The Scope of Evolutionary Ecology

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Biol 417: Evolutionary Ecology

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Evolutionary Ecology

Tinbergen's 4 questions

Niko Tinbergen noted that any biological phenomenon can be describe it in terms of 4 components:

1. Ultimate (evolutionary) explanations
   - 1.1 adaptive function
   - 1.2 phylogenetic history
2. Proximate explanations
   - 2.1 physiological mechanisms
   - 2.2 developmental history

	Dynamic view *Explanation of current form in terms of a historical sequence*	**Static view** *Explanation of the current form of species*
Proximate view ***How*** an individual organism's structures function	**Ontogeny (development)** Developmental explanations for changes in ***individuals***, from DNA to their current form	**Mechanism (causation)** Mechanistic explanations for how an organism's structures work
Ultimate (evolutionary) view ***Why*** a species evolved the structures (adaptations) it has	**Phylogeny (evolution)** The history of the evolution of sequential changes in a ***species*** over many generations	**Function (adaptation)** A species trait that solves a reproductive or survival problem in the **current** environment

— Tinbergen (1963)

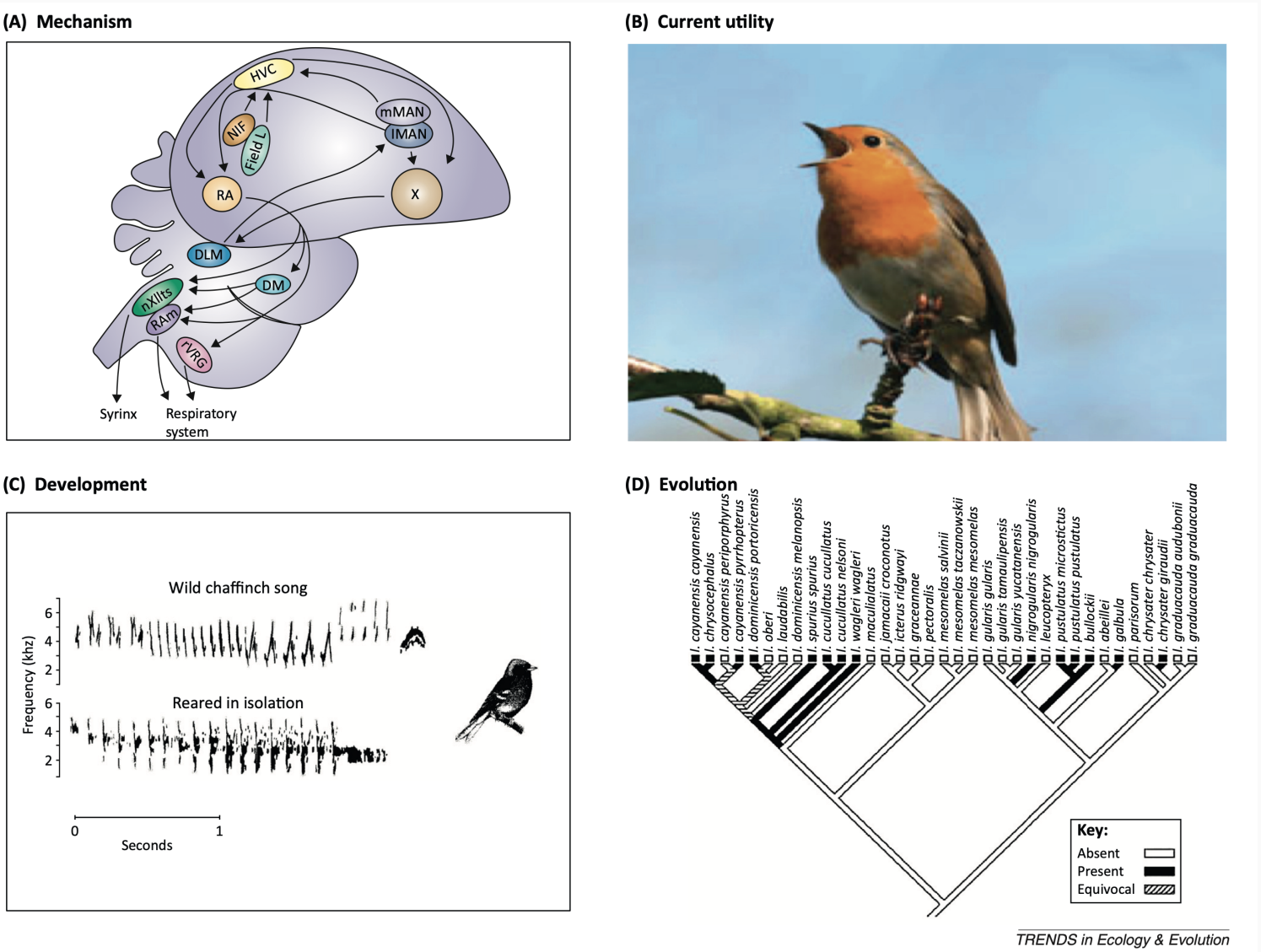
Songbirds and Tinbergen's 4 Qs

Tinbergen argued that we only truly understand a trait if we can fill in this table:

