Host Response

Steven Roberts

Little Background First

Main Interest - *Physiology* (how stuff works)

Fish Reproduction

Fish Growth

Shellfish Growth / Metamorphosis

Shellfish Immune Response

Shellfish Response to Environmental Change

Shellfish Epigenetics - Adaptation / Plasticity

Host Response

Steven Roberts

Let's Anthropomorphize

What might scare marine invert?

Today: *Physiological Response* to things that are bad

It is important the think about the big picture.

What else is going on with the critter...

really big picture -

What has the population experienced.

Defense Systems

- Anatomic Features
- **Immunity**

Anatomic Features

Anatomic Features

Key reference: Arnott, S. A., Neil, D. M. and Ansell, A. D. (1999). Escape trajectories of the brown shrimp *Crangon crangon*, and a theoretical consideration of initial escape angles from predators. *J. Exp. Biol*. **202**, 193-209.

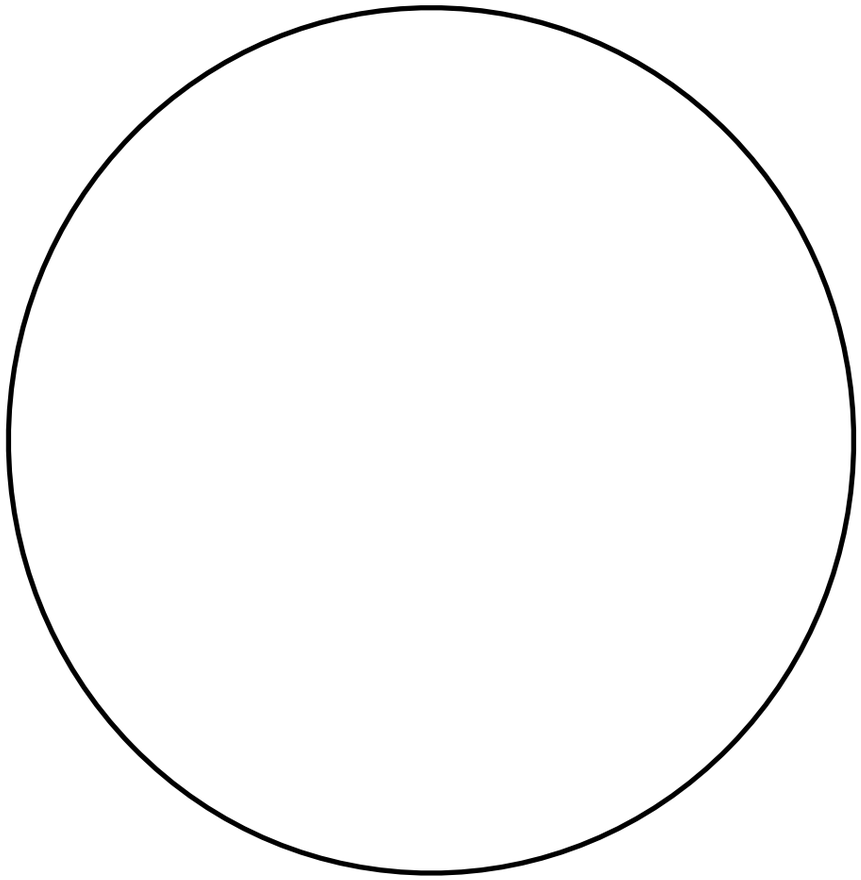
Anatomic Features

FLOWER GARDEN BANKS
NATIONAL MARINE SANCTUARY
NATIONAL MARINE SANCTUARIES

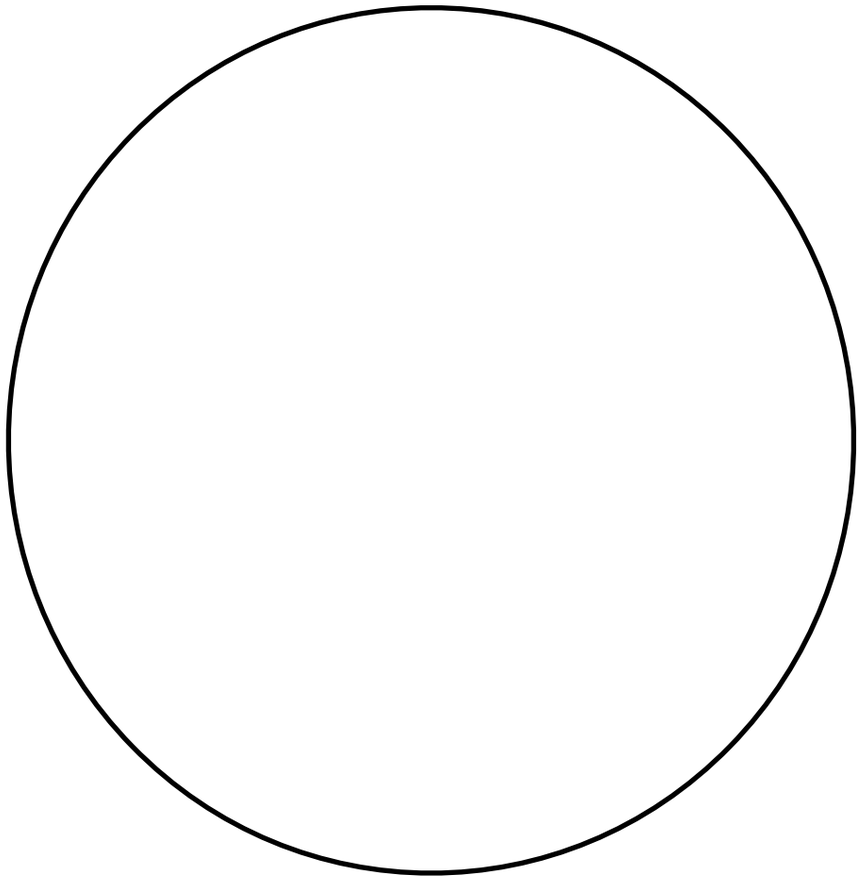
tinyurl.com/cgbso7

What is the overarching fear in those three examples?

What is the overarching fear in those three examples?



What is the overarching fear in those three examples?



Defense Systems

- Anatomic Features
- **Immunity**

Immune System

- Defense against ***pathogens***
- Removal of "worn-out" cells and tissue debris (**wound healing** and tissue repair)
- ID and destruction of **abnormal cells** that originate in the body.

Immune System

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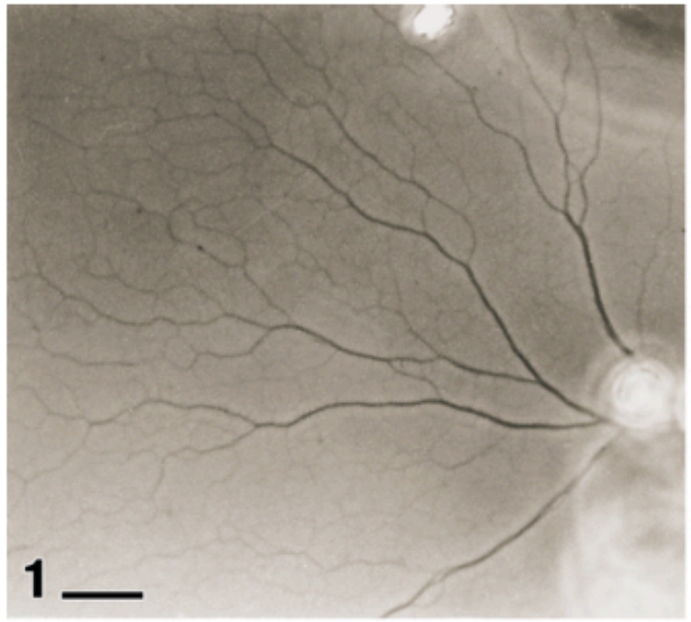
Pathogens

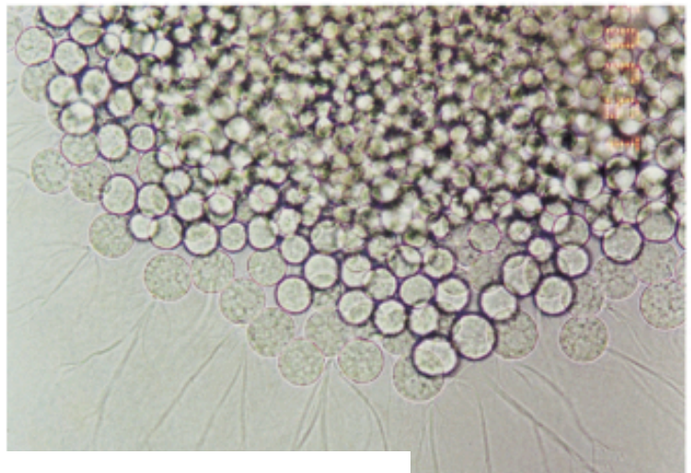
Pathogens

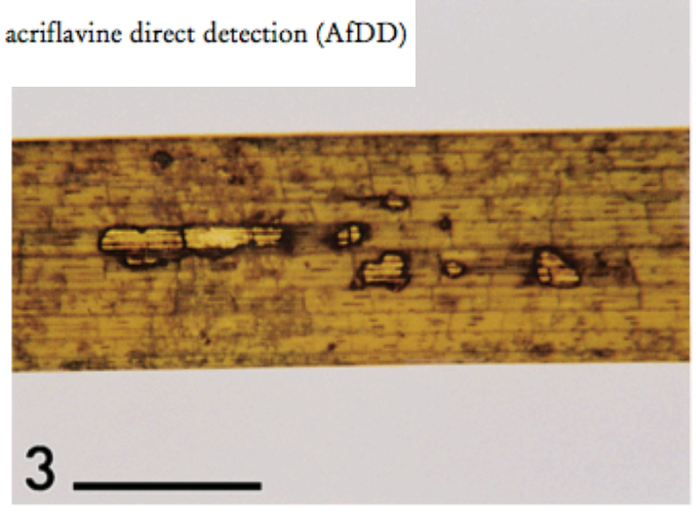
- Disease producing power known as _____
- Bacteria - release enzymes or toxins
- Internal parasites (larger; protozoa, fungi) - use resources, damage tissue
- Virus - not self sustaining; lack ability to for *energy production* and *protein synthesis*

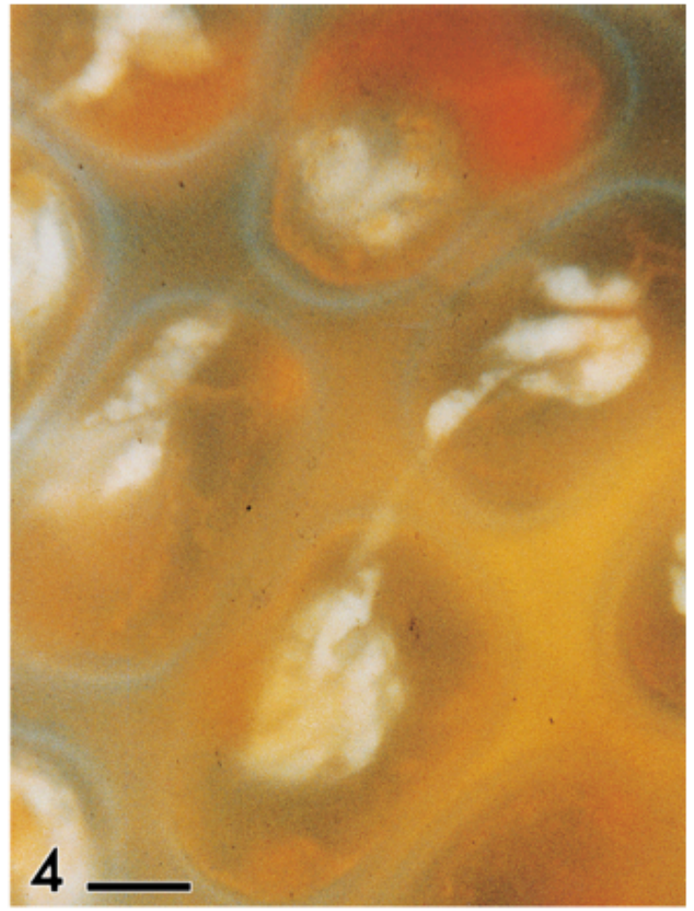
Bacteria - Vibrio

Protists
Fungi-like
Thraustochytrids









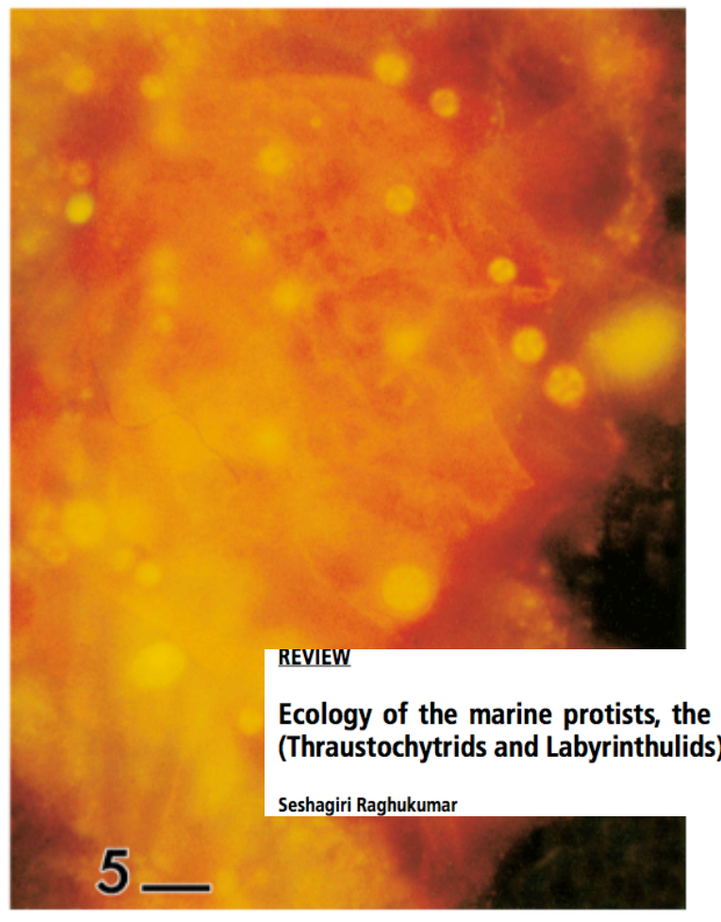


Fig. 1. Cells of a thraustochytrid growing on a nutrient agar medium. Bar represents 50 µm.

Fig. 2. Ectoplasmic net elements of a thraustochytrid cell. Scale bar = 20 µm.

Fig. 3. Leaves of the seagrass *Thalassia hemprichii* Escherson showing necrosis, presumably caused by *Labyrinthula* sp. Scale bar = 1 cm.

Fig. 4. Epifluorescence micrograph of cells of *Labyrinthula* within the tissue of the seagrass *Thalassia hemprichii* Escherson, labelled with Calcofluor. Scale bar = 20 µm.

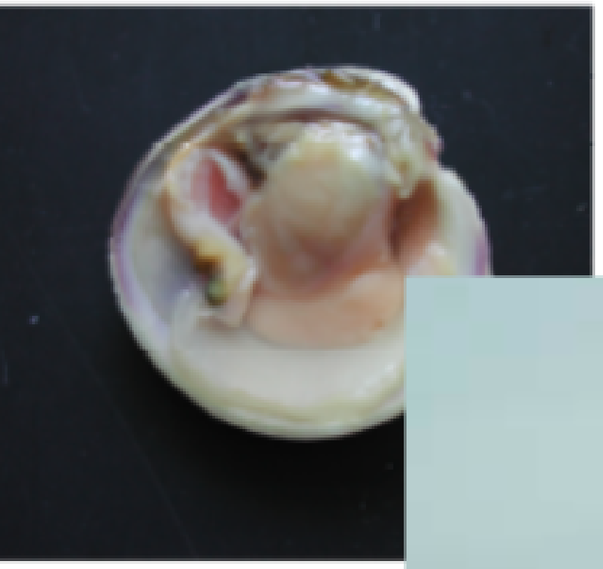
Fig. 5. Cells of thraustochytrids in phytoplankton detritus, stained using the acriflavine direct detection (AfDD) technique. Scale bar = 10 µm.

