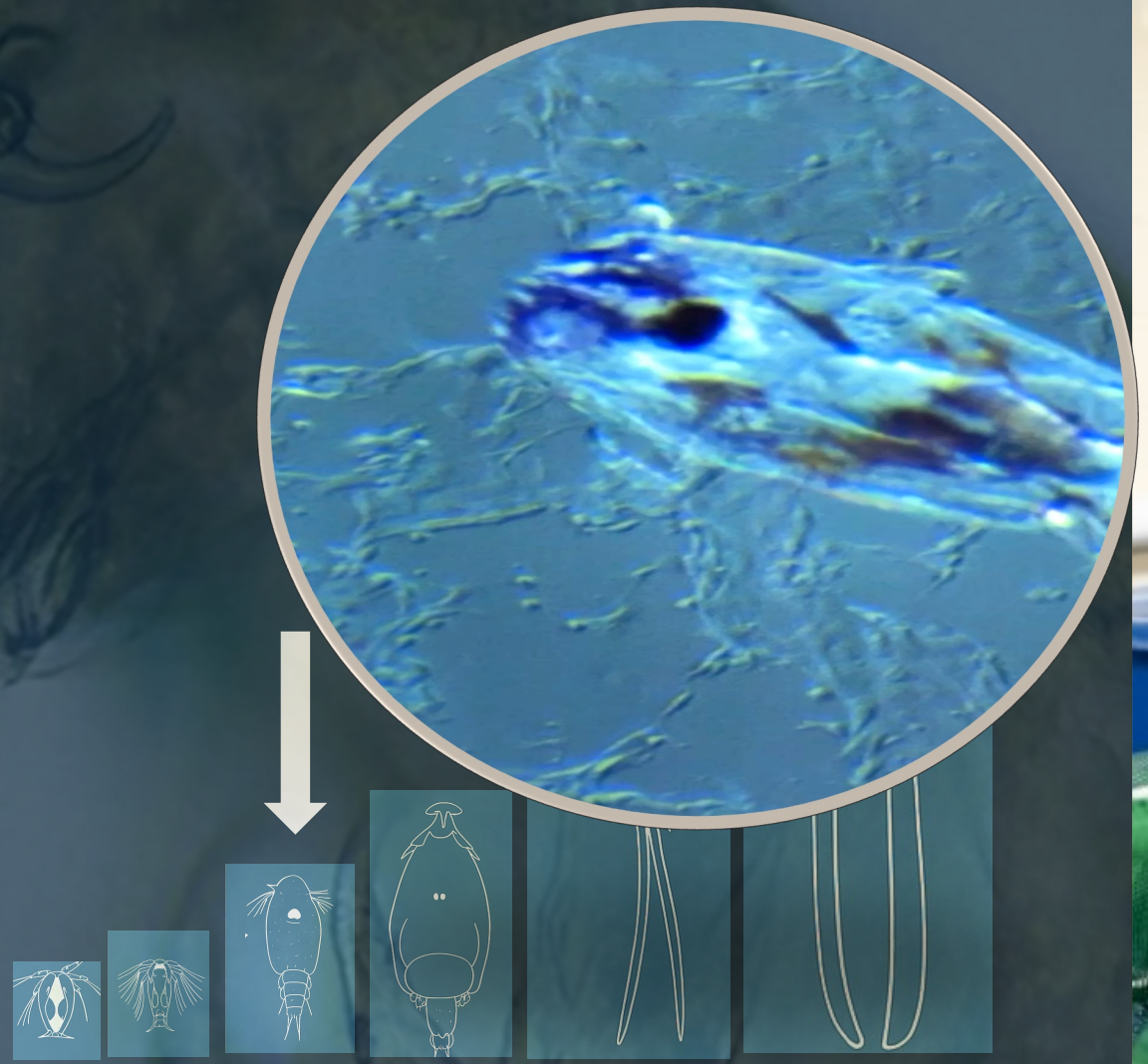
Forsøksdesign

Stillehavslaks

Pink salmon (Pukkel laks)
Chum salmon (ketalaks)
Coho salmon (Sølvlaks)

Atlantic salmon (Atlantisk la

Forsøksdesign



Mark FAST

UPEI, Canada

Forsøksdesign

Ingen lus på Chum eller Pink (Forsøk 1)

24 timer

12 timer

Nofima

Forsøksdesign

Ingen lus på Chum eller Pink (Forsøk 2)

24 timer

12 timer

Nofima

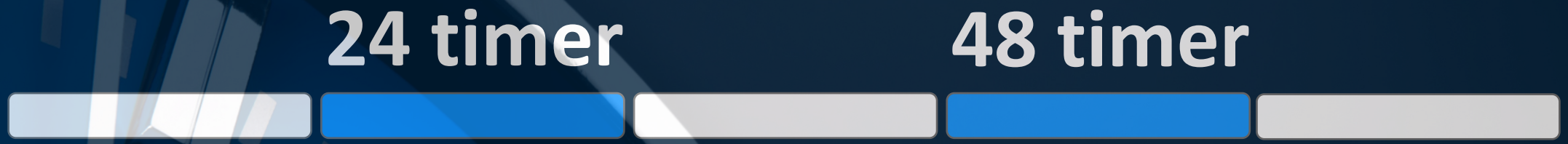
Forsøksdesign

All fisk bedøvet og smittet med lus (forsøk 3)

12 timer

Nofima

Forsøksdesign



24 timer

48 timer

12 timer

36 timer

60 timer

2,5 dager

Nofima

Forsøksdesign

7 dager

Nofima

BAKGRUNN

FORSØKSDESGIN

RESULTATER

GENREDIGERING

VEIEN VIDERE

Nofima

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BAKGRUNN

FORSØKSDESGIN

RESULTATER

GENREDIGERING

VEIEN VIDERE

Keratinocytes drive the epithelial hyperplasia key to sea lice resistance in coho salmon

Research article | Open access | Published: 29 July 2024

Volume 22, article number 160, (2024) Cite this article

S. J. Salisbury

Sveen, R. D. H

4280 Acc

Abstrac

Cell Tissue Res. 2025 Aug;401(2):181-211. doi: 10.1007/s00441-025-03976-0. Epub 2025 Jun 4.

Local inflammation at the salmon louse (Lepeophtheirus salmonis) attachment site contributes to copepodid rejection in coho salmon (Oncorhynchus kisutch)

Lene Sveen [1], Mark D Fast [2], Torstein Tengs [3], Rachel A Kline [4], Judit Aguilar Marti [4], Dominic Kurian [4], Gerrit Timmerhaus [3], Marianne Vaadal [3], Ross D Houston [5], James E Bron [6], Sean J Monaghan [6], Haitham H Mohammed [7 8], Rose Ruiz Daniels [6 4], Sarah Salisbury [4], Diego Robledo [4], Mark Braceland [7 9], Miroslava Hansen [3 10], Nicholas Robinson [3 11]

Affiliations + expand

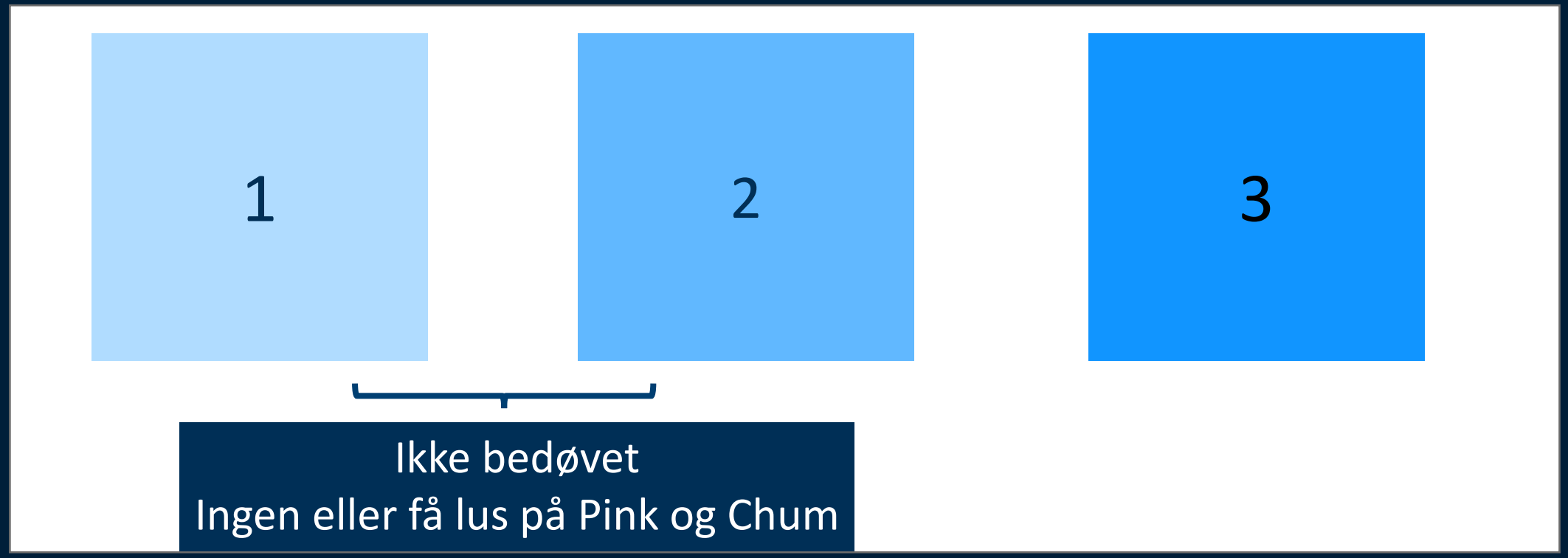
PMID: 40464919 PMCID: PMC12325551 DOI: 10.1007/s00441-025-03976-0

Abstract

The study investigates the susceptibility of Atlantic salmon (Salmo salar) and Pacific salmon species (pink salmon, Oncorhynchus gorbuscha; coho salmon, Oncorhynchus kisutch; and chum salmon, Oncorhynchus keta) to the parasitic salmon lice (Lepeophtheirus salmonis). The research had two main objectives: to characterize the morphology of the scaly skin in four salmonid species and to compare the cellular response at the louse attachment site in coho salmon and Atlantic salmon. Three consecutive challenge trials were conducted, with successful louse infestation only achieved across all four species in the third trial using mild anesthesia with tricaine methanesulfonate. Skin and fin samples were collected at 12, 24, 36, 48, 60, and 168 h post-

Resultater

Tre forsøk på å smitte fisken



Nofima

Resultater

Chum og pink merker at **lusa biter**, **må bedøves**

Dis Aquat Organ. 2007 May 9;75(3):229-38. doi: 10.3354/dao075229.

Differential rejection of salmon lice by pink and chum salmon: disease consequences and expression of proinflammatory genes

Simon R M Jones [1], Mark D Fast, Stewart C Johnson, David B Groman

Affiliations + expand

PMID: 17629118 DOI: 10.3354/dao075229

Free article

podids fish-1) level
theirus salmonis copepodids
nce of L. salmonis was
d chum salmon following the
non. At both exposures, the
f unexposed chum. Neither
ese levels. Despite the
ent of L. salmonis on the
ties following either
21 d after low exposure. An
es interleukin-8 (IL-8),
1beta) in fin and head kidney
n this species. Together,
L. salmonis in the juvenile

Comparative transcriptomics of Atlantic Salmo salar, chum Oncorhynchus keta and pink salmon O. gorbuscha during infections with salmon lice Lepeophtheirus salmonis

Ben J G Sutherland, Kim W Koczka, Motoshige Yasuike, Stuart G Jantzen, Ryosuke Yazawa, Ben F Koop [1], Simon R M Jones

Affiliations + expand

PMID: 24628956 PMCID: PMC4004277 DOI: 10.1186/1471-2164-15-200

Abstract

Background: Salmon species vary in susceptibility to infections with the salmon louse (Lepeophtheirus salmonis). Comparing mechanisms underlying responses in susceptible and resistant species is important for estimating impacts of infections on wild salmon, selective breeding of farmed salmon, and expanding our knowledge of fish immune responses to ectoparasites. Herein we report three L. salmonis experimental infection trials of co-habited Atlantic Salmo salar, chum Oncorhynchus keta and pink salmon O. gorbuscha, profiling hematocrit, blood cortisol concentrations, and transcriptomic responses of the anterior kidney and skin to the infection.

Results: In all trials, infection densities (lice per host weight (g)) were consistently highest on chum salmon, followed by Atlantic salmon, and lowest in pink salmon. At 43 days post-exposure, all lice had developed to motile stages, and infection density was uniformly low among species. Hematocrit was reduced in infected Atlantic and chum salmon, and cortisol was elevated in infected chum salmon. Systemic transcriptomic responses were profiled in all species and large differences in response functions were identified between Atlantic and Pacific (chum and pink) salmon. Pink and chum salmon up-regulated acute phase response genes, including complement and coagulation components, and down-regulated antiviral immune genes. The pink salmon response involved the largest and most diverse iron sequestration and homeostasis mechanisms.

Nofima

Resultater

Chum og pink merker at **lusa biter**, **må bedøves**

Kjempespennende

Dis Aquat Organ. 2007 May 9;75(3):229-38. doi: 10.3354/dao075229.

Differential rejection of salmon lice by pink and chum salmon: disease consequences and expression of proinflammatory genes

Simon R M Jones [1], Mark D Fast, Stewart C Johnson, David B Groman

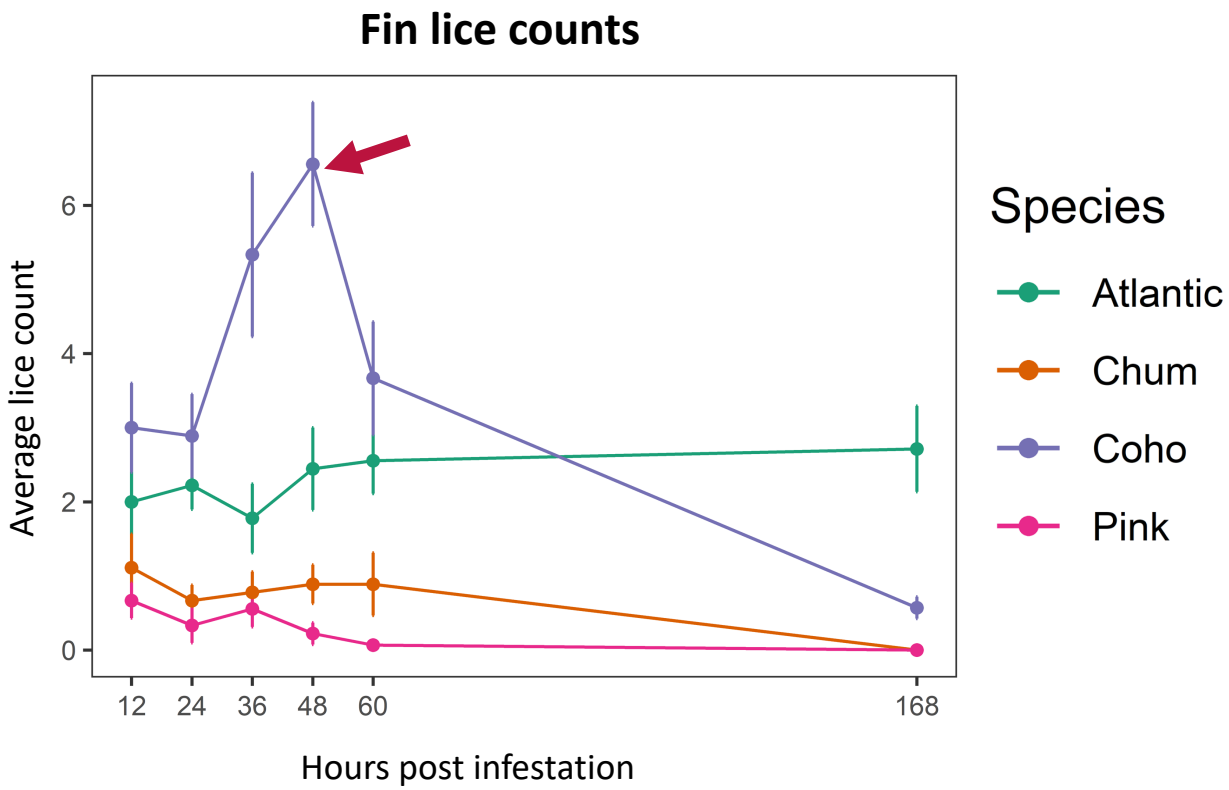
Affiliations + expand

PMID: 17629118 DOI: 10.3354/dao075229

Free article

Comparative transcriptomics of Atlantic Salmo salar, chum Oncorhynchus keta and pink salmon O. gorbuscha during infections with salmon lice Lepeophtheirus salmonis