	Dynamic	**Static**
Proximate (How)	Ontogeny (development)	Mechanism (causation)
Ultimate (Why)	Phylogeny (evolution)	Function (adaptation)

... and was awarded a Nobel Prize prize for his work.

Tinbergen's 4 questions cont.



— Bateson & Laland (2013)

Evolutionary ecology

What does this have to do with Evolutionary Ecology?

Evolution

"[A] theory in biology postulating that the various types of plants, animals, and other living things on Earth have their origin in other preexisting types and that the distinguishable differences are due to modifications in successive generations."

— Encyclopedia Britannica

Ecology

"Ecology is the study of the relationships between living organisms, including humans, and their physical environment; it seeks to understand the vital connections between plants and animals and the world around them."

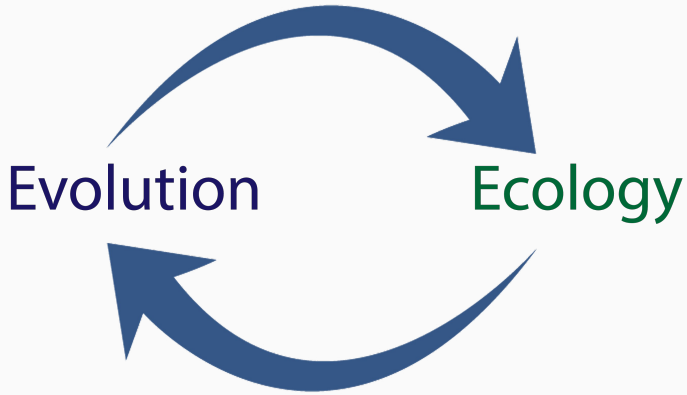
— Ecological Society of America

Evolutionary Ecology

"Evolutionary ecology lies at the intersection of ecology and evolutionary biology. It approaches the study of ecology in a way that explicitly considers the evolutionary histories of species and the interactions between them. Conversely, it can be seen as an approach to the study of evolution that incorporates an understanding of the interactions between the species under consideration."

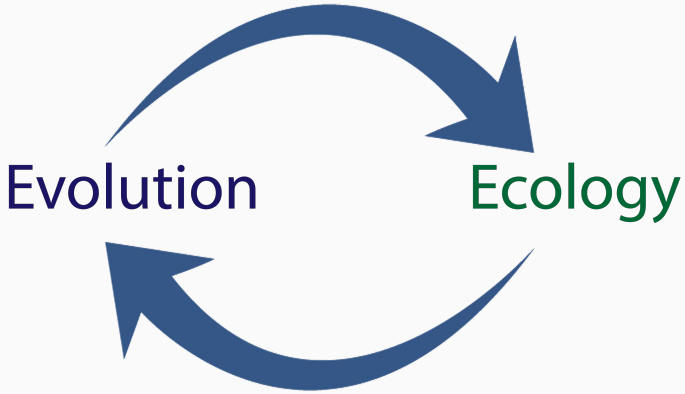
— Wikipedia

Evolutionary ecology cont.[2]