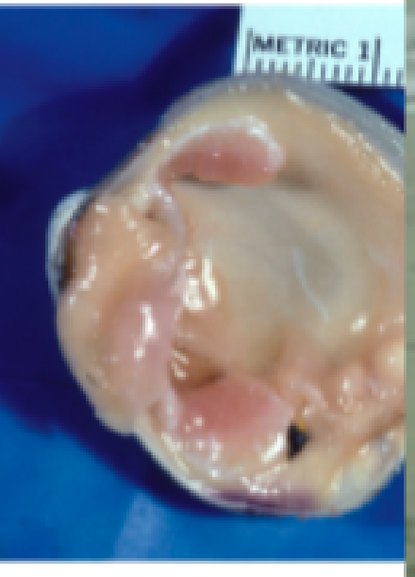
REVIEW

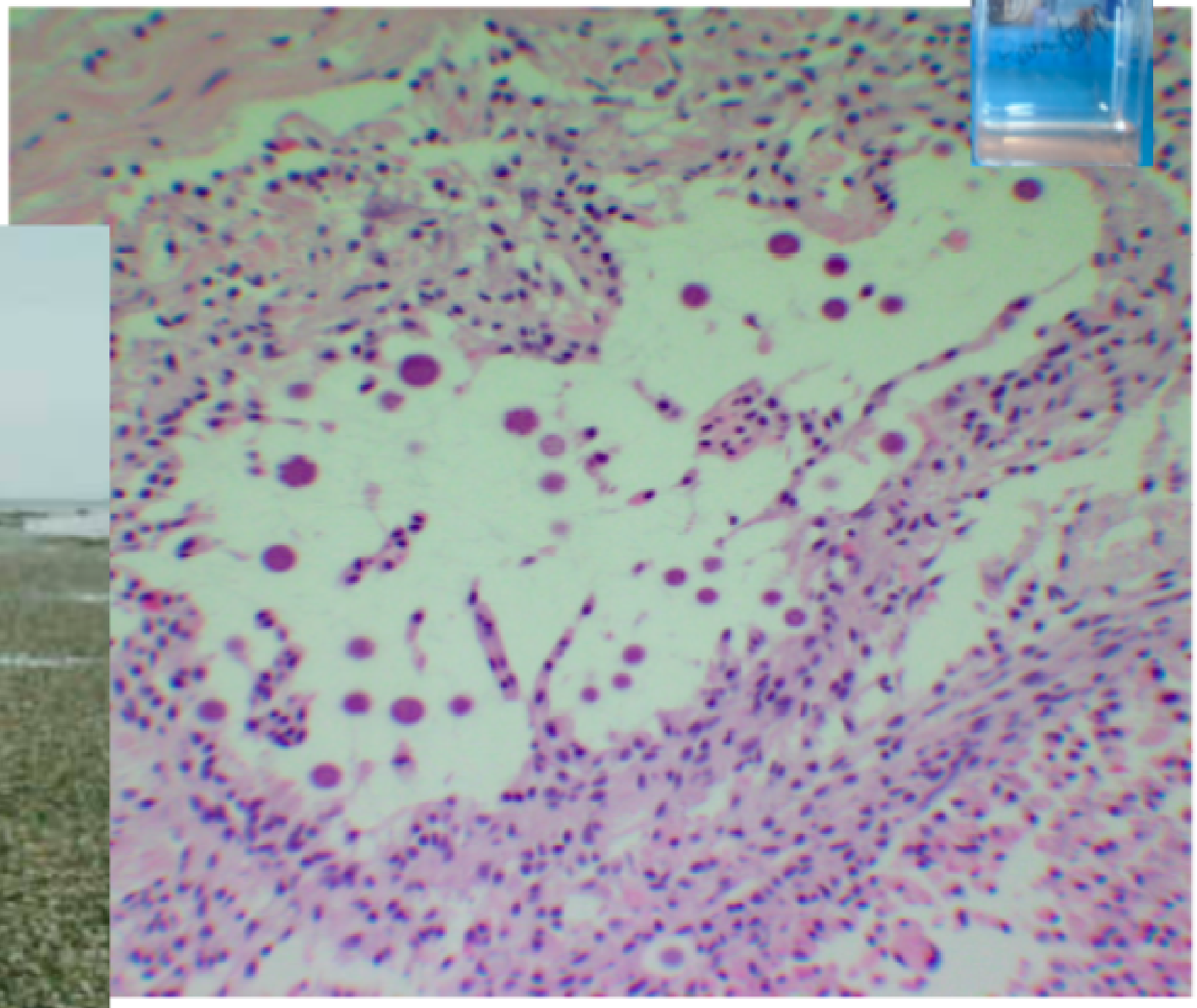
Ecology of the marine protists, the Labyrinthulomycetes (Thraustochytrids and Labyrinthulids)

Seshagiri Raghukumar

Fungi - QPX



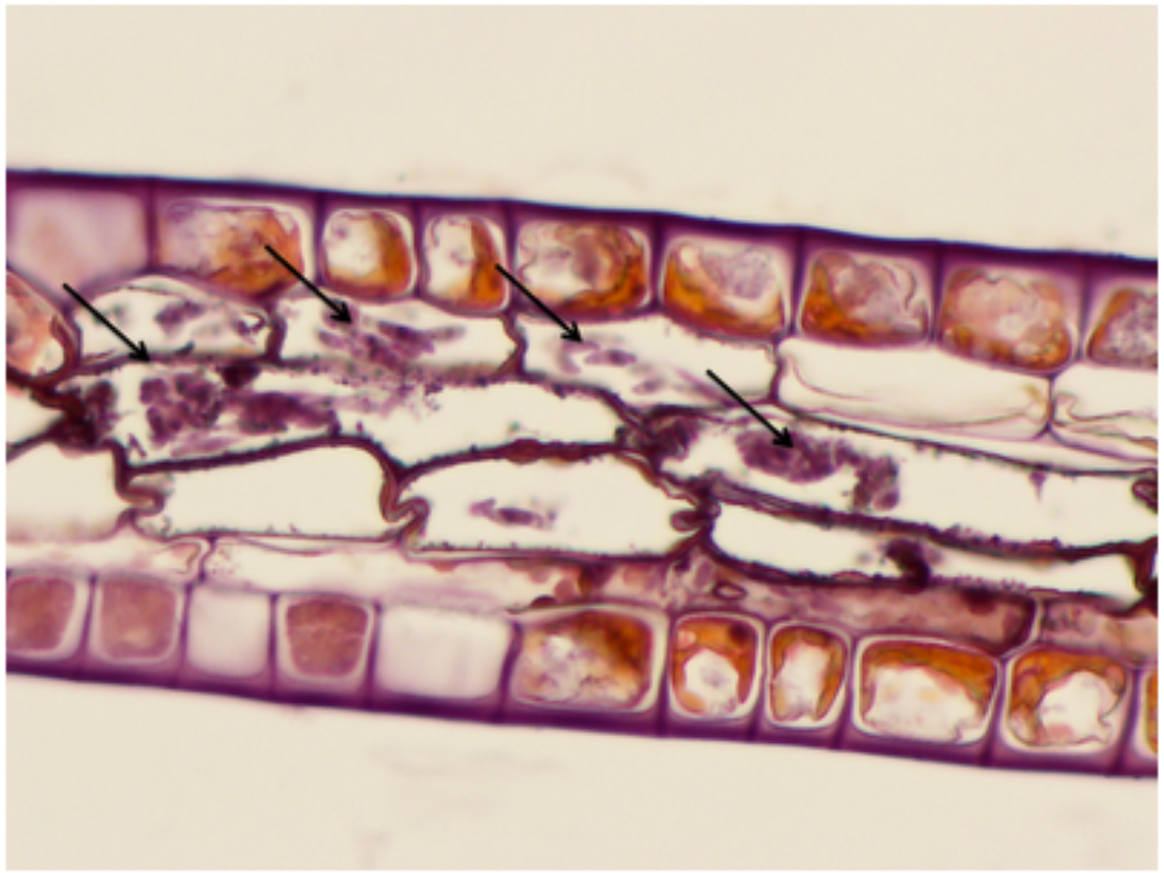




Roxanna Smolowitz

Colleen Burge - Oct 14, 2011 - Limited

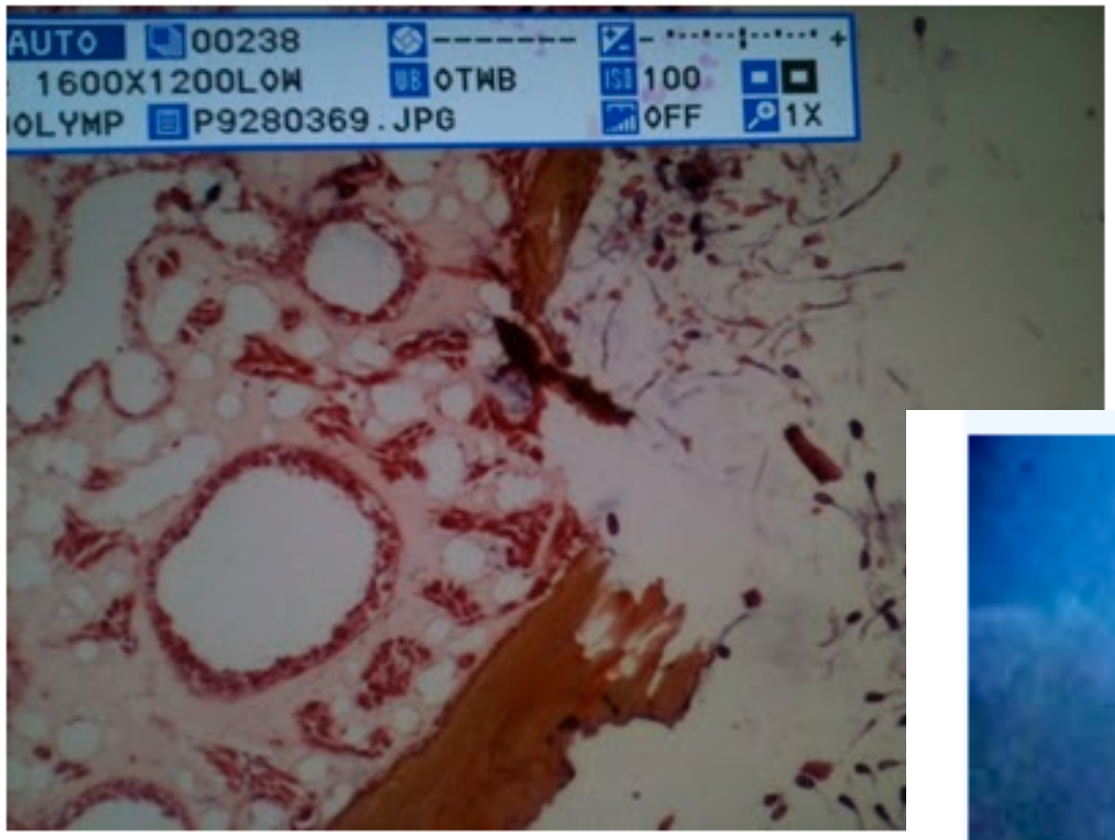
arrows point to sea grass Labyrinthula, I think (40X), don't ask me about th



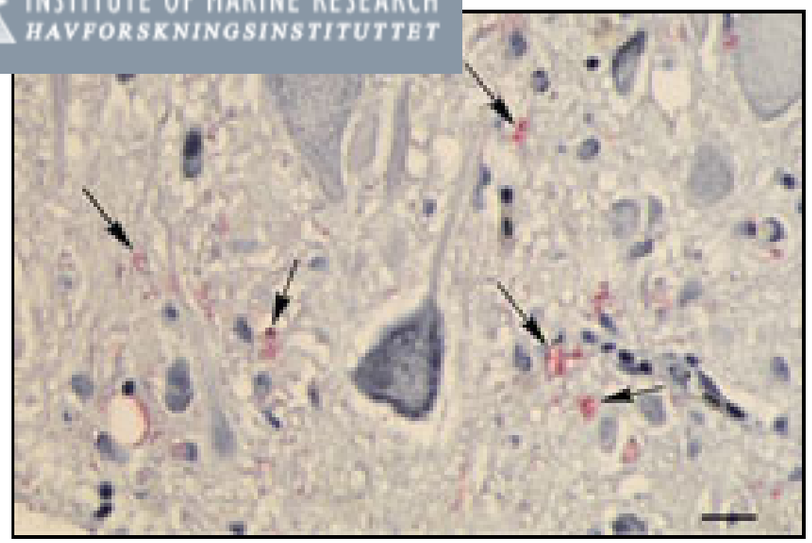
More photos from Colleen Burge

Colleen Burge - Sep 28, 2011 - Mobile - Limited

Really sad sea fan, really happy Laby



Virus - Nodavirus



Brain of salmon contaminated by nodavirus.

Development of diagnostic and management techniques to select cod broodstocks and hatchery stocks free from nodavirus

Northeastern Regional AQUACULTURE Center

Phage

Abalone

Caused by a bacteria..

Immune Response

- Innate Immunity - non-specific
- Acquired Immunity- adaptive; selectively targets

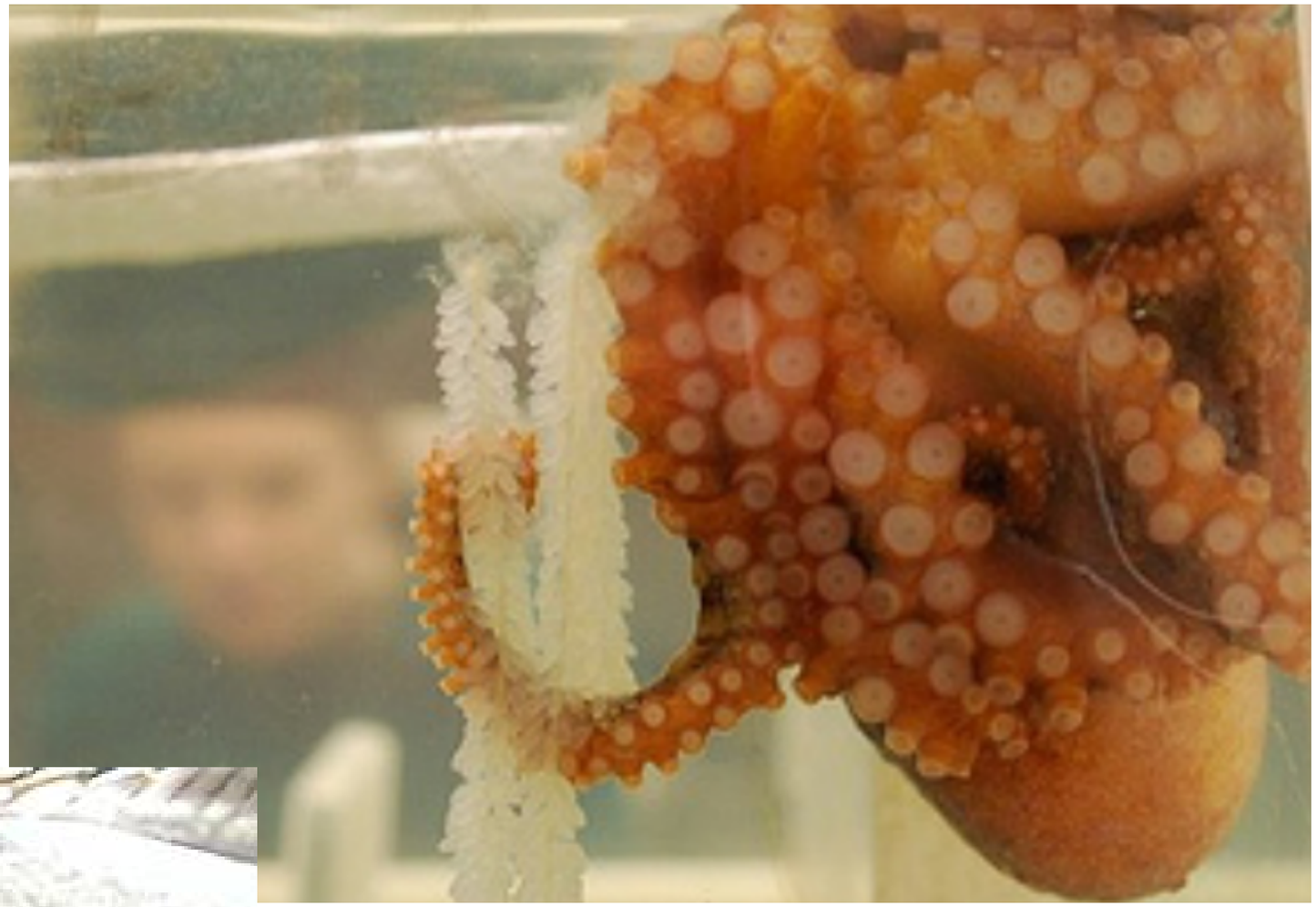
Immune Response

- **Innate Immunity - non-specific**
- Acquired Immunity- adaptive; selectively targets

Innate Immunity

- Present from birth
- "Non-specific" - acts on many pathogens and does not show specificity within a pathogen type
- Does not become more efficient on subsequent exposure to same pathogen

Chemico-physical Barrier

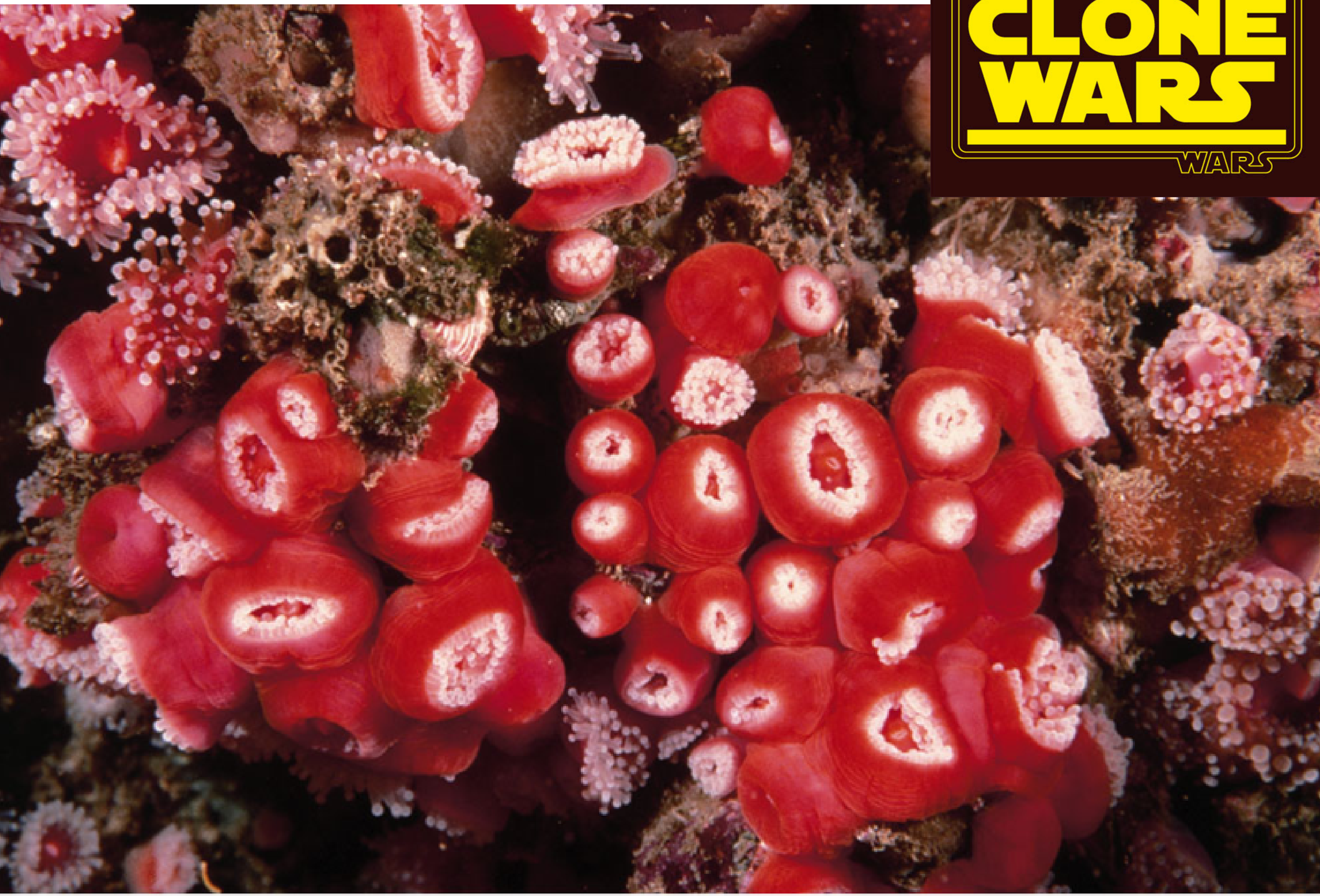


anti-microbial peptides

beneficial microbial communities

from the beginning...

