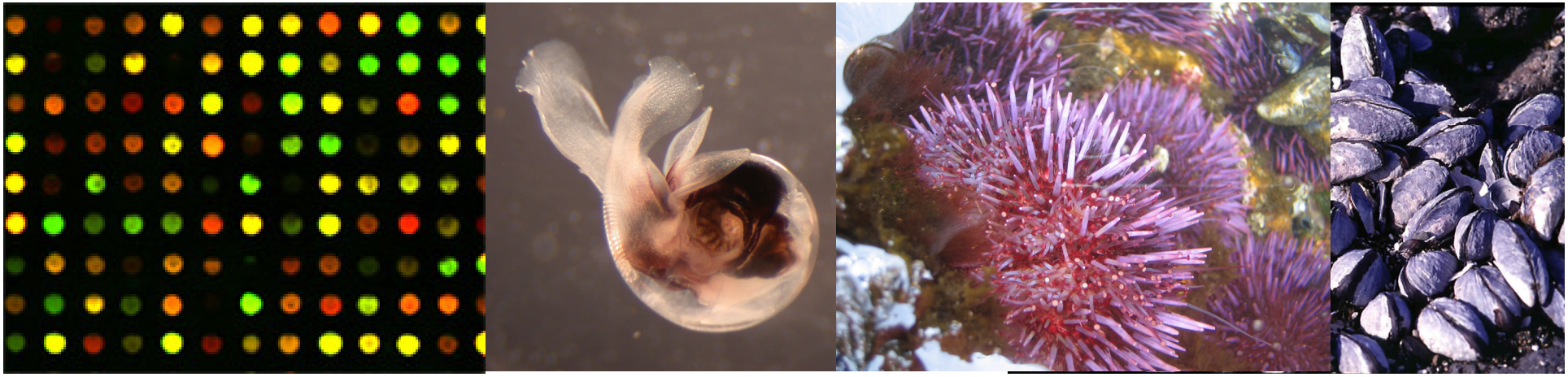


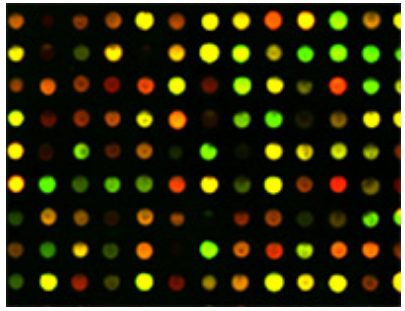
# *Fieldnotes in Global Change Genomics*

Gretchen E. Hofmann
UC Santa Barbara

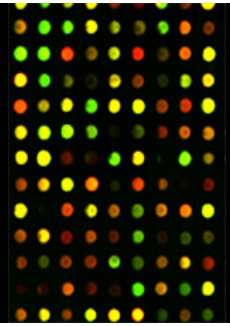
NSF
Gordon and Betty MOORE FOUNDATION
the David & Lucile Packard FOUNDATION

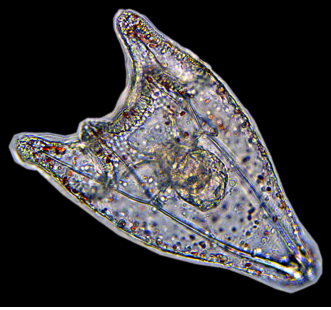
# Outline

- Highlight role of genomics in studying OA
- Report on potential of this approach
- Three parts
  - Looking for biological thresholds
  - Learning how the phenotype can change
  - Next generation sequencing and the future



# Biological Thresholds

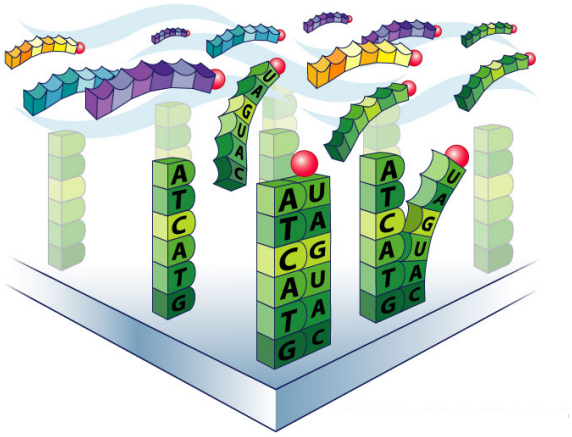




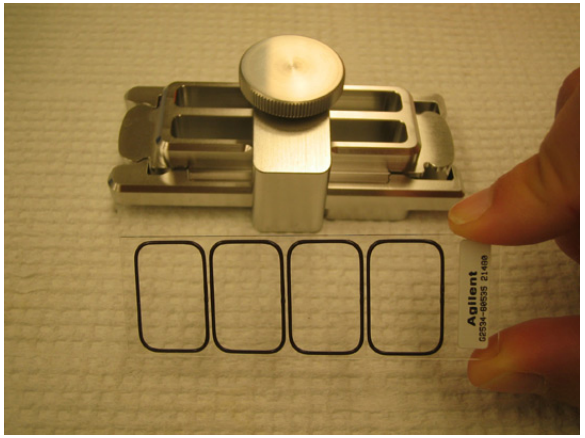
- Gene expression profiling in sea urchin larvae developing under varying $CO_2$ levels
- Identify responses of contemporary genotypes
- Explore thresholds for biological processes
- Balancing act:  Gene regulatory networks, plasticity and time for evolution

