GENETICS AND MOLECULAR BIOLOGY FOR ENVIRONMENTAL ANALYSIS

MOLECULAR ECOLOGY
LESSON 1

Prof. Alberto Pallavicini
pallavic@units.it

WHO I AM…

- Google scholar: http://scholar.google.it/citations?user=tsyE2vYAAAAJ&hl=it
- University of Trieste: http://www.units.it/persone/index.php/from/abook/persona/8042
- Department of Life Sciences

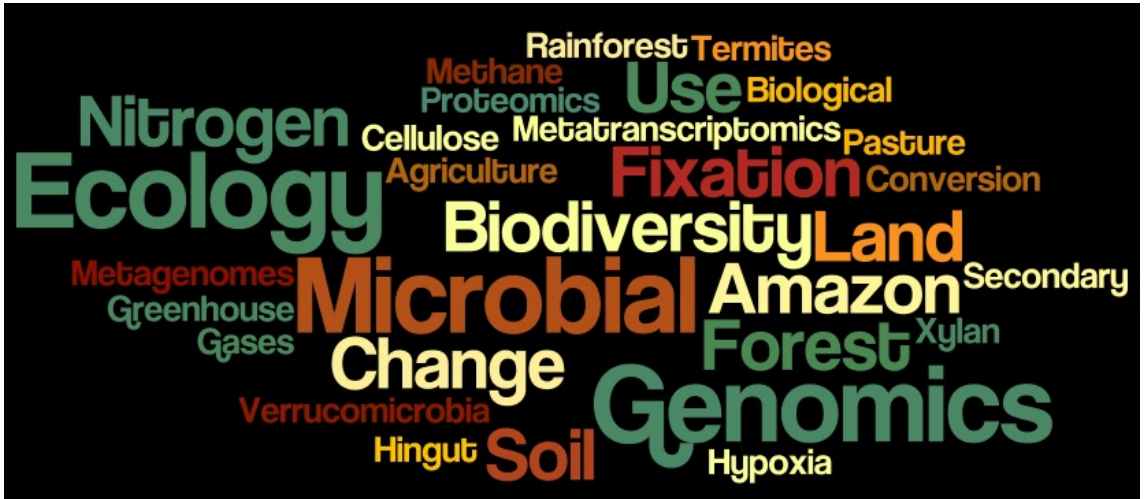
https://dsv.units.it/it/ricerca/ambiti/biologia-ambientale?q=it/node/18399

APPROXIMATIVE SYLLABUS?

- Molecular Genetics in Ecology 1h
- Molecular Biology for Dummies 9h
- Molecular Markers in Ecology 4h
- Population Genetics 6h
- Conservation Genetics 2h
- DNA Sequencing and Analysis 4h
- Comparing Genomes 2h
- Structure and Function in Communities 4h
- Stress Responses 4h
- Variation and Adaptation 2h
- Studying Ecologically Important Traits: QTL Analysis, and Reverse Genetics 2h

INTRODUCTION

- Perhaps the most significant development in molecular ecology in the past 10 years has been in the area of ecogenomics.
- Ecogenomics moves away from the more traditional approach of using neutral (non-adaptive) molecular markers to infer patterns of genetic diversity and gene flow, and instead attempts to provide an understanding of adaptive gene functions in an ecological context.



WHAT IS MOLECULAR ECOLOGY?

- Over the past 25 years, molecular biology has revolutionized ecological research.

- **genetic diversity**
- track the movements of individuals
- measure inbreeding
- identify the remains of individuals
- characterize new species
- retrace historical patterns of dispersal

WHAT IS MOLECULAR ECOLOGY?

- genomic techniques for:
  - the functioning of different genes
  - the ways in which evolutionary adaptations (or lack thereof) can determine whether an organism will be able to survive a changing environment.
  - cost-effective molecular genetic
  - identifying the geographic source of invasive species from only a few samples or without any direct evidence
  - monitoring populations of elusive species

THE EMERGENCE OF MOLECULAR ECOLOGY

- Ecology = how organisms in the wild interact with one another and with their physical environment.
- Field observation or experimental manipulations.

- **But … phenotypic** data have some limitations

THE EMERGENCE OF MOLECULAR ECOLOGY

- The wing patterns of African butterflies in the genus *Bicyclus* will vary depending on the amount of rainfall during their larval development period; as a result, the same genotype can give rise to either a wet season form or a dry season form (Roskam and Brakefield, 1999).