How do organisms distinguish self from non-self?



This is a picture of two *A elegantissima* or *A. sola* fighting with acrorhagia. Taken at San Simeon, CA by Dave Cowles

more images @ tinyurl.com/am3ncs

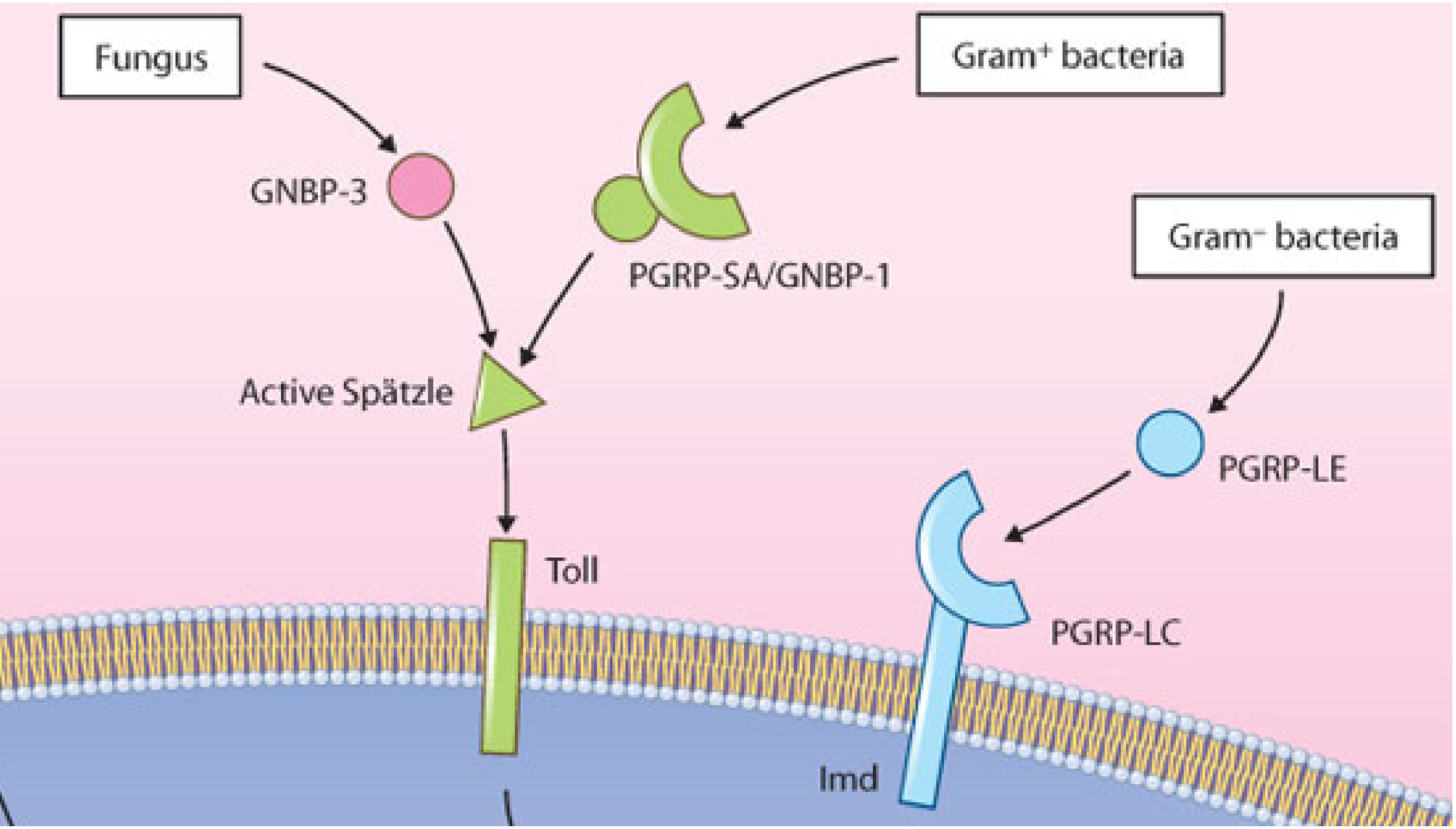
34

This is a picture of two *A elegantissima* or *A. sola* fighting with acrorhagia. Taken at San Simeon, CA by Dave Cowles

How do organisms distinguish self from non-self?

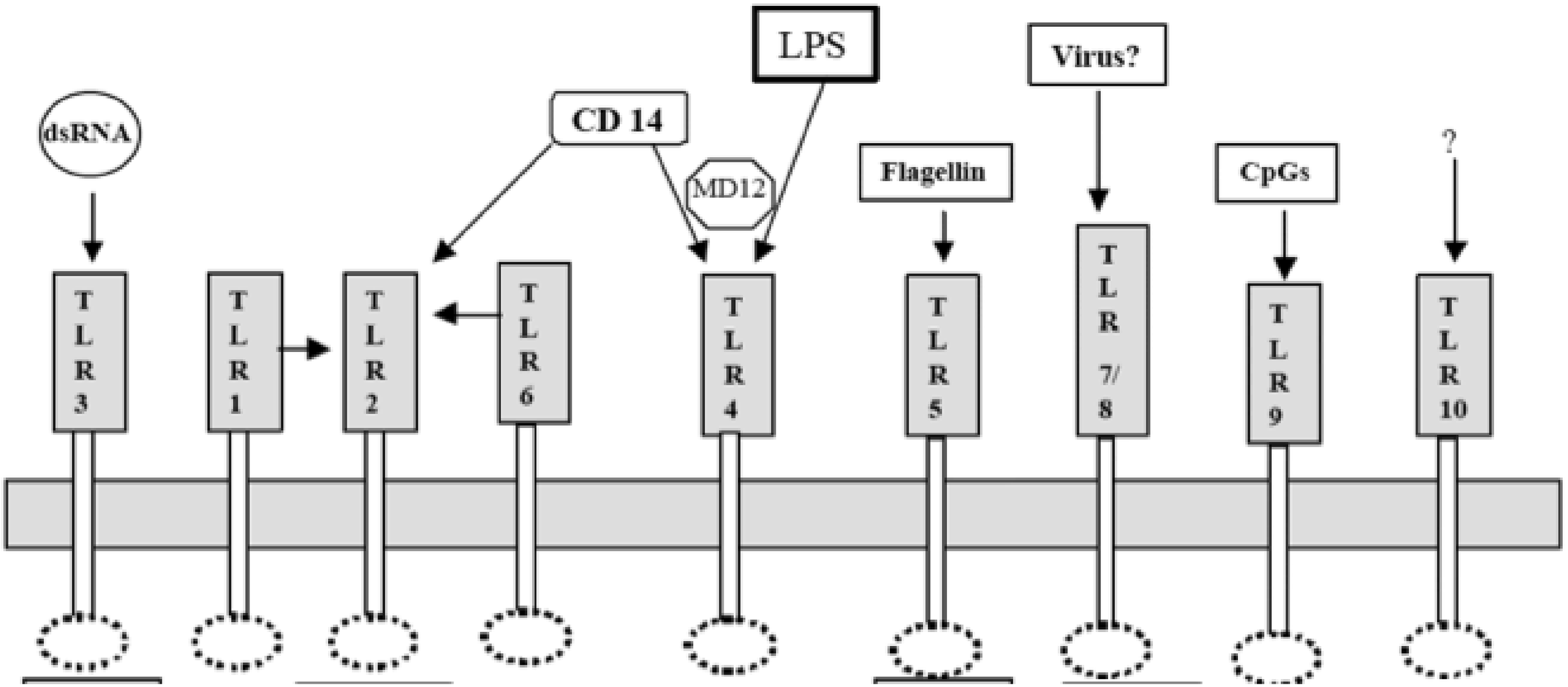
pattern recognitions proteins (PRPs)

PRPs



Toll-like Receptors
Peptidoglycan recognition proteins

PRPs - Toll-like Receptors



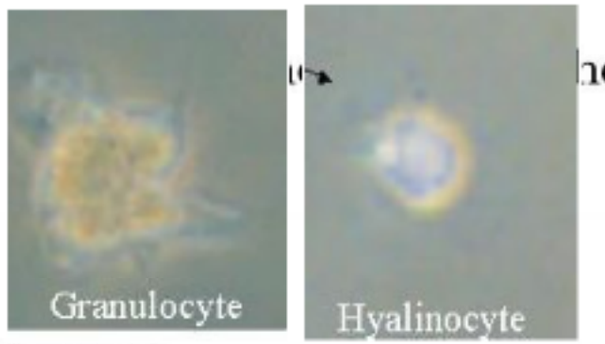
That's how the immune system knows bad things are there...

Innate Immunity

Chemico-physical barrier (shell, mucus)

Hemolymph

CELLS:



hemocytes

SERUM:
soluble lectins
hydrolytic enzymes
antimicrobial peptides

chemokinesis
chemotaxis
binding and internalization
oxidative burst activation
lysosomal enzymes
antimicrobial peptides

Laura Canesi, Gabriella Gallo, Miriam Gavioli, and Carla Pruzzo
Bacteria–hemocyte Interactions and Phagocytosis in Marine
Bivalves. 2002. Microscopy Research And Technique 57:469–476

Innate Immunity

Chemico-physical barrier (shell, mucus)

Hemolymph

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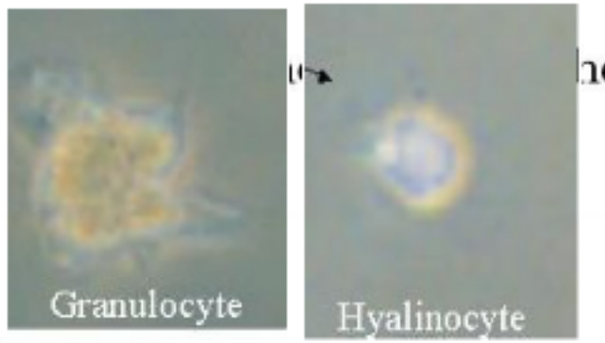


SERUM:
soluble lectins
hydrolytic enzymes
antimicrobial peptides

Laura Canesi, Gabriella Gallo, Miriam Gavioli, and Carla Pruzzo
Bacteria–hemocyte Interactions and Phagocytosis in Marine Bivalves. 2002. Microscopy Research And Technique 57:469–476

What else?

BUT WAIT - How do these immune cells know where to go?

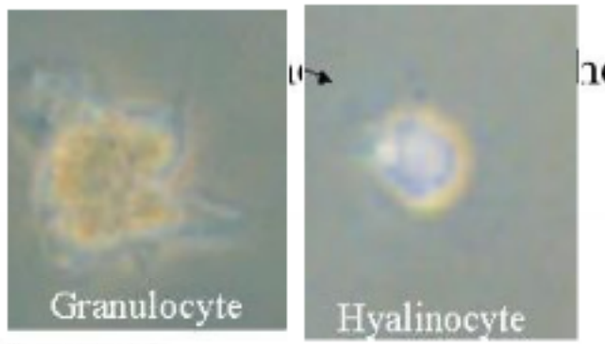
Chemotaxis

Innate Immunity

Chemico-physical barrier (shell, mucus)

Hemolymph

CELLS:



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Bacteria–hemocyte Interactions and Phagocytosis in Marine
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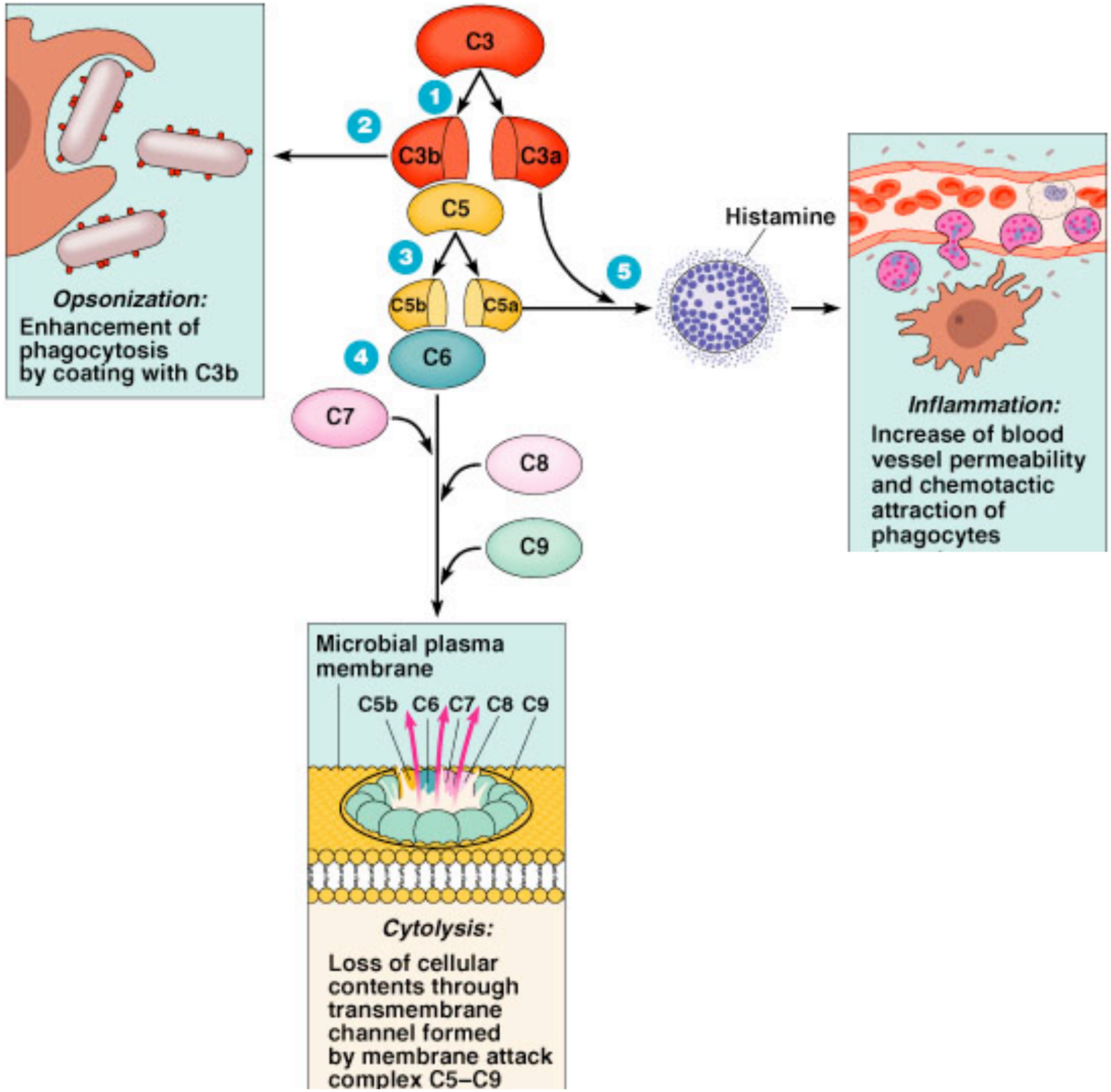
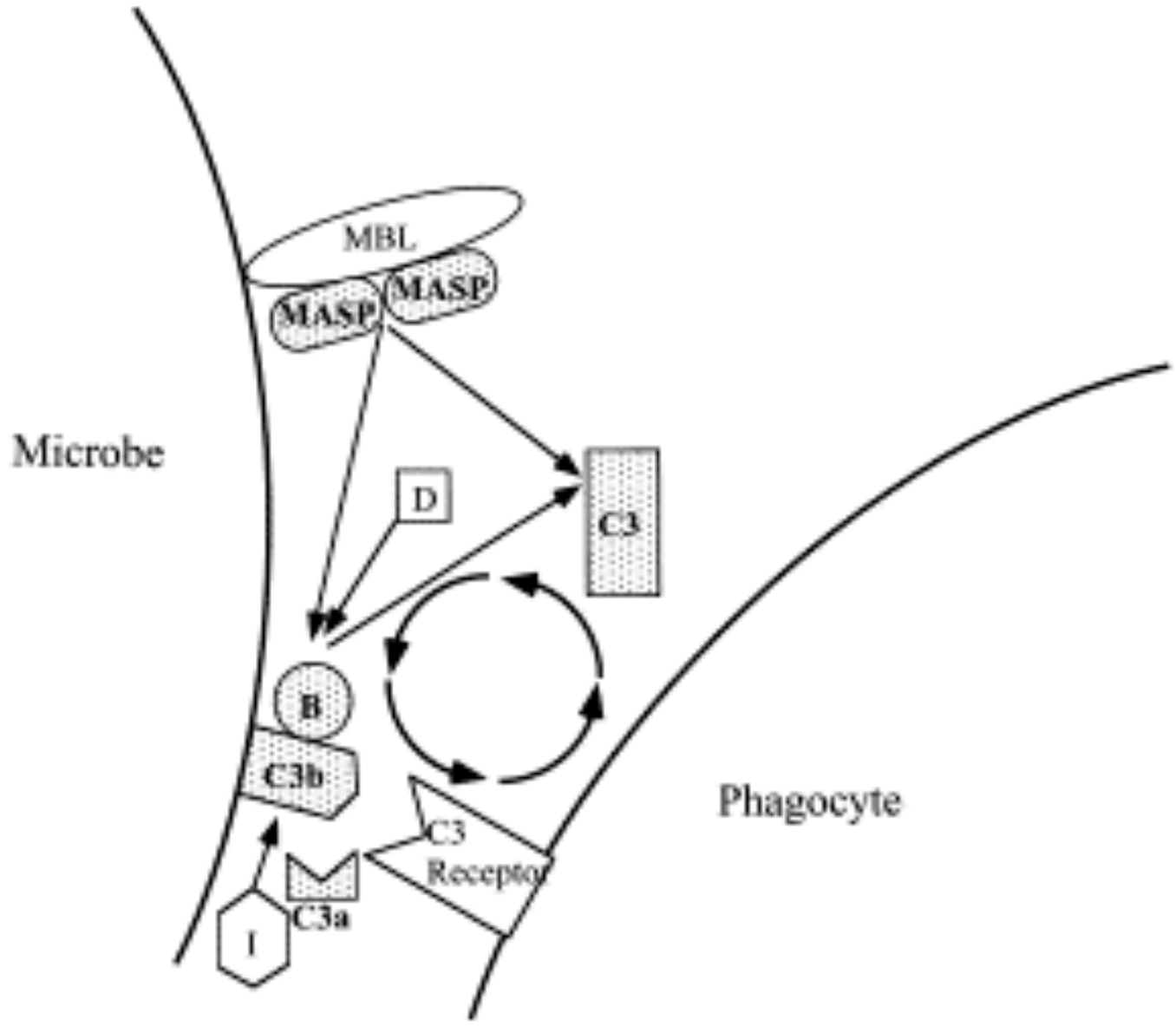
Complement System