	Dynamic	**Static**
Proximate (How)	Ontogeny (development)	Mechanism (causation)
Ultimate (Why)	Phylogeny (evolution)	Function (adaptation)

Evolutionary ecology cont.[3]



Evolutionary Ecology is focused on providing comprehensive answers to "Why?" questions.

Why are there so many species?

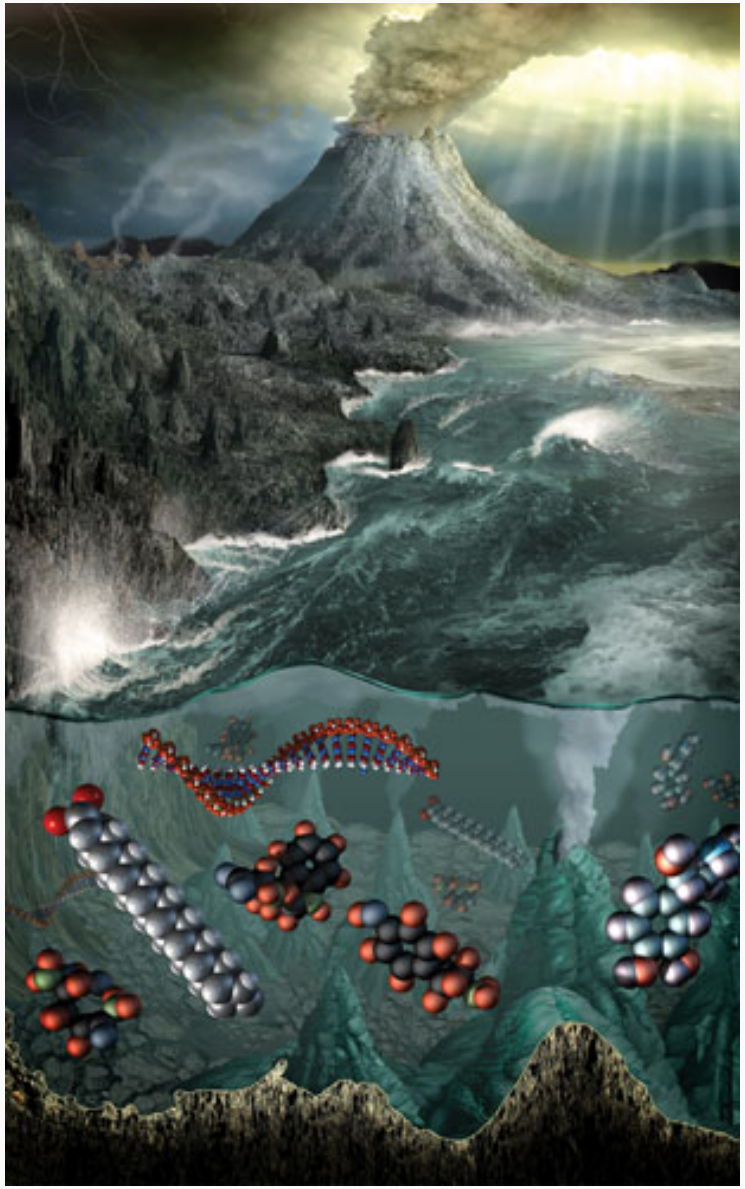
RNA world hypothesis

Source: Science

Life started from self replicating molecules.