THE EMERGENCE OF MOLECULAR ECOLOGY

- **phenotypic plasticity**

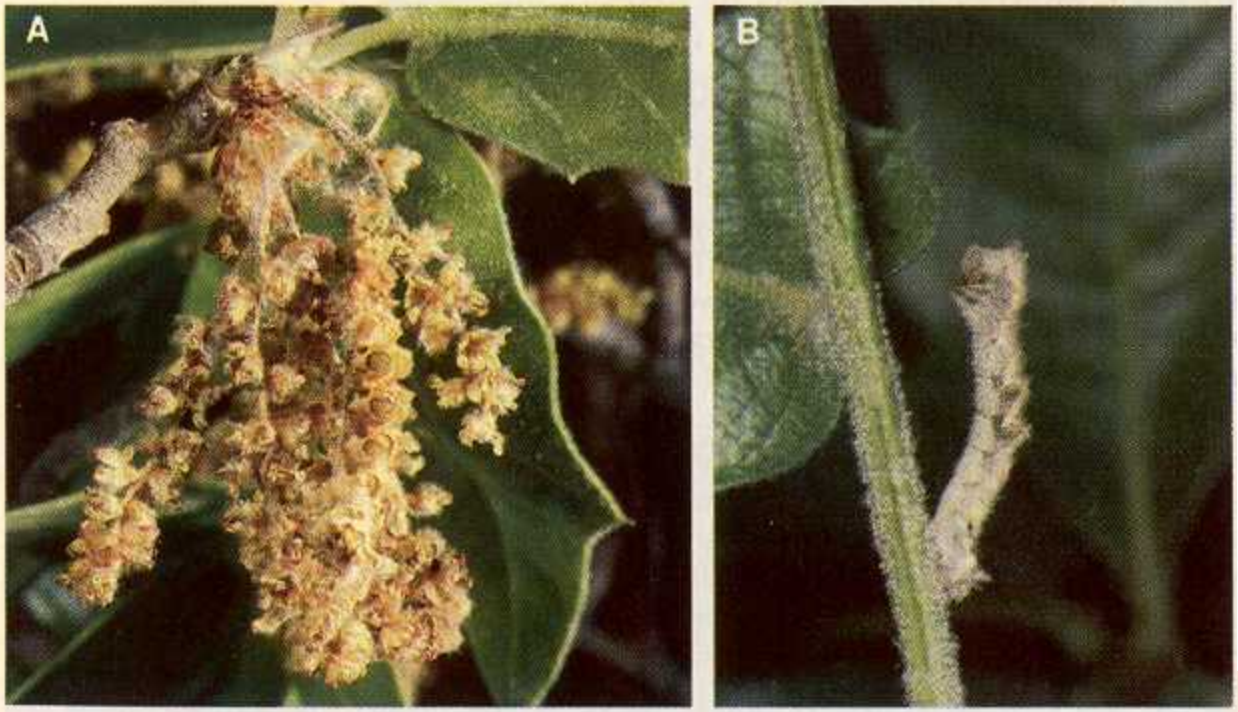
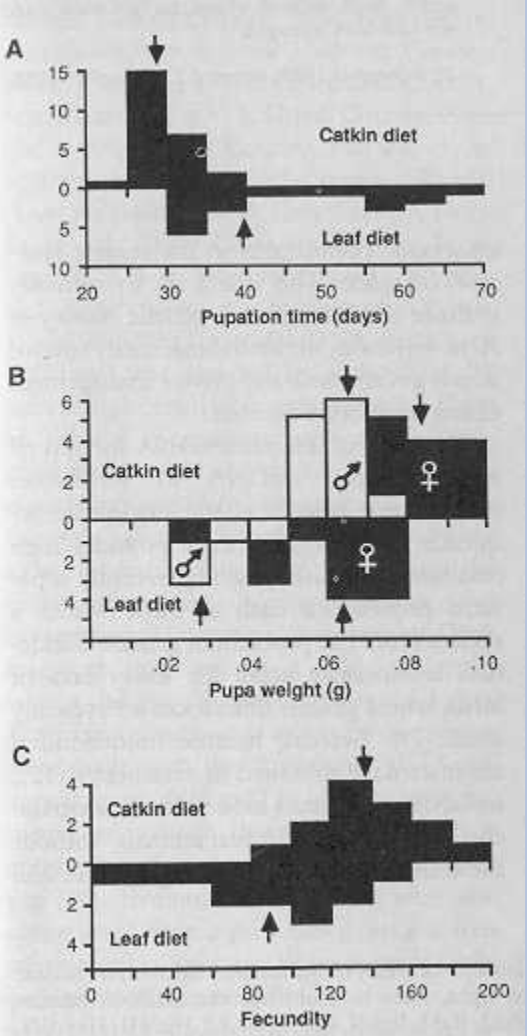


Fig. 1. Morphs of the catepillar *Nemoria arizonaria*. (**A**) A catkin morph in its normal hiding position; (**B**) a twig morph in its normal hiding position. These two caterpillars are full sibs that were raised on different diets.