Complement System - Invertebrates



Complement systems in invertebrates. The ancient alternative and lectin pathways

L. Courtney Smith[a,*], Kaoru Azumi[b] and Masaru Nonaka[c]

Immune Response

- **Innate Immunity** - non-specific
- Acquired Immunity

Today: *Physiological Response* to things that are bad

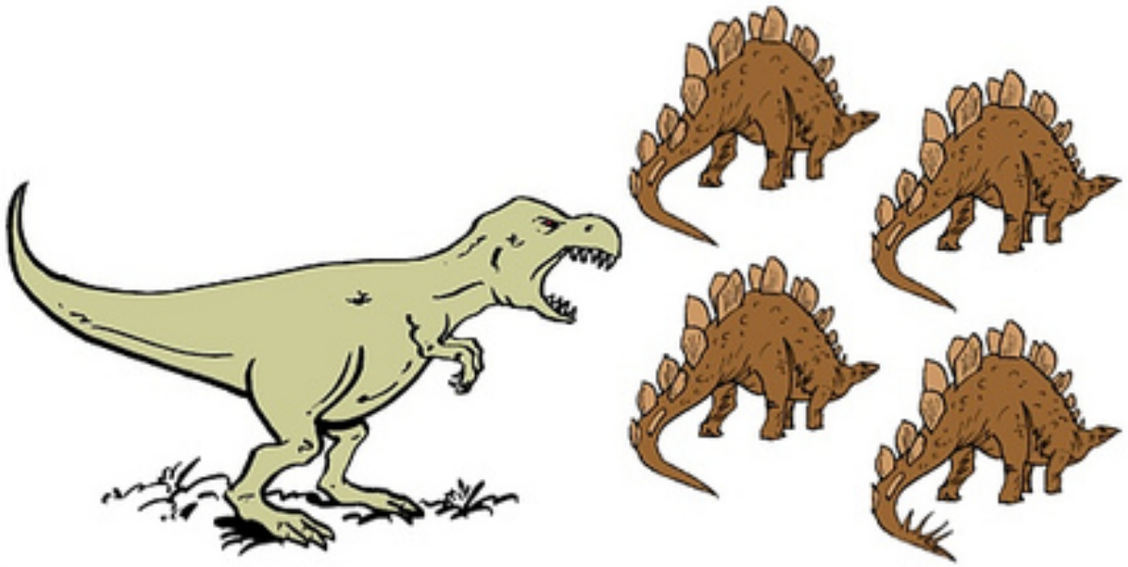
It is important the think about the big picture.

What else is going on with the critter...

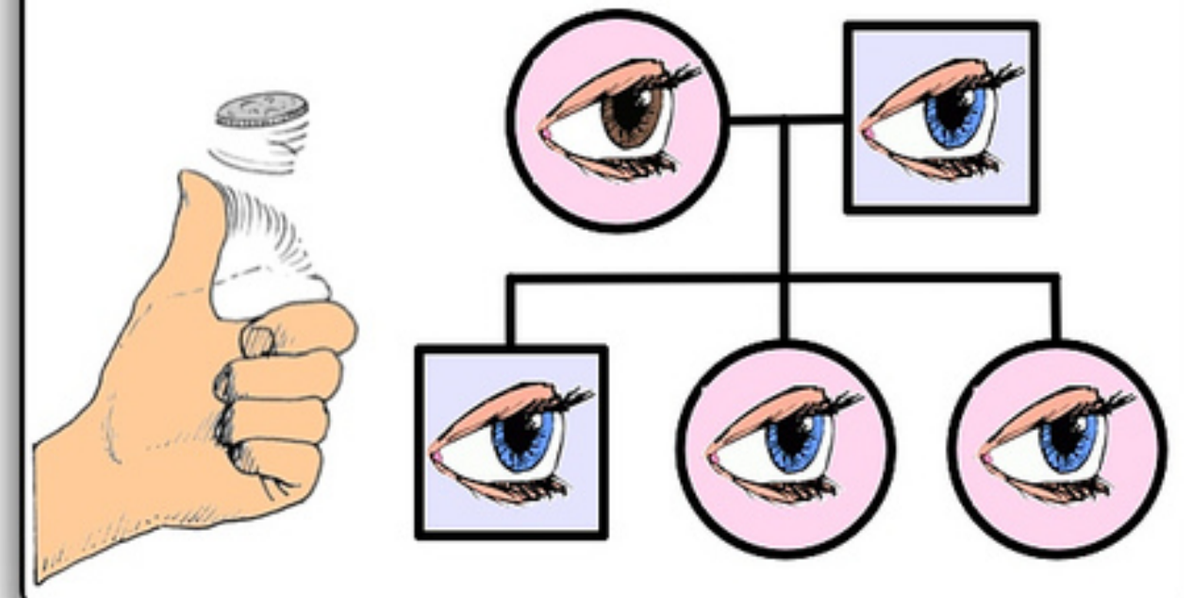
really big picture -

What has the population experienced.

NATURAL SELECTION

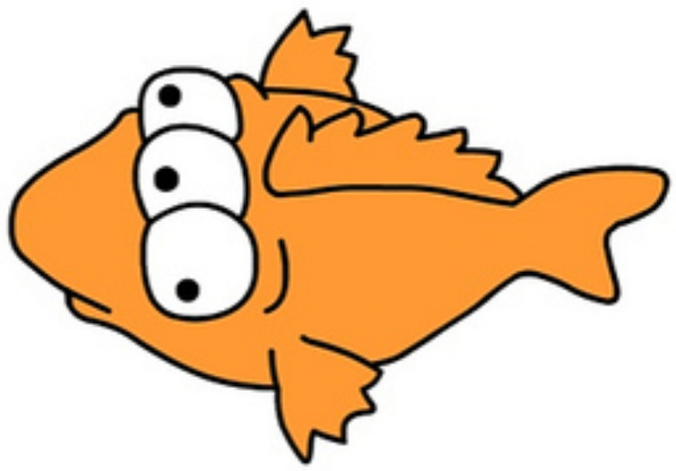


GENETIC DRIFT

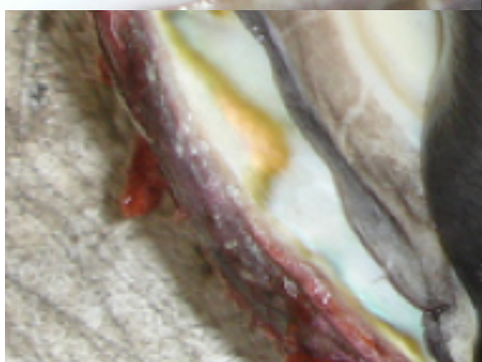


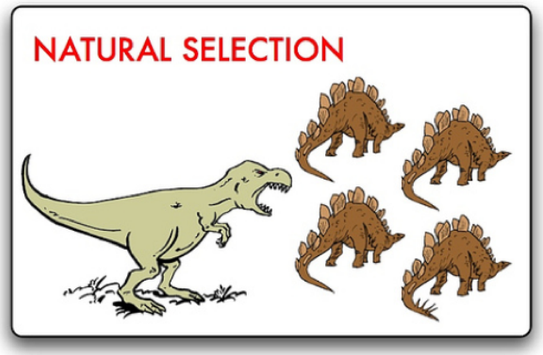
MIGRATION

MUTATION



Two part story

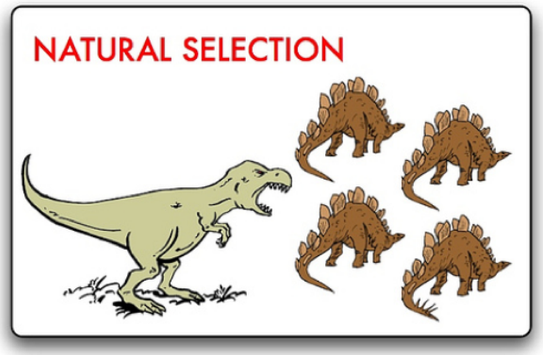




flickr | cpurrin l

Roxannna Smolowitz
Rick Karney

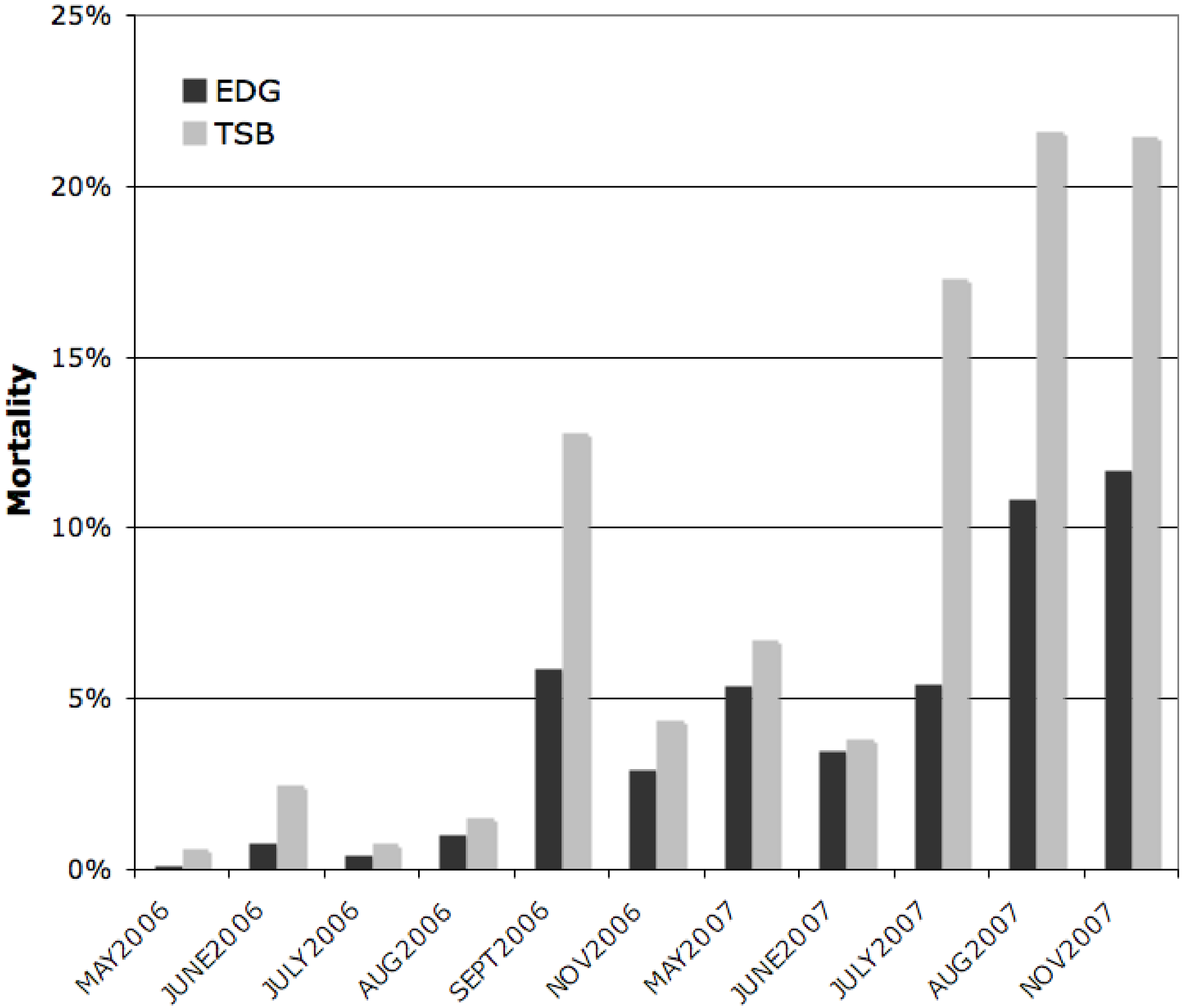
Disease Resistance ?