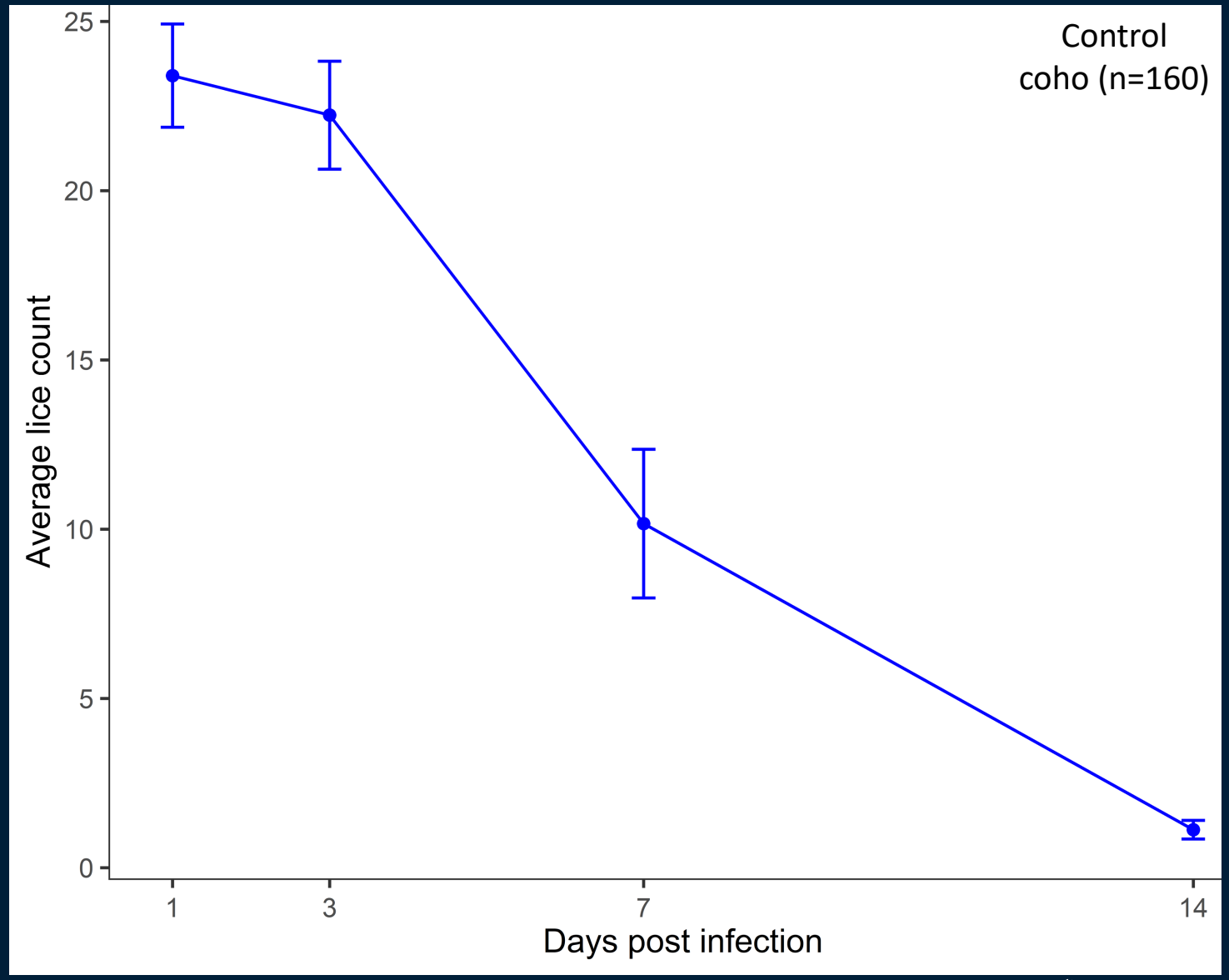
Resultater



Flest lus på Coho

Resultater

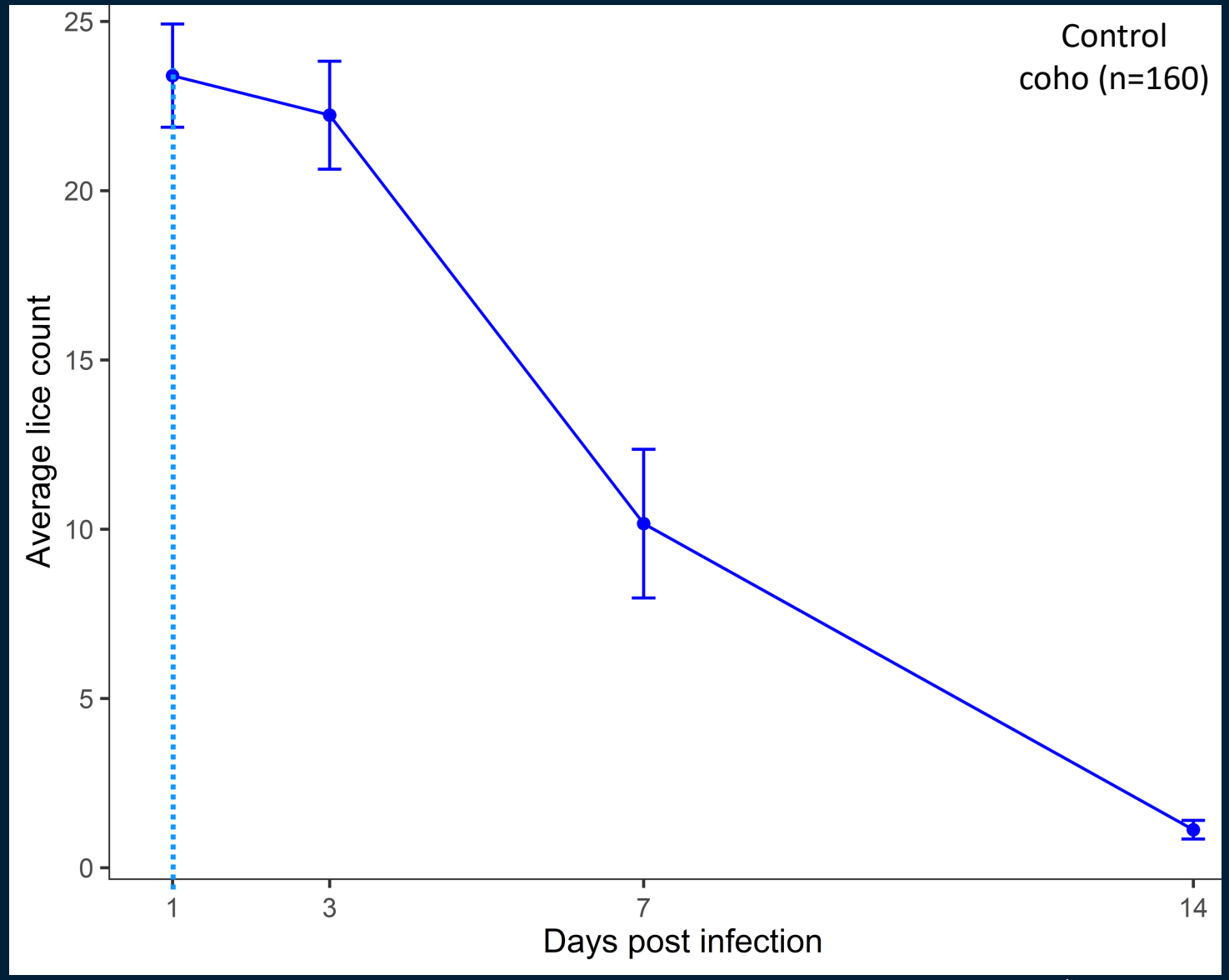
1. Lusa setter seg på coho laks



Nofima

Resultater

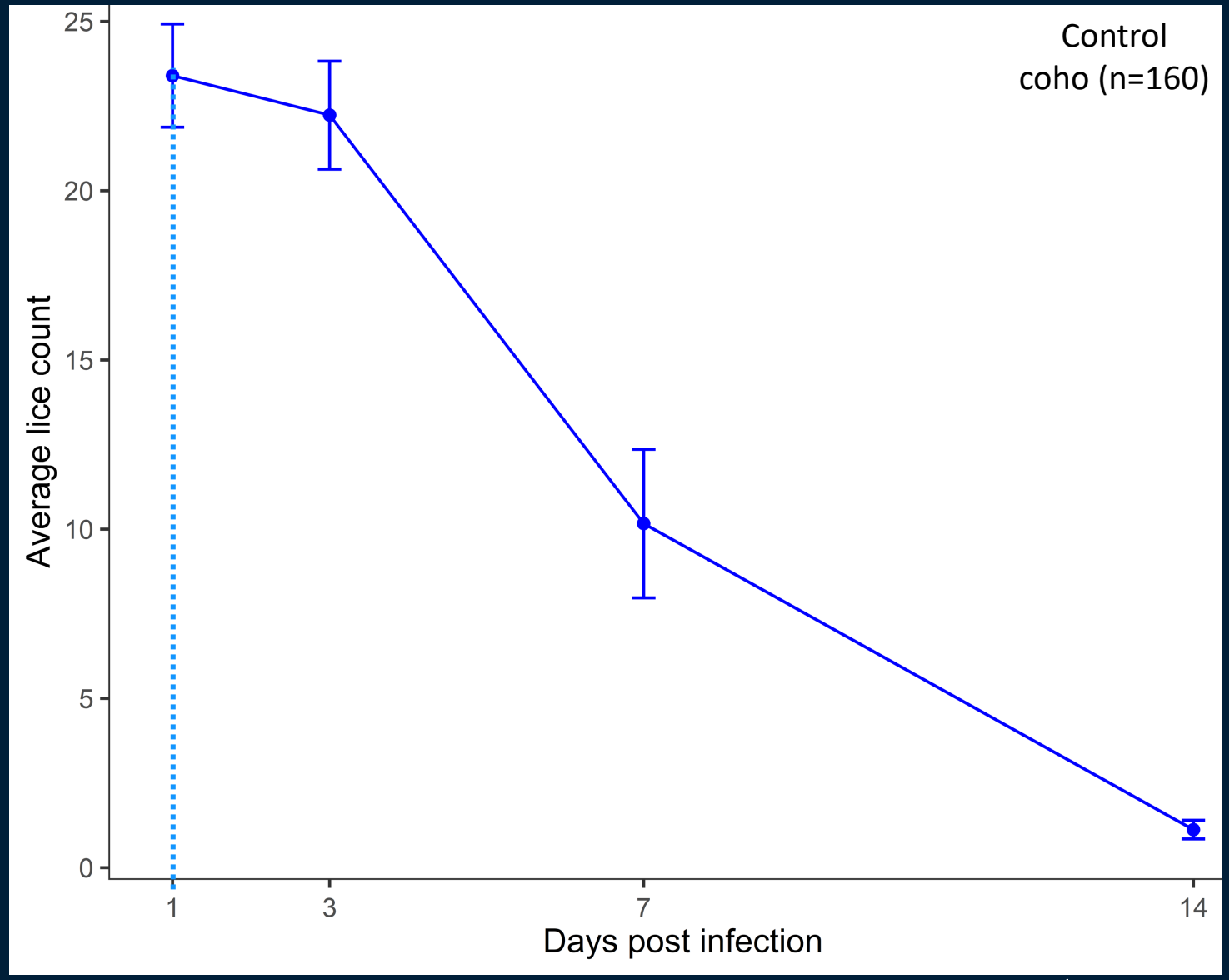
1. Lusa setter seg på coho laks



Nofima

Resultater

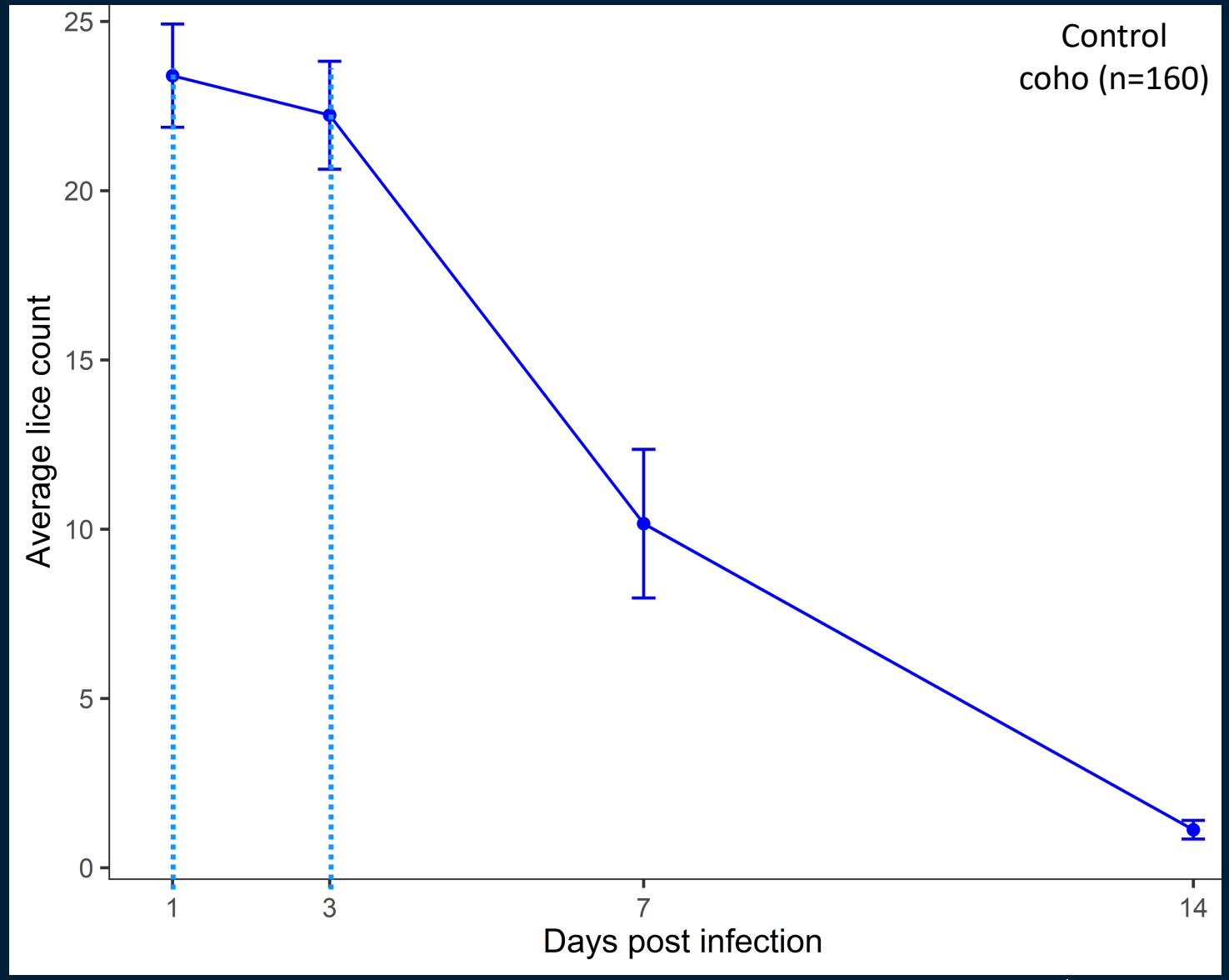
1. Responsen starter umiddelbart



Nofima

Resultater

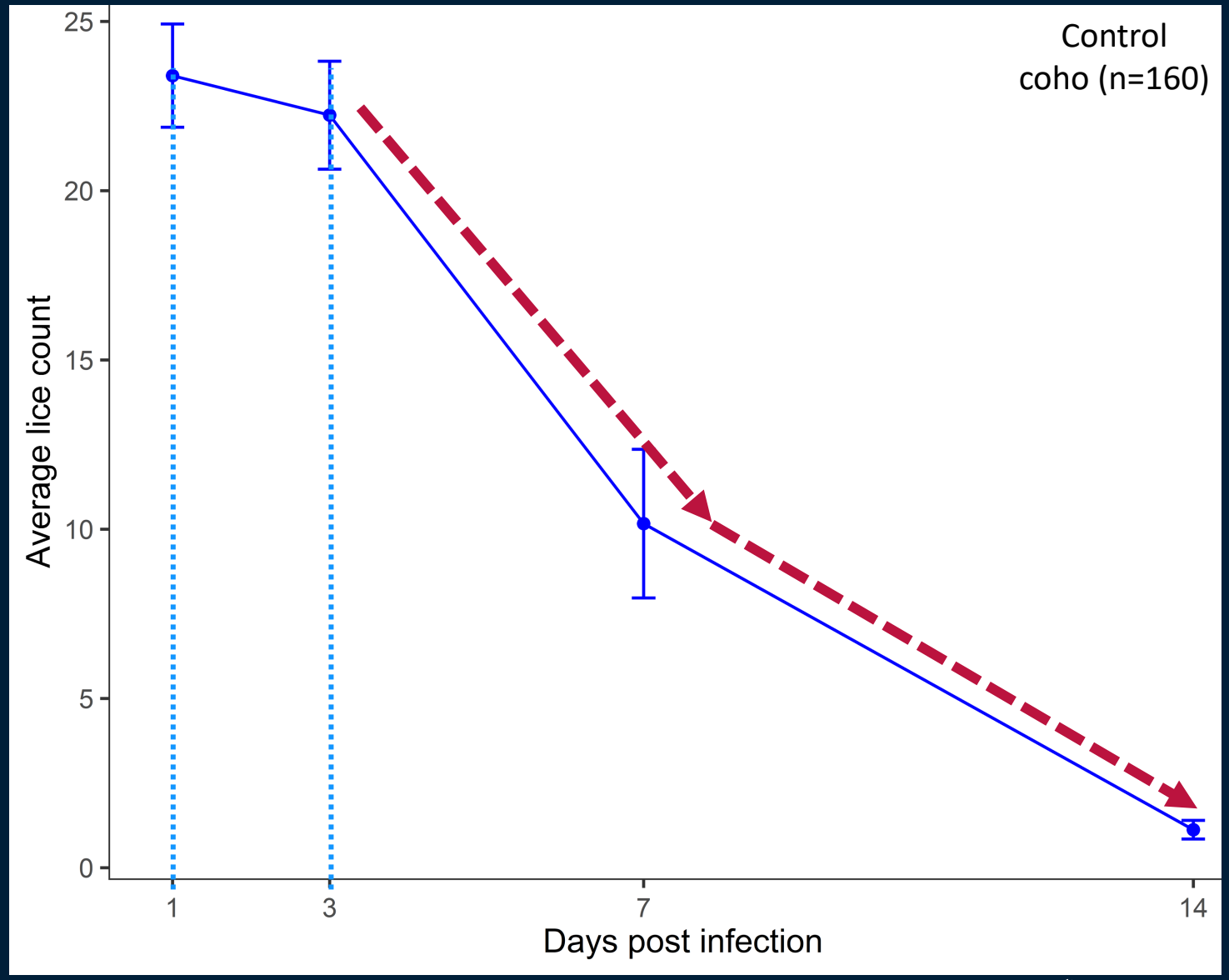
2. Gradvis redusksjon i lusetall



Nofima

Resultater

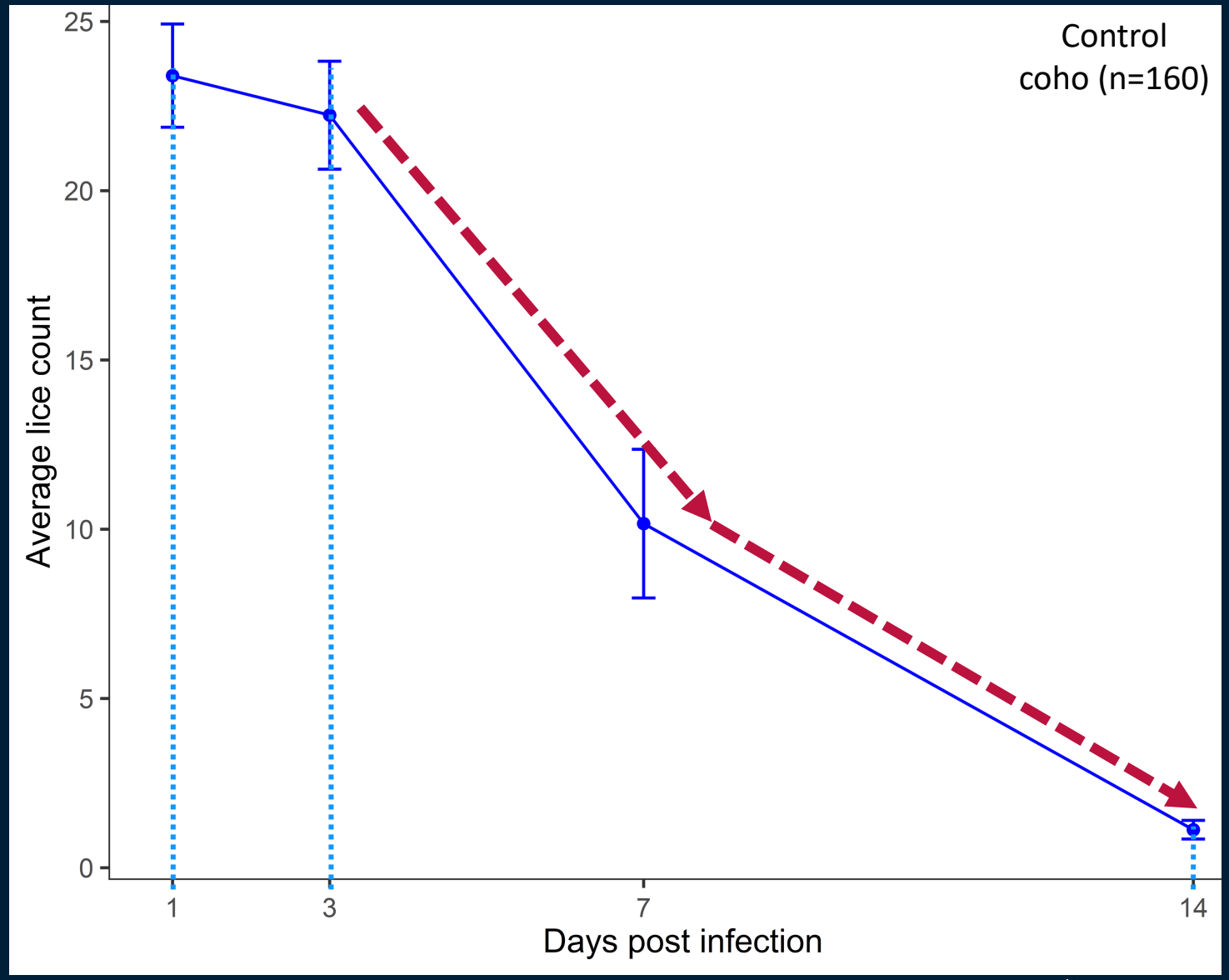
2. Gradvis redusksjon i lusetall



Nofima

Resultater

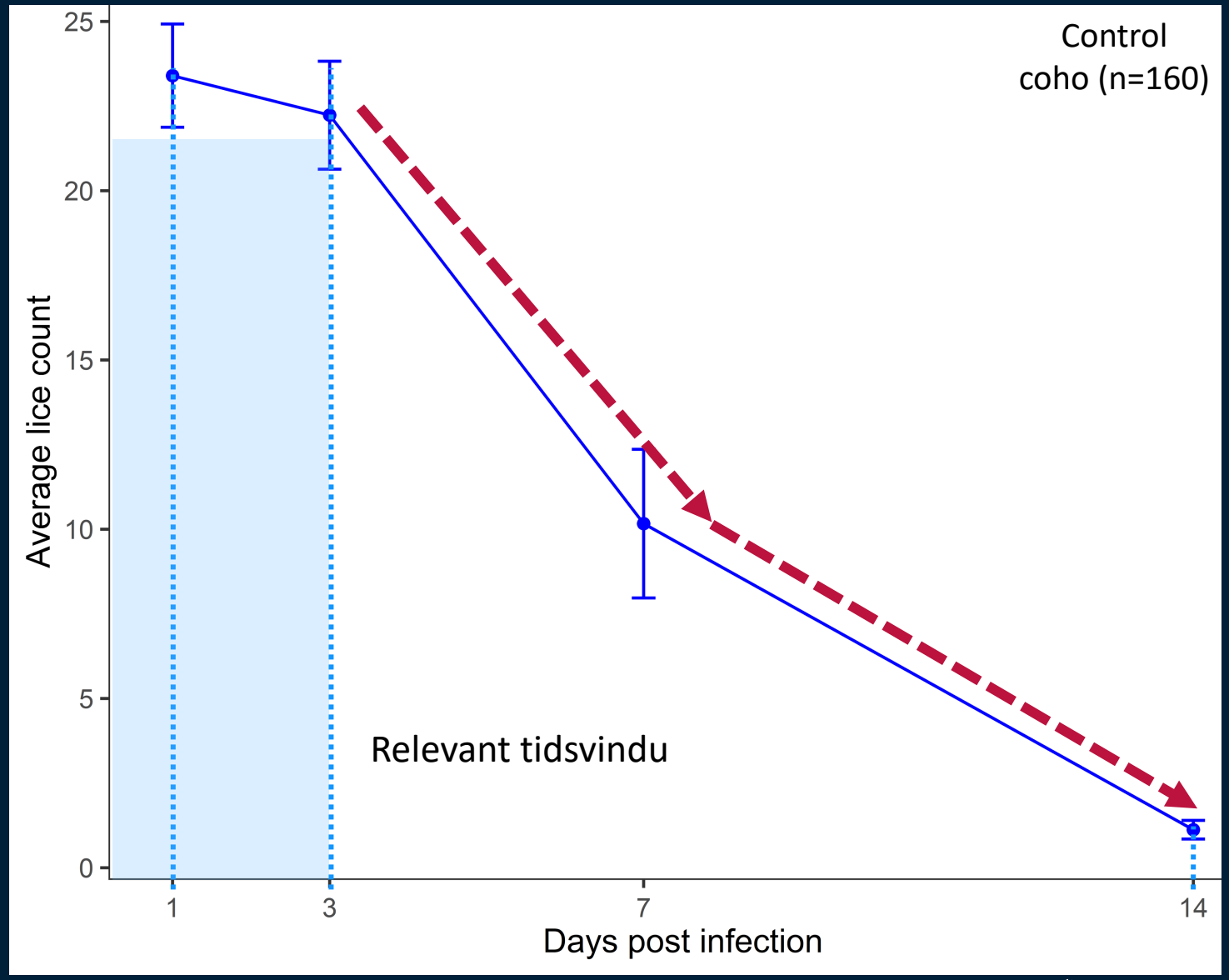
3. Nesten ingen lus etter 14 dager



Nofima

Resultater

3. Nesten ingen lus etter 14 dager

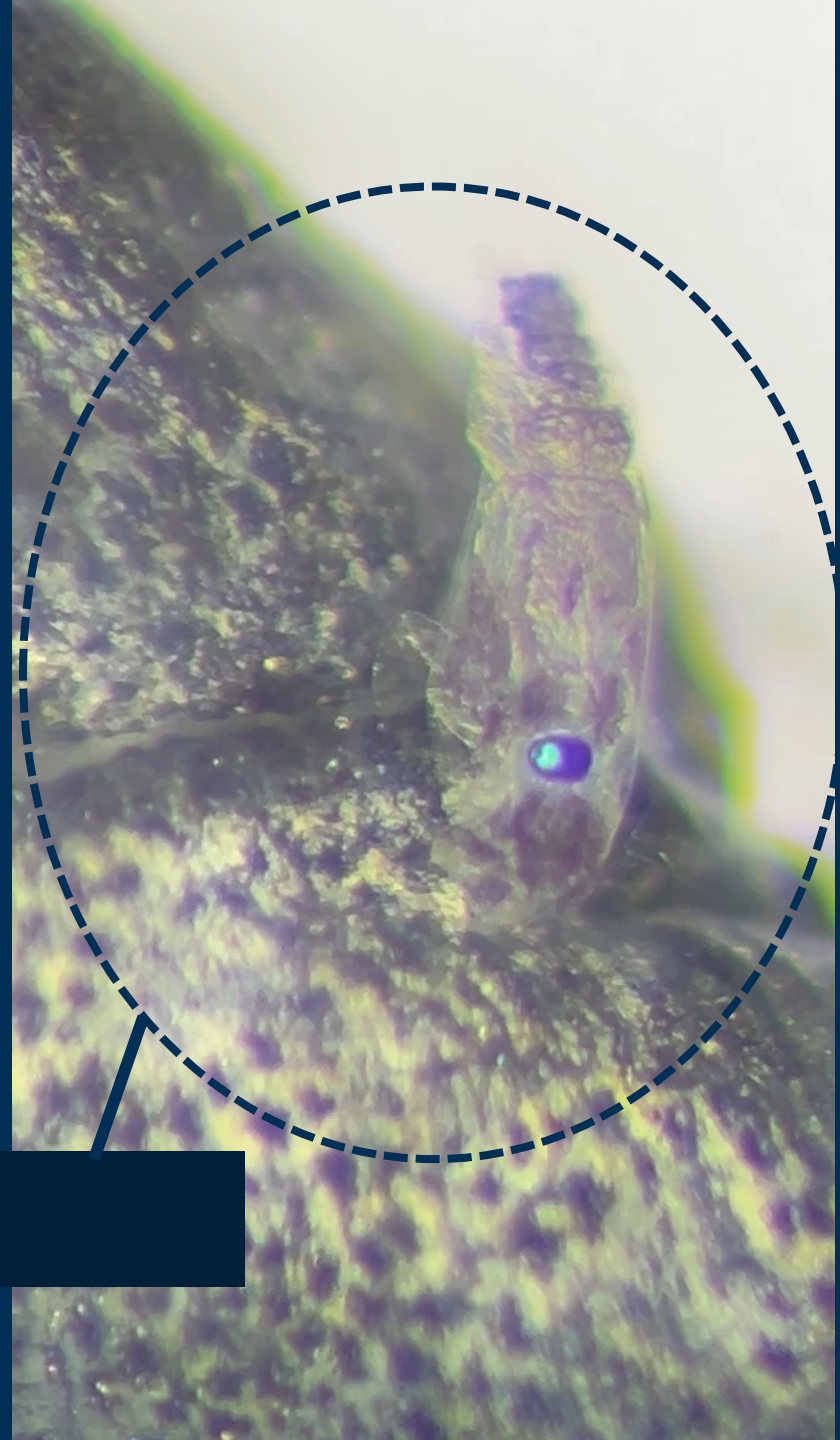


Nofima

Resultater

Sarah Salisbury
Roslin institute

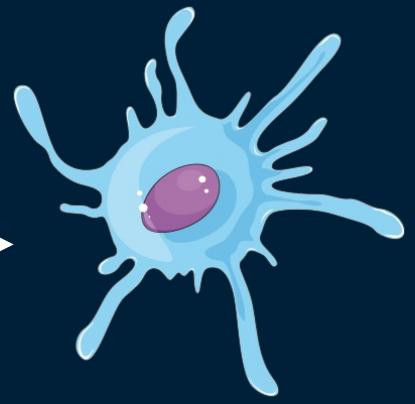
Rose R. Daniels
Roslin institute