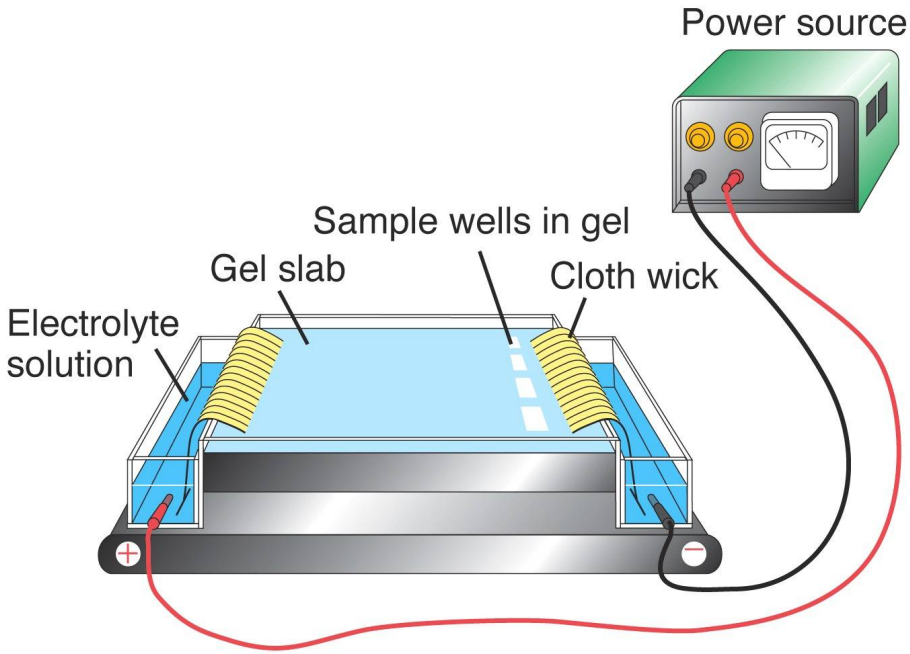


THE EMERGENCE OF MOLECULAR ECOLOGY

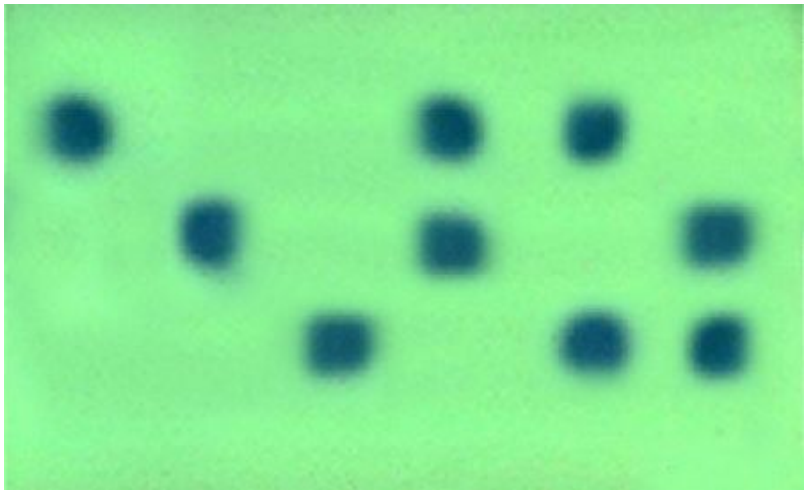
Characteristic	Environmental influence	Example
Sex	Temperature during embryonic development	Eggs of the American snapping turtle *Chelydra serpentina* develop primarily into females at cool temperatures, primarily into males at moderate temperatures, and exclusively into females at warm temperatures (Ewert *et al*., 2005)
Growth patterns in plants	Soil nutrients, water availability	Southern coastal violet (*Viola septemloba*) allocated a greater proportion of biomass to roots and rhizomes in poor-quality environments (Moriuchi and Winn, 2005)
Leaf size	Light intensity	Dandelions (*Taraxacum officinale*) produce larger leaves under conditions of relatively strong light intensity (Brock *et al*., 2005)
Migration between host plants	Age and nutritional quality of host plants	Diamondback moths (*Plutella xylostella*) most likely to migrate as adults if the juvenile stage fed on mature plants (Campos *et al*., 2004)
Feeding-related morphology	Food availability	Sea urchin larvae (*Strongylocentrotus purpuratus and S. franciscanus*) produce longer food-gathering arms and smaller stomachs when food is scarce (Miner, 2005)
Plumage coloration	Carotenoids in diet	The plumage of male house finches