# Sea Urchin Oligonucleotide Arrays

- Purple Urchin Genome sequenced & largely annotated
- Choose genes in pathways of interest
- Oligonucleotide sequence is synthesized on the chip *in situ*
- Probes are 25 - 100 base pairs in length
- Multiple probes/gene

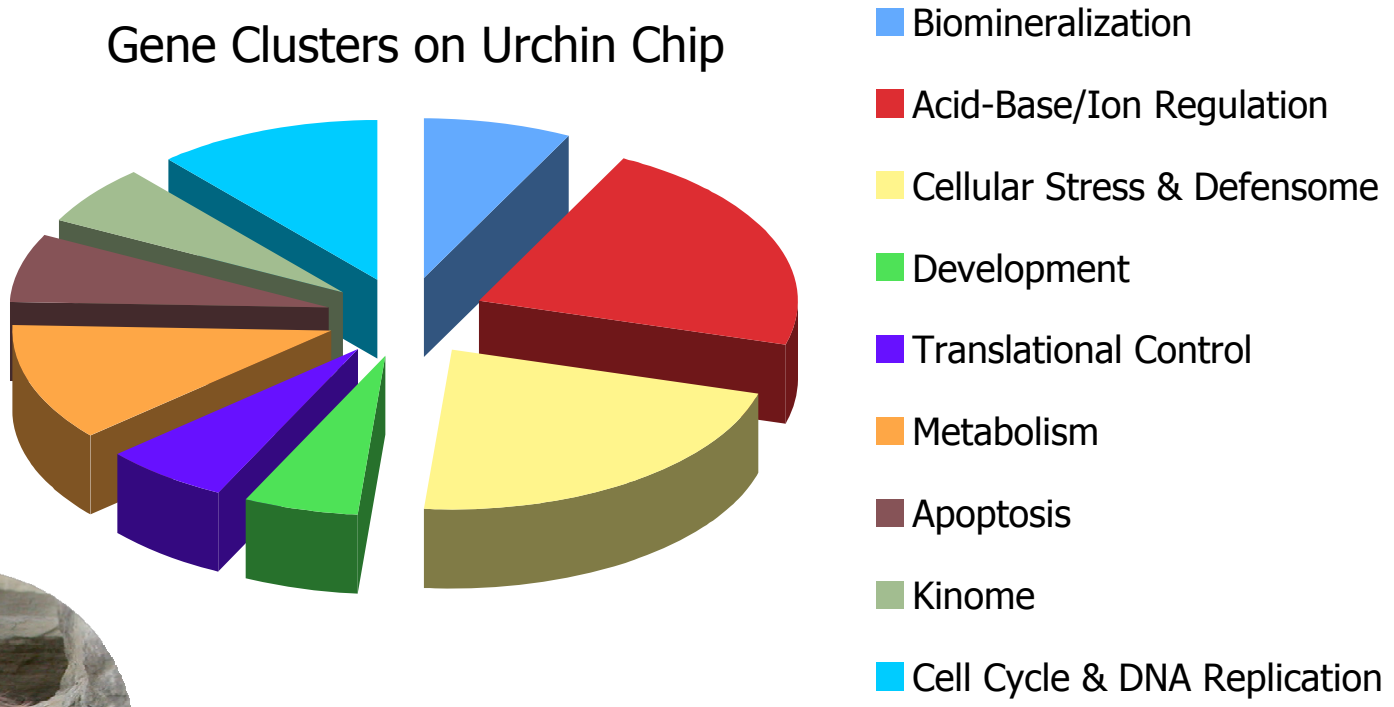