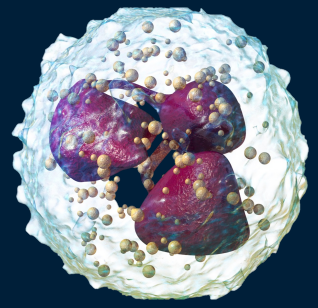


Encellekjerne sekvensering

Resultater

Fiskeskinn / finne

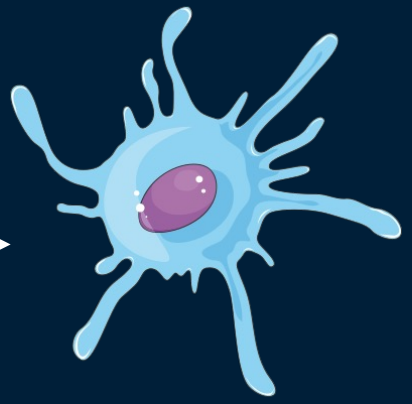


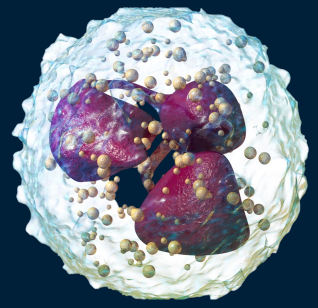


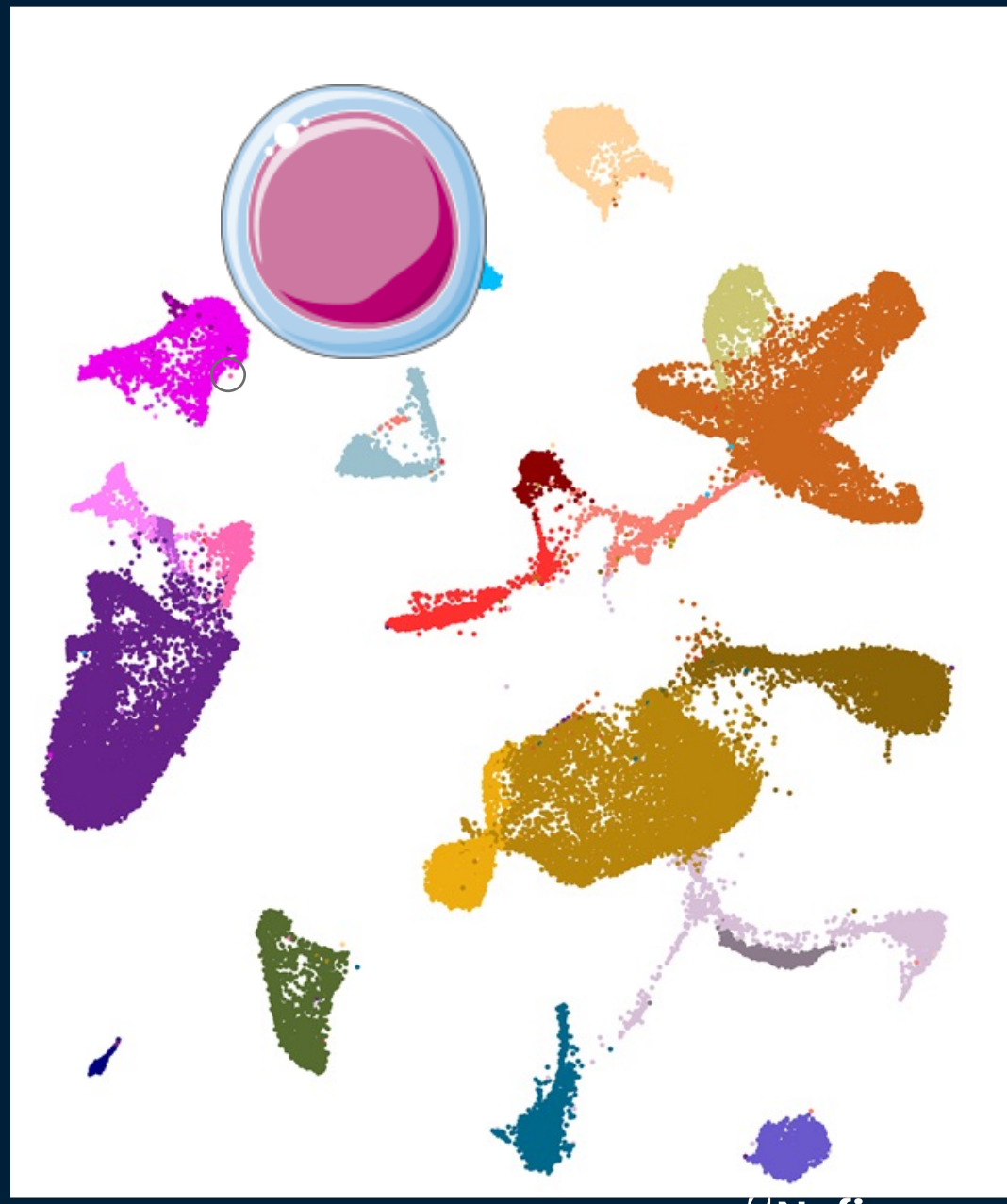
Nofima

Resultater

Fiskeskinn / finne



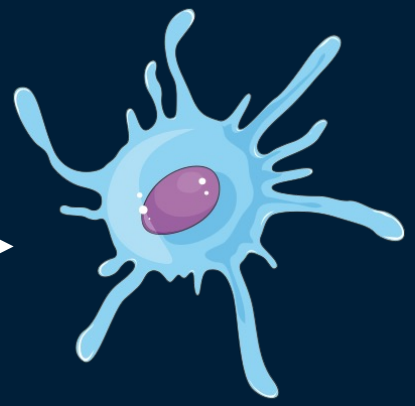


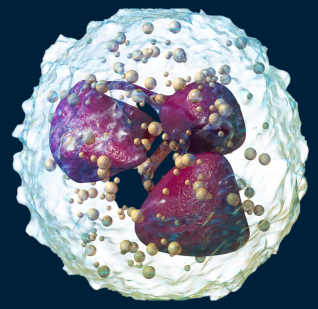


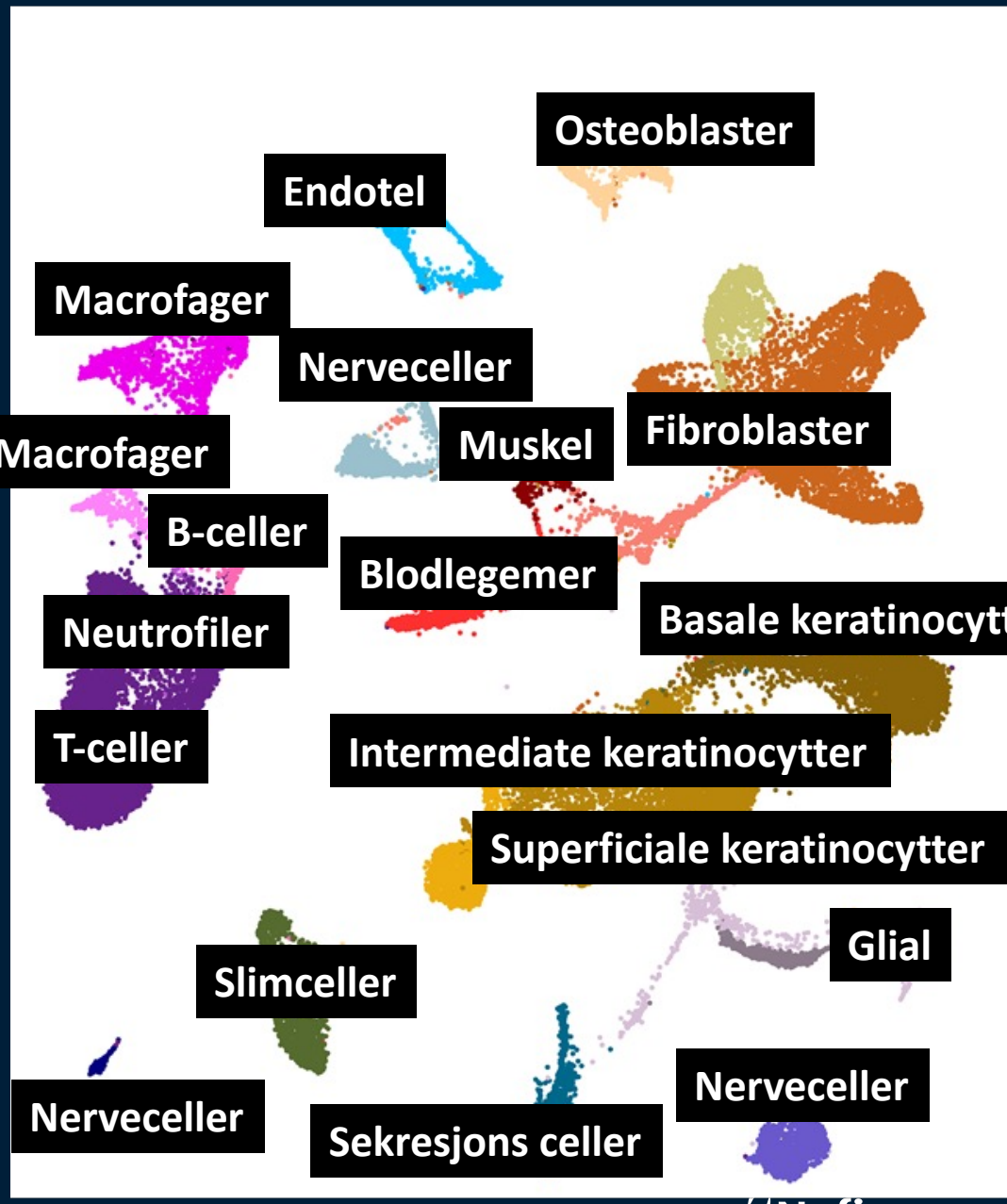
Nofima

Resultater

Fiskeskinn / finne



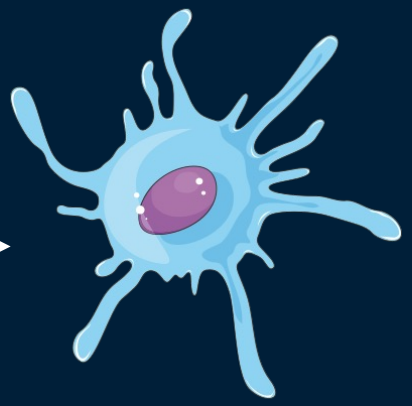


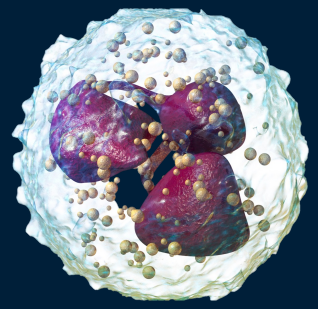


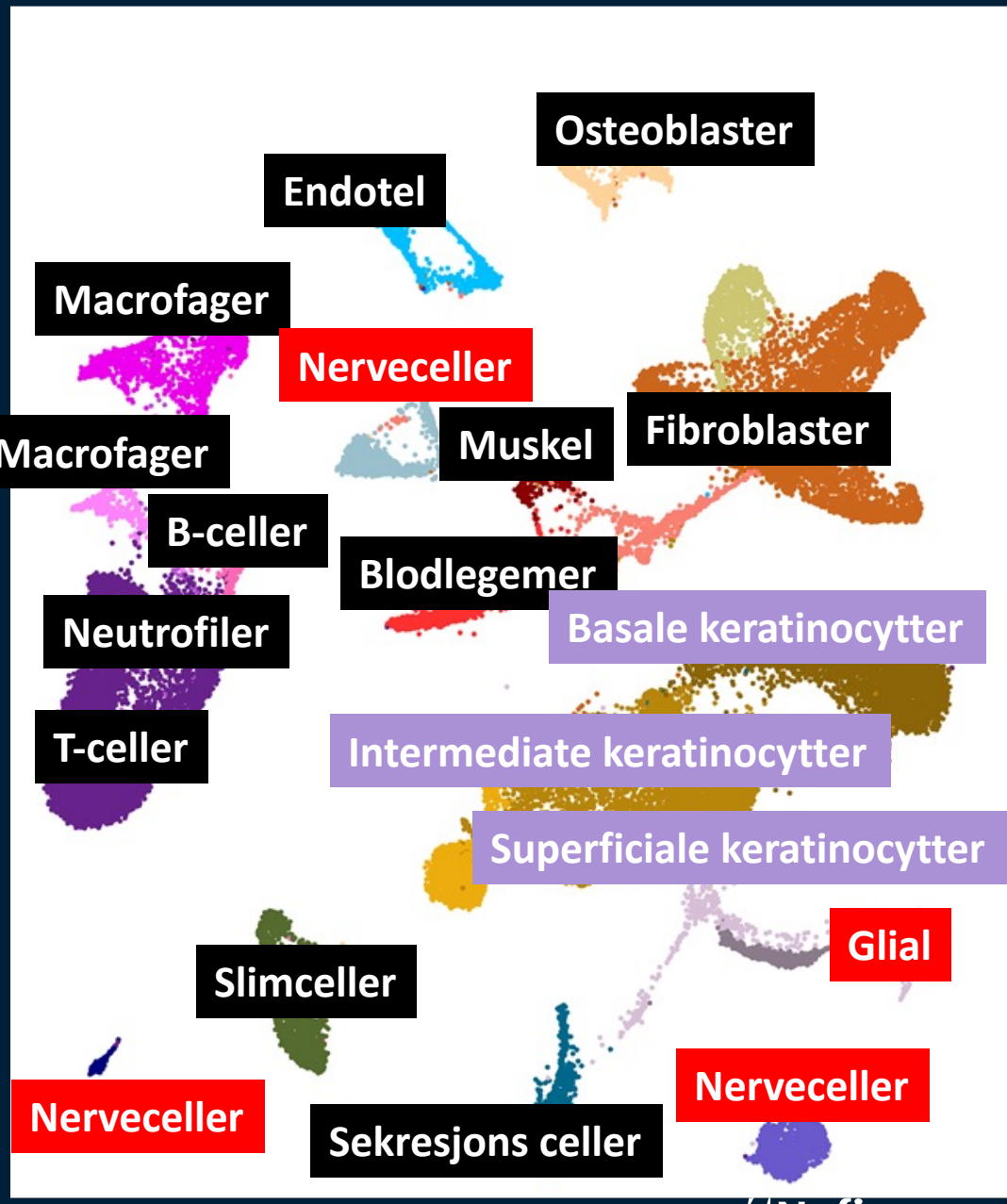
Nofima

Resultater

Fiskeskinn / finne →





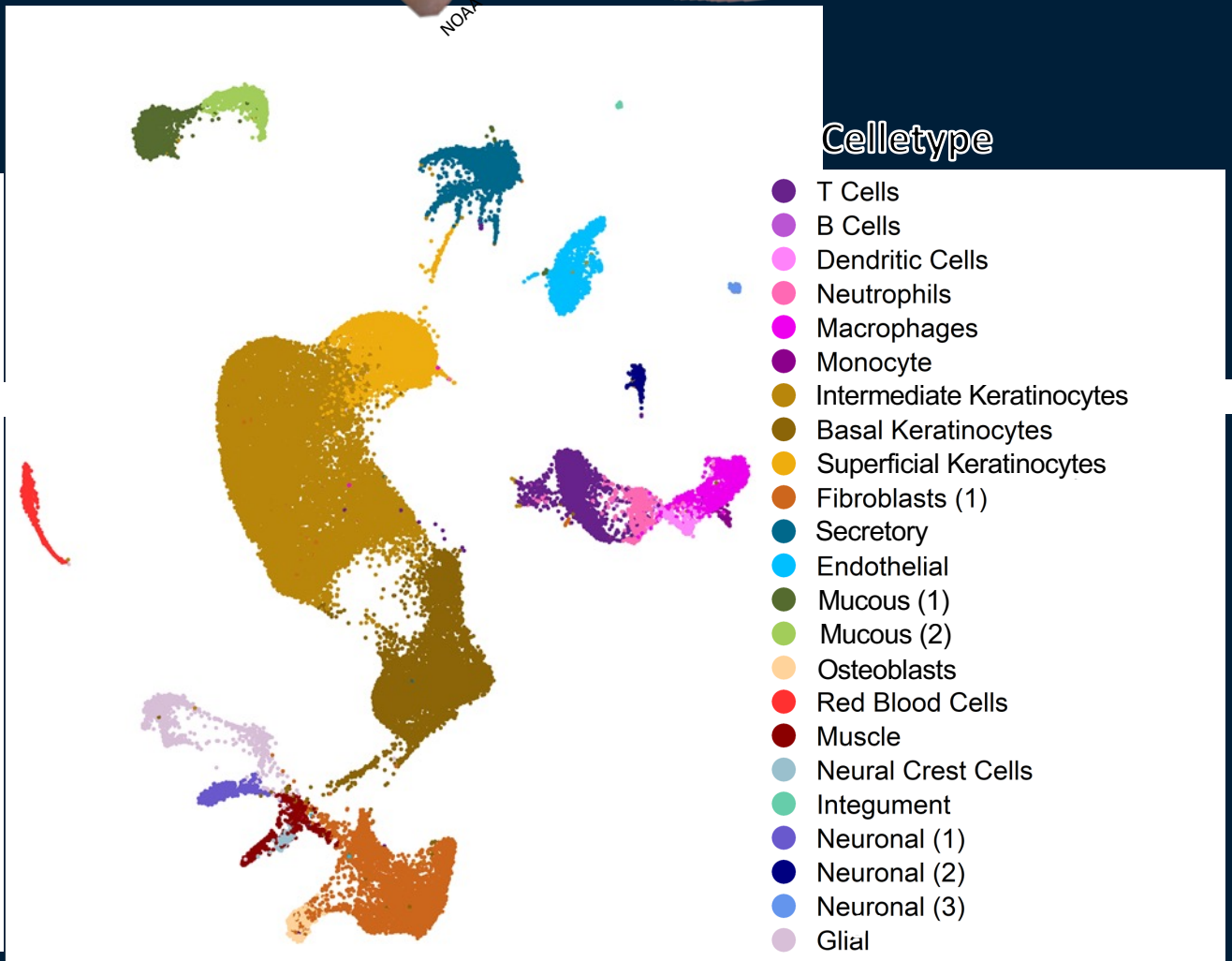


Nofima

Resultater

ATLANTIC

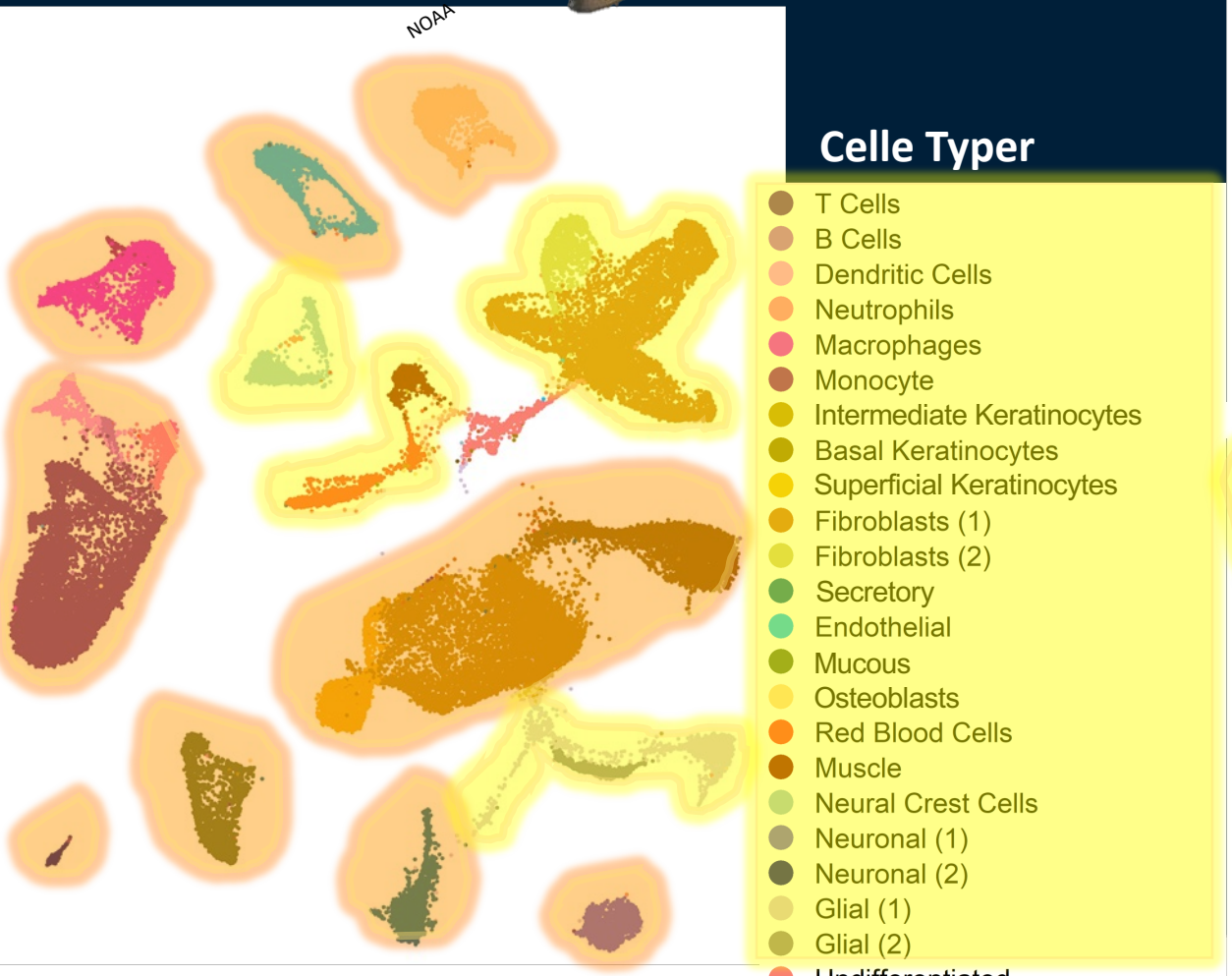
COHO

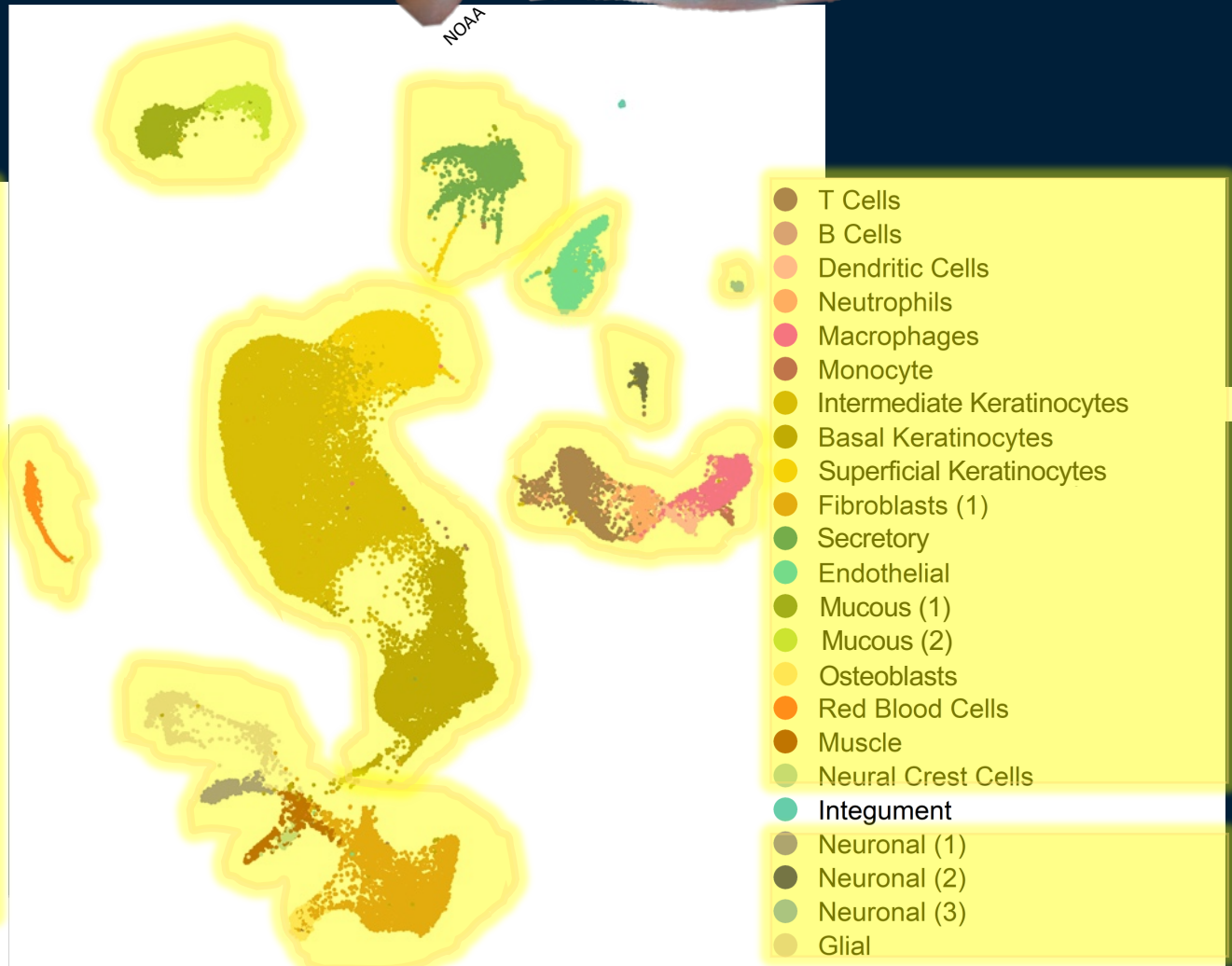


Resultater

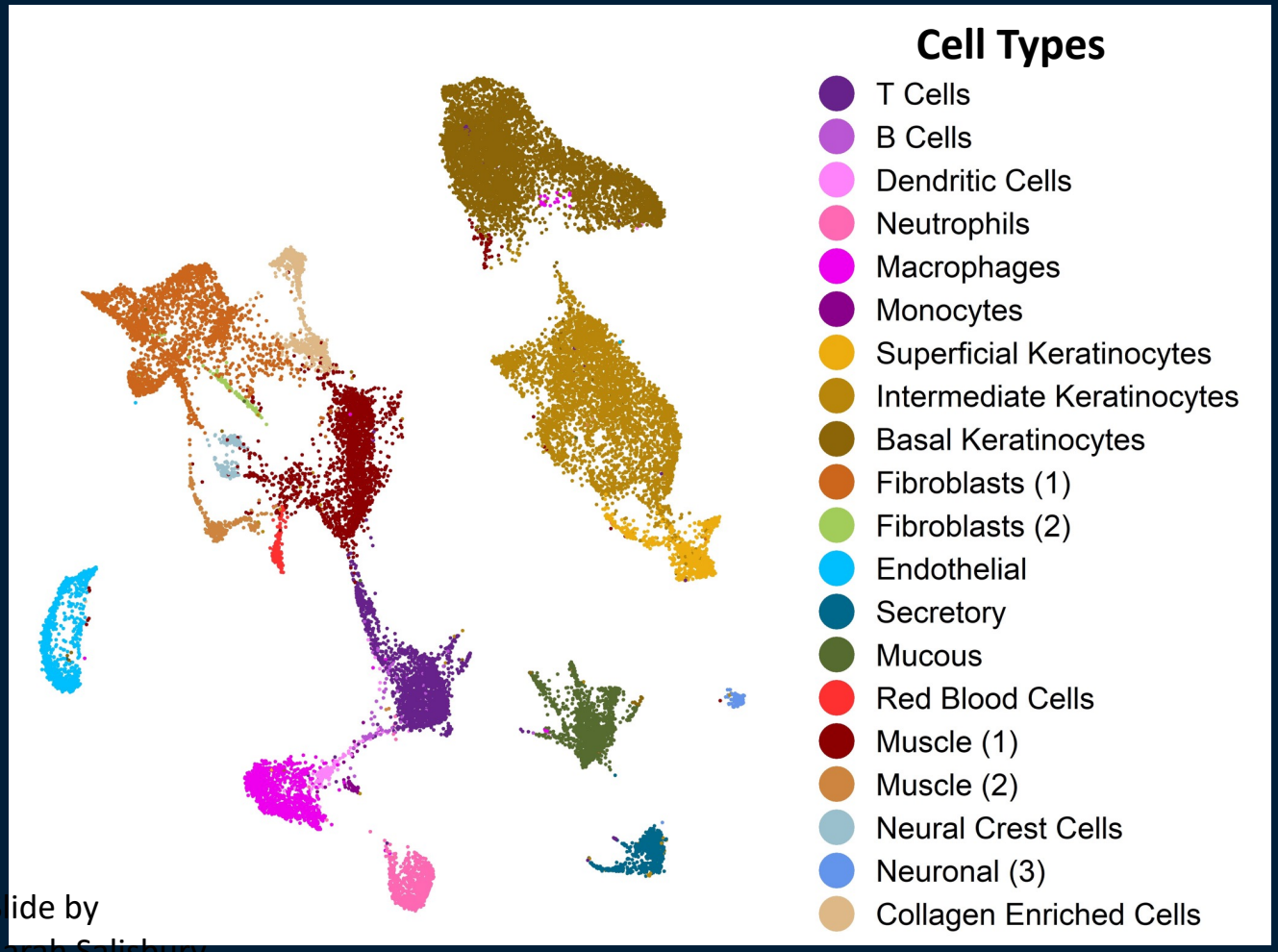
ATLANTIC

COHO

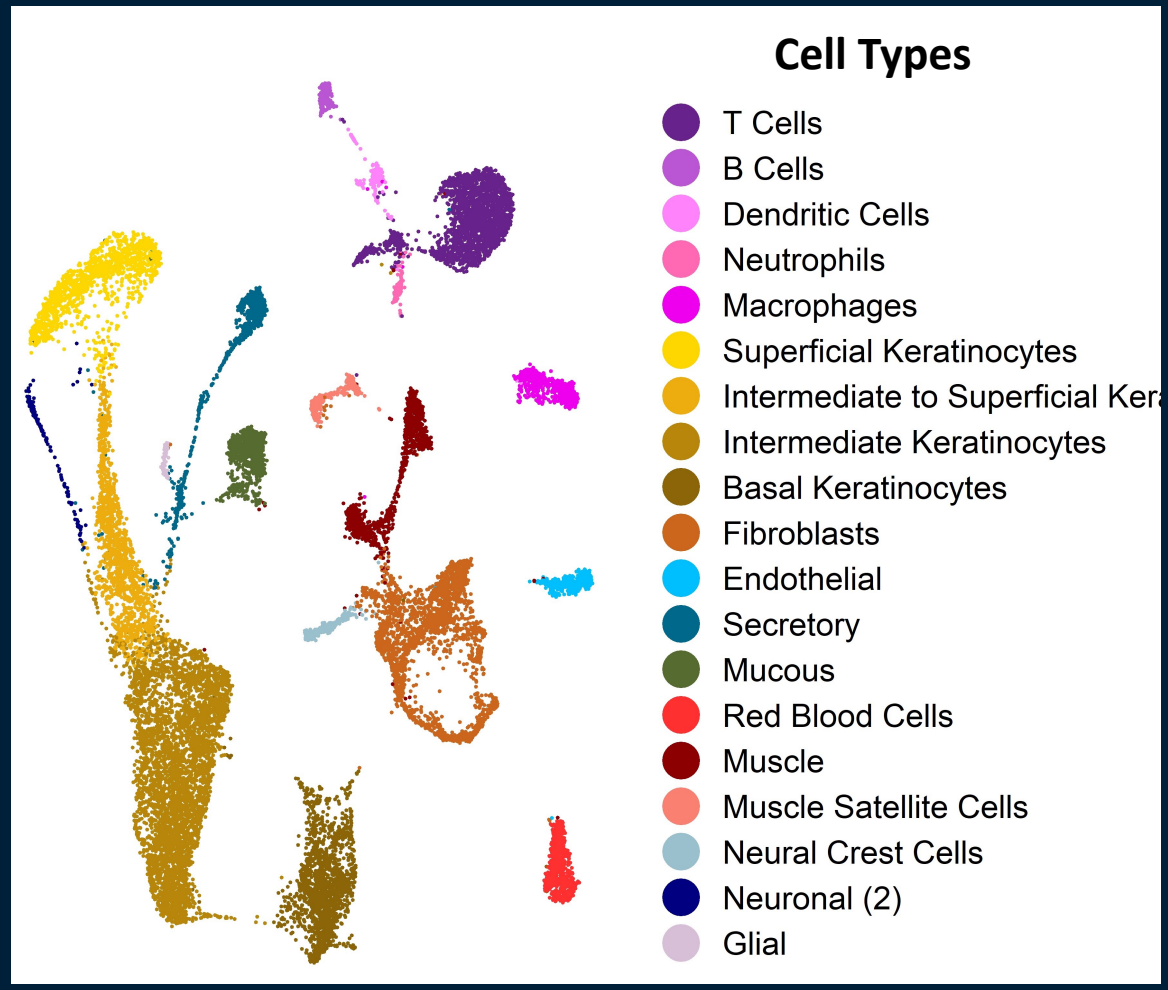