PROTEIN ALLOZYMES

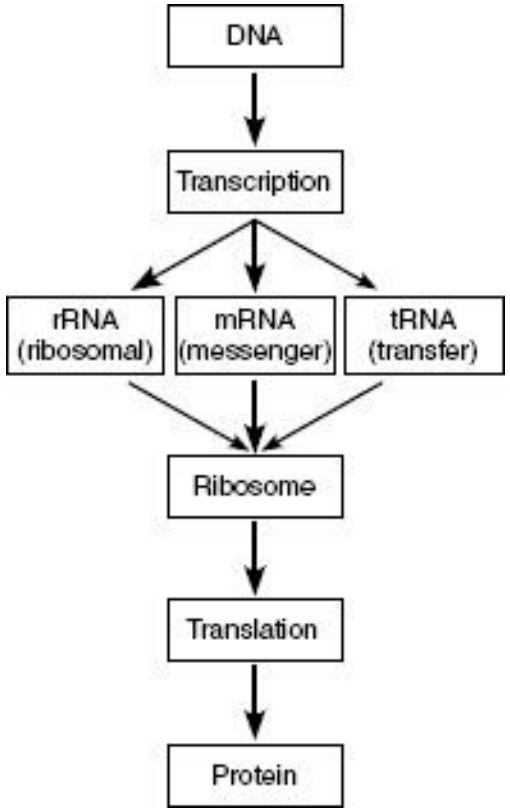
- **in the ‘60s gel electrophoresis** of allozymic proteins
- The very first direct information on some of the genetic properties of individuals, populations, species and higher taxa



PROTEIN ALLOZYMES



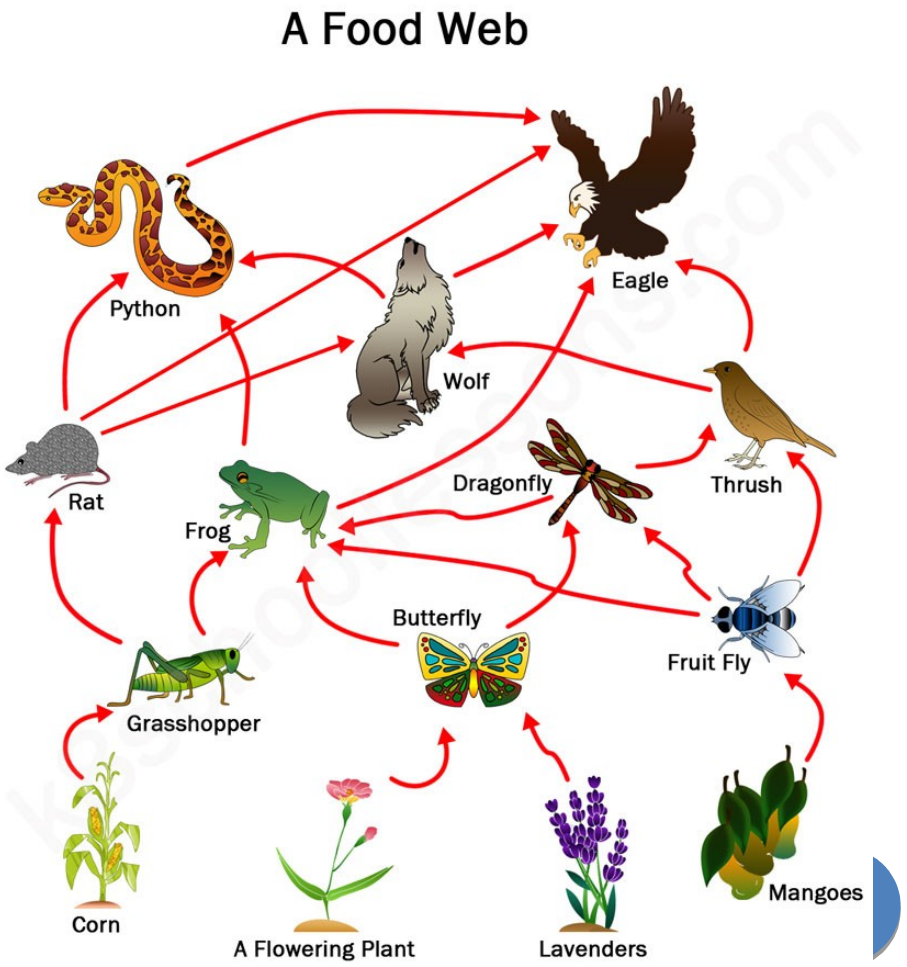
PLEASE REMEMBER…



- not all variations in DNA sequences will translate into variable protein products
- Less than 2% of the human genome, for example, codes for proteins
- DNA markers are now the most common source of data in molecular ecology