Hybridization of fluorescently tagged samples. Courtesy of Affymetrix



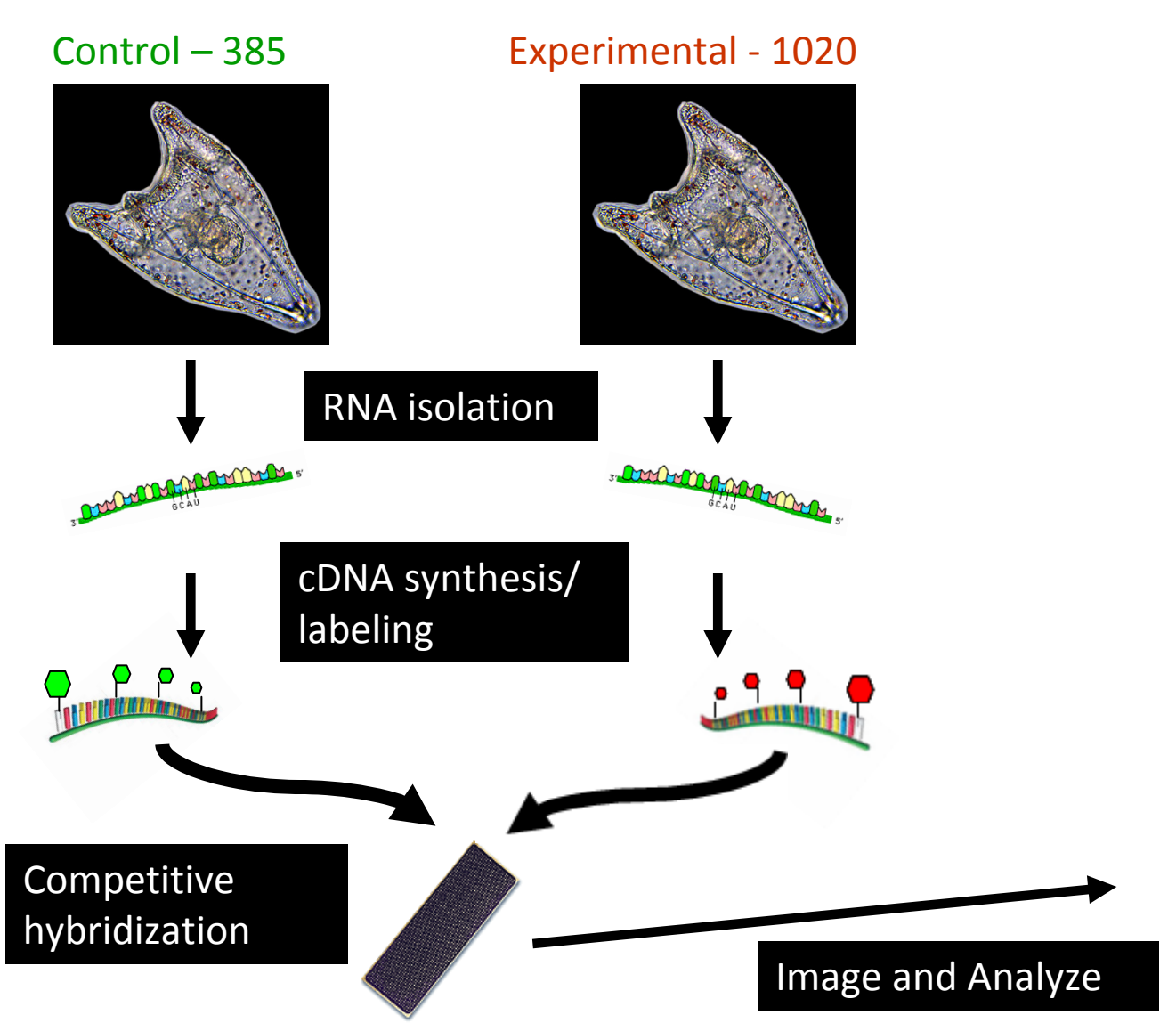

Agilent Technologies

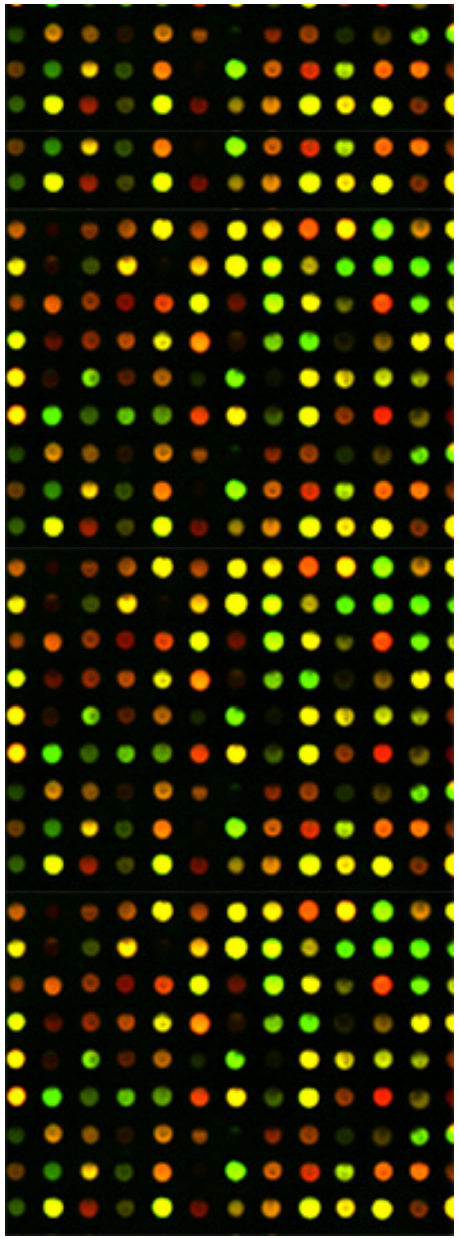
# Boutique oligonucleotide array (Agilent)
## Cell processes of interest in OA studies
## ~1,000 genes