— Orgel (2004); Becker *et al.* (2016)

Complexity and variability increased



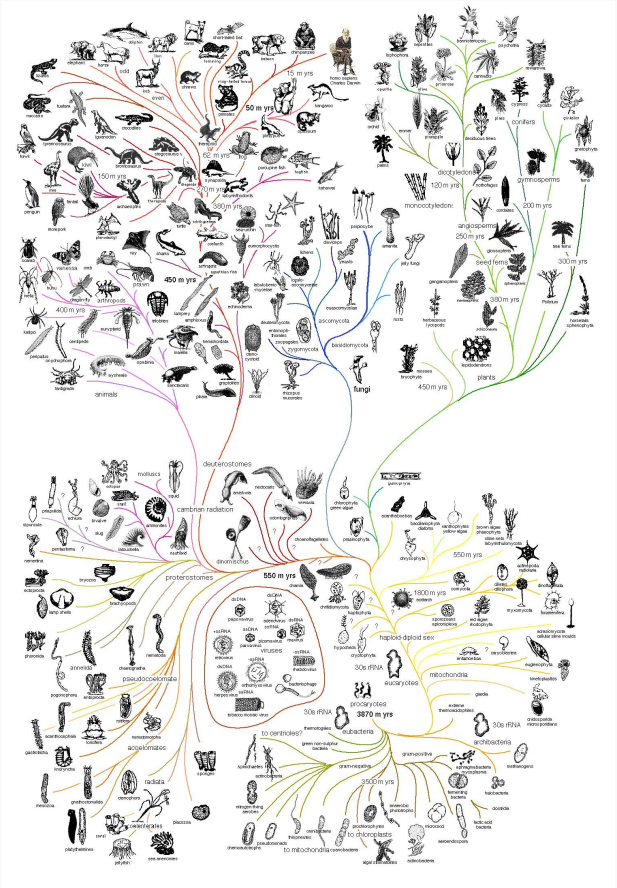
Source: The Scientist

Competition for resources

Source: Henry De la Beche

Life is diverse

Why hasn't one species taken over all of the available matter and energy on Earth?



Source: Chris King

Why are British badgers social?