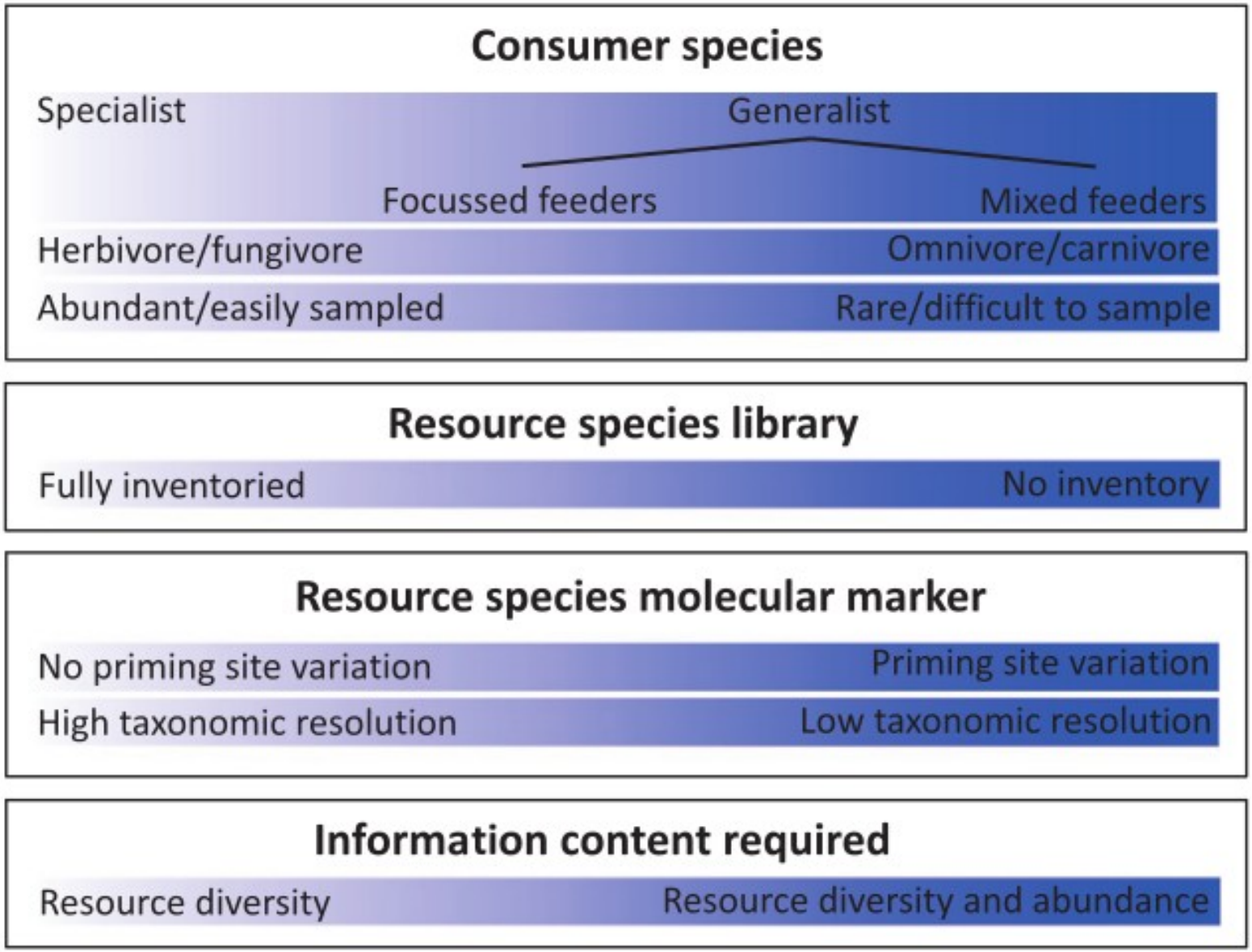
DNA sequence–based trophic ecology

Trophic interactions represent the primary data for investigations ranging from single species conservation through to the resolution of community food webs.