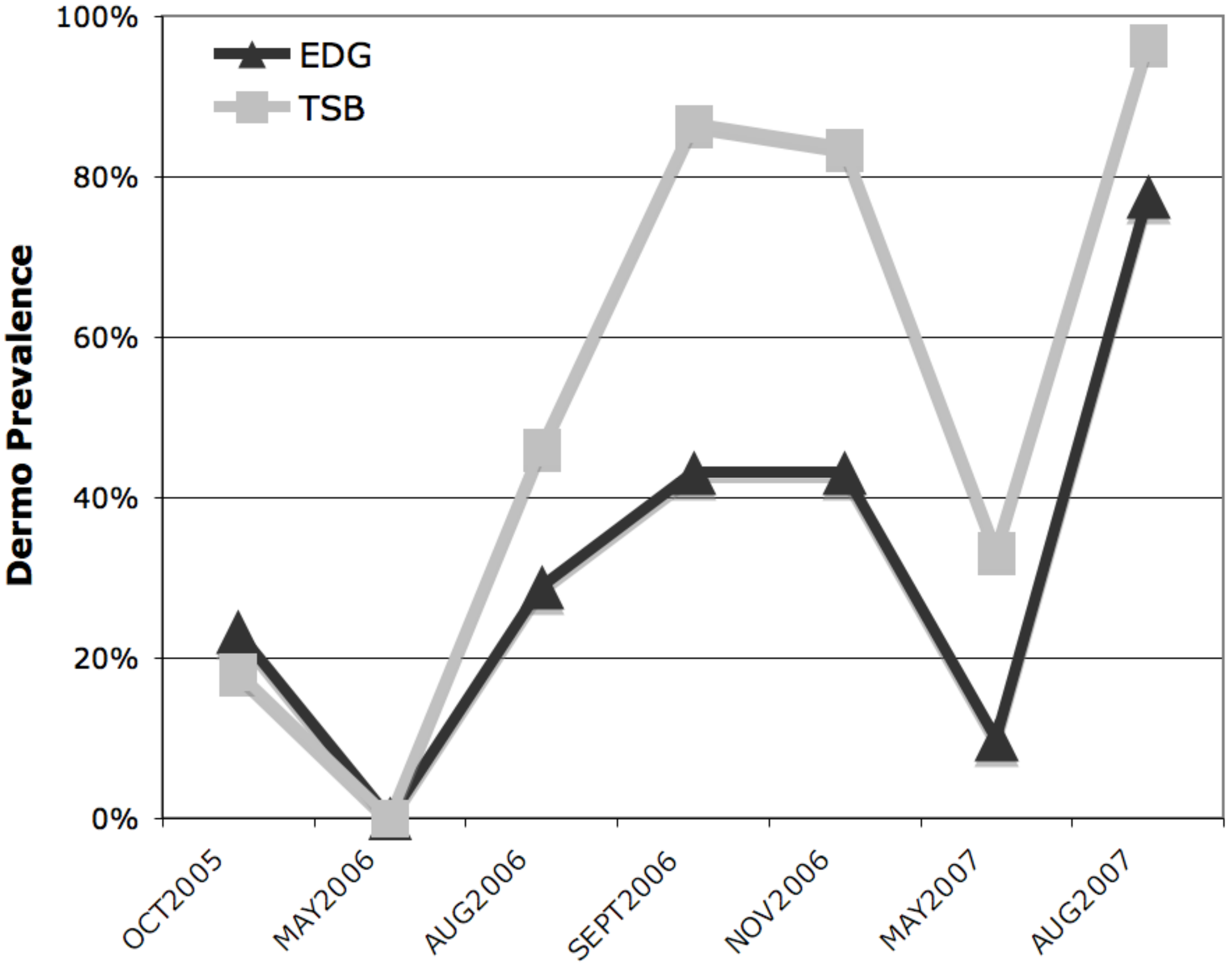


flickr | cpurrin l

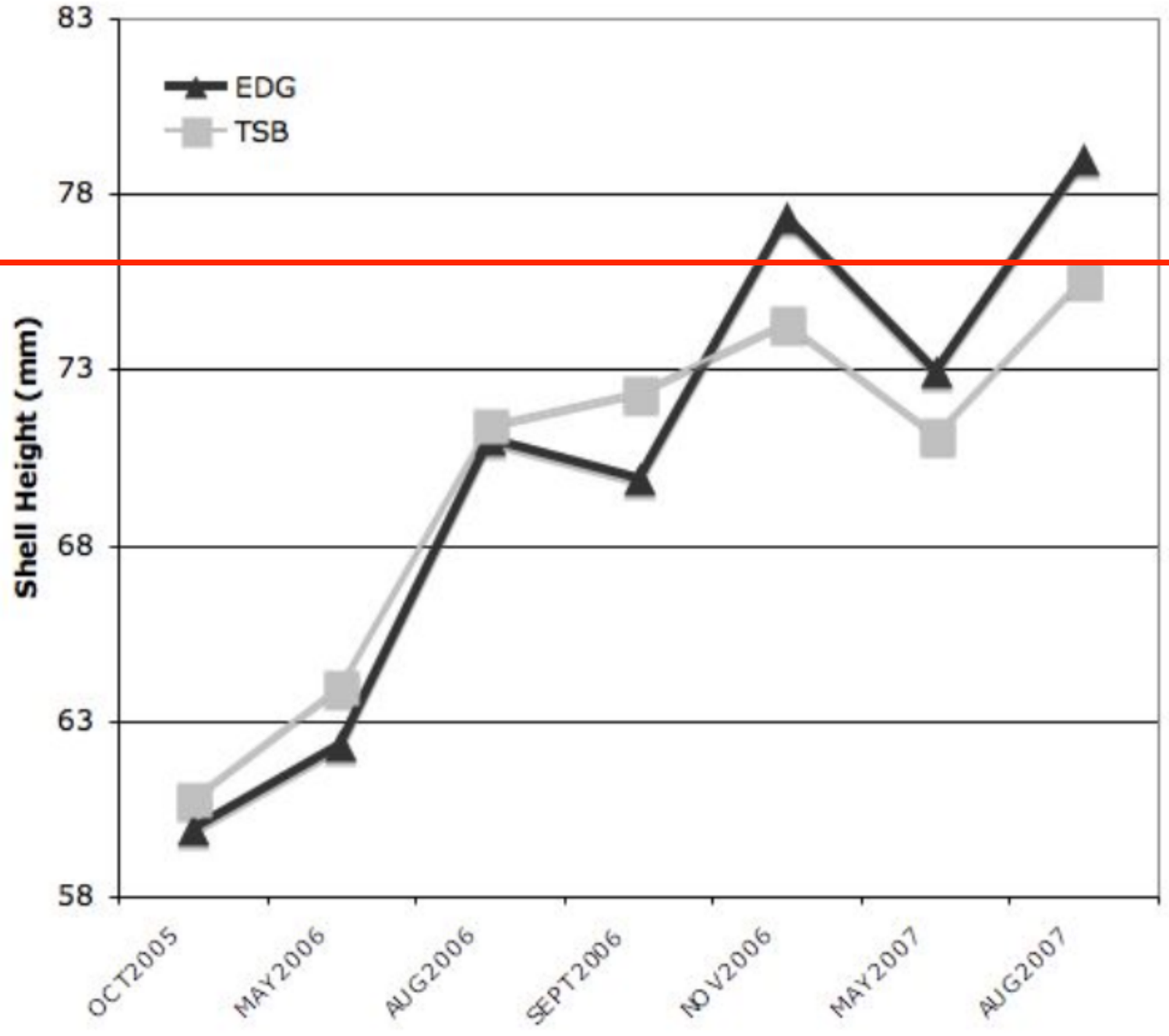
Roxannna Smolowitz
Rick Karney


Water Rd
Bold Water Rd
Kanonika Rd
Kanonika Rd
Brown
Meeting House Way
Hotchkiss Ln
Wilson's Landing
Rd to the Plains
Court St
Zoll Rd
Wilson's Landing
Wilson's Landing
Meeti
Jacob's Neck Rd
Bold Water Rd
Turkeyland Cove Rd
Turkeyland Cove Rd
Kingspoint Way
Loon Cove Rd
Slough Cove Rd
Motick Trail
Jacob's Neck Rd
Jacob's Neck Rd
Swan Lake Farm
Eastern Point
Jobes Neck Cove Rd
Eastern Point
Swan Lake Farm
Edgartown
Great Pond
Slough Cove Rd
Herring Creekfarm Rd
Herring Creekfarm Rd
Fuller's Cove Rd
Crackatuxet Cove Rd
Great Pai
Garden Cove Rd
Crackatuxet
Cove


25%
20%
15%
10%
5%
0%
Mortality
EDG
TSB
MAY2006
JUNE2006
JULY2006
AUG2006
SEPT2006
NOV2006
MAY2007
JUNE2007
JULY2007
AUG2007
NOV2007


100%
80%
60%
40%
20%
0%
Dermo Prevalence
EDG
TSB
OCT2005
MAY2006
AUG2006
SEPT2006
NOV2006
MAY2007
AUG2007

Market size


83
78
73
68
63
58
EDG
TSB
Shell Height (mm)
OCT2005
MAY2006
AUG2006
SEPT2006
NOV2006
MAY2007
AUG2007

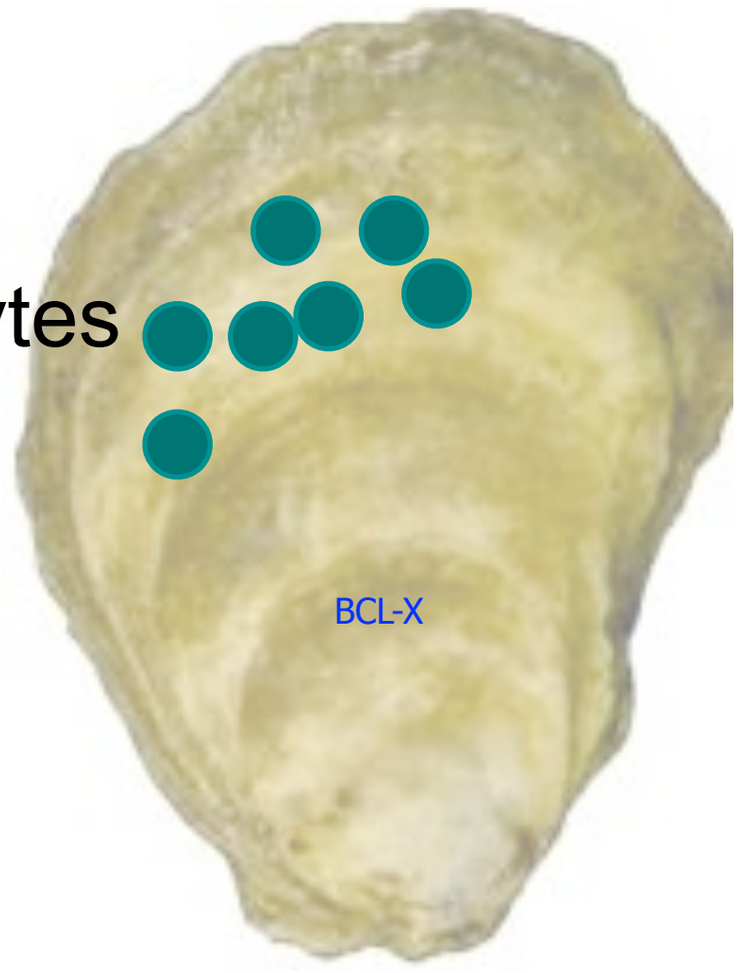
Mechanisms

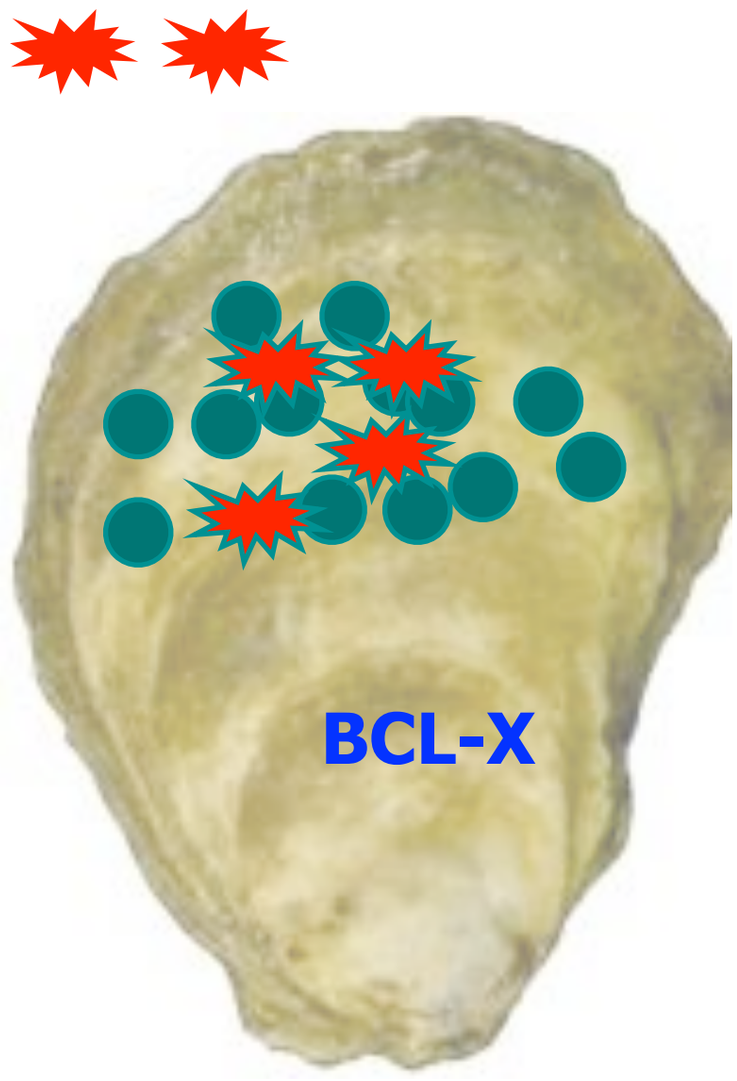
They are different,
but how / why?

Schematic

Parasite

Hemocytes





Resistant

Wild-type

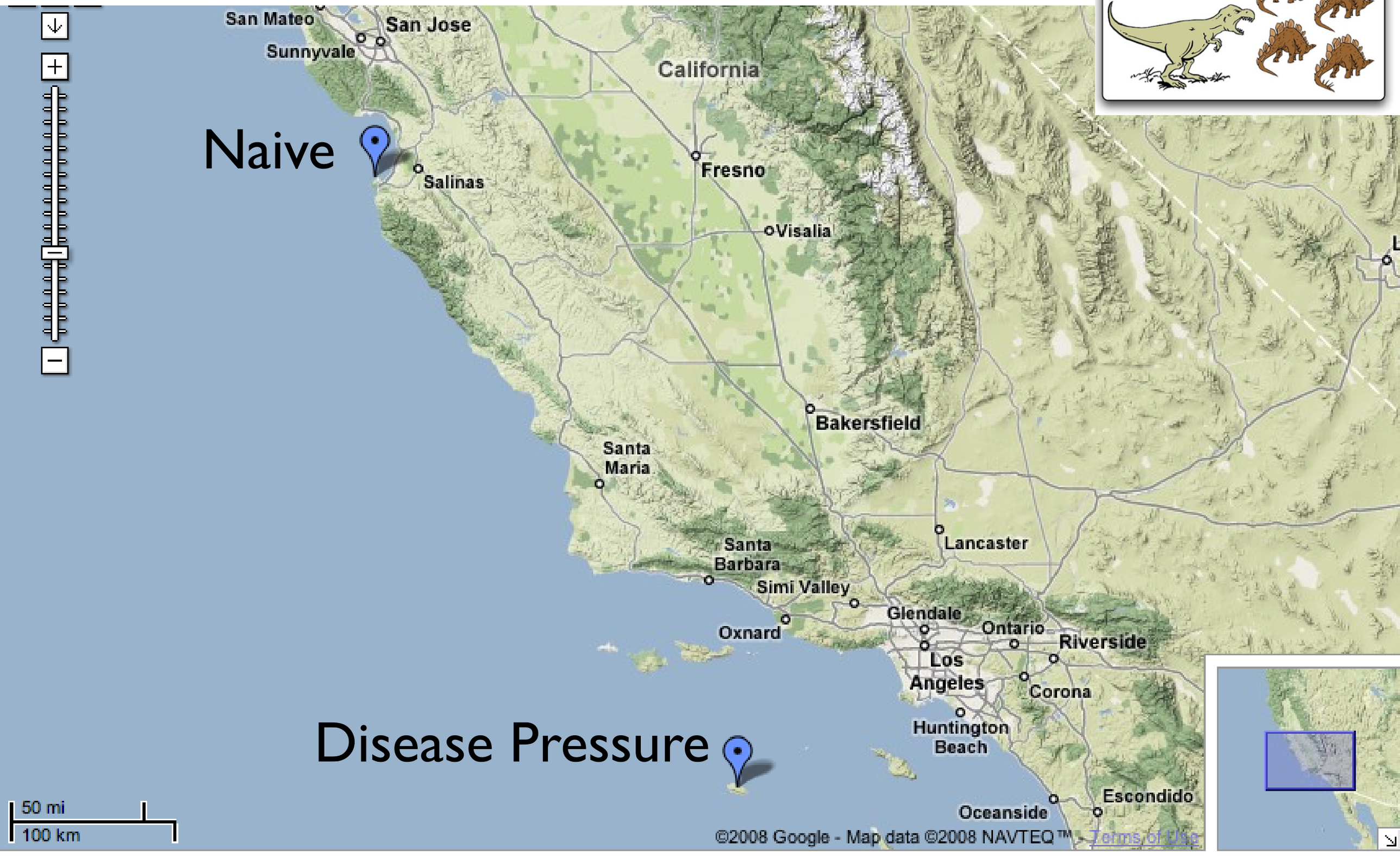
Apoptosis – BCL-X

- Resistant oyster strains could downregulate apoptosis suppression
- Allowing for increased apoptosis
- Decreasing number of cells available for *Perkinsus* proliferation