CHUM

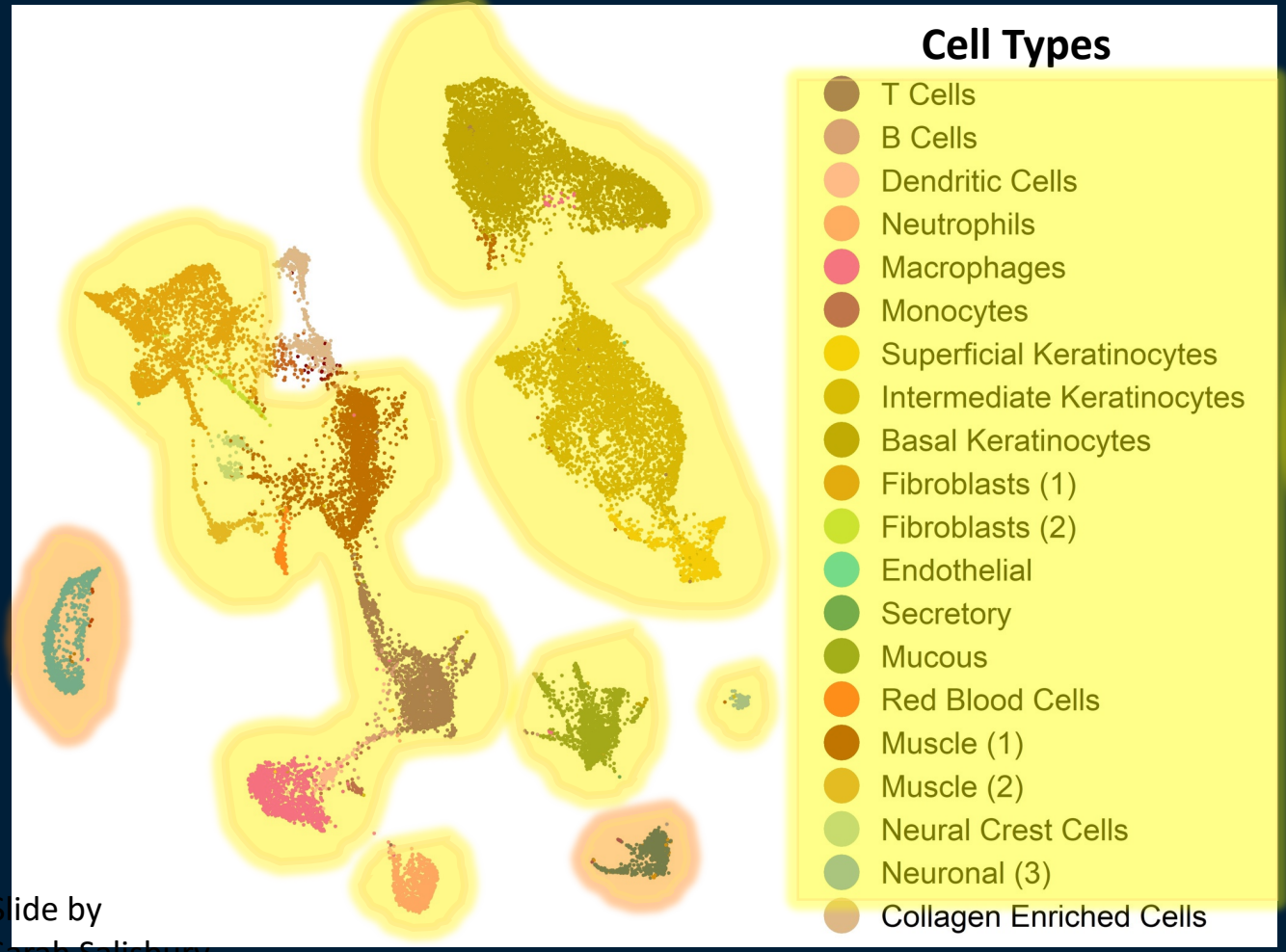


PINK

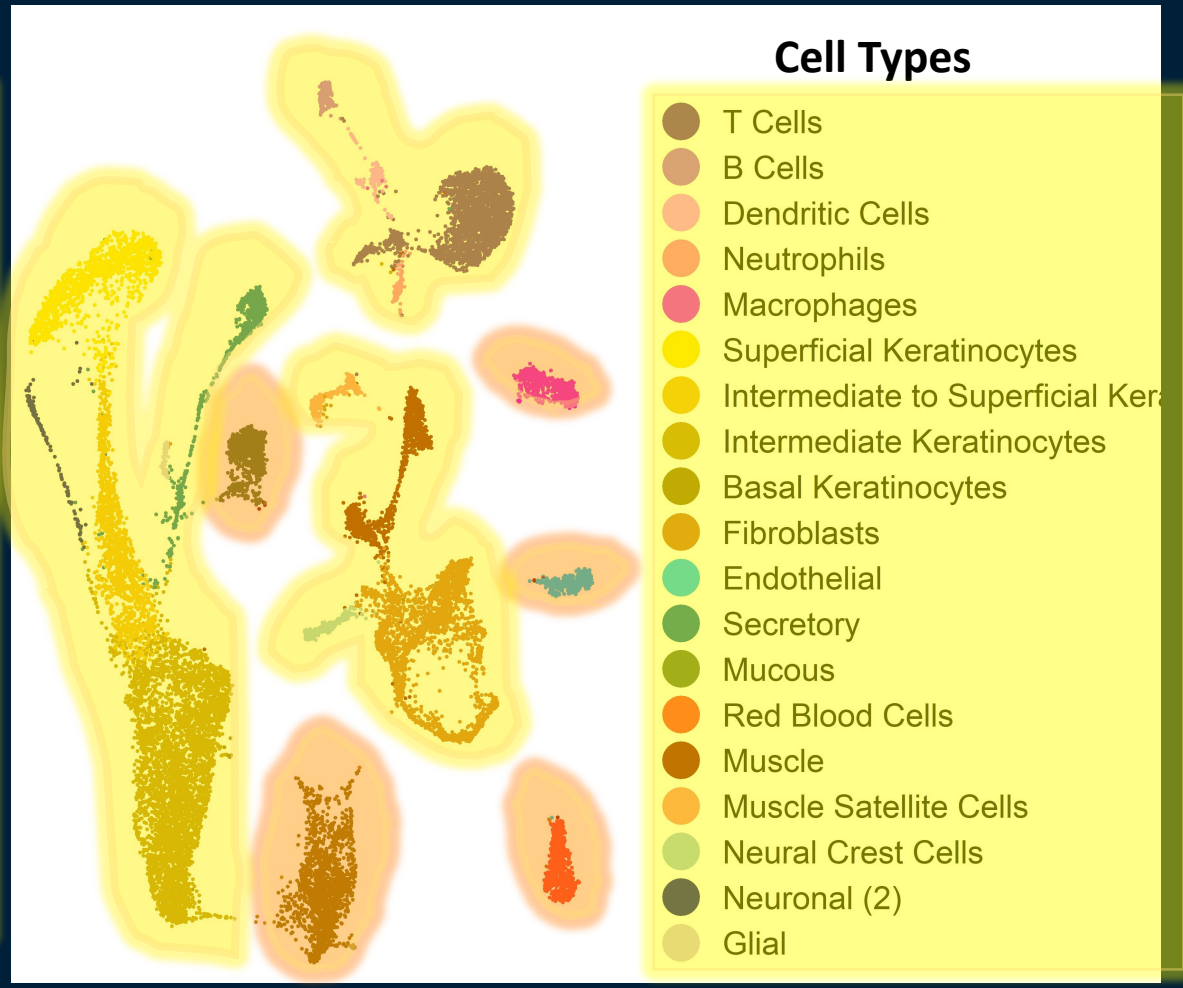


Slide by
Sarah Salisbury

CHUM

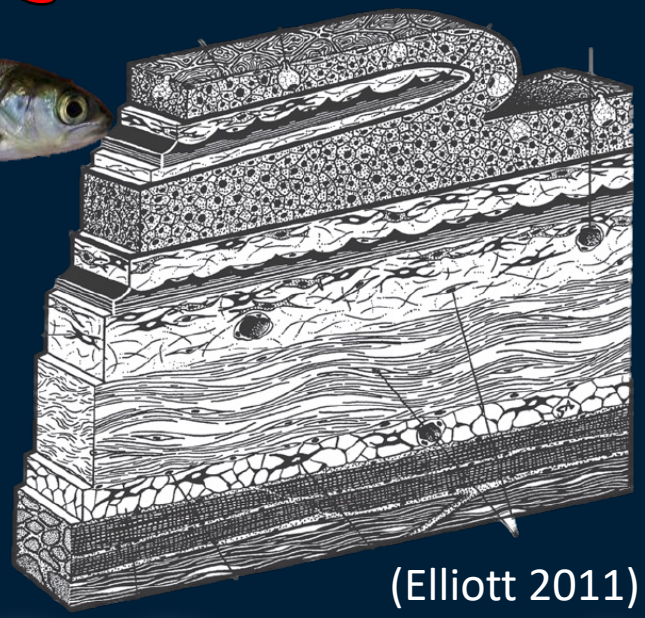


PINK



Slide by
Sarah Salisbury

ATLANTIC



(Elliott 2011)

COHO

It's not the cells, it's what you do with them!

Alle fire arter har samme celletyper

CHUM

PINK

Isn't that a bit boring?

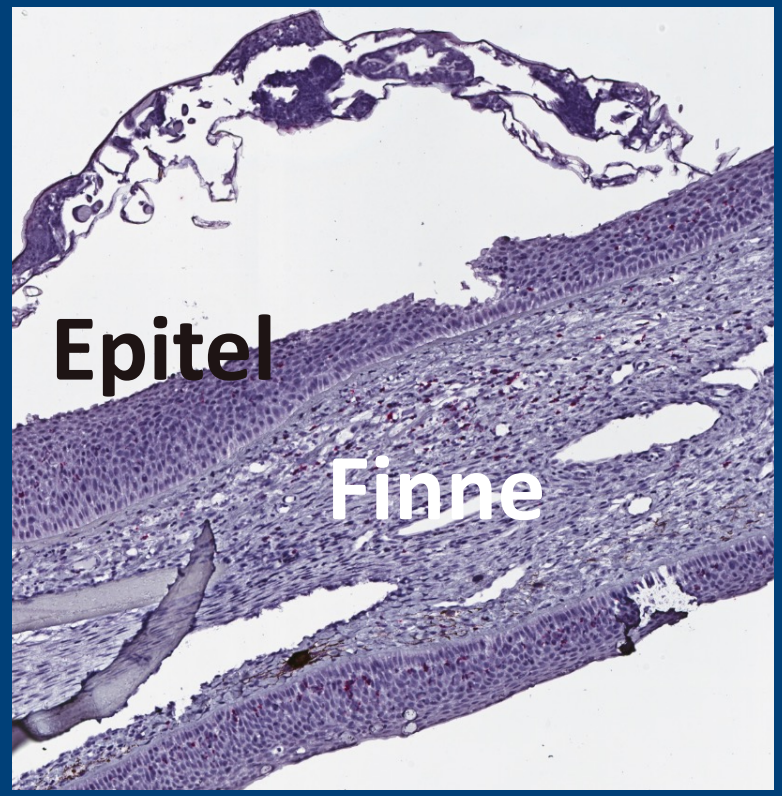
Slide by Sarah Salisbury

Slide by: Sarah Salisbury

Nofima

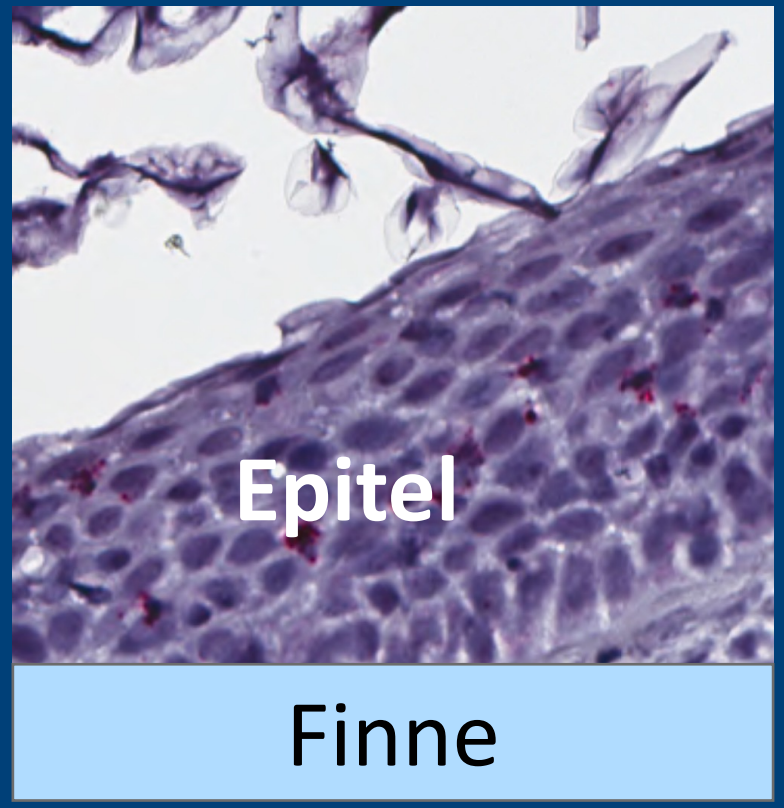
Resultater

Epitelcellene (Keratinocytter)



Resultater

Epitelcellene (Keratinocytter)

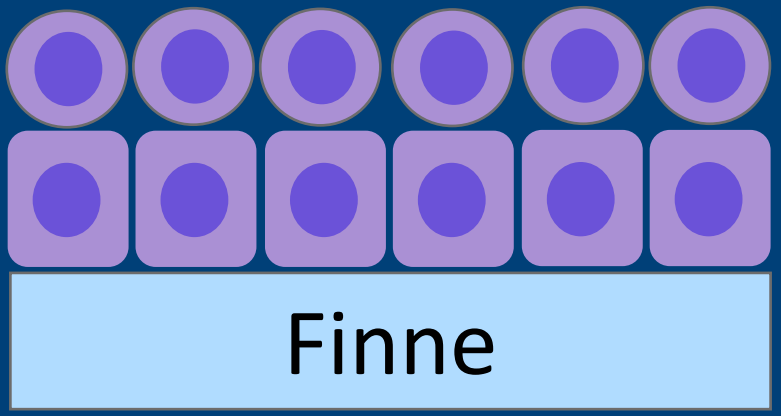


Resultater

Basal keratinocytes

Resultater

Intermediate keratinocytes



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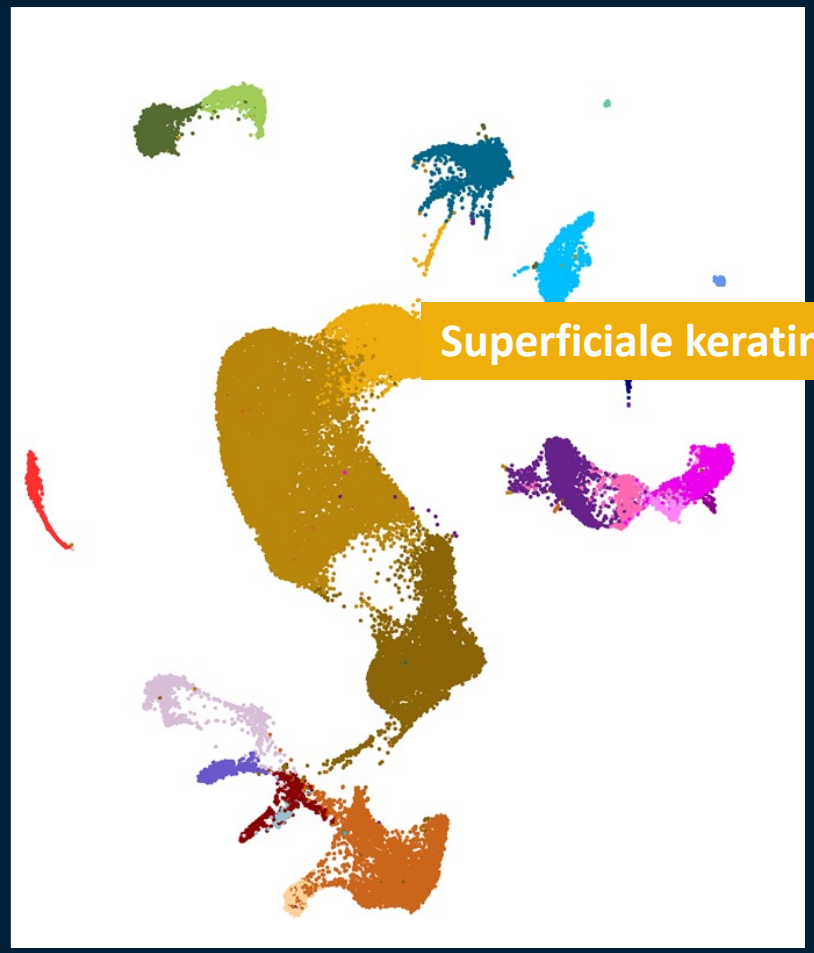
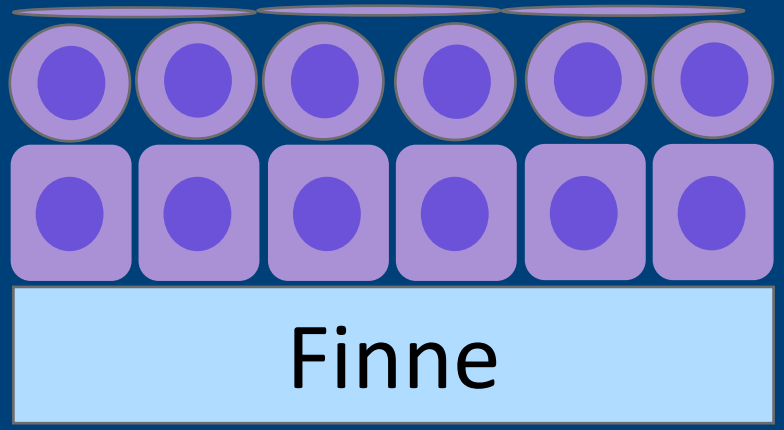