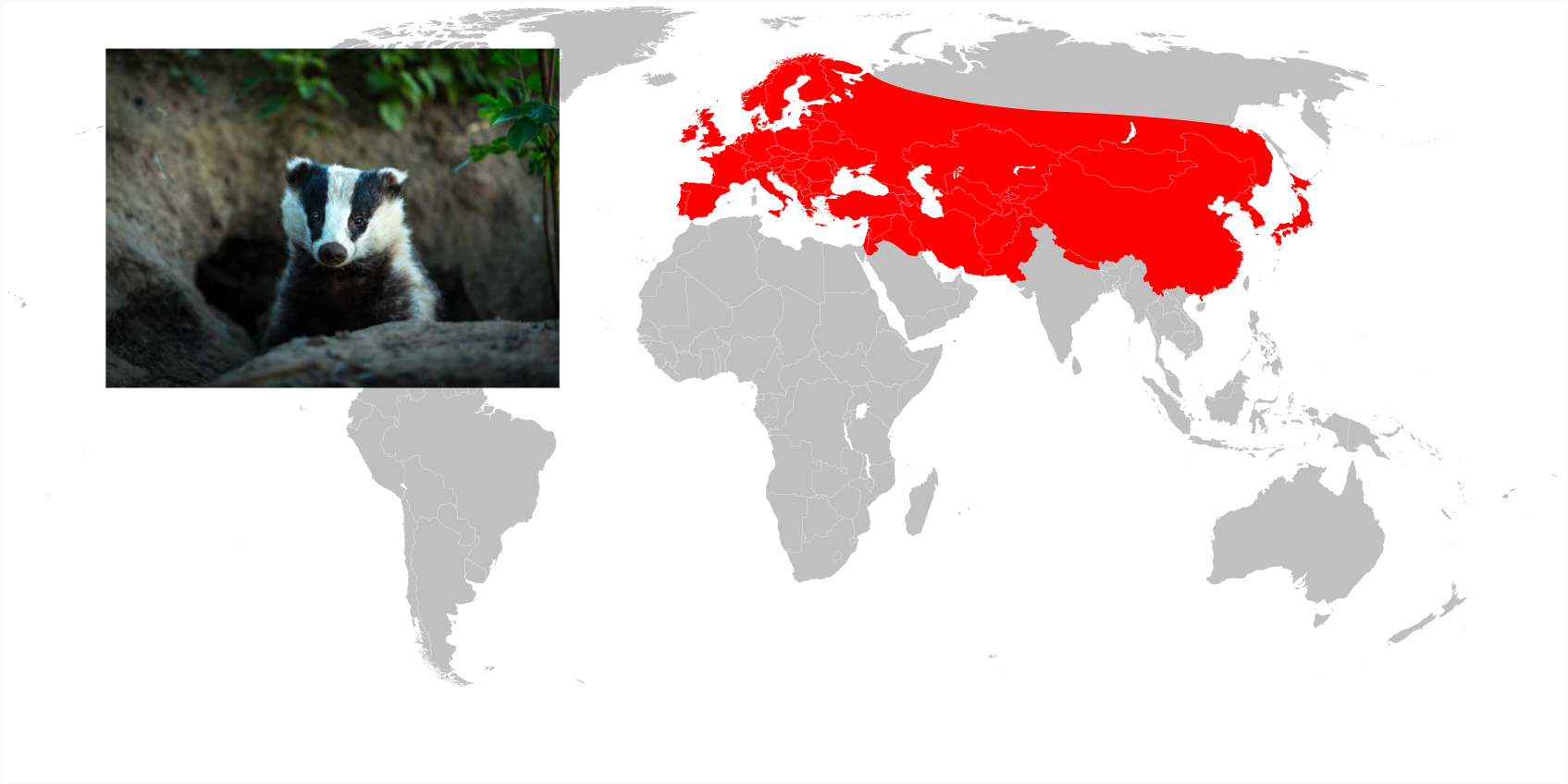
Conditions favouring sociality

Sociality involves sharing resources with conspecifics (food, mates, shelter, etc.), so is only expected to be favoured when the benefits outweigh the costs.