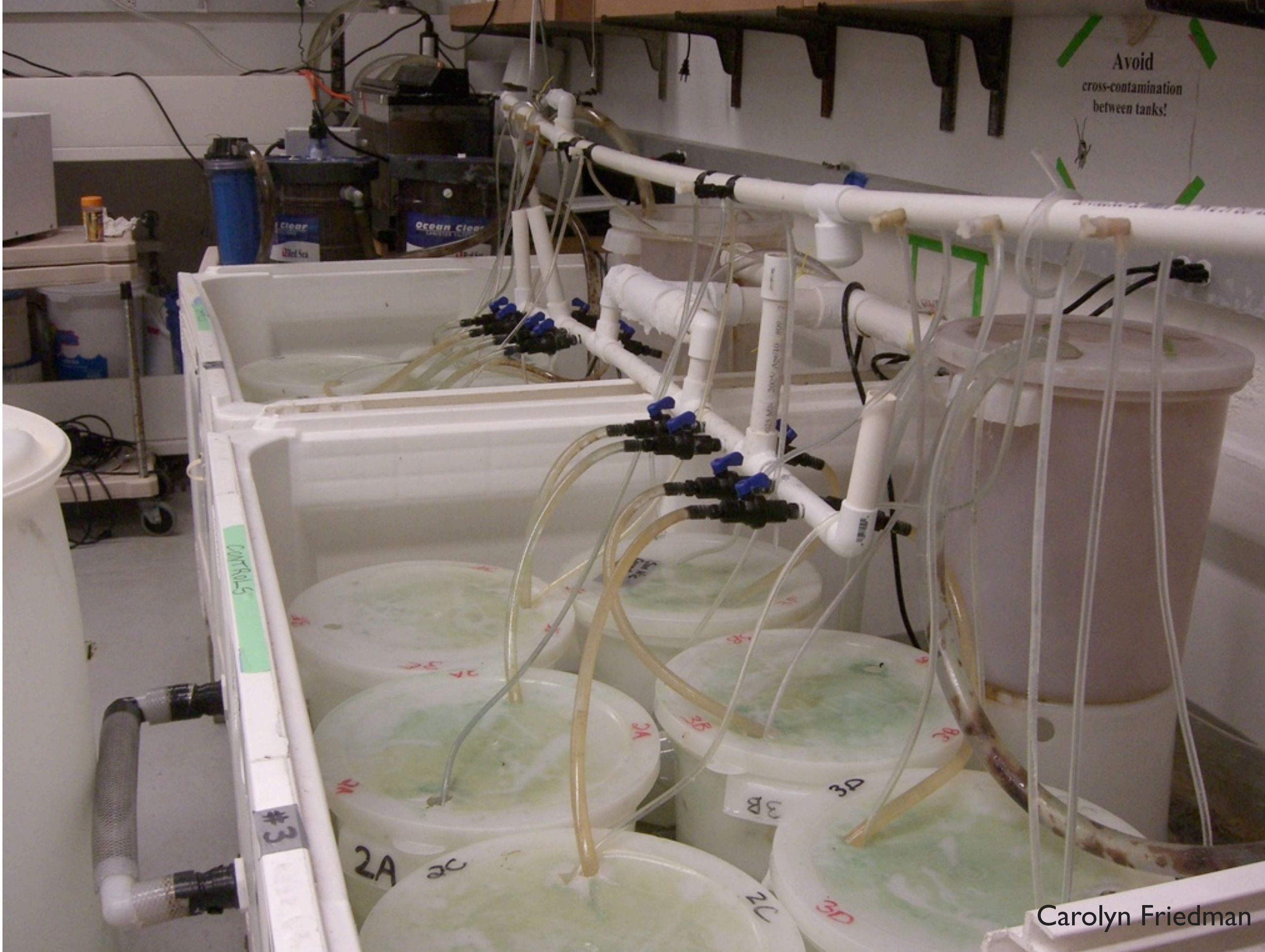
Summary - Oyster

- Offspring of survivors of heavy disease pressure are more tolerant to disease
- Mechanisms involved in host responses to *P. marinus* include proteases and apoptosis

Abalone

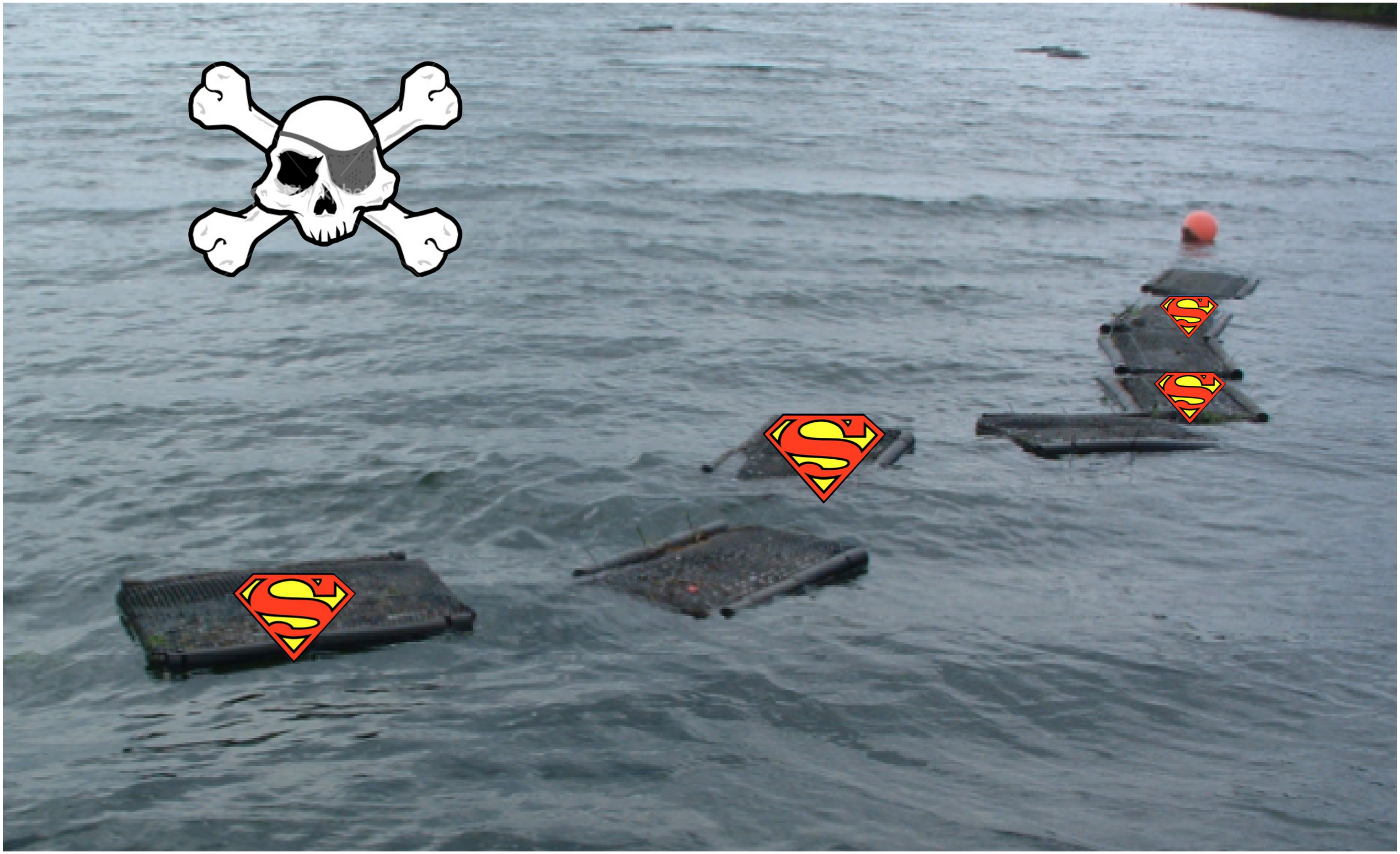


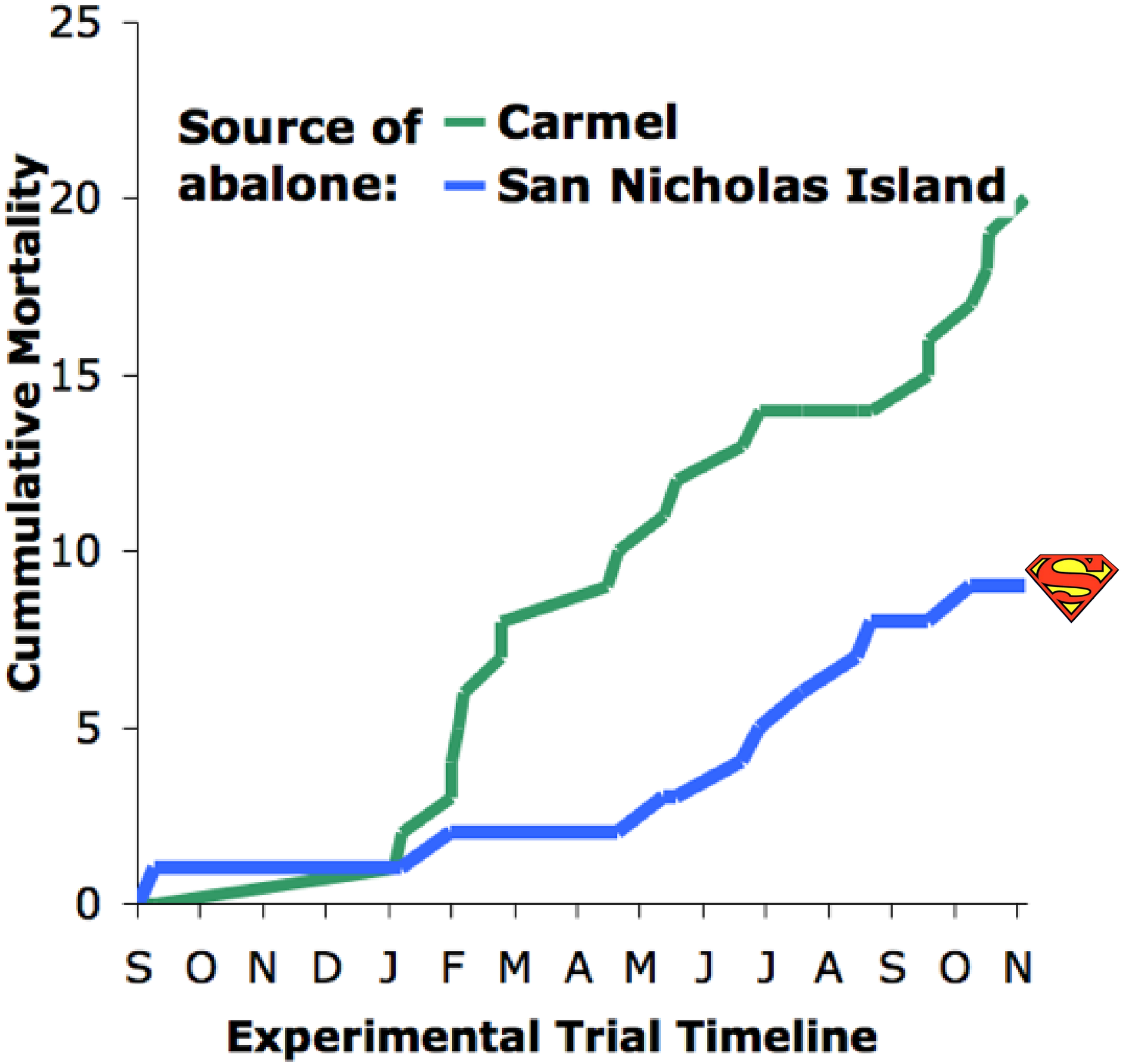
Glenn VanBlaricom, Carolyn Friedman

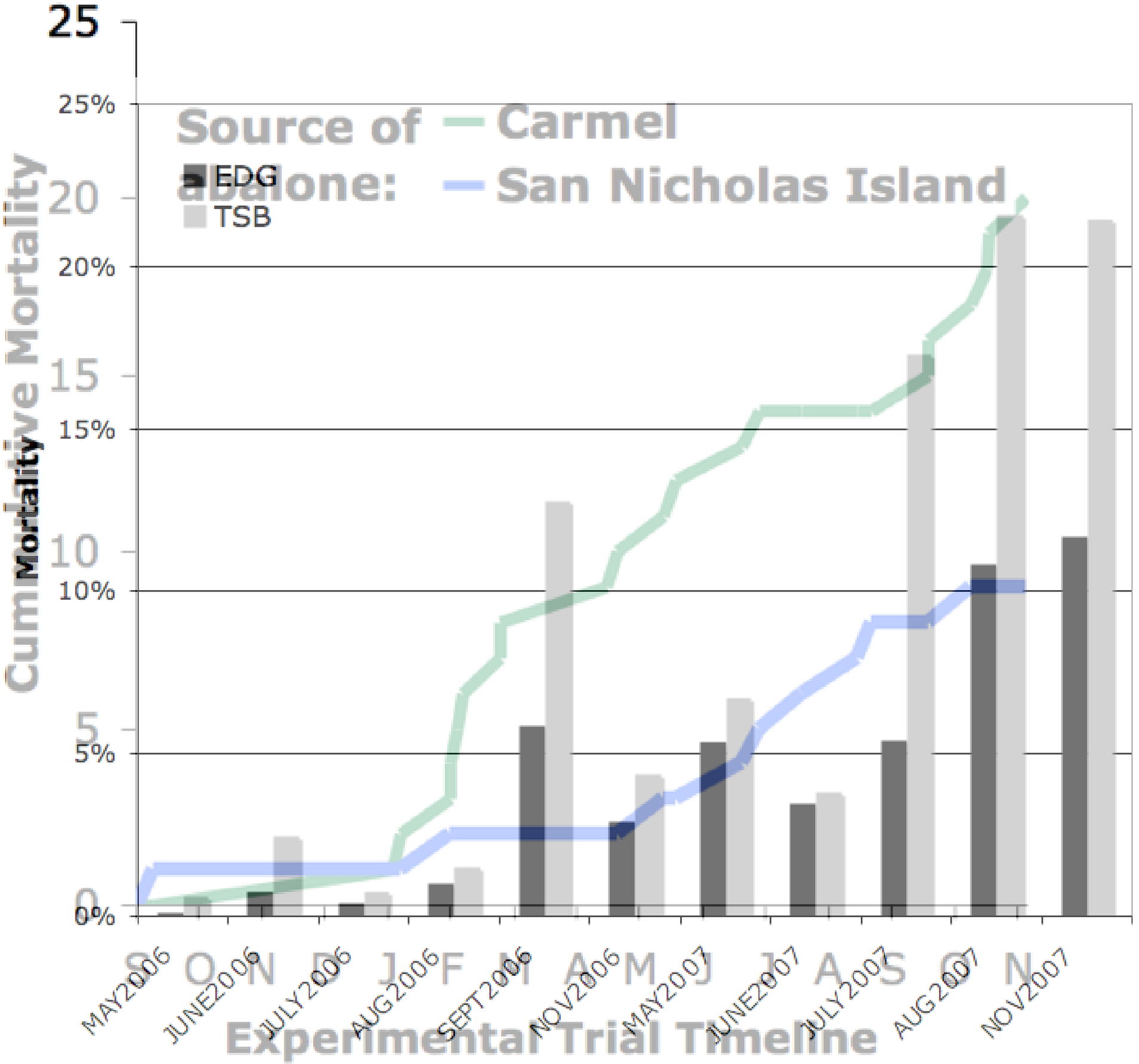

Avoid
cross-contamination
between tanks!
Ocean Clear
Red Sea
CONTROLS
#3
2A
2C
3B
3D
Carolyn Friedman