Superficial keratinocyttes



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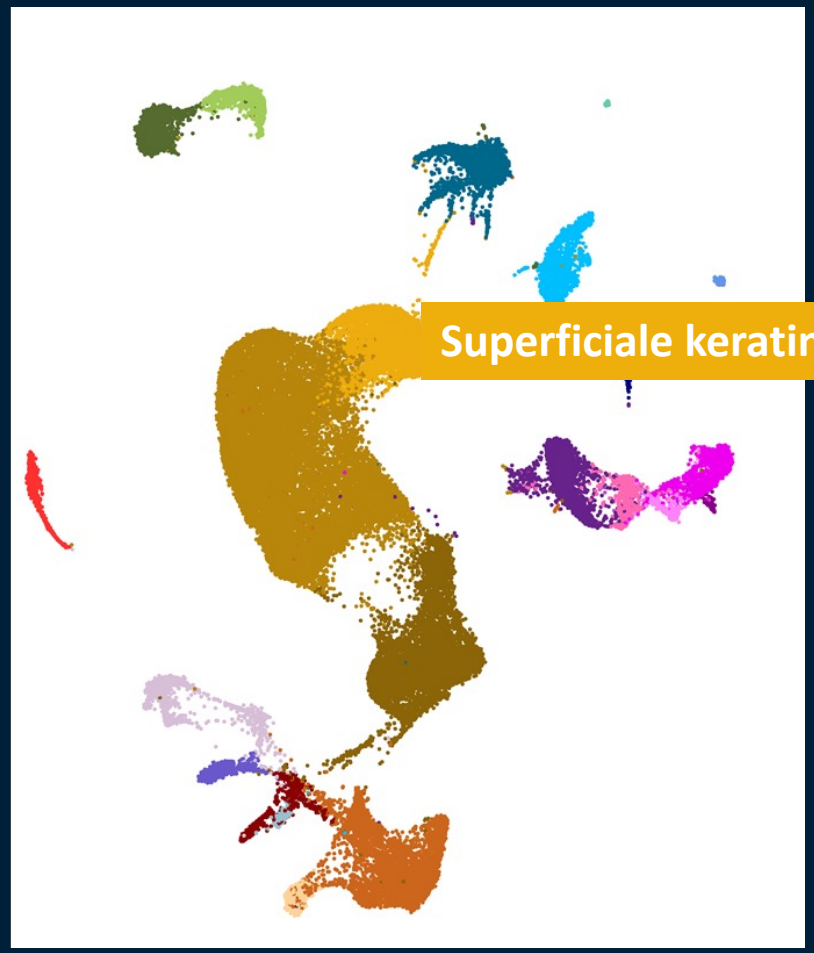
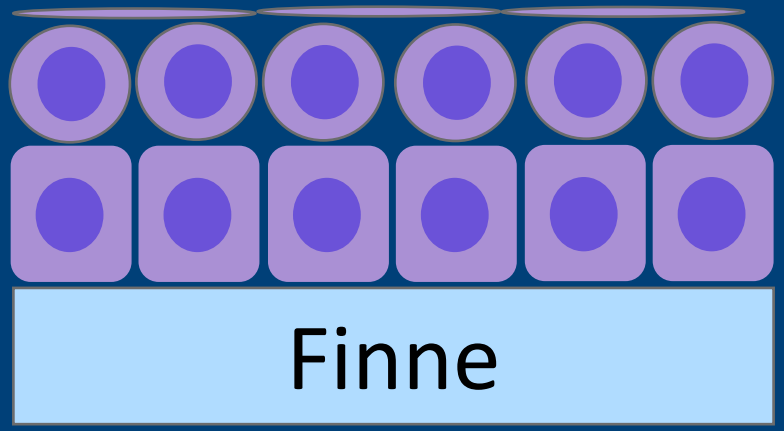


Lus



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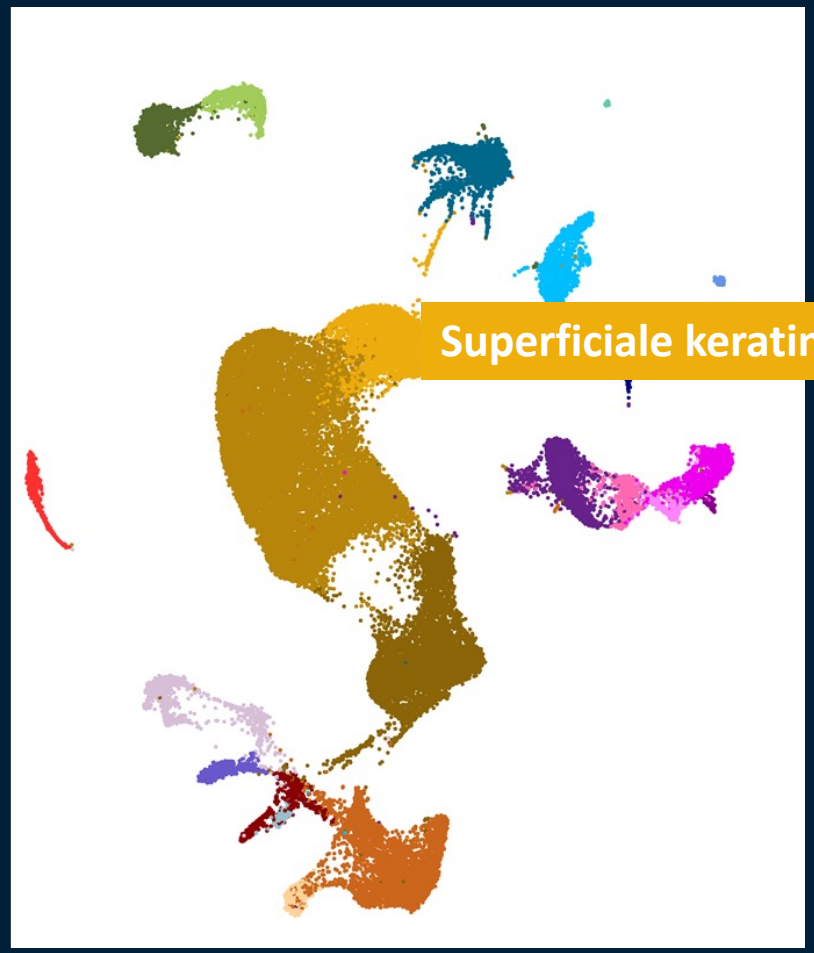
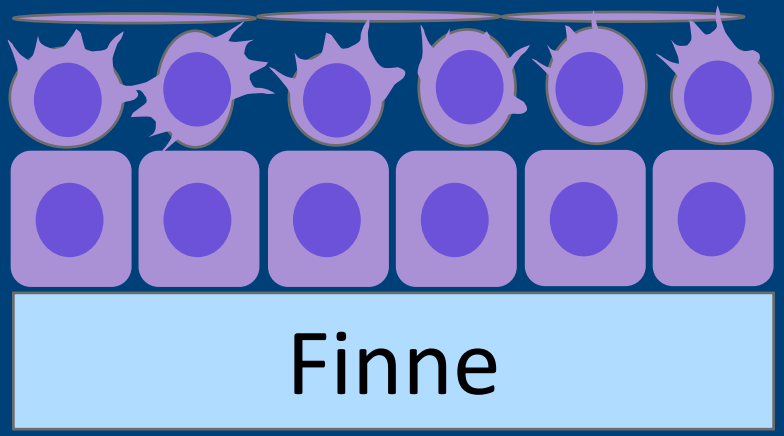
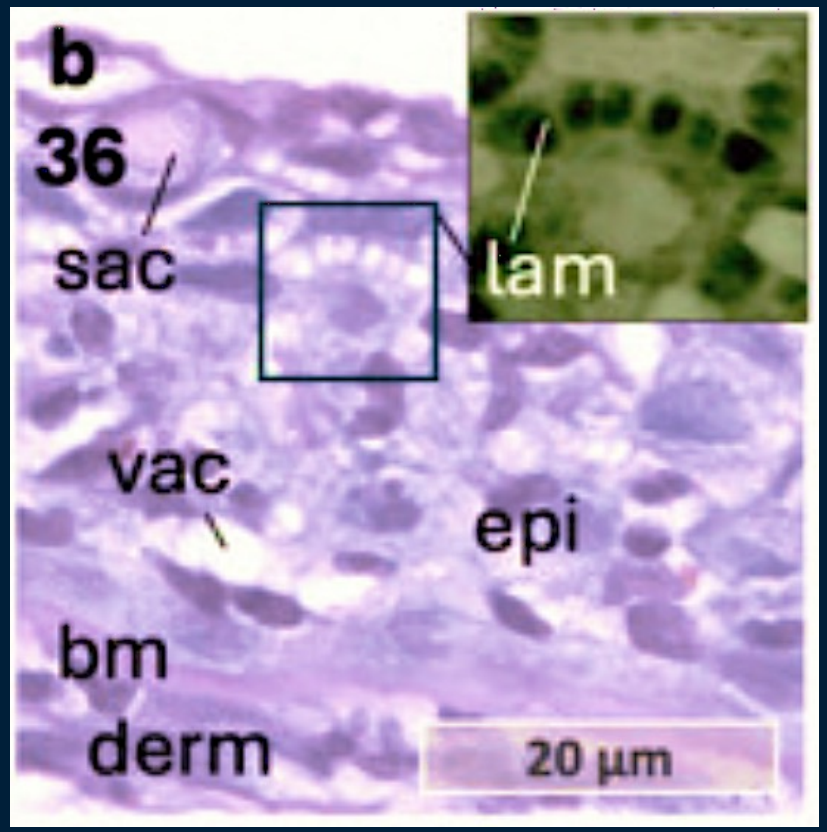


Lus



Resultater



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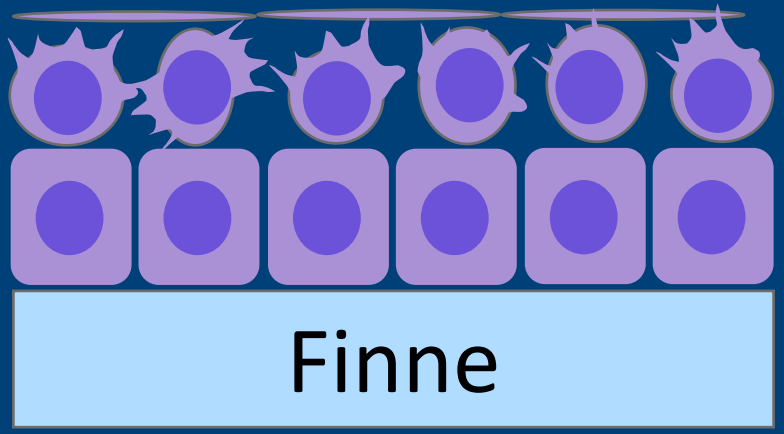
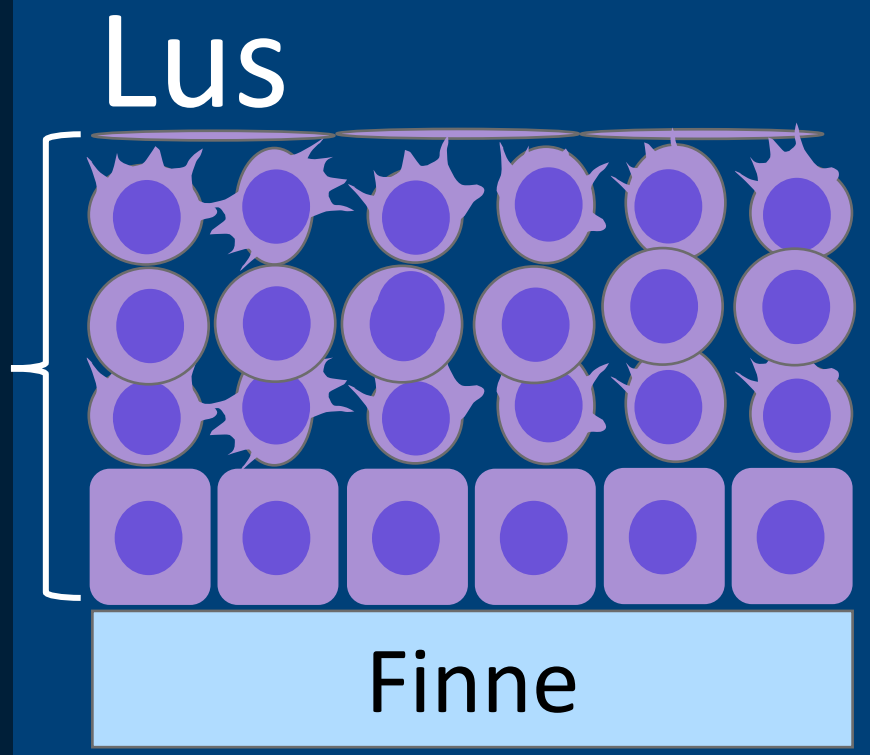
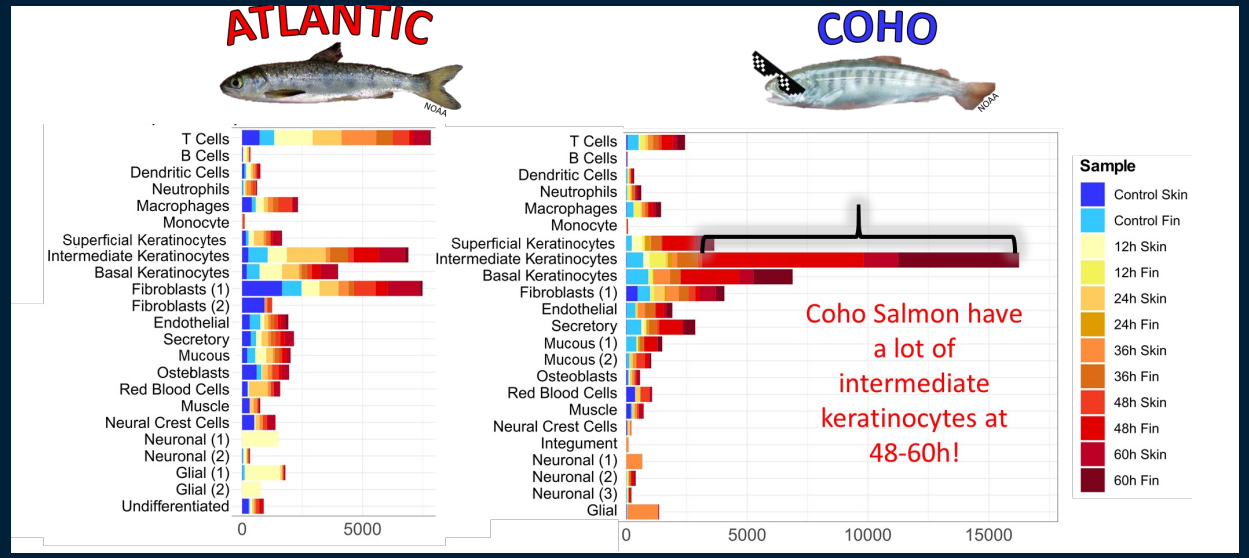


Resultater

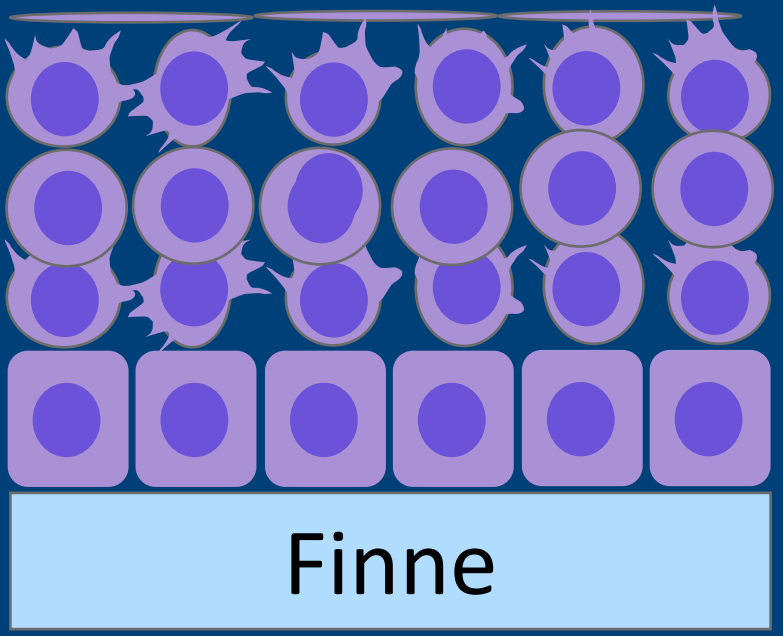
Økning i antall intermediate epitelceller 40 – 60 timer etter smitte



Resultater

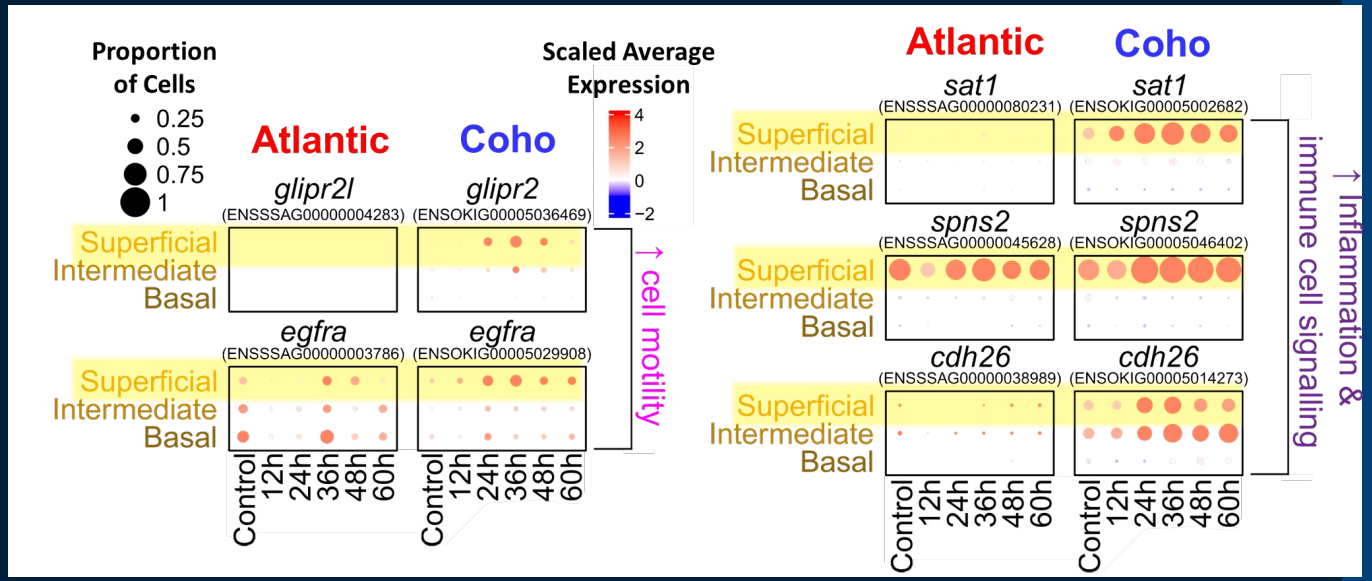


Lus

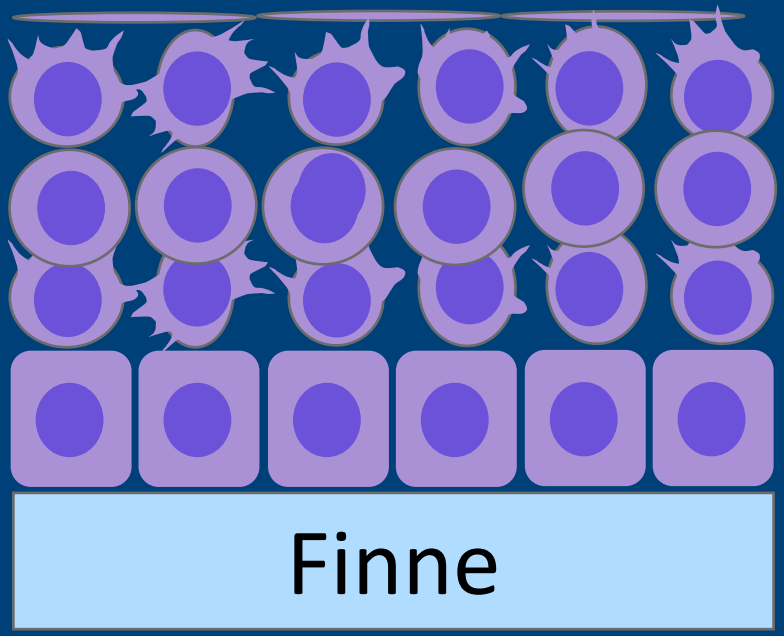


Resultater

Epitelcellene utrykker forskjellige gener

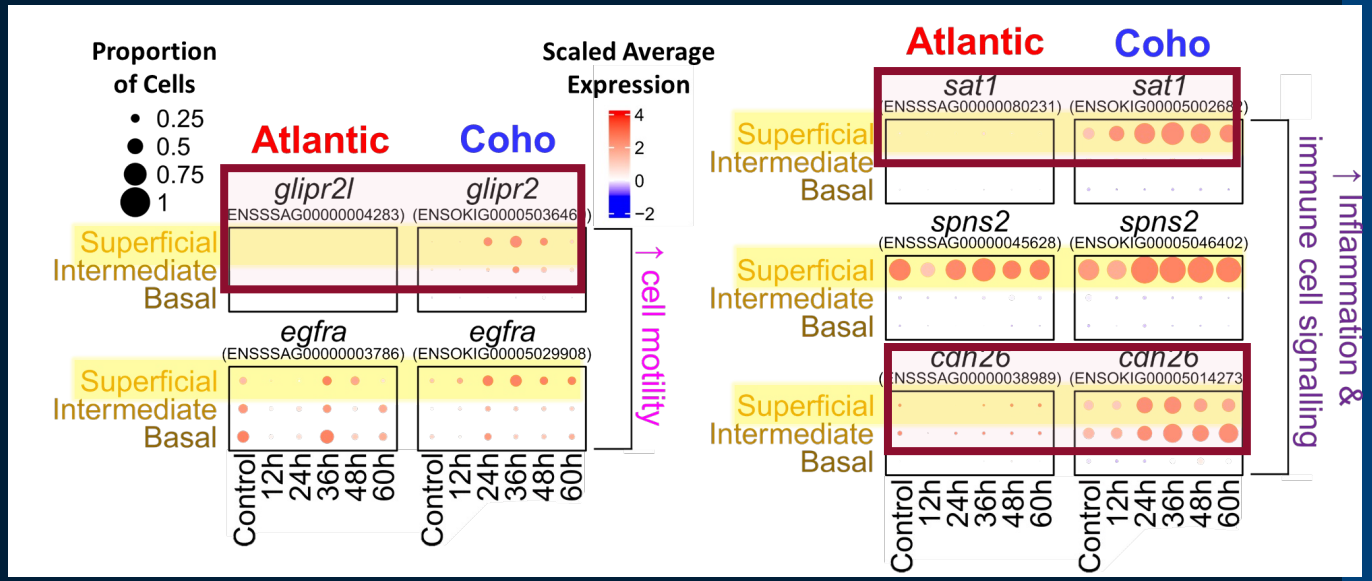


Lus



Resultater

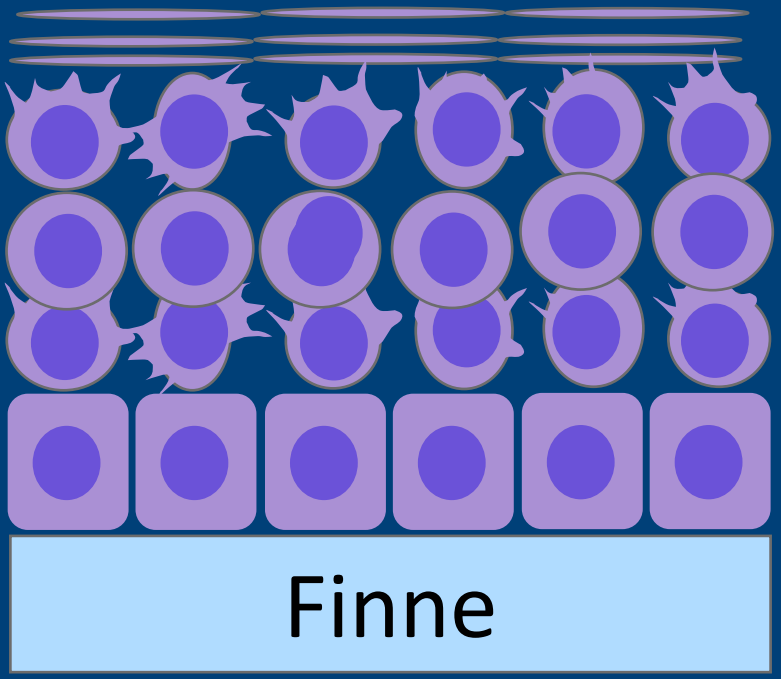
Epitelcellene utrykker forskjellige gener