$$\text{Benefits} > \text{Costs}$$

Badgers are solitary by default

Benefits $\not>$ Costs



Source: Wikipedia

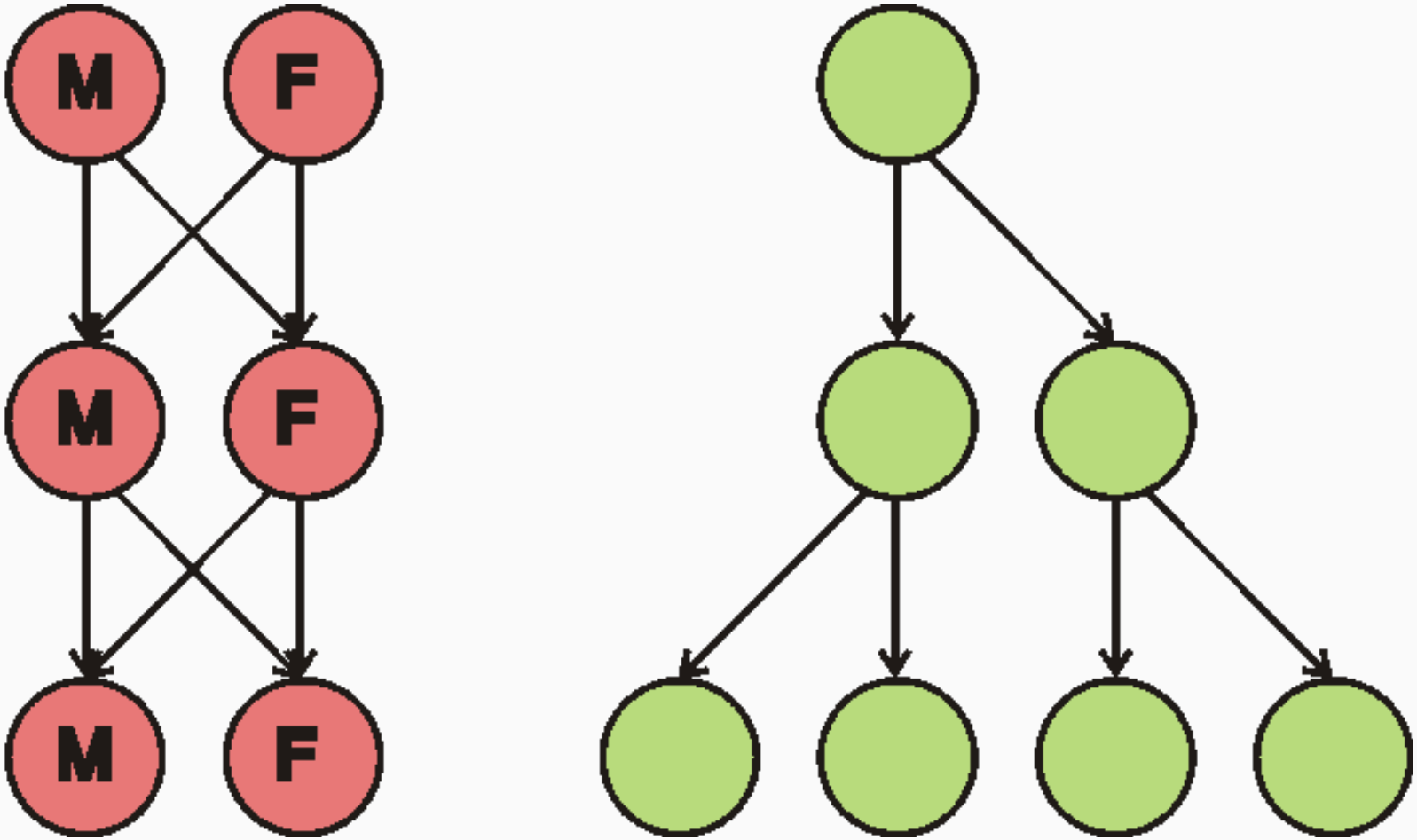
British badgers are group-living

Source: Getty Images

- Don't hunt/forage together
- No alloparental care
- Minimal allogrooming
- No protection from predation
- Mating is completely polygynandrous (both within and between groups)
- Don't maintain exclusive territories

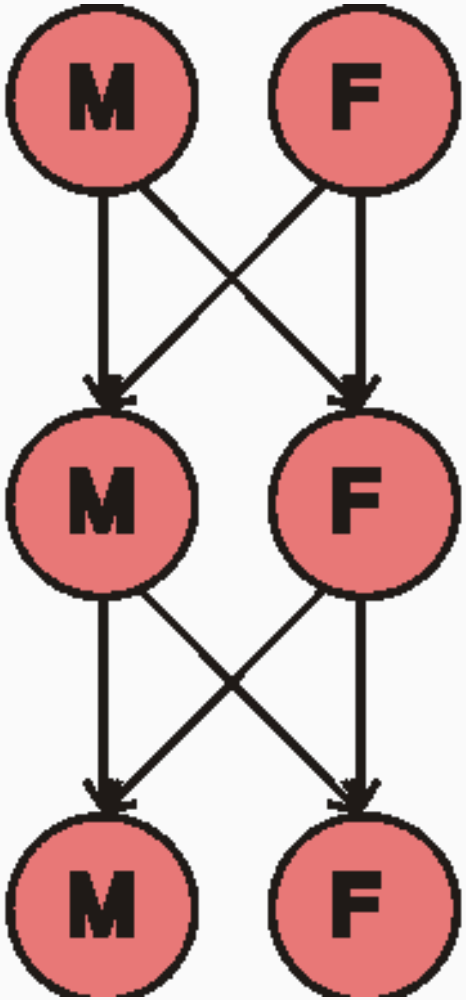
Why does sexual reproduction exist?