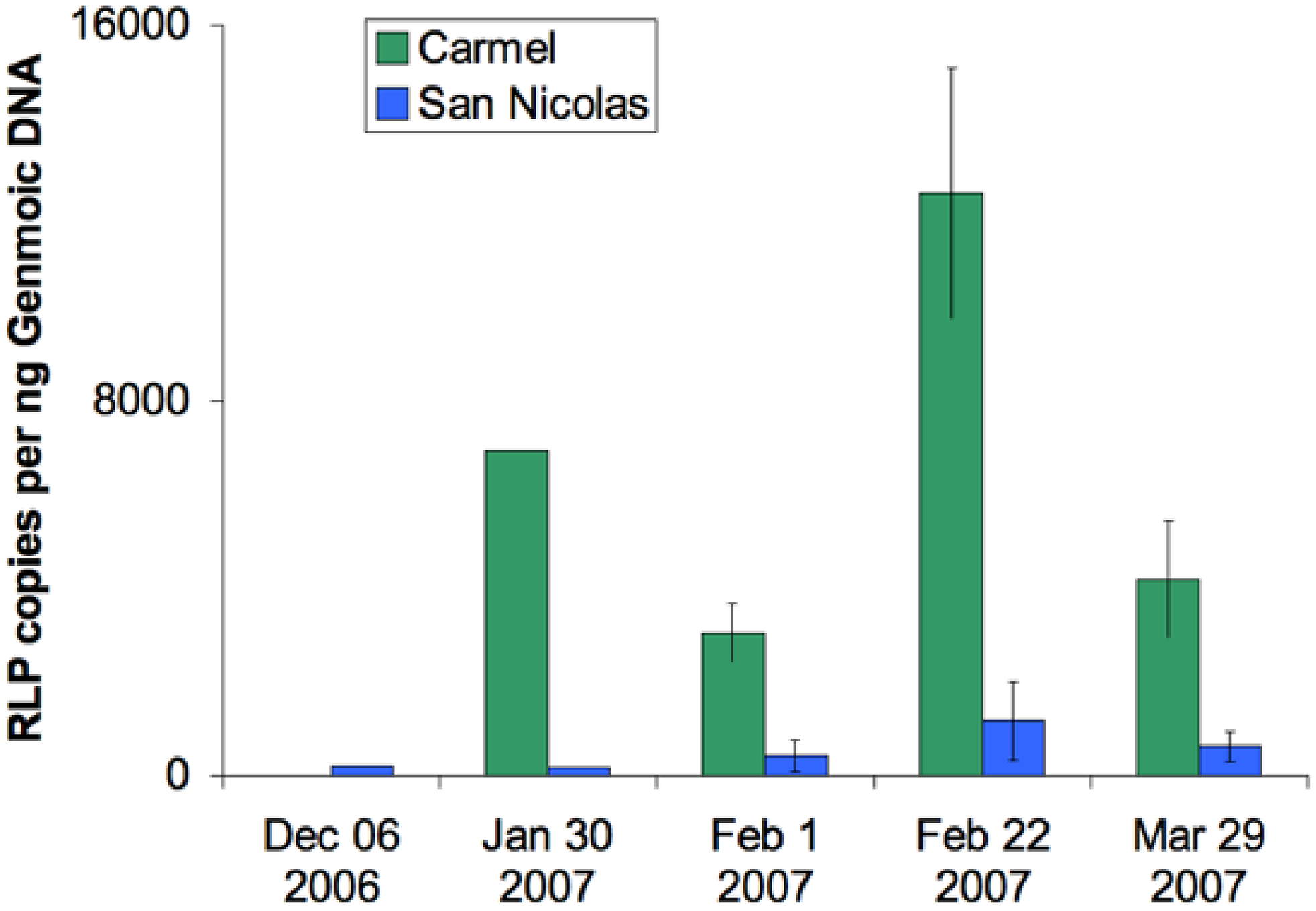
Carolyn Friedman

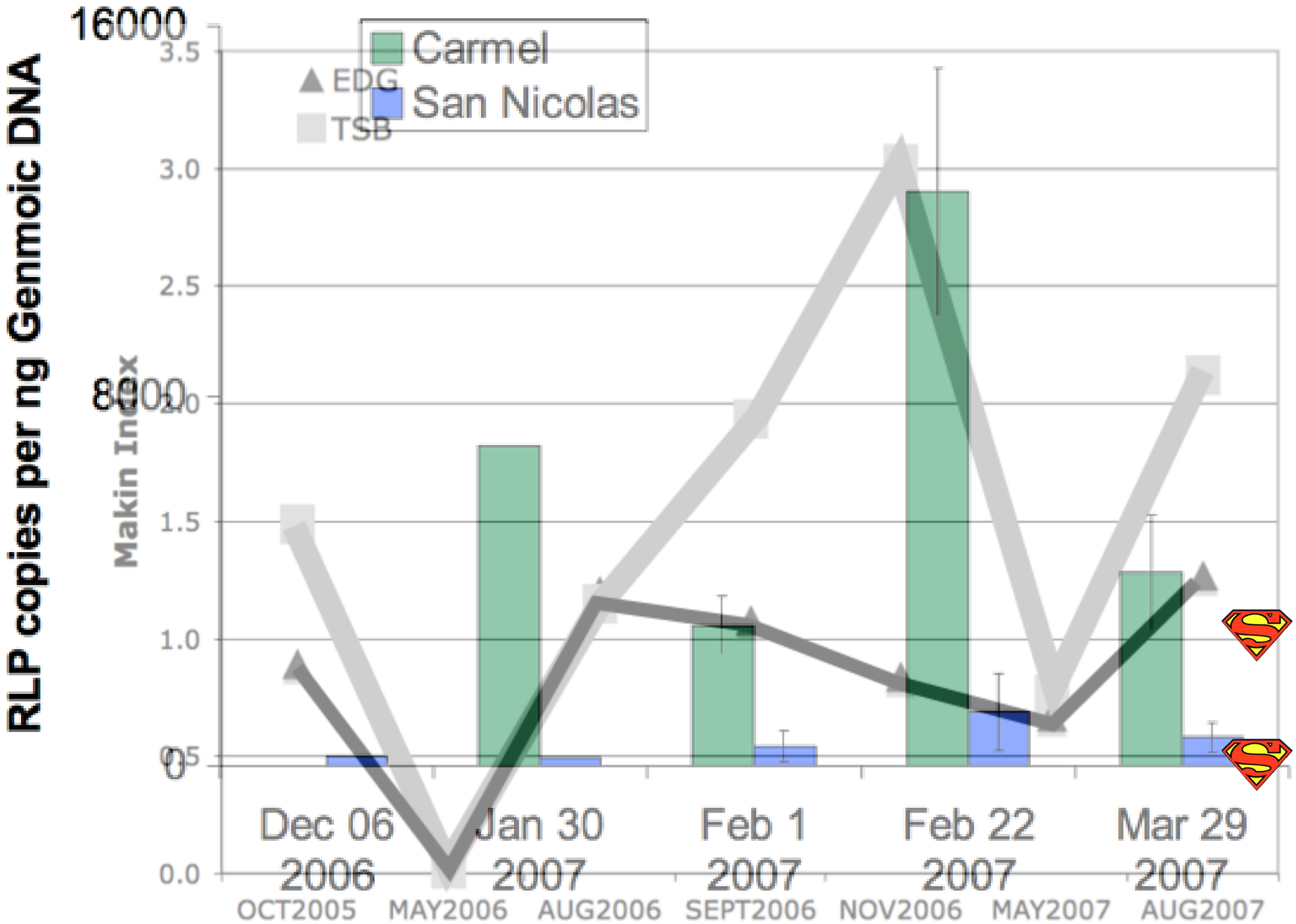
analagous to ...




Source of abalone:
Carmel
San Nicholas Island
Cumulative Mortality
25
20
15
10
5
0
S O N D J F M A M J J A S O N
Experimental Trial Timeline


25
25%
20
20%
15
15%
10
10%
5
5%
0
0%
Cumulative Mortality
Source of abalone:
EDG
TSB
Carmel
San Nicholas Island
S O N D J F M A M J J A S O N
MAY2006
JUNE2006
JULY2006
AUG2006
SEPT2006
NOV2006
MAY2007
JUNE2007
JULY2007
AUG2007
NOV2007
Experimental Trial Timeline


RLP copies per ng Genmoic DNA
16000
8000
0
Carmel
San Nicolas
Dec 06
2006
Jan 30
2007
Feb 1
2007
Feb 22
2007
Mar 29
2007


RLP copies per ng Genmoic DNA
16000
8000
0
Makin Index
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Carmel
San Nicolas
EDG
TSB
Dec 06 2006
Jan 30 2007
Feb 1 2007
Feb 22 2007
Mar 29 2007
OCT2005
MAY2006
AUG2006
SEPT2006
NOV2006
MAY2007
AUG2007

Increased Resistance

Better survival AND less pathogen load

How?

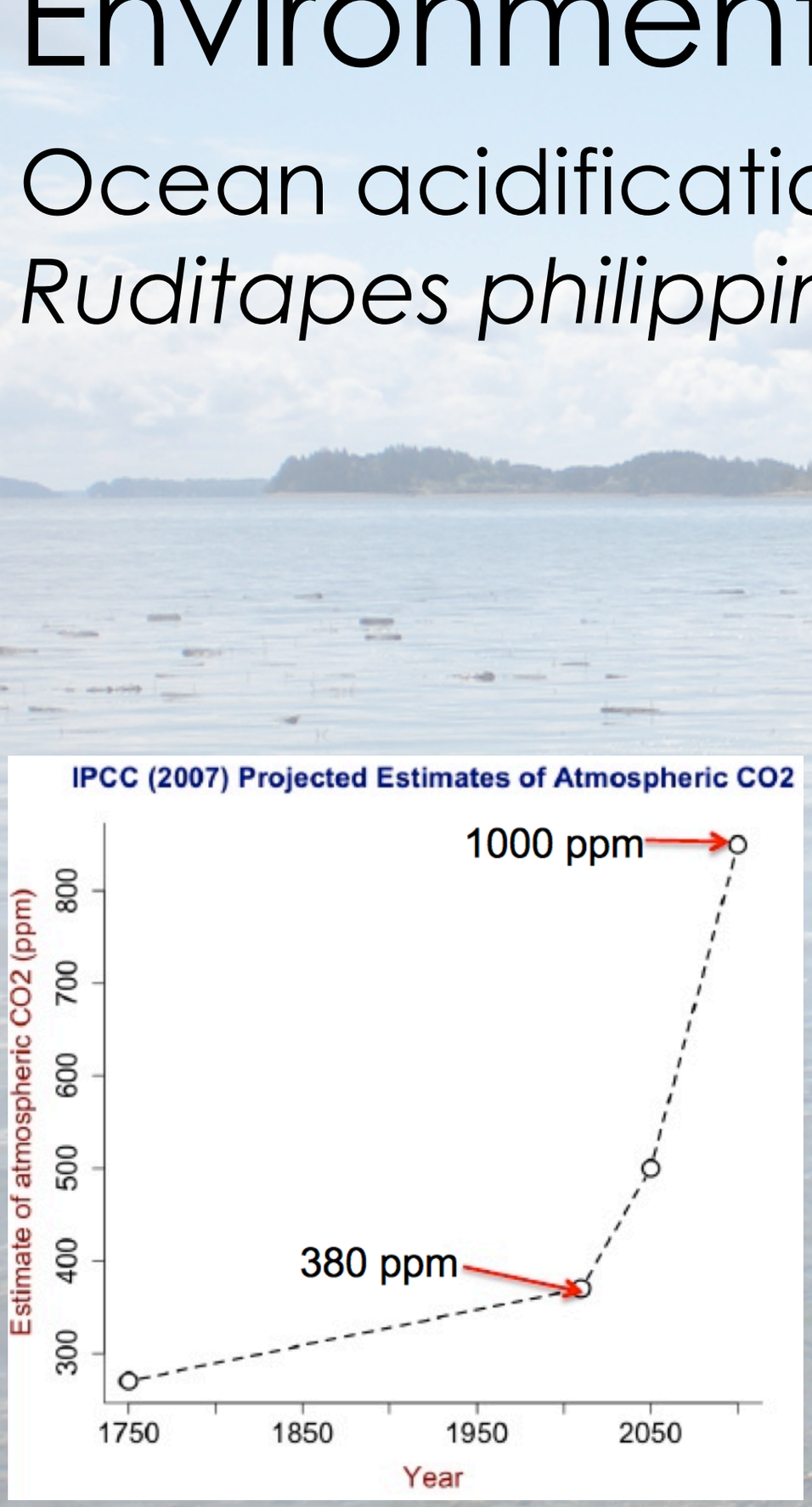
Differences?

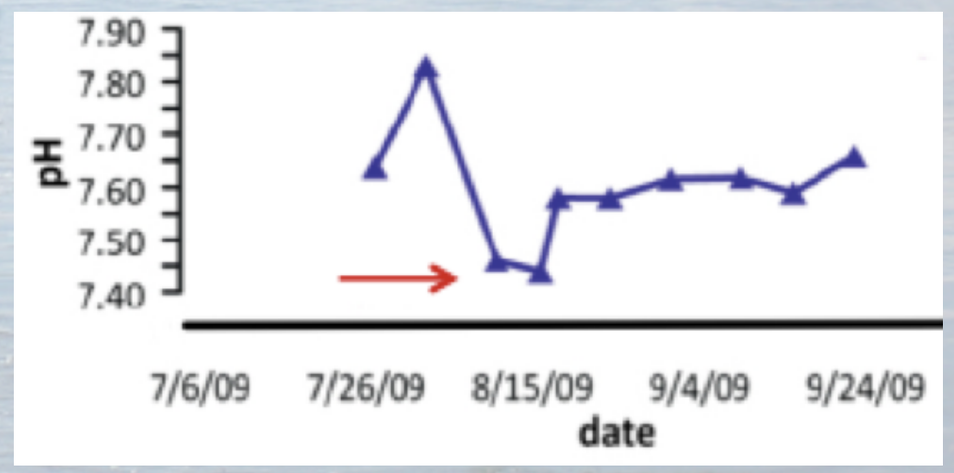
Only Lisa Knows

Environmental stress

Ocean acidification and clam larvae

Ruditapes philippinarum



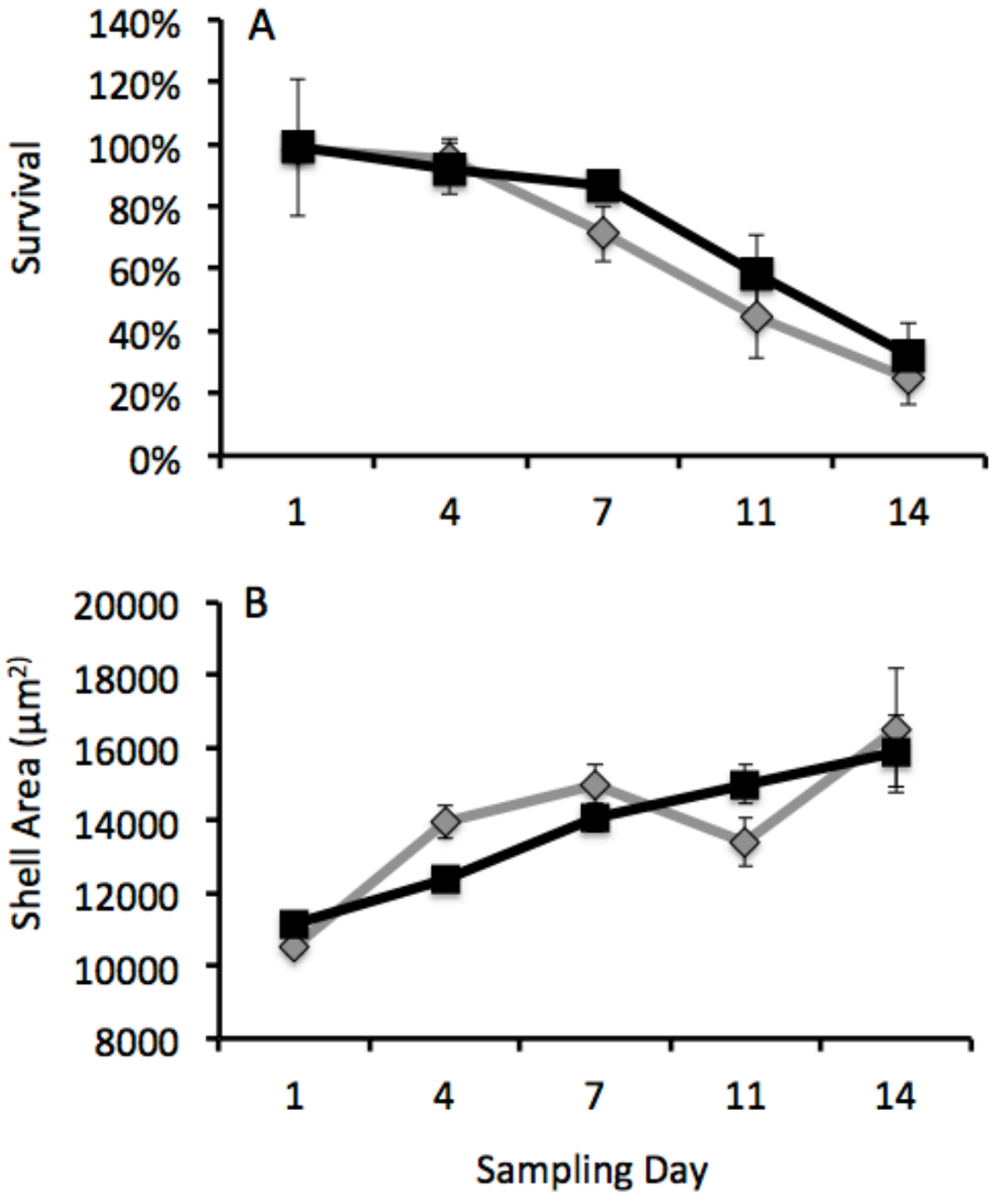


Locales in PNW already experiencing acidified conditions

Above Figure: Alin et al. Feely et al. 2008, 2010

Environmental stress

Ocean acidification and clam larvae



Larval Exposures:
No affect on growth or survival

Metzger et al. *in review*

Environmental stress

Ocean acidification and clam larvae

240 million reads

3800 : 162 DEGs
781 annotated
55 processes

Metzger et al. *in review*

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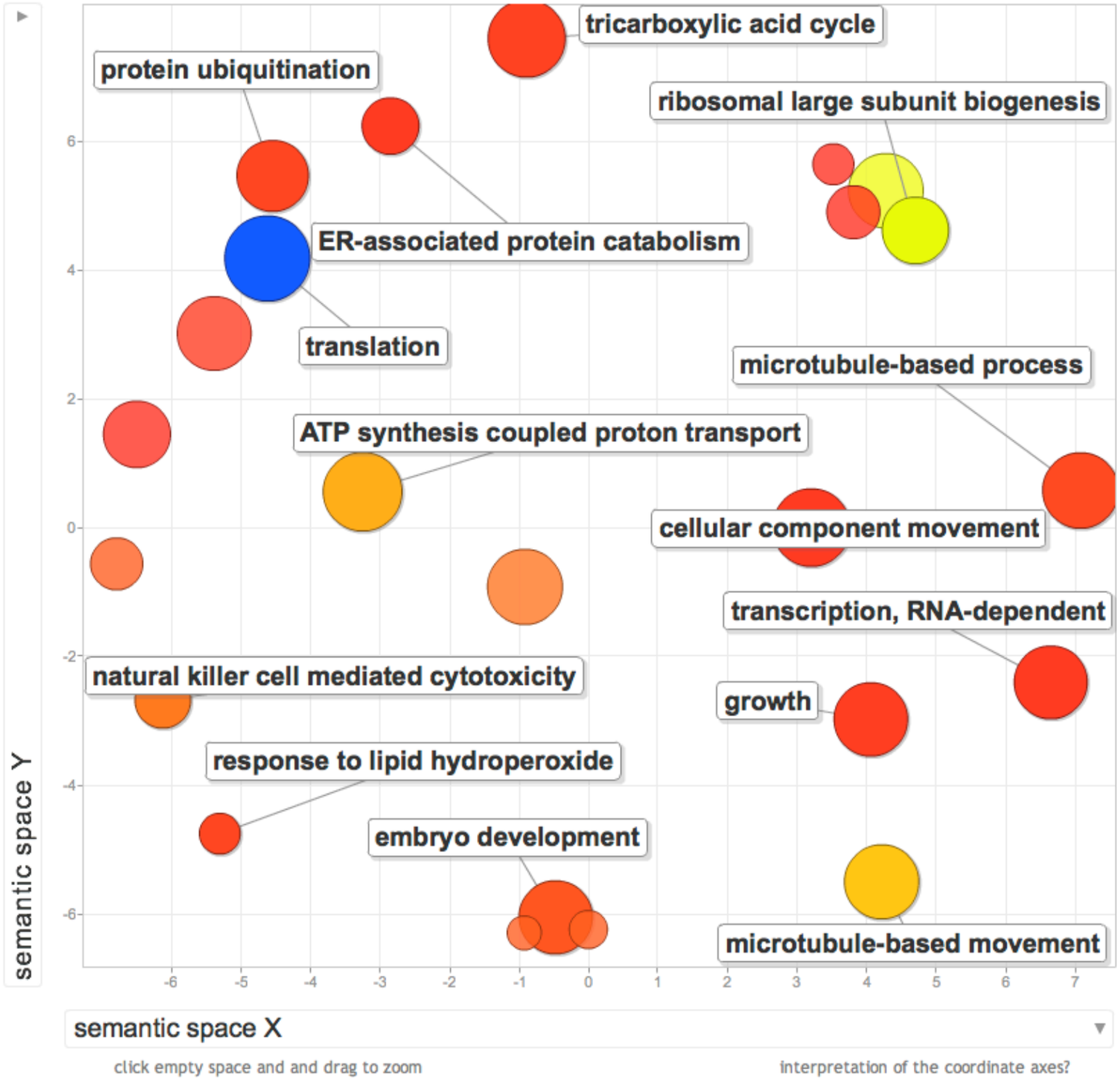