Cdh26
Sat1

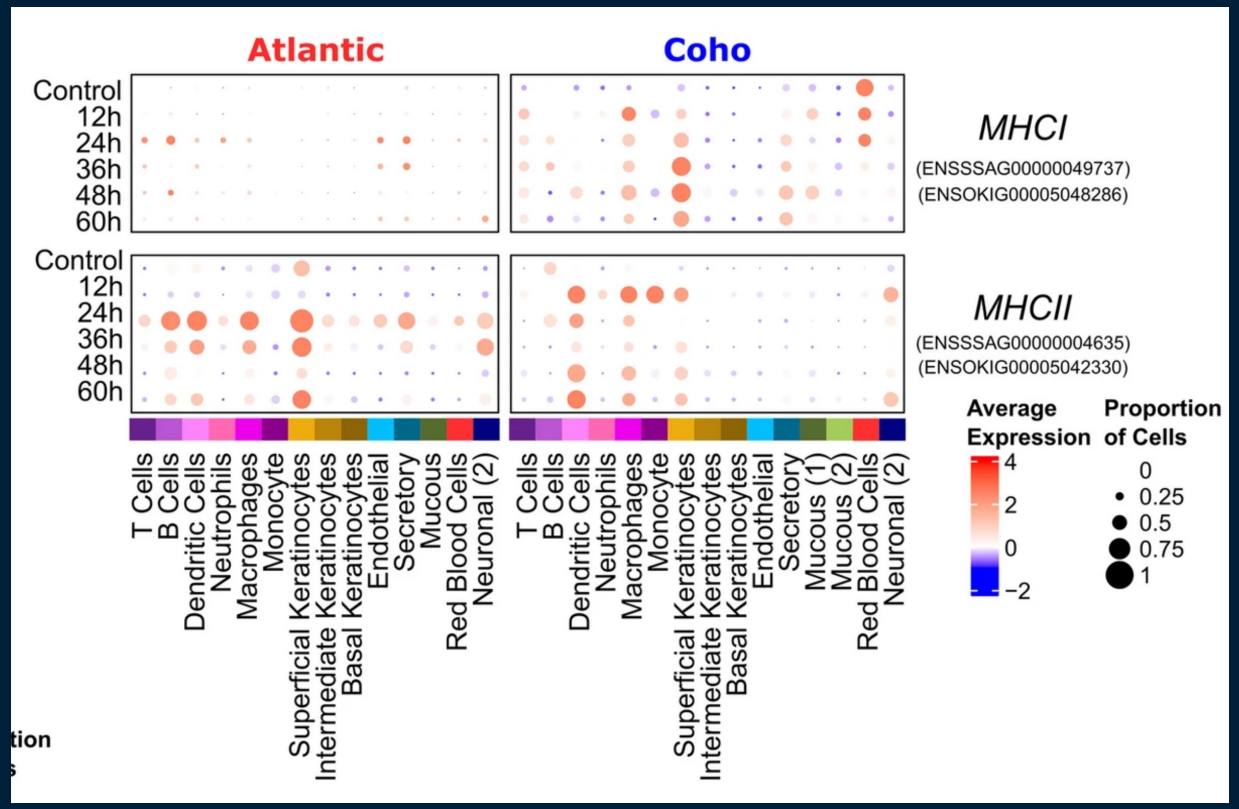
Cdh26
Sat1

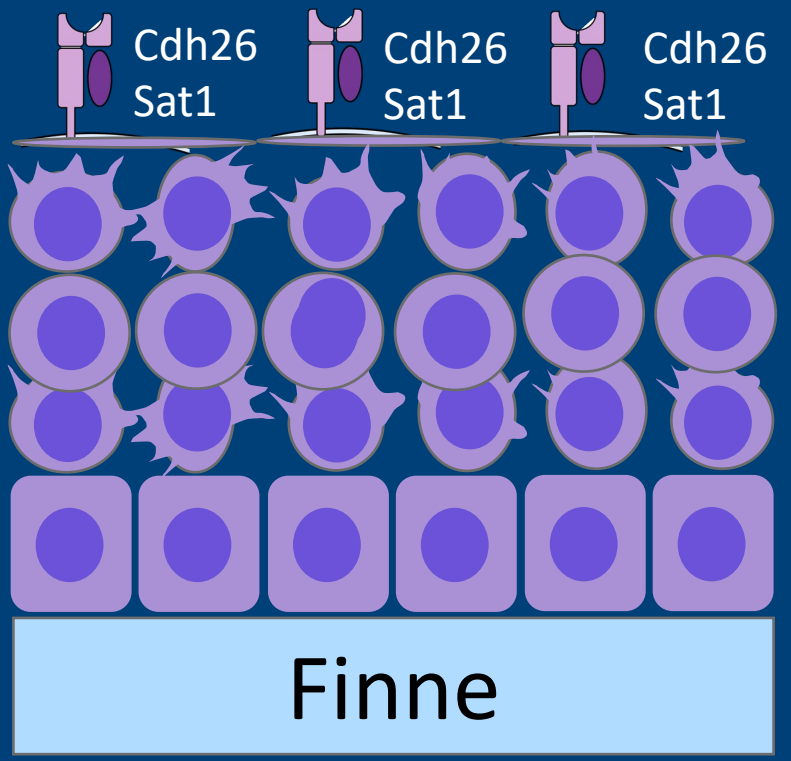
Cdh26
Sat1



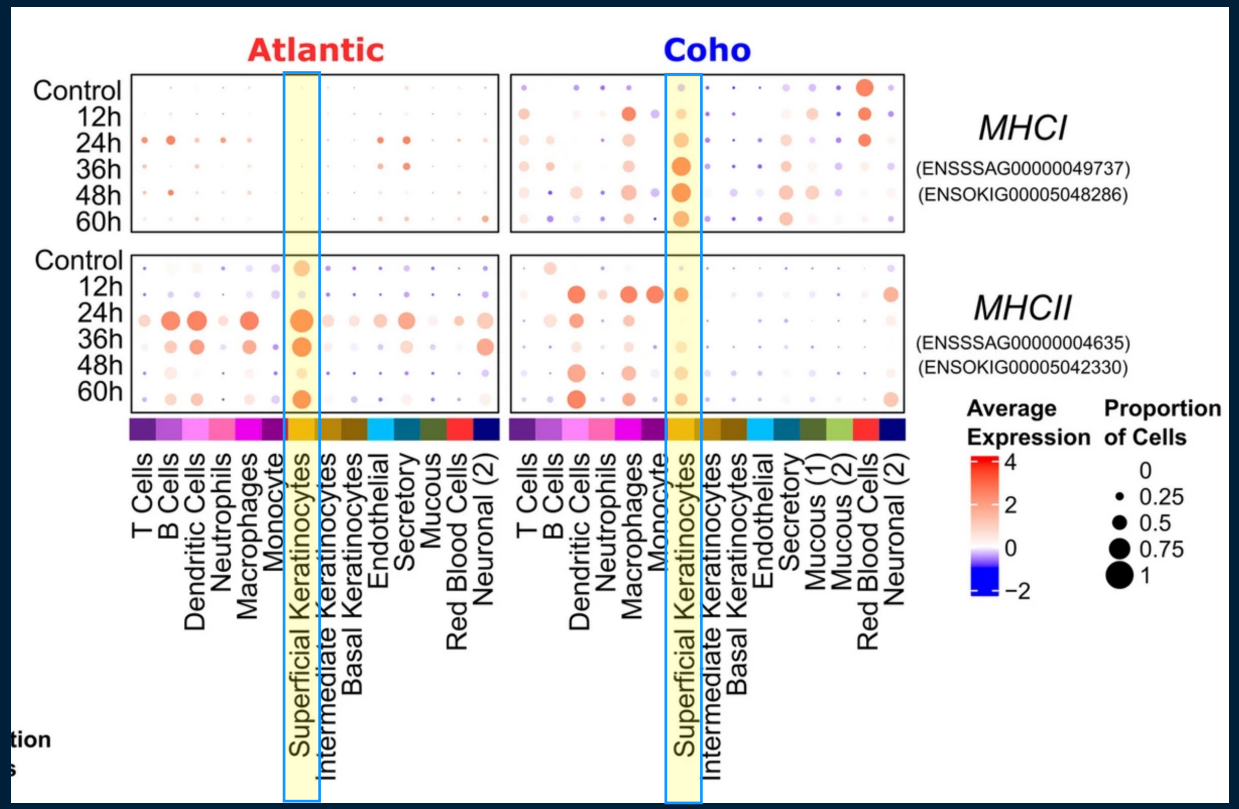
Resultater

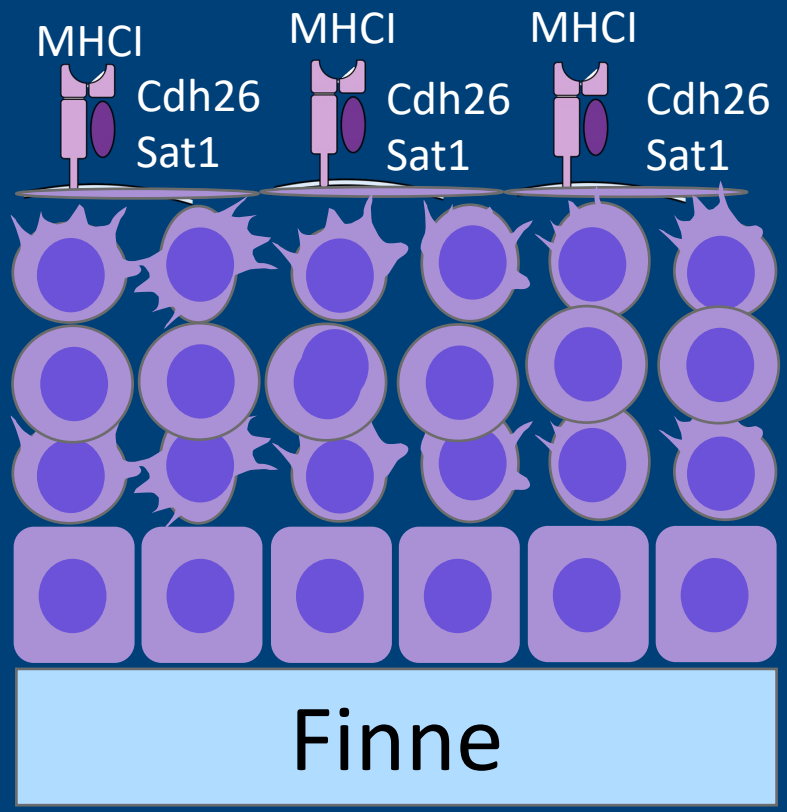
Epitelcellene utrykker forskjellige gener



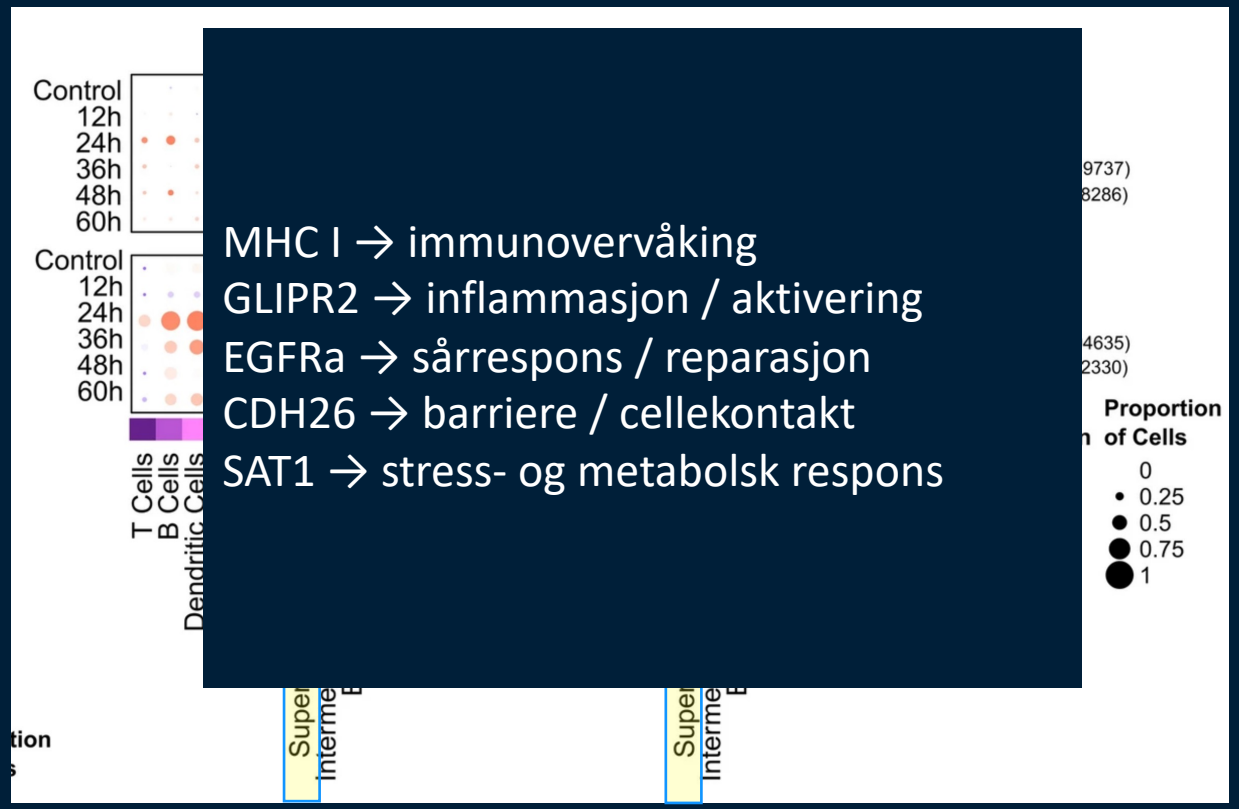


Resultater

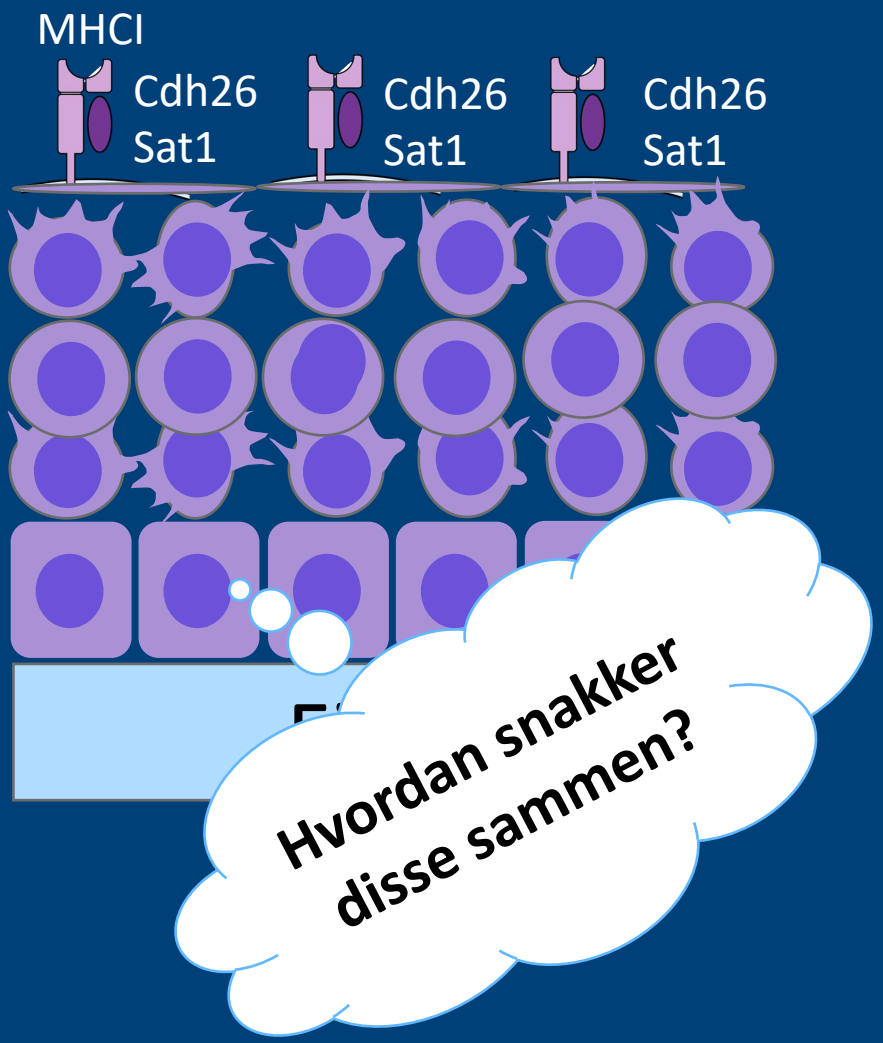

Atlantic
Coho
Control
12h
24h
36h
48h
60h
MHCI
(ENSSSAG00000049737)
(ENSOKIG00005048286)
MHCII
(ENSSSAG00000004635)
(ENSOKIG00005042330)
Average Expression
4
2
0
−2
Proportion of Cells
0
0.25
0.5
0.75
1
T Cells
B Cells
Dendritic Cells
Neutrophils
Macrophages
Monocyte
Superficial Keratinocytes
Intermediate Keratinocytes
Basal Keratinocytes
Endothelial
Secretory
Mucous
Mucous (1)
Mucous (2)
Red Blood Cells
Neuronal (2)


MHCI
Cdh26
Sat1
MHCI
Cdh26
Sat1
MHCI
Cdh26
Sat1
Finne

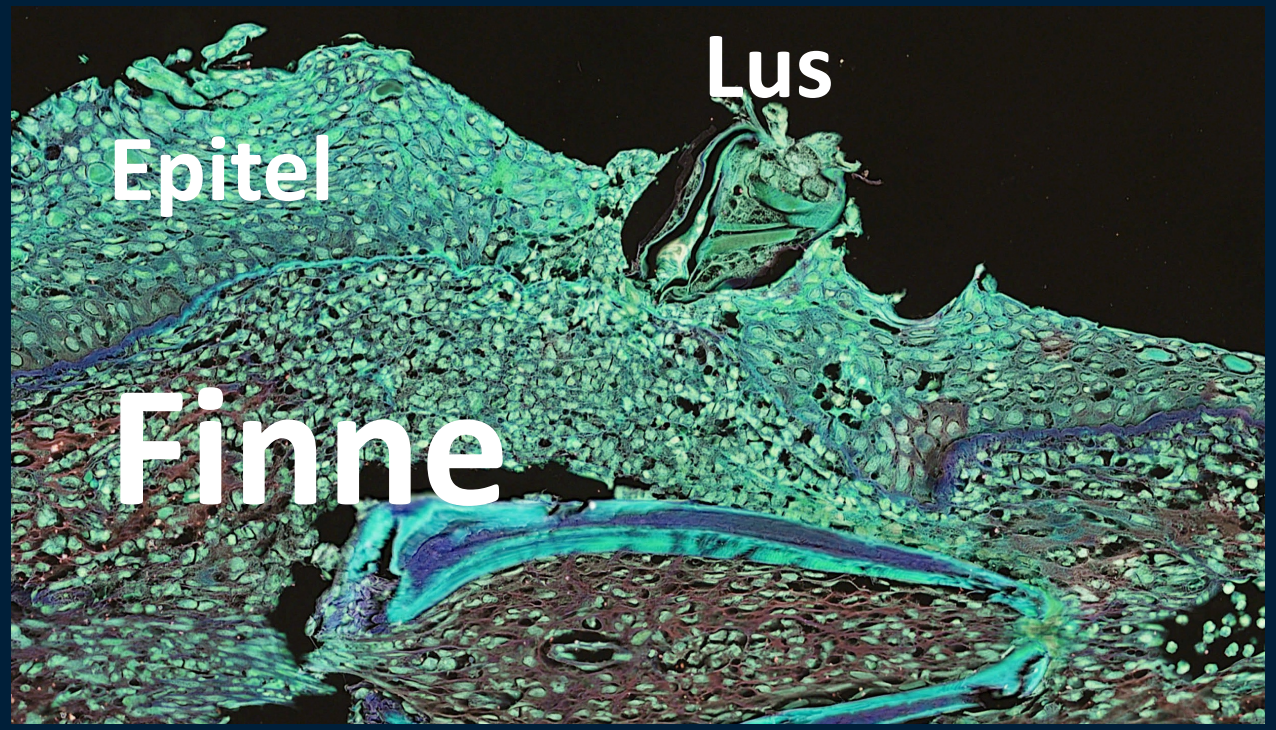
Resultater

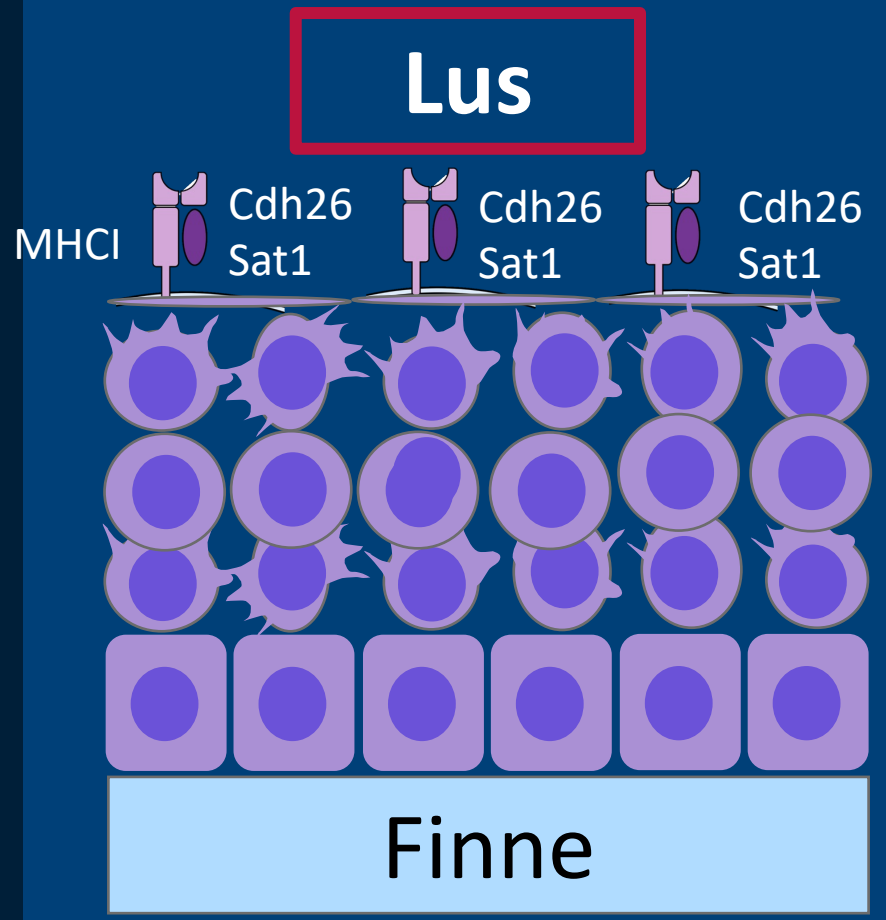


MHC I → immunovervåking
GLIPR2 → inflammasjon / aktivering
EGFRa → sårrespons / reparasjon
CDH26 → barriere / cellekontakt
SAT1 → stress- og metabolsk respons

