Model organisms and developmental biology

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Development and the Environment

- It was long thought that the environment played only a minor role in development.
- One reason developmental biologists have largely ignored the environment's effects is that most animals studied in developmental biology—*C. elegans*, *Drosophila*, zebrafish, *Xenopus*, chicks, and laboratory mice—have been selected for their lack of such effects.
- These model organisms make it easier to study the genes that regulate development, but they can leave us with the erroneous impression that everything needed to form the embryo is present in the fertilized egg.

The Environment as a Normal Agent in Producing Phenotypes

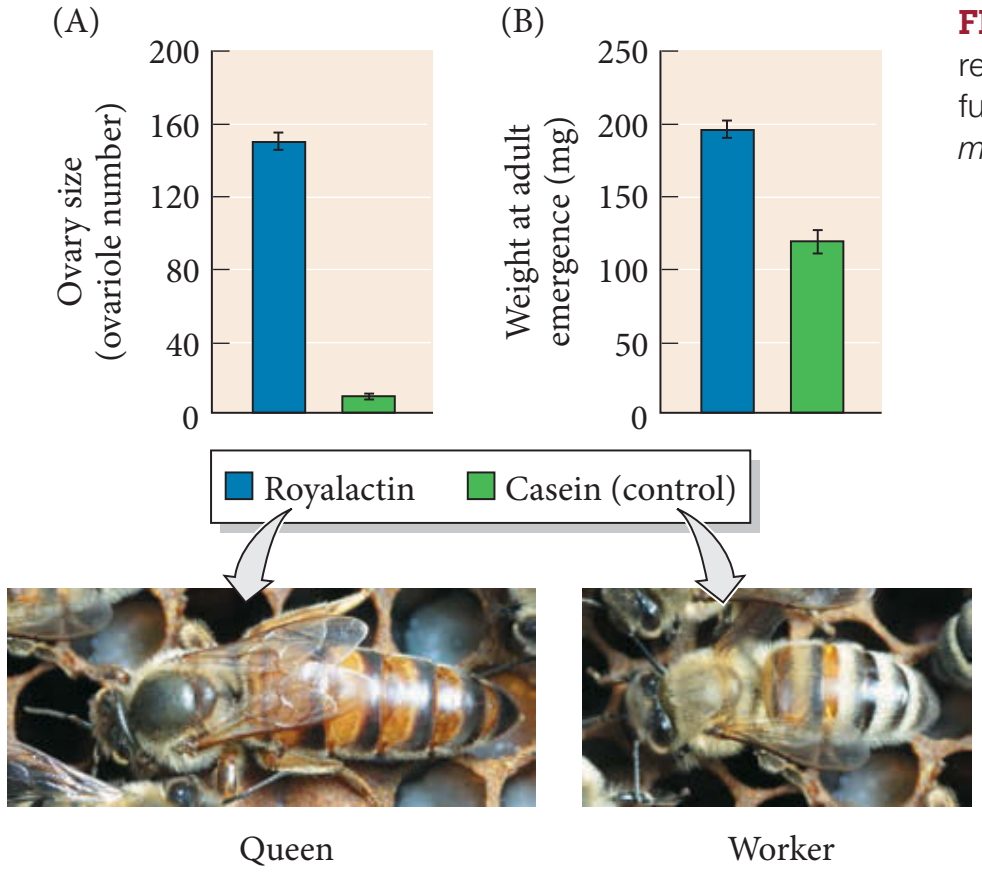
- Diet-induced polyphenisms

(C)

(D)

(E)

(F)