DNA sequence–based trophic ecology

The expansion of publicly available genomic resources, technical advances in PCR amplification, the development of next-generation DNA sequencing technology and increased understanding of the degradation properties of DNA sequence have been capitalized upon to refine and improve the general approach of developing species-specific primers


Consumer species
Specialist
Generalist
Focussed feeders
Mixed feeders
Herbivore/fungivore
Omnivore/carnivore
Abundant/easily sampled
Rare/difficult to sample
Resource species library
Fully inventoried
No inventory
Resource species molecular marker
No priming site variation
Priming site variation
High taxonomic resolution
Low taxonomic resolution
Information content required
Resource diversity
Resource diversity and abundance

- The main challenges and priorities for DNA sequence–based trophic ecology

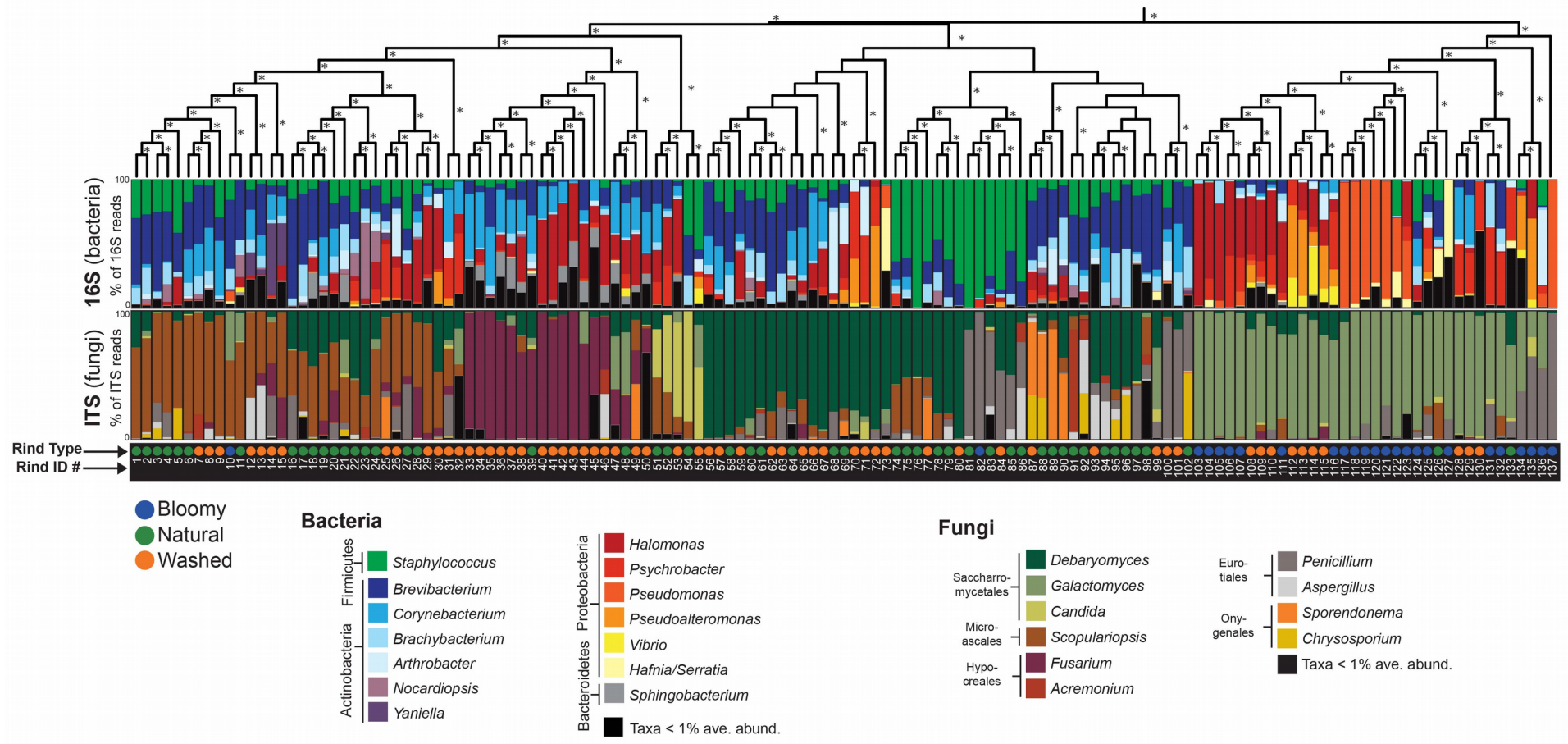
  - Development of methods that provide accurate and unbiased identification of all resource species.