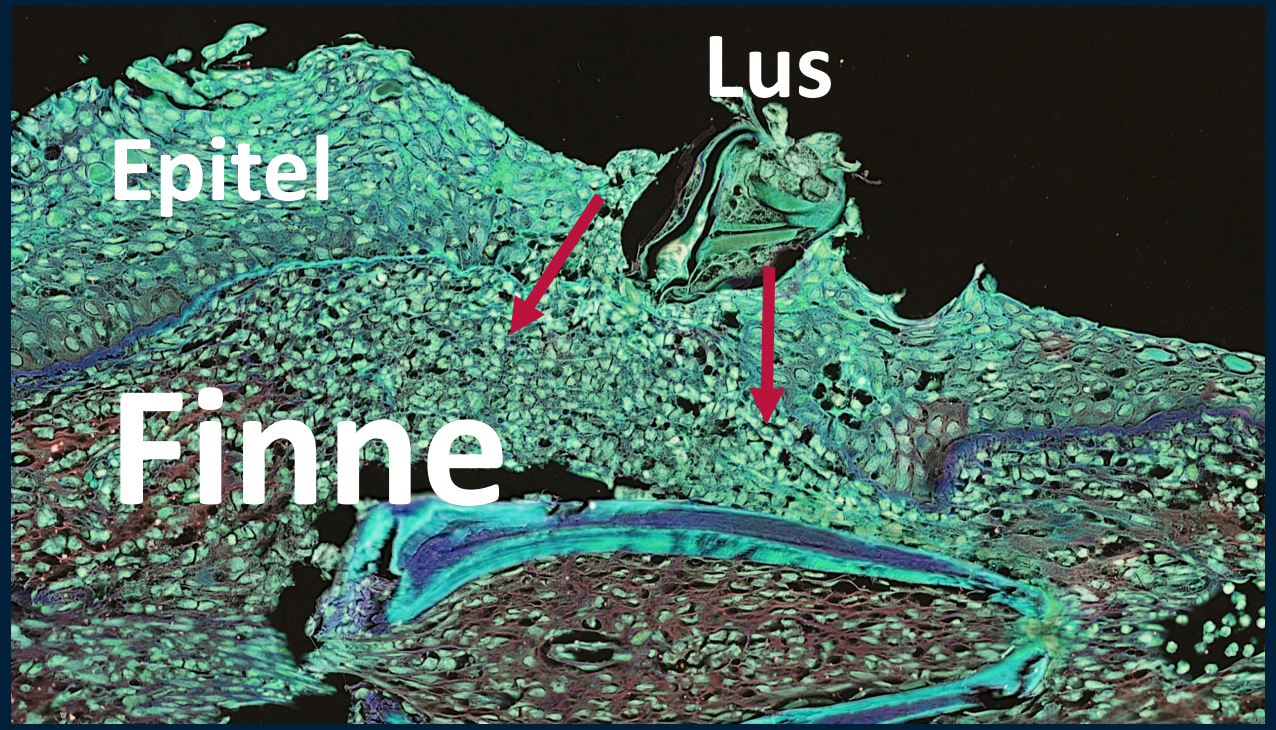


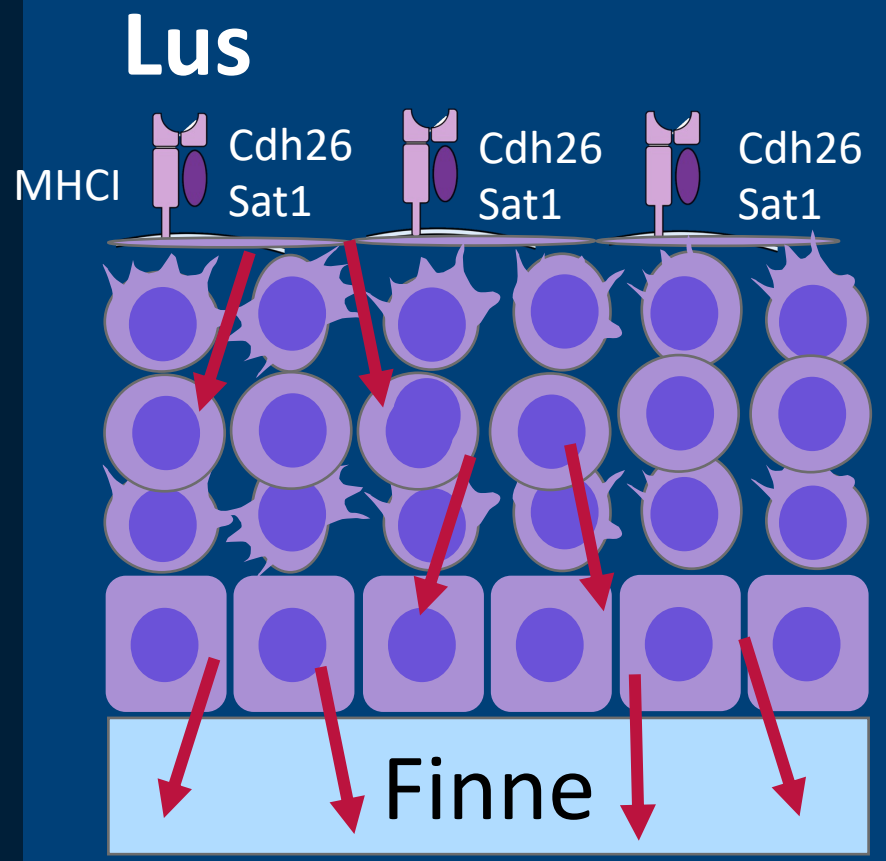
Resultater


Lus
Epitel
Finne

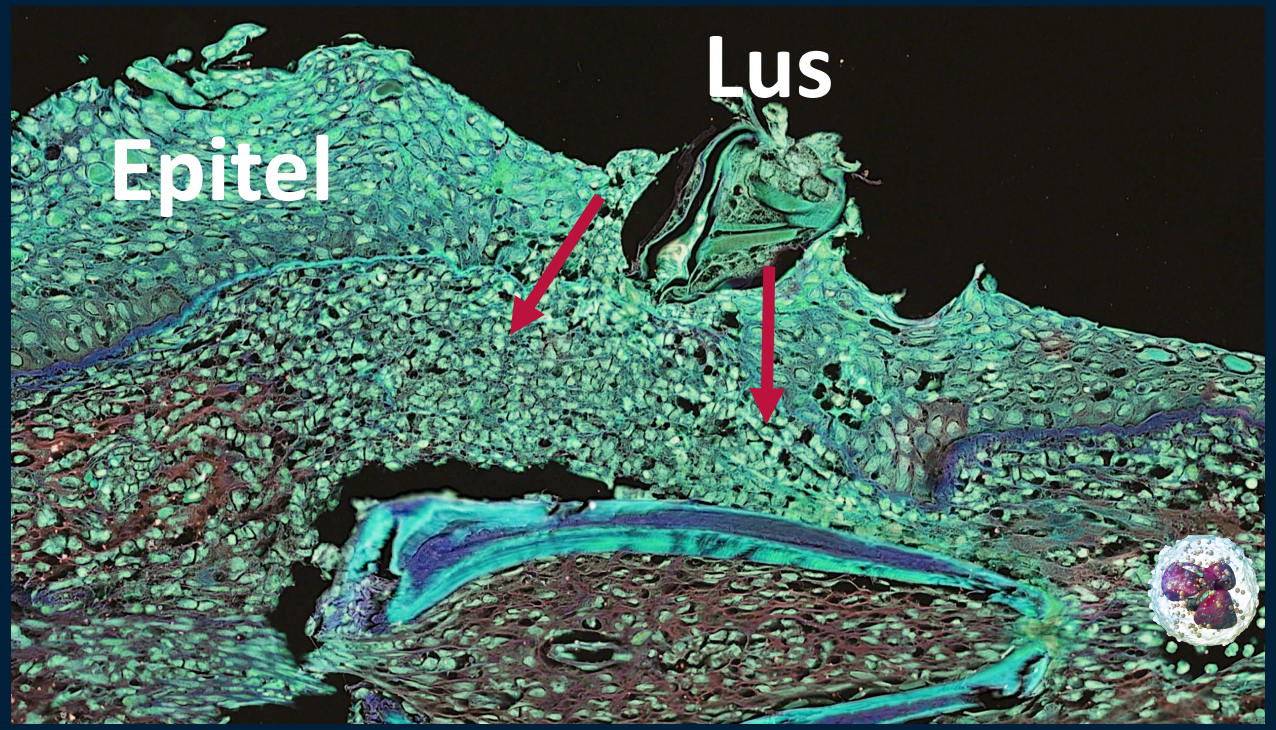

Lus
MHCI
Cdh26
Sat1
Cdh26
Sat1
Cdh26
Sat1
Finne

Resultater

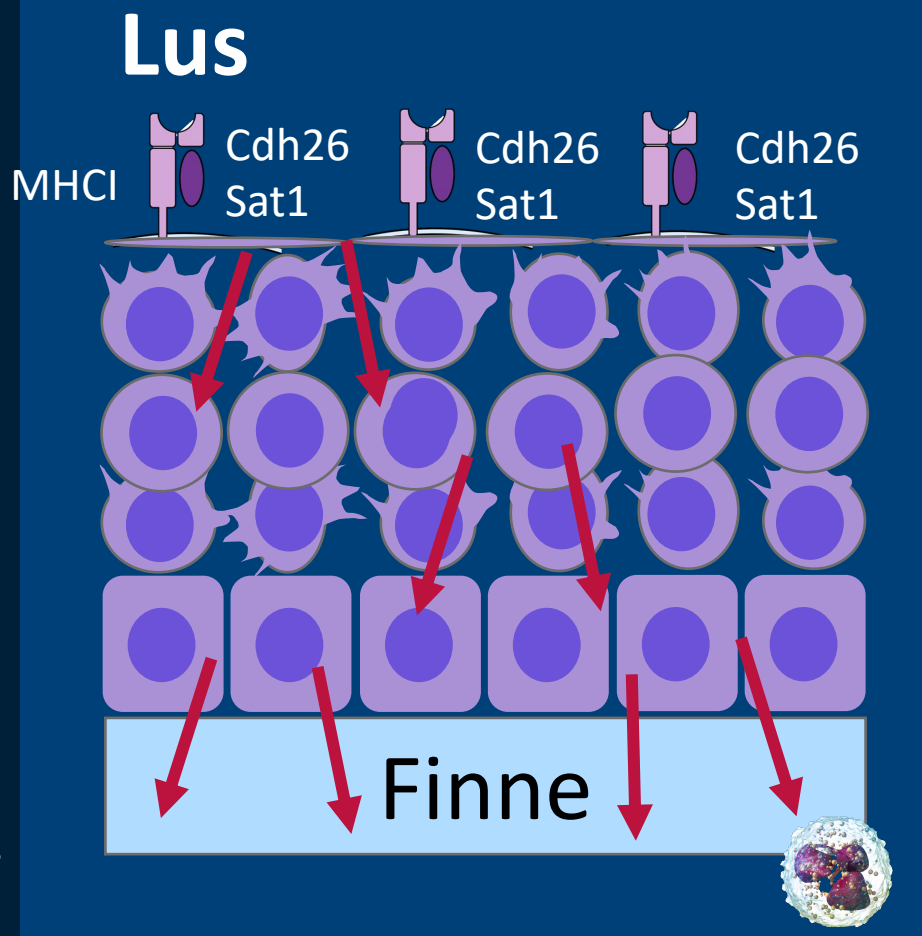

Lus
Epitel
Finne


Lus
MHCI
Cdh26
Sat1
Cdh26
Sat1
Cdh26
Sat1
Finne

Resultater

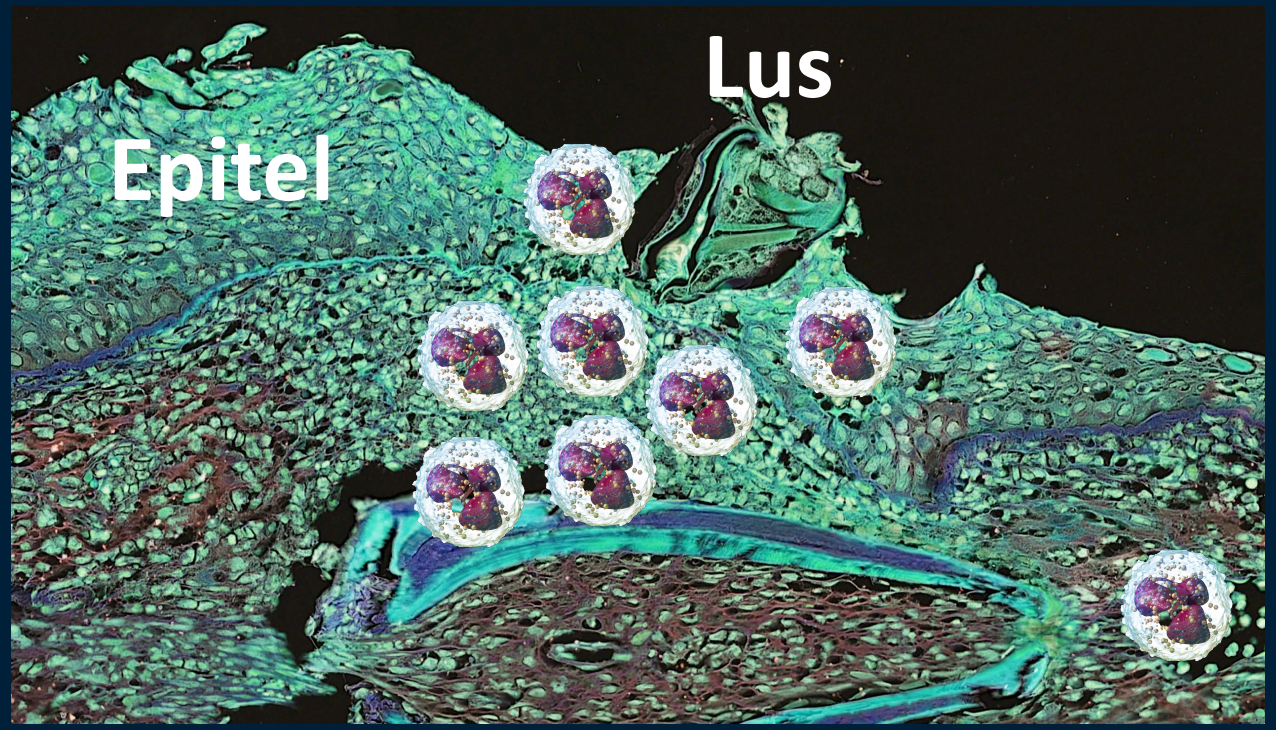


Nøytrofiler

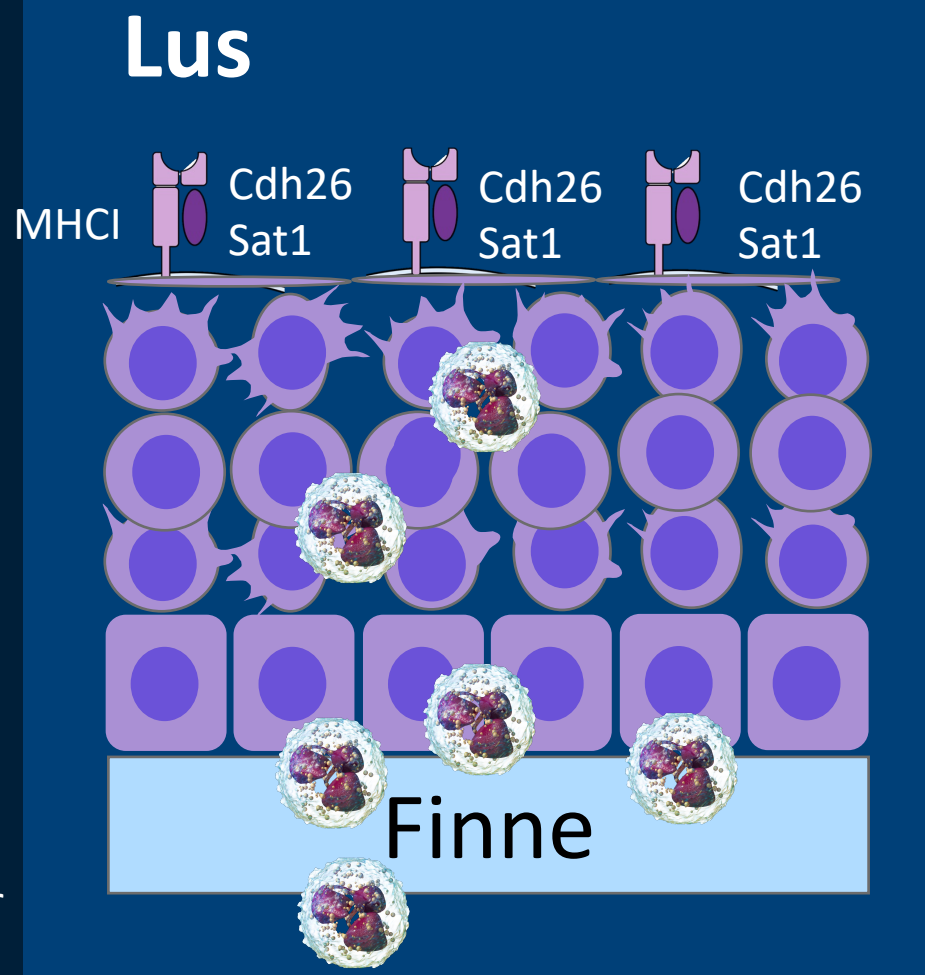


Nøytrofiler

Resultater



Nøytrofiler



Nøytrofiler

Resultater

Nofima

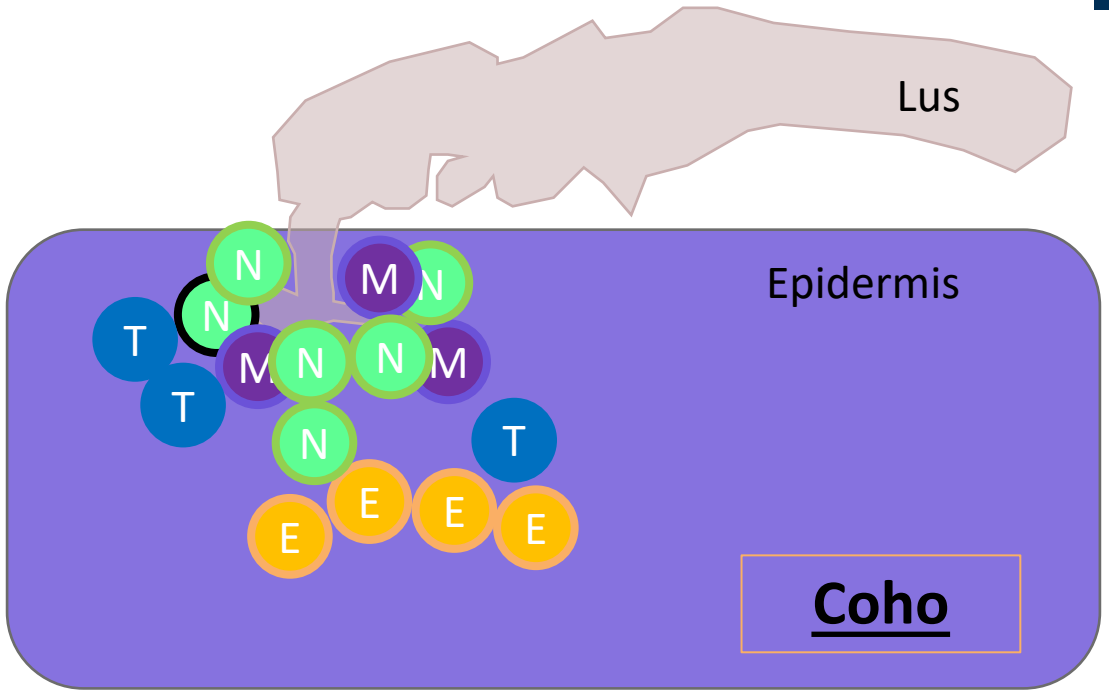
Oppsummering resultater

Oppsummering

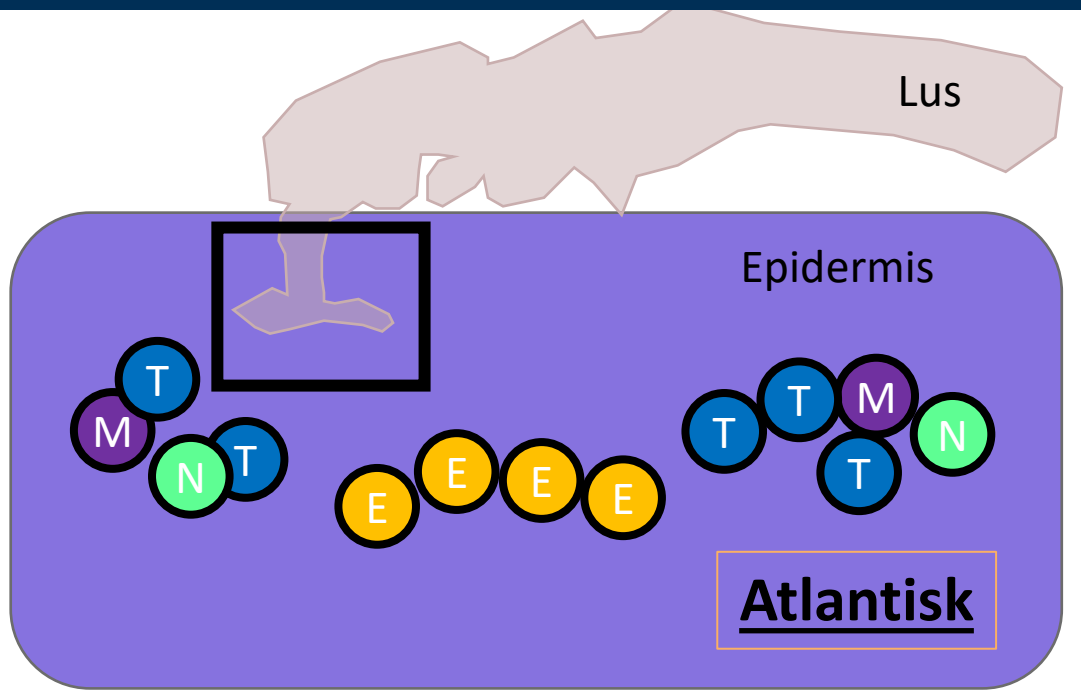
Chum og Pink

Første strategi er ”shake it off”