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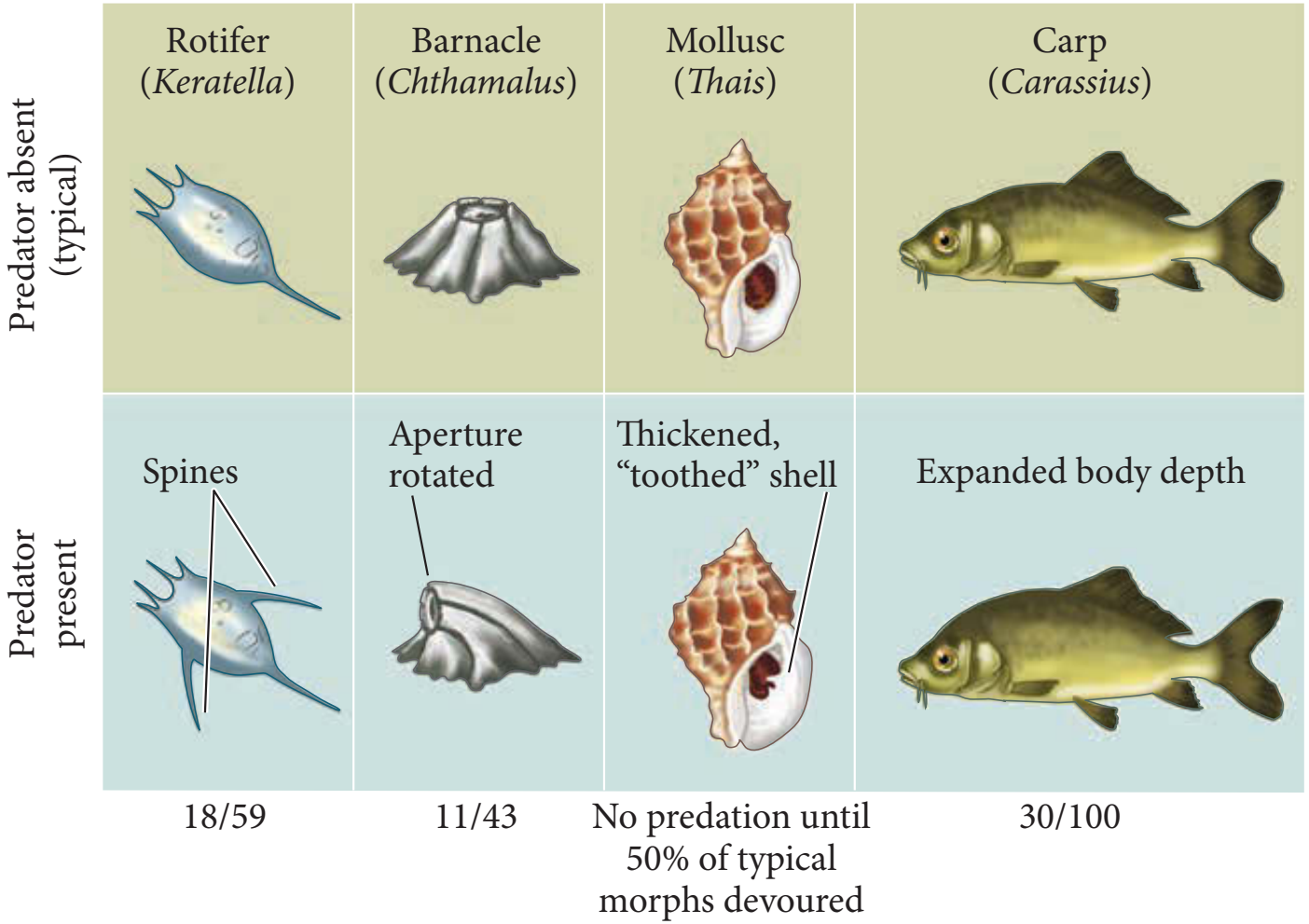
Diet and DNA methylation

These two mice are genetically identical; both contain the *viable-yellow* allele of the *Agouti* gene, whose protein product converts brown pigment to yellow and accelerates fat storage.

Predator-induced polyphenisms

- (1) The induced morph is more successful at surviving the predator.
- (2) Soluble filtrate from water surrounding the predator is able to induce the changes.
- (3) Chemicals that are released by a predator and can induce defenses in its prey are called **kairomones**.

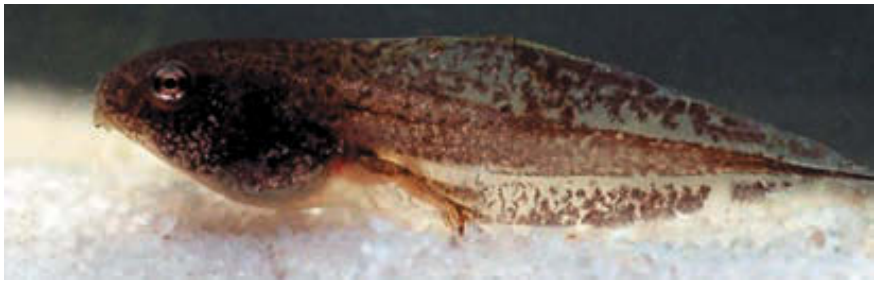
(A)


Predator absent (typical)
Predator present
Rotifer (*Keratella*)
Barnacle (*Chthamalus*)
Mollusc (*Thais*)
Carp (*Carassius*)
Spines
Aperture rotated
Thickened, "toothed" shell
Expanded body depth
18/59
11/43
No predation until 50% of typical morphs devoured
30/100

Amphibian phenotypes induced by predators

(A) Predator present

(B) Predator absent



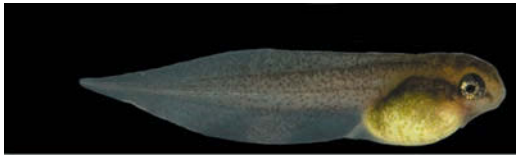
Predator-induced poly- phenism in frog tadpoles. (A) Tadpoles of the tree frog *Hyla chrysoscelis* devel- oping in the presence of cues from a predator's larvae develop strong trunk muscles and a red coloration. (B) When predator cues are absent, the tadpoles grow sleeker, which helps them compete for food. (Photographs courtesy of T. Johnson/USGS.)