Sexual and asexual reproduction



Source: Michael Reeve, CC BY-SA 3.0

Sex is inefficient



Source: Michael Reeve, CC BY-SA 3.0

- Only half of your genes are passed on
- Meiosis is slower and more costly than mitosis
- Reduces linkage disequilibrium
- Requires finding a suitable mate
- Courtship and mating costs
- Small populations are prone to extinction

Why do flowers and pollinators exhibit strong, extreme co-evolution?

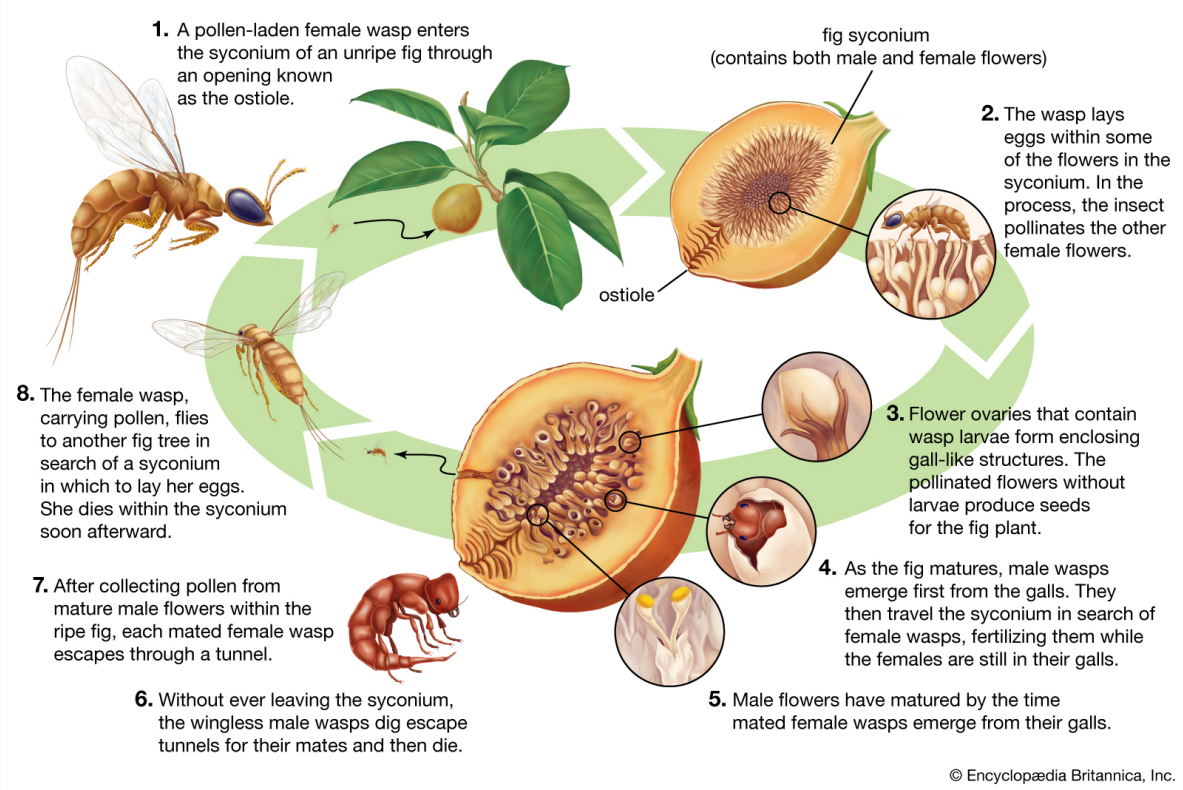
Extreme morphologies

The hawk moth *Xanthopan morganii praedicta* uses a ~30cm long proboscis to feed from the equally long corolla tubes of Madagascar star orchid (*Angraecum sesquipedale*).

Source: Encyclopedia Britannica

Complex, intertwined life cycles

Fig wasps and fig trees have complex, interdependent life cycles, and each species of fig tree has its own species of wasp.



Source: Encyclopedia Britannica

Why do grunions strand themselves on beaches?