Dr. Anne Todgham
San Francisco State University

# Microarray Experimental Design

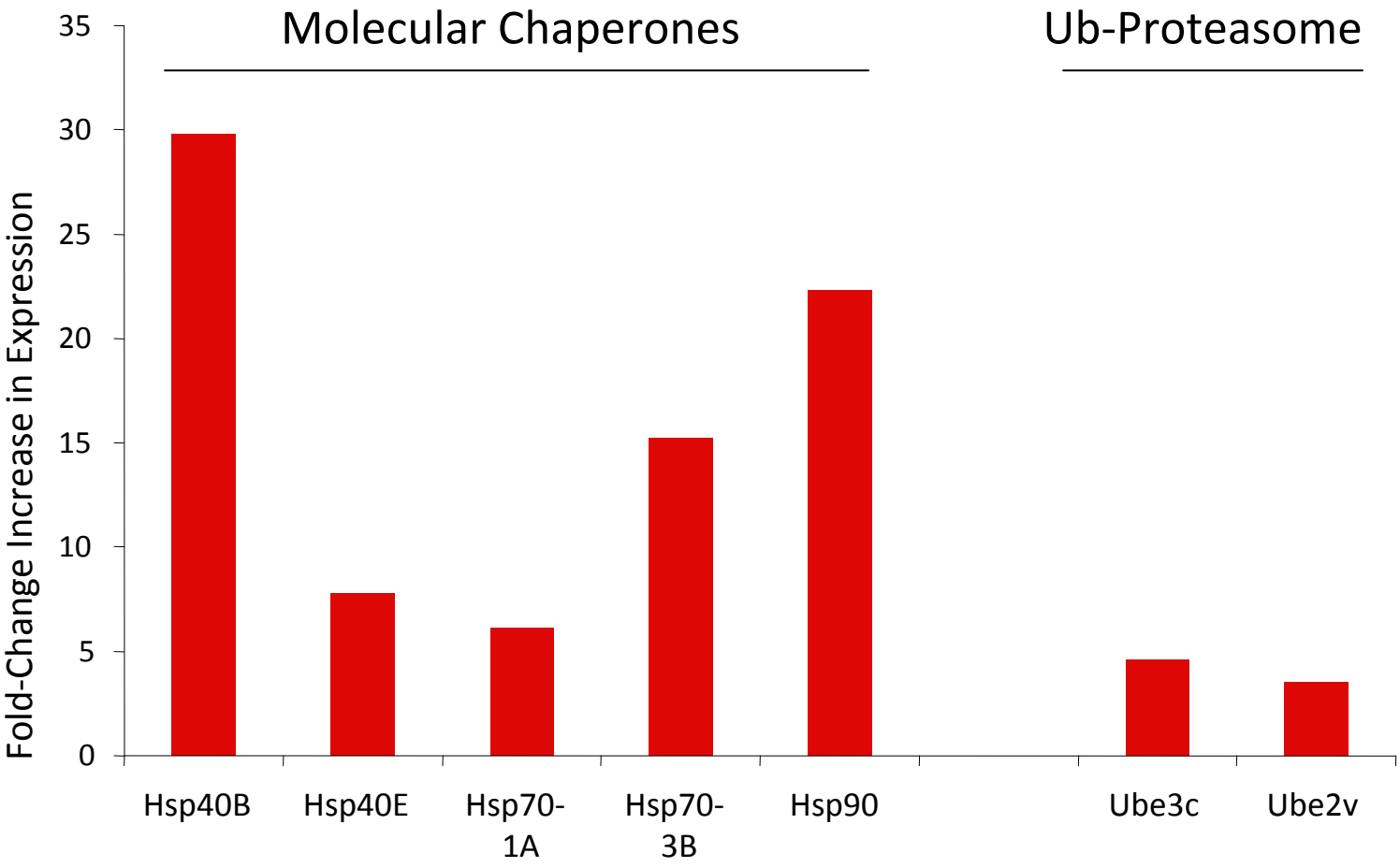


# Example of Expression Data for Urchin Larvae

| Exposure | Response | Result |
|---|---|---|
| Heat Stress:<br>1 hour at 25°C | Classic Heat Shock | |
| Ocean Acidification:<br>380ppm vs. 1020ppm | Unknown | |

# Up-regulation of genes in defensome under heat stress…



# Expression Data for Urchin Larvae @ ~40h

| Exposure | Response | Result |
|---|---|---|
| Heat Stress:<br>1 hour at 25°C | Classic Heat Shock | √ |
| Ocean Acidification:<br>380ppm vs. ~500ppm | Unknown | ???? |

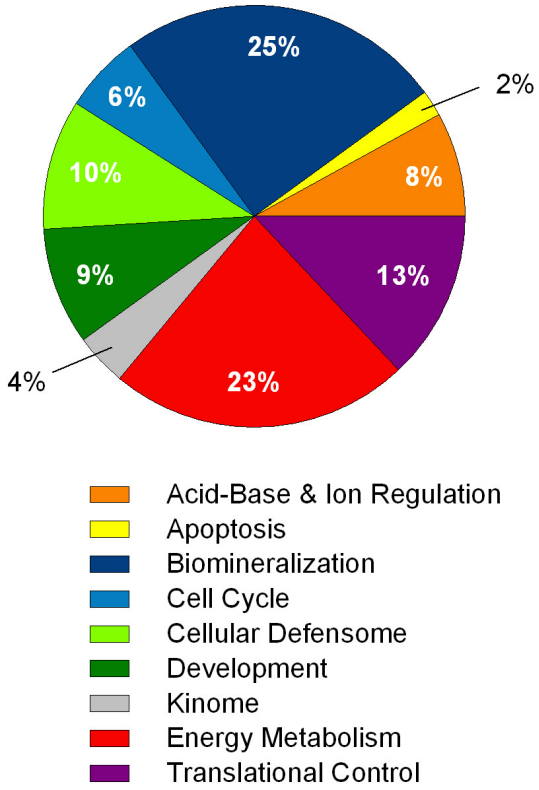
Expected response to heat stress 10 °C above rearing temp