240 million reads

RuphiBase

RNA-Seq

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55 processes

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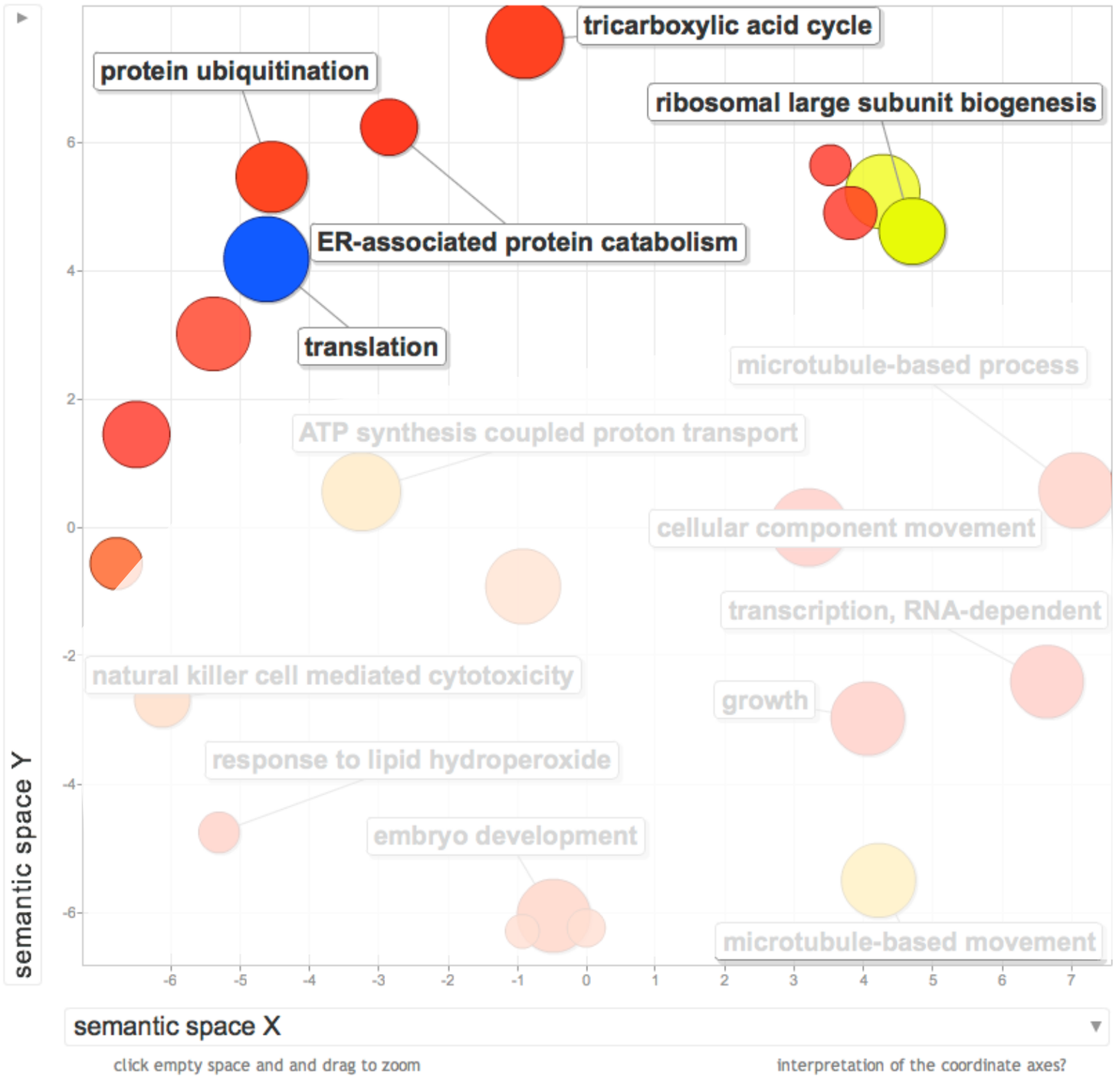


Translation

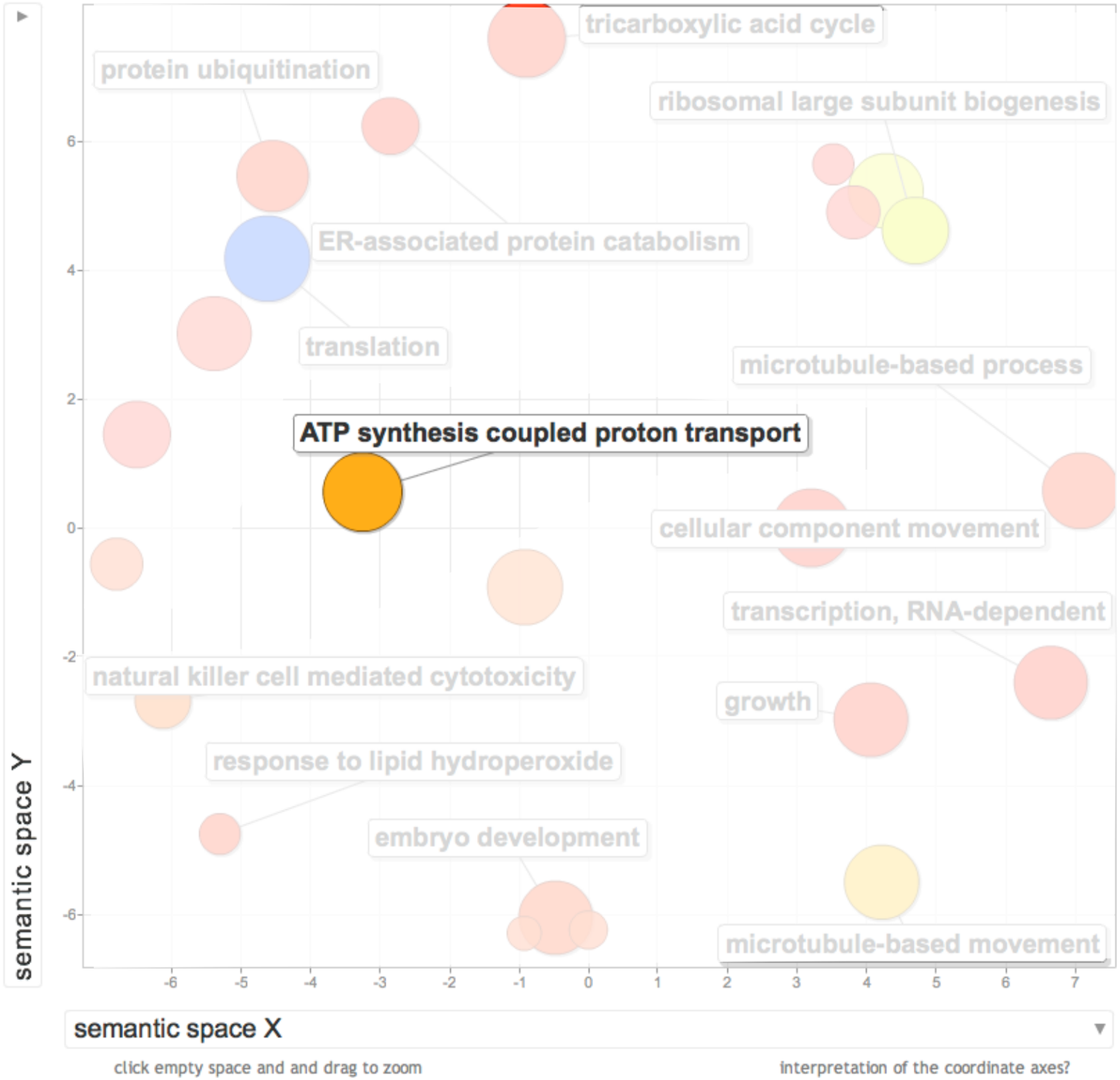
ATP coupled proton transport

Development

Metzger et al. *in review*

Environmental stress

Ocean acidification and clam larvae



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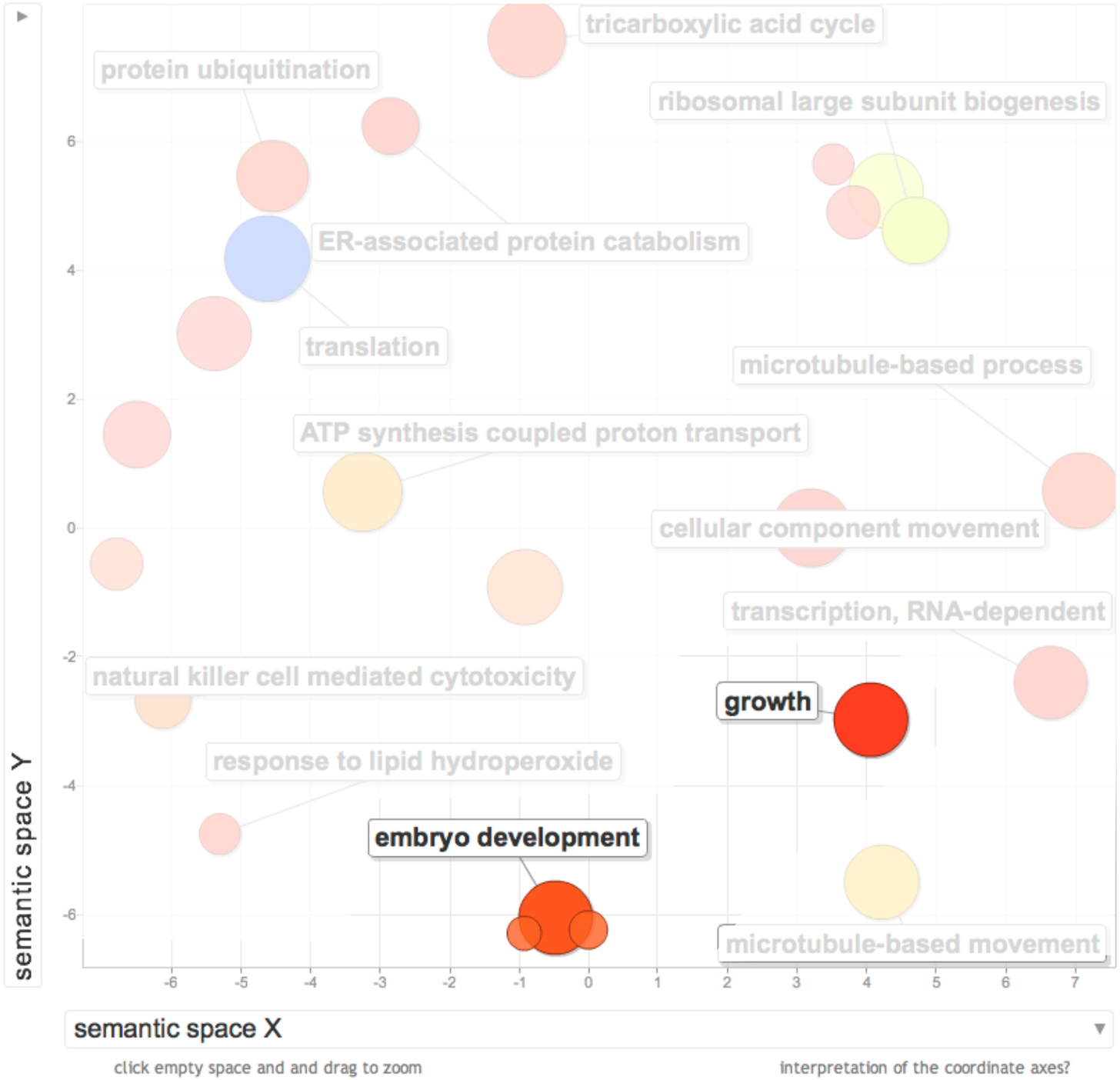

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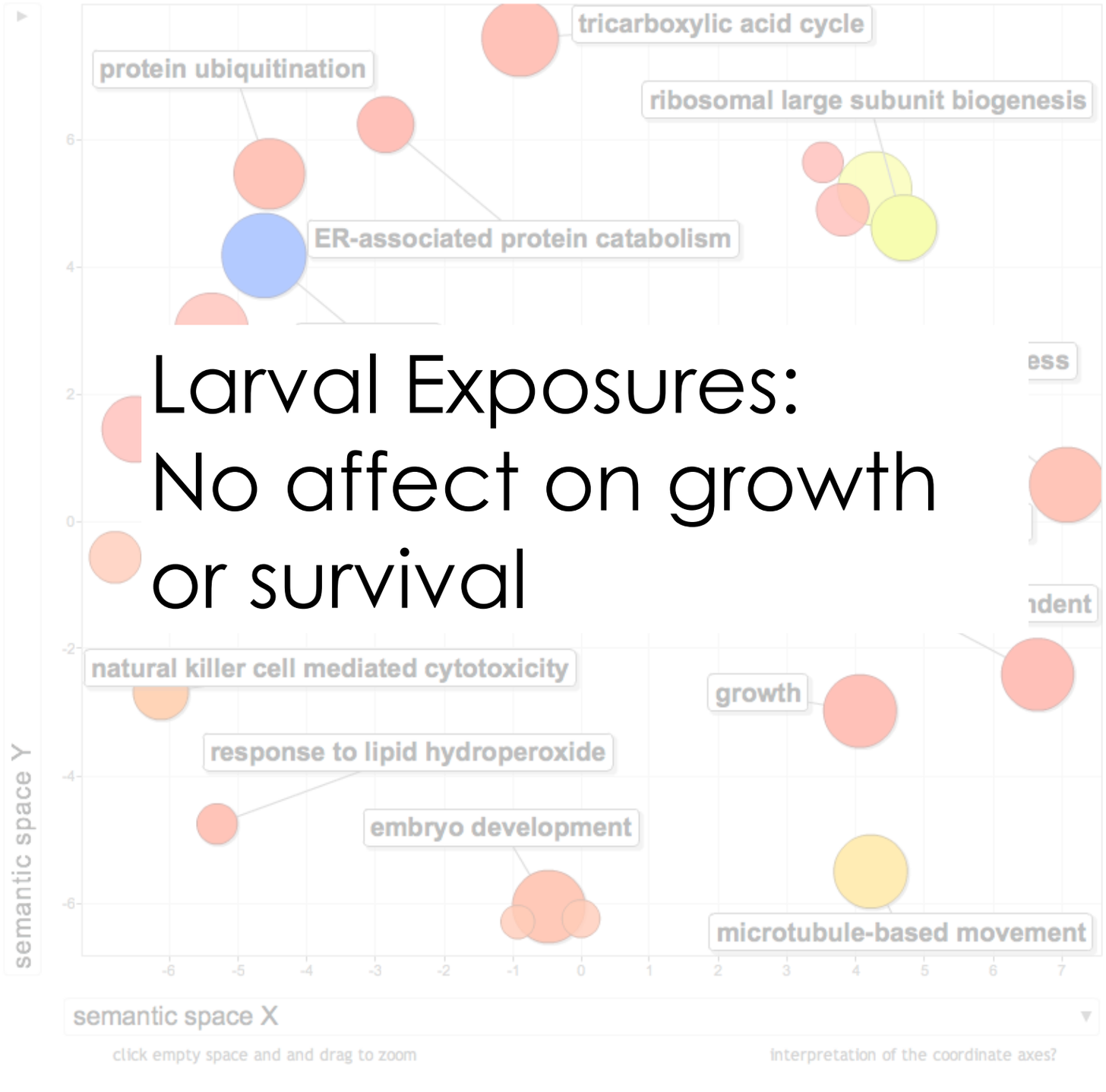

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Metzger et al. *in review*

Genomics