Grunion runs

Like clockwork, every lunar high tide (spring tide) grunions (*Leuresthes tenuis*) rush onto beaches in southern California.

Source: Visit Oceanside

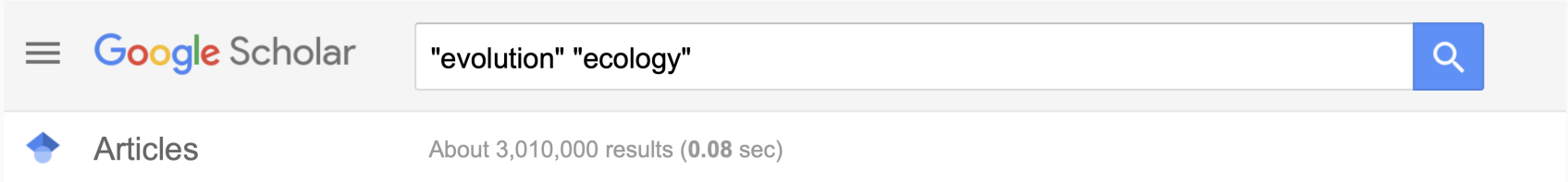
Summary

The living world is highly patterned, and these patterns are complex and dynamic in space and time.

Evolutionary ecology tries to uncover why these patterns exists.

For some of these question we have good answers, for most though we're still working on finding plausible explanations.

...it's a massive field

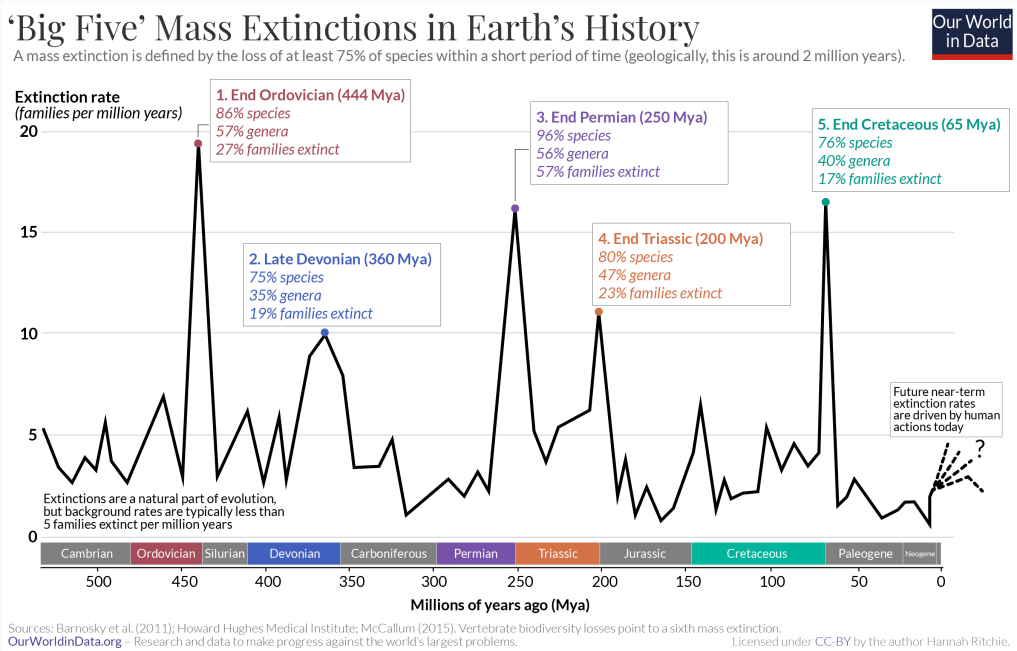


Evolution

"*Nothing in biology makes sense except in the light of evolution*."

— Theodosius Dobzhansky

The Earth is at risk of experiencing another mass extinction event.



Source: Our World in Data

Understanding how and why existing ecological patterns came to be can give us the information we need to help protect species.

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