Overall, suppression in larval stage:

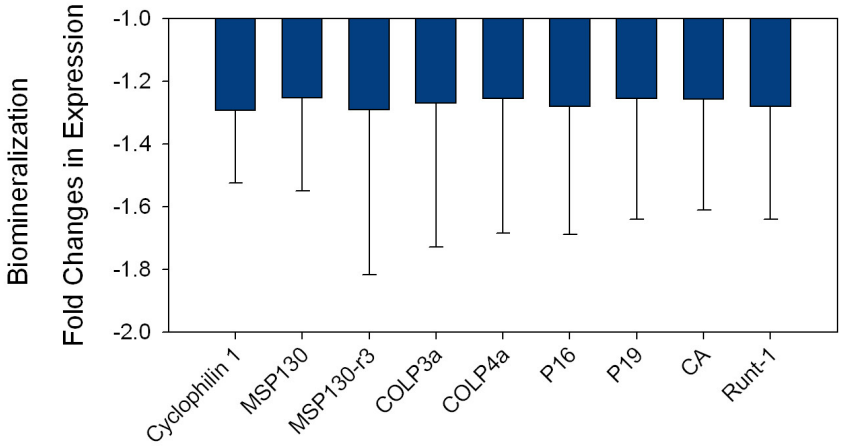
Strong threshold at 500 ppm $CO_2$ (~pH 7.8)
No major stress response as observed for HS

Significant Expression Changes:
83 genes at 500 ppm $CO_2$
178 genes at ~970 ppm CO