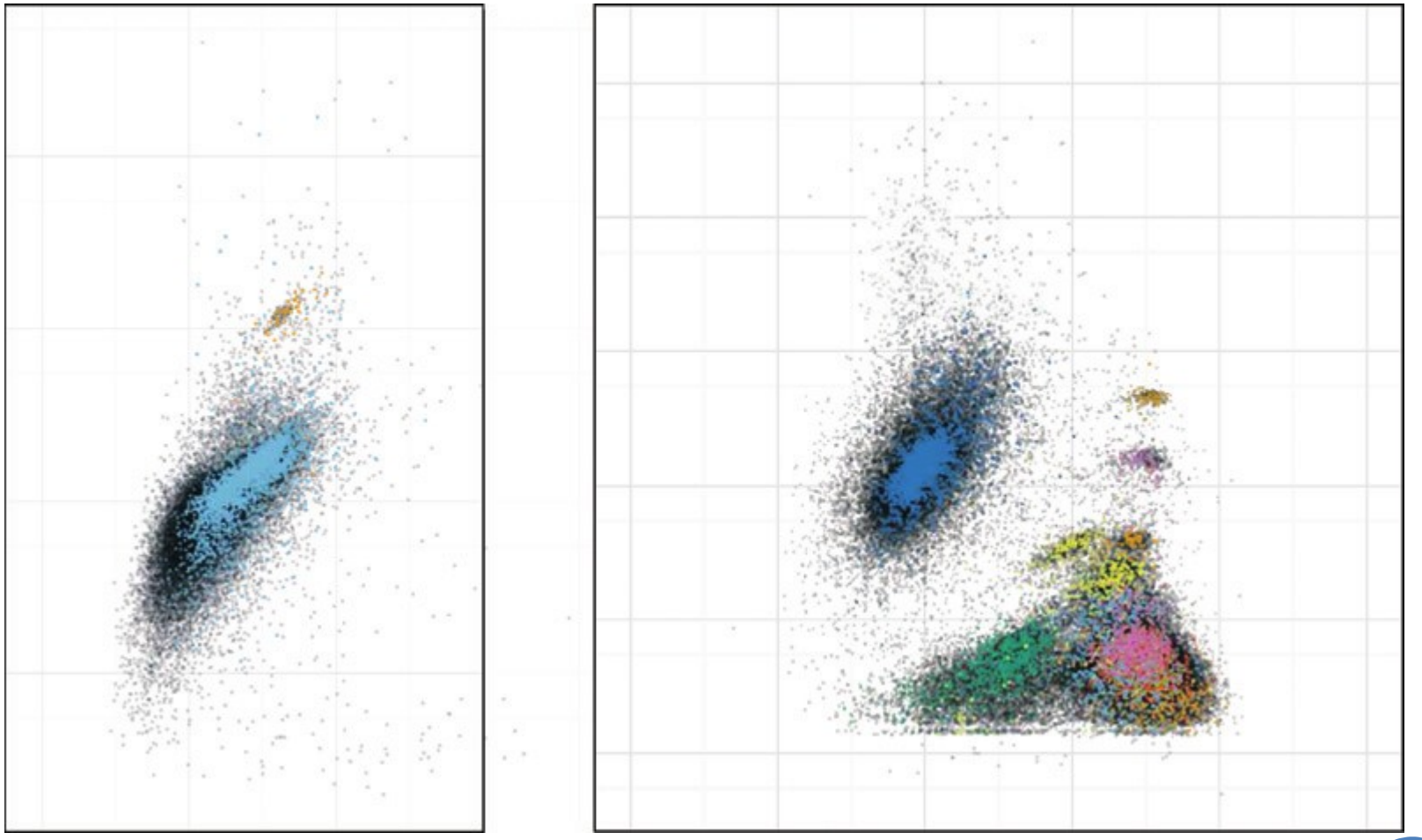
  - Development of methods that provide accurate and unbiased quantitative estimates of the proportional representation of resource species

- The main challenges and priorities for DNA sequence–based trophic ecology
  - Elimination of DNA amplification step
  -
  - Evaluation of diet preferences of consumers.