Vibrational cues alter developmental timing

Embryos of the Costa Rican red-eyed tree frog (*Agalychnis callidryas*) use vibrations transmitted through their egg masses to escape egg-eating snakes.

(A)

(B)



(C)

B) Immature tadpole, induced to hatch at day 5. (C) A normal tadpole hatches at day 7 and has better-developed musculature. (Courtesy of K. Warkentin.)

Larval settlement of coral larvae

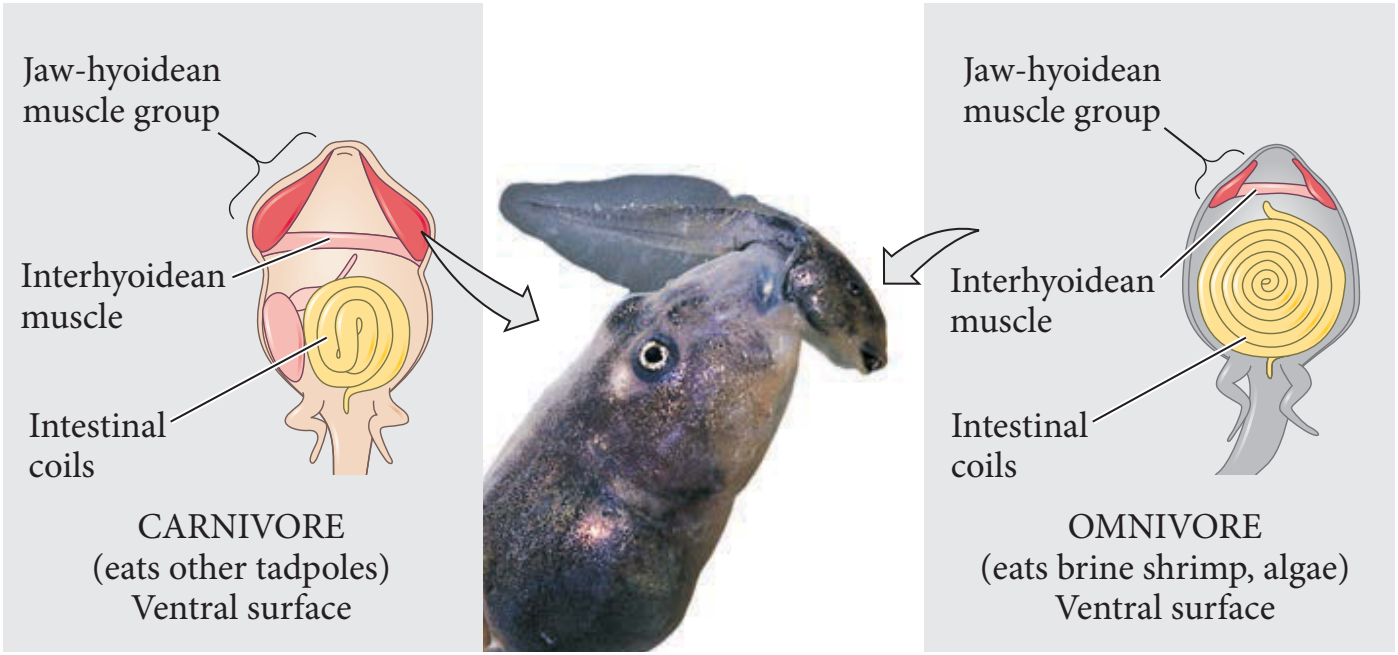
- Most of the cues known for larval settlement of coral reef are chemicals. However, in at least one case, vibrational cues appear to direct marine larvae to coral reefs.

- Coral reefs are the largest biological structures on Earth, and they grow by recruiting planktonic coral (cnidarian) larvae. While chemical cues work within a small distance of the reef, it is the “noise of the reef”—the snapping of **shrimp claws** and the noises made by thousands of **reef fish**—that attract coral larvae from long distances.

The hard life of spadefoot toads (*Scaphiopus hammondi*)

- The timing of their metamorphosis is controlled by the pond. If the pond is drying out and getting smaller, some of the tadpoles embark on an alternative developmental pathway. They develop a wider mouth and powerful jaw muscles, which enables them to eat (among other things) other *Scaphiopus* tadpoles.

- The signal for accelerated metamorphosis in *Scaphiopus* appears to be the change in water volume. In the laboratory, *Scaphiopus hammondi* tadpoles are able to sense the removal of water from aquaria, and their acceleration of metamorphosis depends on **the rate at which the water is removed.** The stress-induced corticotropin-releasing hormone signaling system appears to modulate this effect.



Polyphenism in tad- poles of the spadefoot toad *Scaphiopus couchii*. The typical morph (right) is an omnivore, feeding on arthropods and algae. When ponds are drying out quick- ly, however, a carnivorous (cannibalistic) morph forms (left). It develops a wider mouth, larger jaw muscles, and an intes- tine modified for a carnivorous diet. The center photograph shows a cannibalistic tadpole eating a smaller pondmate.

Thanks!