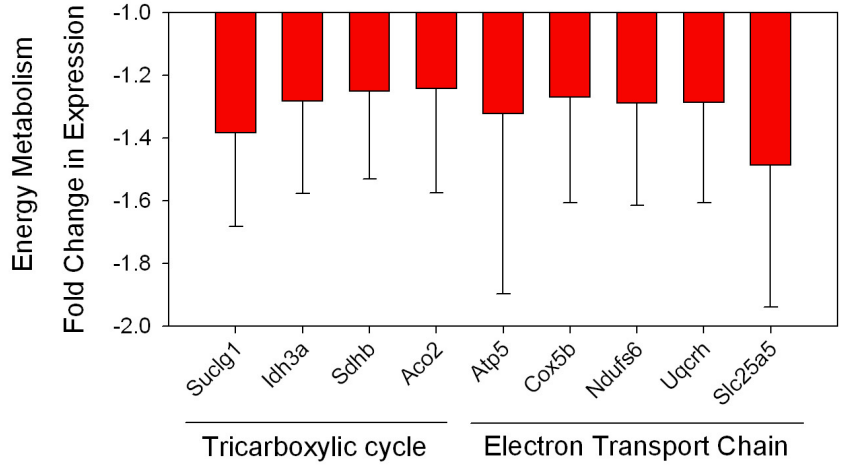
A




B

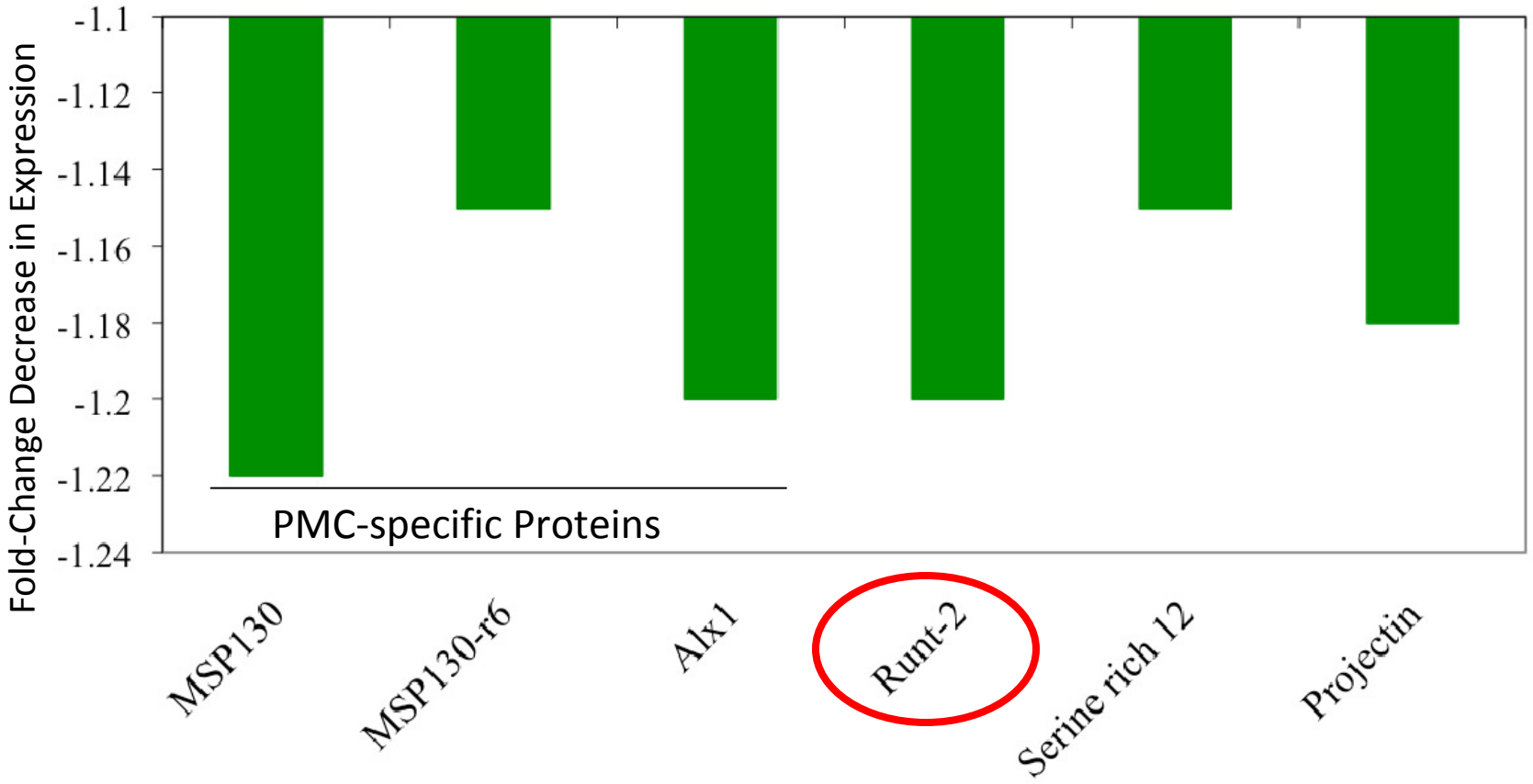



C

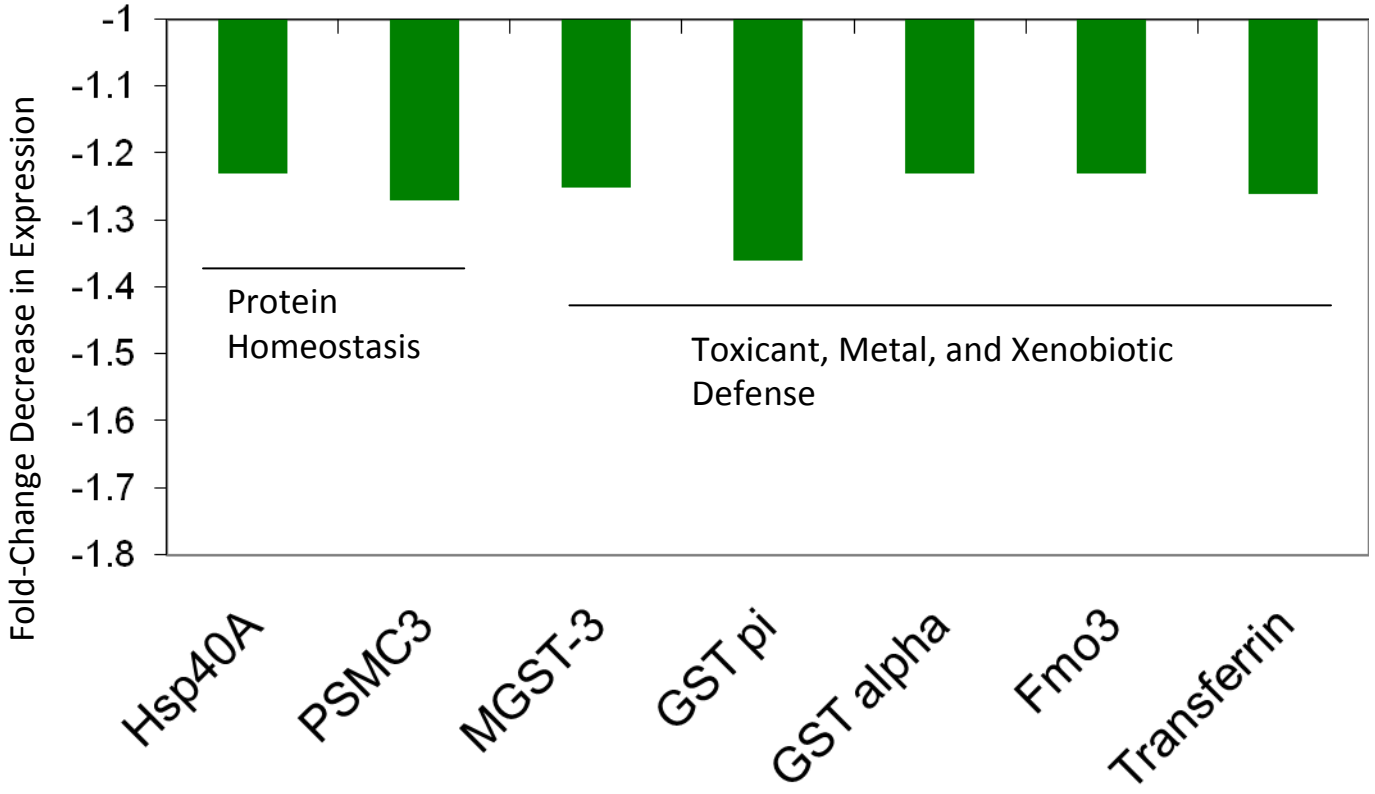



Todgham and Hofmann (2009) *J. Exp. Biol.* 212: (in press)