Influential passengers: microbial diversity within multicellular organisms

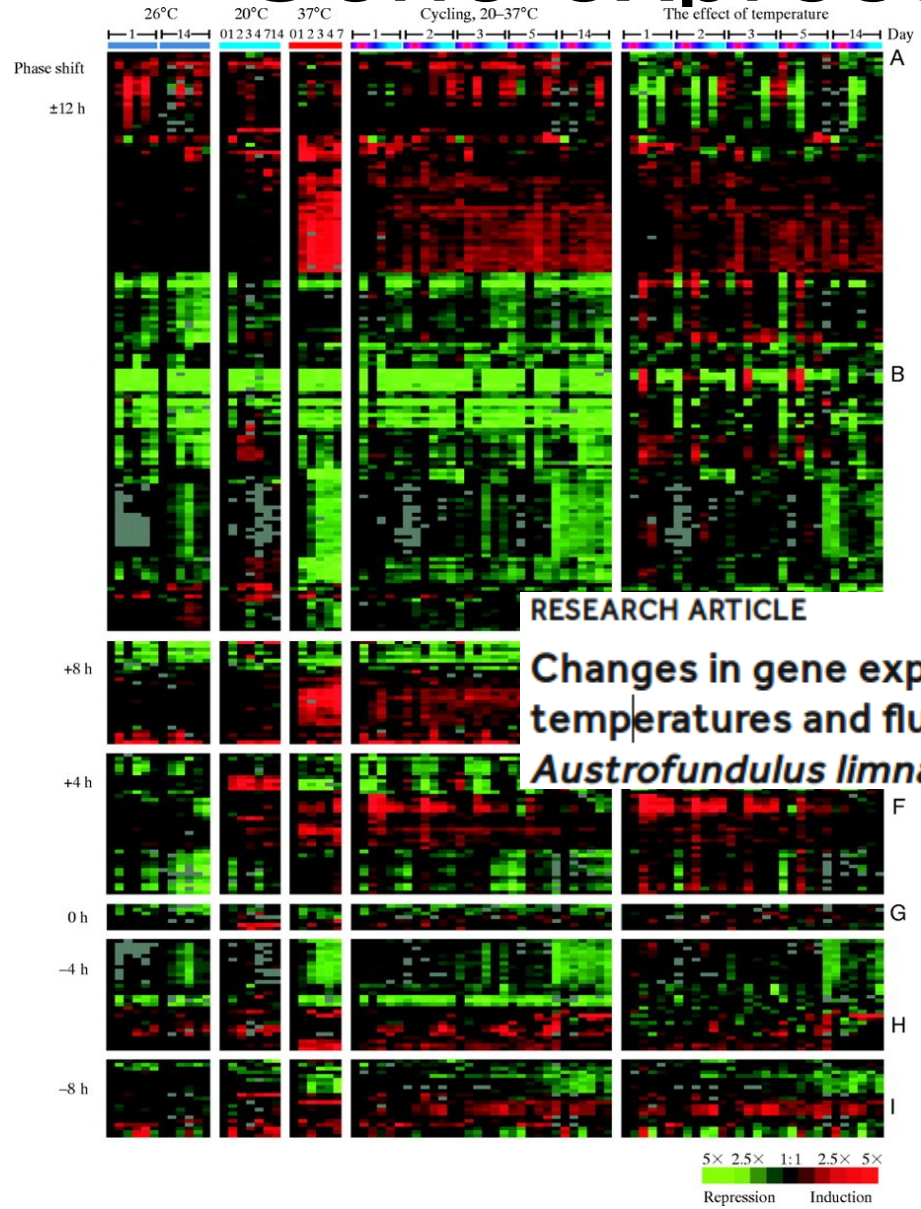
- Cohabiting microorganisms (bacteria, fungi, protists) play diverse roles in the biology of multicellular hosts.


16S (bacteria)
% of 16S reads
ITS (fungi)
% of ITS reads
Rind Type
Rind ID #
Bloomy
Natural
Washed
Bacteria
Firmicutes
Staphylococcus
Actinobacteria
Brevibacterium
Corynebacterium
Brachybacterium
Arthrobacter
Nocardiopsis
Yaniella
Proteobacteria
Halomonas
Psychrobacter
Pseudomonas
Pseudoalteromonas
Vibrio
Hafnia/Serratia
Bacteroidetes
Sphingobacterium
Taxa < 1% ave. abund.
Fungi
Saccharo-mycetales
Debaryomyces
Galactomyces
Candida
Micro-ascales
Scopulariopsis
Hypo-creales
Fusarium
Acremonium
Euro-tiales
Penicillium
Aspergillus
Ony-genales
Sporendonema
Chrysosporium
Taxa < 1% ave. abund.



Visualization of host and associated microbial genomes in two systems.

Gene expression and CGC



RESEARCH ARTICLE

Changes in gene expression associated with acclimation to constant temperatures and fluctuating daily temperatures in an annual killifish *Austrofundulus limnaeus*


Photo by Tony Terceira © 2006



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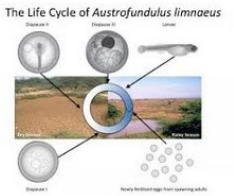
The Life Cycle of *Austrofundulus limnaeus*



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AS © J.F. Fels (pair, male below)

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