Immunceller…



Immunceller målrettet mot festepunktet



Immunceller mangler spesifikk retning, reagerer på erosjon av epitel

BAKGRUNN

FORSØKSDESGIN

RESULTATER

GENREDIGERING

VEIEN VIDERE

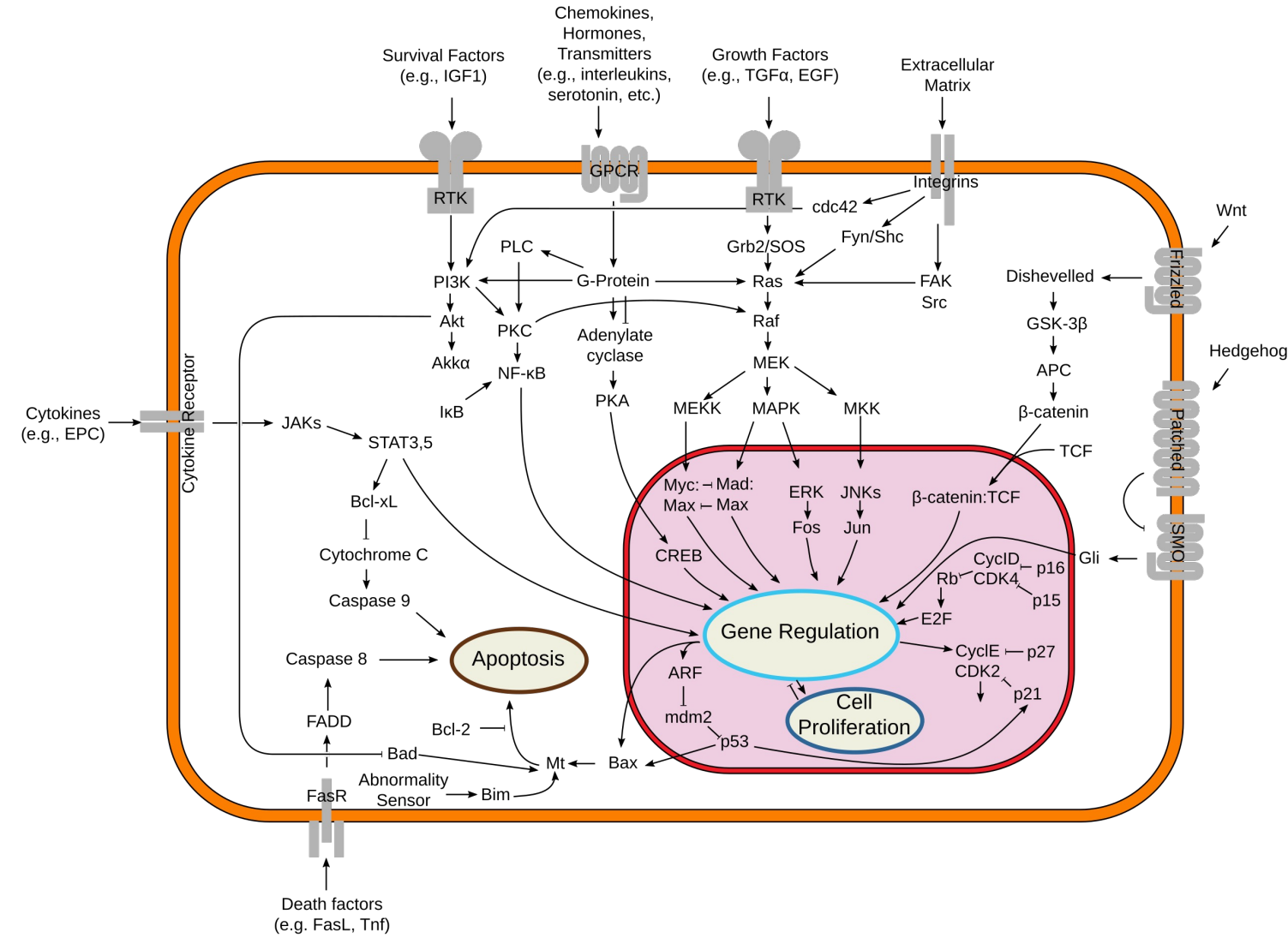
Nofima

Nofima


Nofima
INSTITUTE OF MARINE RESEARCH
UNIVERSITY of Prince Edward ISLAND

Genredigering

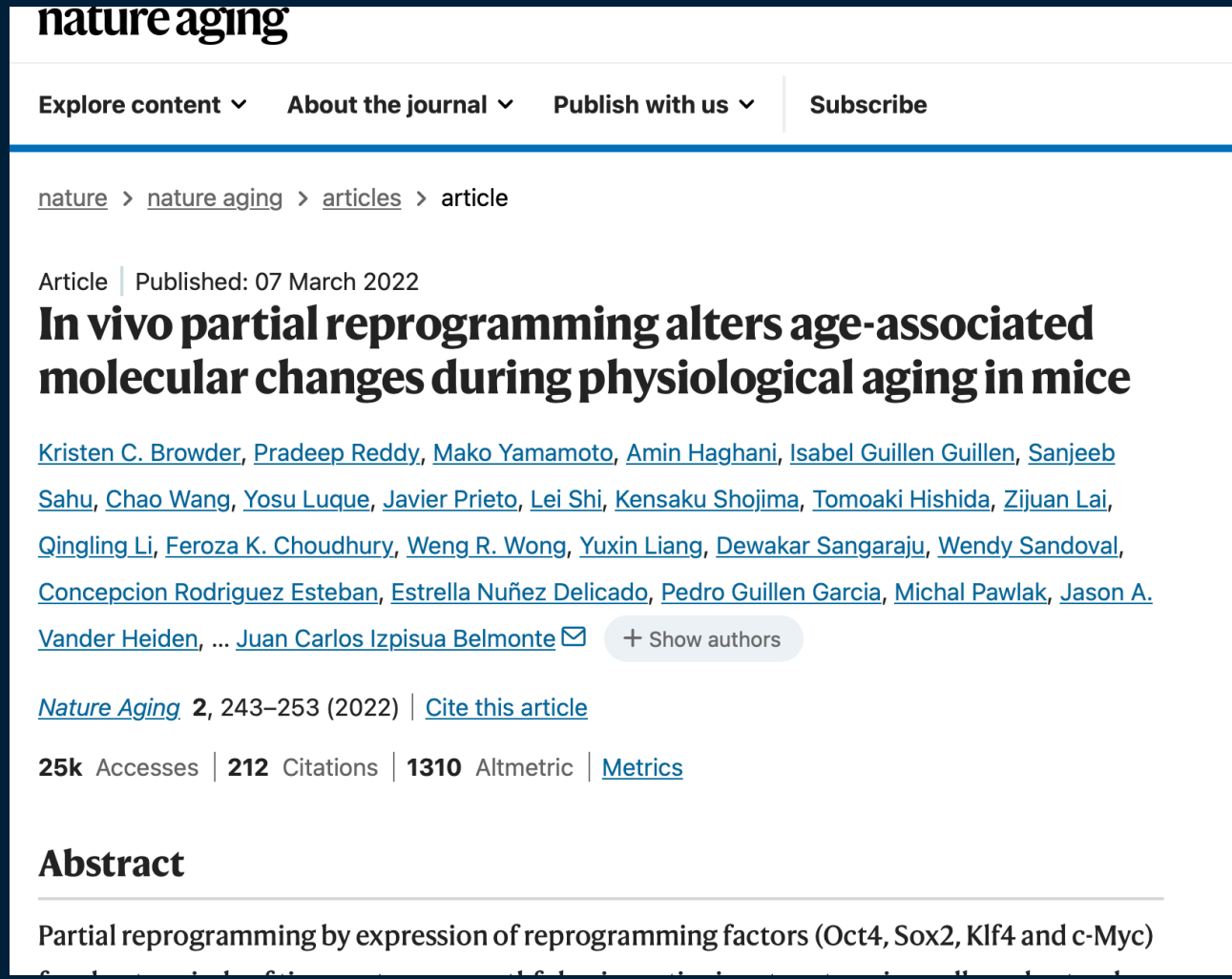
Hvilken gener skal vi velge?



Genredigering

Yamanaka-faktorer er
en gruppe på fire proteiner
Oct4, Sox2, Klf4 og c-Myc ,

som kan omprogrammere **voksne, spesialiserte celler** tilbake til **ung tilstand**



nature aging

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Article | Published: 07 March 2022

In vivo partial reprogramming alters age-associated molecular changes during physiological aging in mice

Kristen C. Browder, Pradeep Reddy, Mako Yamamoto, Amin Haghani, Isabel Guillen Guillen, Sanjeeb Sahu, Chao Wang, Yosu Luque, Javier Prieto, Lei Shi, Kensaku Shojima, Tomoaki Hishida, Zijuan Lai, Qingling Li, Feroza K. Choudhury, Weng R. Wong, Yuxin Liang, Dewakar Sangaraju, Wendy Sandoval, Concepcion Rodriguez Esteban, Estrella Nuñez Delicado, Pedro Guillen Garcia, Michal Pawlak, Jason A. Vander Heiden, ... Juan Carlos Izpisua Belmonte ✉ + Show authors

Nature Aging **2**, 243–253 (2022) | Cite this article

25k Accesses | **212** Citations | **1310** Altmetric | Metrics

Abstract

Partial reprogramming by expression of reprogramming factors (Oct4, Sox2, Klf4 and c-Myc)

Nofima

16 forskjellige typer genredigert laks er under uttesting

Nofima

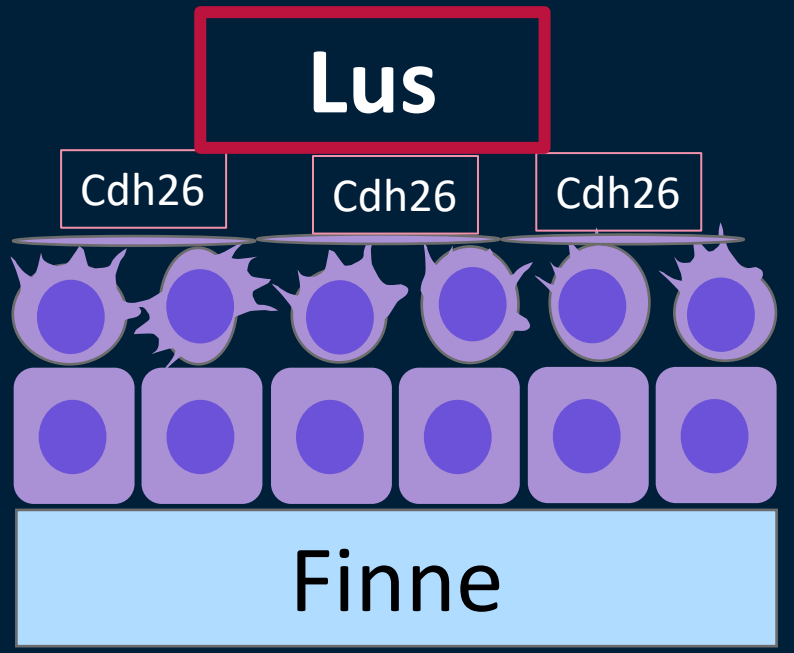
Genredigering

Cdh26 → immune modulering, tiltrekke seg hvite blodlegmer (neutrophiler)

Pbrm_1 → Proliferering

Mrc1a →Reseptor for gjenkjenning av parasitter og aktivering av medfødt immunrespons

Socs3 → Regulerer **inflammasjon og immunrespons**



Nofima

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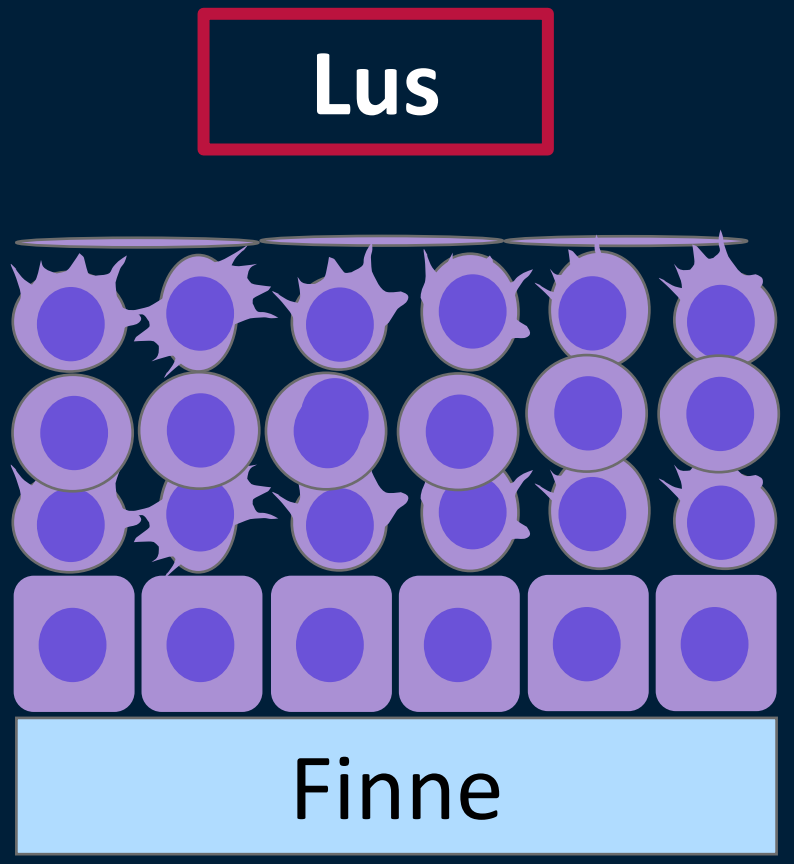

Nofima

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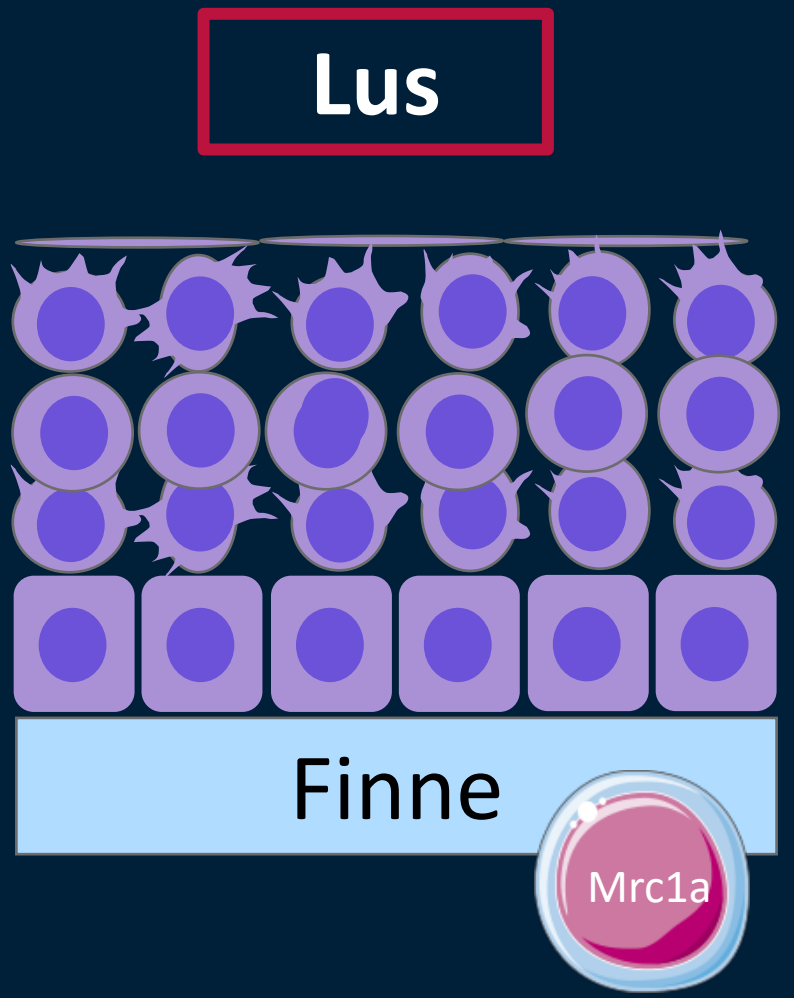

Nofima

Genredigering

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Pbrm_1 → Proliferering

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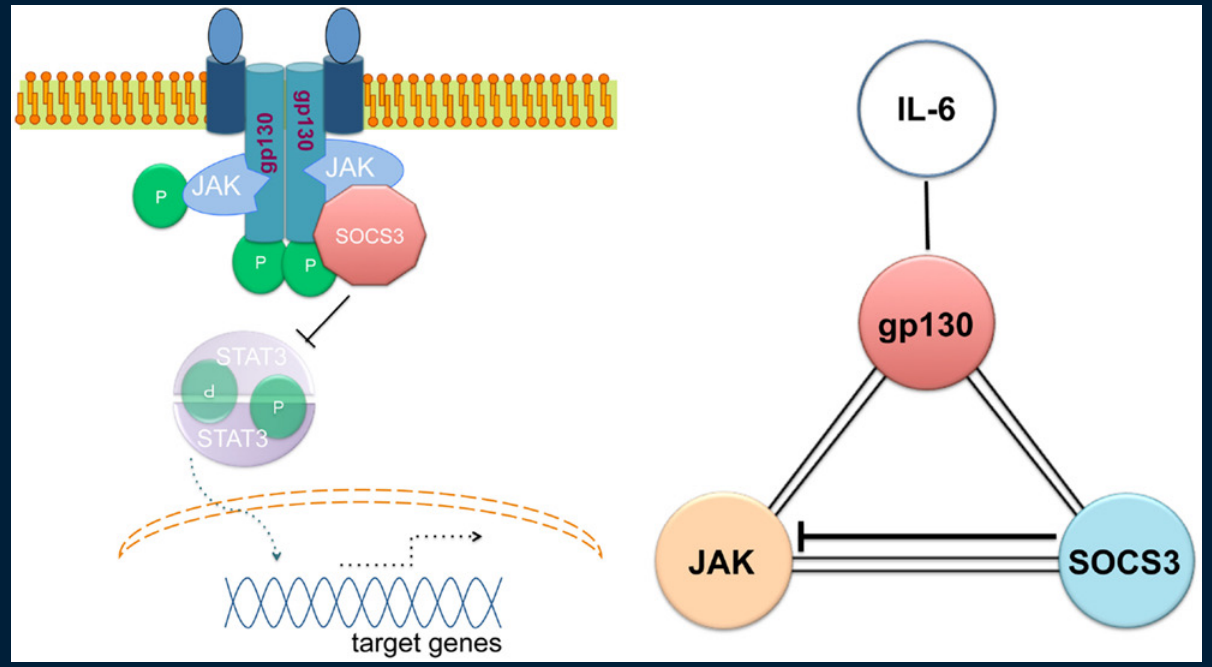
Socs3 → Regulerer **inflammasjon og immunrespons**

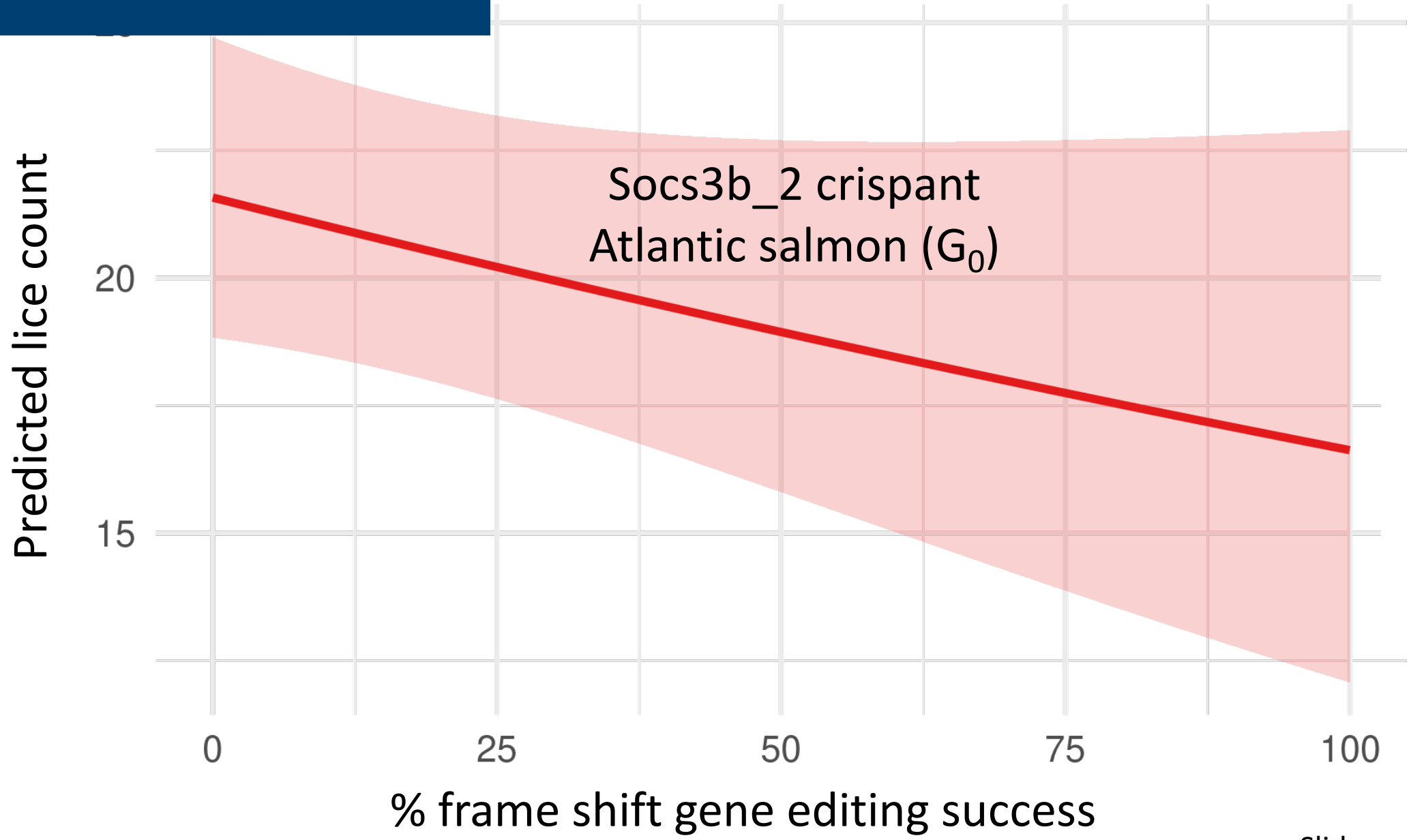
SOCS3 hovedregulator



Carrow og Rottenberg 2014

Nofima

Genredigering



NS

~25% reduction in lice count in full socs3a knockout

Slide av: Teshome Bizuayehu

BAKGRUNN

FORSØKSDESGIN

RESULTATER

GENREDIGERING

VEIEN VIDERE

Nofima

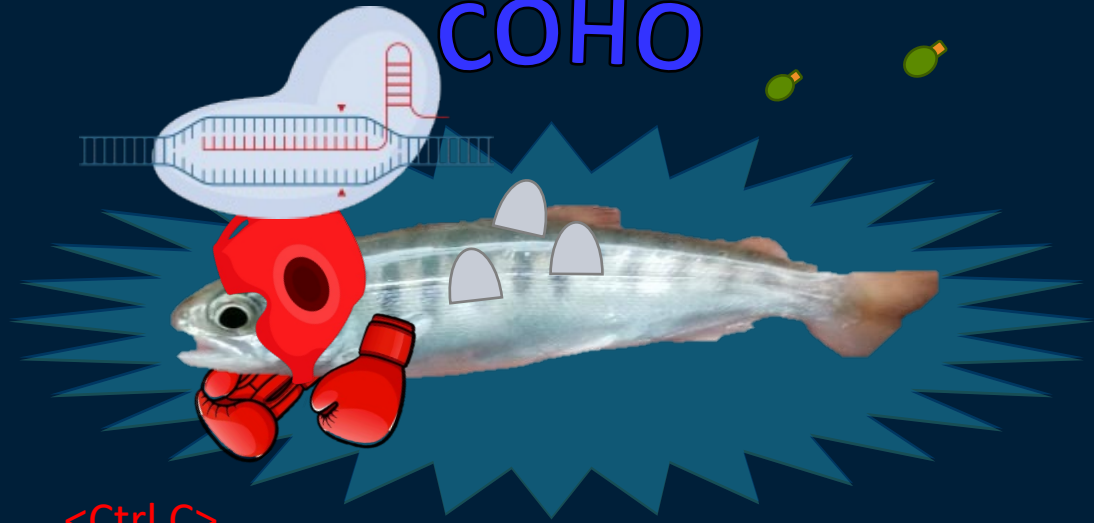
Nofima

Veien videre

ATLANTIC

<Ctrl V>

COHO



<Ctrl C>

Slide by: Sarah Salisbury

Resultatene identifiserer flere **signalveier og gener** som bidrar til å gjøre coho laks resistent mot lus.

Genredigering eller selektiv avl kan brukes for å forbedre Atlantisk laks sin medfødte immunitet mot lakselus

Slide av: Sarah Salisbury

Institute of Marine Research

Nofima

SalMar
Passion for Salmon

MOWI

University of Prince Edward Island

Rothamsted Research

Benchmark Genetics

The University of Edinburgh

University of Stirling

Bigelow Laboratory for Ocean Sciences

Deakin Marine Research and Innovation Centre

Deakin University

Universitas Bergensis

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