# Thresholds in genes involved in biomineralization genes may be driven by regulators



# In response to ocean acidification, Cellular Stress and Defense genes are **DOWN**



# Expression Data

| Exposure | Response | Result |
|---|---|---|
| Heat Stress:<br>1 hour at 25°C | Classic Heat Shock | √ |
| Ocean Acidification:<br>380ppm vs. 1020ppm | Metabolic suppression | ⇩ |

Still to come: Transcriptomic analyses for interactive effects of temperature and OA & role of GRN in earlier stages.

# Outline

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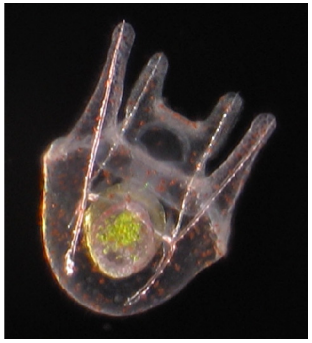


# Evidence for "cost" of growing up in a high $CO_2$ world

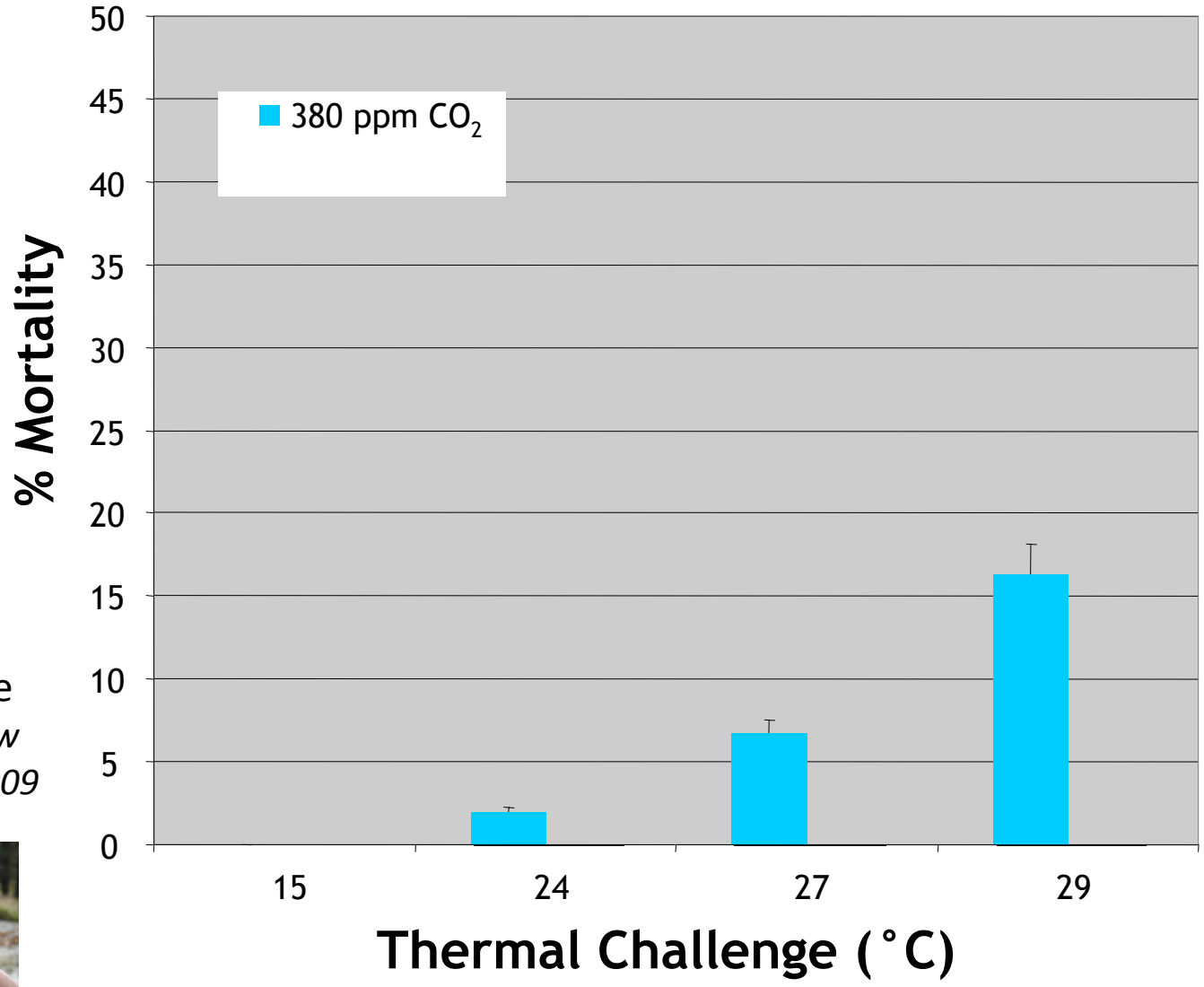
- Larvae raised at 15 °C
- Thermal challenge at a high temperature
- **Reduced** expression of molecular chaperones confirmed with qPCR

Dr. Michael O'Donnell

O'Donnell et al (2009) *Mar Biol* 156: 439-446

# Thermal Challenge(1h) of 4-Arm Purple Urchins

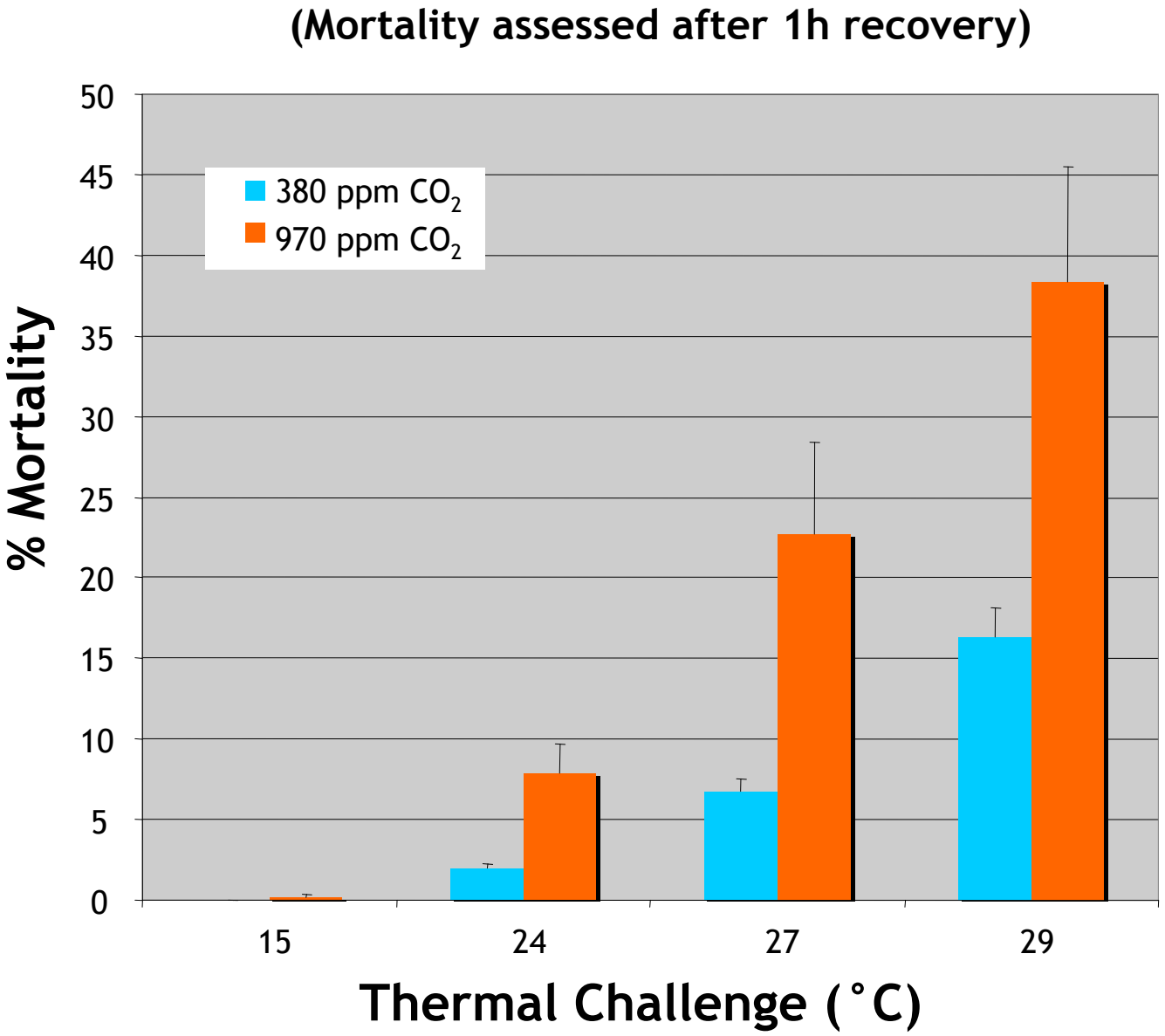
**(Mortality assessed after 1h recovery)**




Fangue & Todgham, unpubl. results

Dr. Nann Fangue
*NSF Postdoc Fellow*
*UC Davis, Sept. 2009*

# Thermal Challenge(1h) of 4-Arm Purple Urchins




Fangue & Todgham, unpubl. results

# Summary

- Identifies biological thresholds in “high resolution”
- Transcriptomic analysis can illustrate plasticity of current genotypes
- Other organisms are on the way – stony coral, pteropods (*Limacina helicina*), *E. hux*

**Coral planular larvae**

# Outline

- Three parts
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# Reporting in on future trends: Emerging New Technologies & OA

- Next generation sequencing
  - "Wild West of Genomics"
  - 454 pyrosequencing, transcriptomics…*Nature*, vol 458, 12 March 2009 (Rinn)
- 10K Era – future where there are 10,000 sequenced genomes, genomic resources
- Experimental evolution
  - *E. hux* genome is published and annotated