Levels of Analysis Quiz

1. Hummingbirds possess a red photoreceptor that allows them to discriminate red flowers from orange ones.

2. When reared under crowded conditions, lemmings are more likely to engage in dispersal behavior than when reared alone.

3. Male deer with large antlers tend to win more contests, secure more matings, and thus sire more offspring than males with small antlers.

4. Butterflies learn to avoid a spot where they have been caught in a net and released.

5. Cave-dwelling fish and crayfish are often blind, suggesting that loss of eye function in cave animals has arisen independently a number of times.

6. The flash of light that ‘flashlight fish’ generate involves production by symbiotic bacteria of an enzyme known as luciferase.

Levels of Analysis Quiz Answers

Mechanism

Development

Function

Evolution

In reality, science involves all of the levels, interacting with each other.
Mechanism can inform Function.

Warning coloration is conspicuous coloration that warns predators that an animal is toxic or otherwise well-defended.

Myotoxia millipedes

Dendrobates poison frogs

Monarch butterflies (Danaus plexippus)

Warning displays can be multimodal

Warning color and warning sound

Are autumn colors a warning?

W.D. Hamilton proposed that autumn foliage is brilliantly colored as a warning to herbivorous insects that the foliage is poor in quality.
Two Suppositions
1. Fall colors are conspicuous to aphids.
2. Fall colors repel aphids.

Information about aphid vision (= mechanism) does not support this hypothesis.

Aphids have three photoreceptors for detecting color. Ultraviolet, blue and green receptors

What wavelengths are reflected by foliage?

How much do these colors excite the photoreceptors?

Red is hardly stimulated at all.
Yellow is stimulated a lot.

Trapping study shows that red is not attractive, while yellow is highly attractive.
Fall Colors = Warning Coloration?

NO...
Red... Red repels but is not conspicuous.
Yellow... Yellow is conspicuous, but attracts.

Q: Why is yellow attractive?
A: Aphids prefer young foliage. Young foliage is light green because it has more yellow in it (due to carotenoids).

Function can inform Mechanism.
The observation that bats had functional flight in complete darkness stimulated a search for an underlying mechanism.

Lazzaro Spallanzini, 1790's
- Blinded bats, but bats still returned to belfry.
- Blocked nose with wax, bats returned no problem.
- Placed transparent hood over head, bats had problems flying even in daylight.

Spallanzini postulated a 'sixth sense'.
Charles Jurine, late 1790’s

- Blocked ears with wax, bats could not navigate.
- Spallanzini followed up with brass tubes in ears. Flight disturbed only if brass tubes were blocked.
- Sense of hearing was involved.

Georges Cuvier, 1800

- One of the most famous early naturalists
- Did not agree with Jurine’s conclusions.
- Proposed instead that sense of touch was involved.

“Since bats see with their ears, do they hear with their eyes?”
— Montagu 1809

Time passes...

Donald Griffin, 1930’s forward

- Showed that a room with bats was filled with ultrasound.
- Tied mouth closed and bats failed to navigate properly.
- Plugged ears and bats failed to navigate properly.

Ergo, bats were using echoes of emitted sound to navigate around obstacles. = echolocation!
In *Myotis* bats, mouth is always open during flight.

Griffin’s results

<table>
<thead>
<tr>
<th>Number of Bats Used</th>
<th>Experimental Treatment</th>
<th>Experimental Number of Flights</th>
<th>Average % Misses</th>
<th>Control Number of Flights</th>
<th>Average % Misses</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Both ears covered (controls untreated)</td>
<td>5,016</td>
<td>70%</td>
<td>3,001</td>
<td>70%</td>
</tr>
<tr>
<td>12</td>
<td>Both ears covered (controls untreated)</td>
<td>1,047</td>
<td>35%</td>
<td>1,037</td>
<td>26%</td>
</tr>
<tr>
<td>9</td>
<td>Ears and eyes covered (controls with only the eyes covered)</td>
<td>654</td>
<td>31%</td>
<td>832</td>
<td>26%</td>
</tr>
<tr>
<td>8</td>
<td>Glass tubes in ears and closed (controls with the same tubes in ears but open)</td>
<td>580</td>
<td>35%</td>
<td>636</td>
<td>26%</td>
</tr>
<tr>
<td>12</td>
<td>Both ears covered (controls with one ear covered)</td>
<td>833</td>
<td>29%</td>
<td>580</td>
<td>30%</td>
</tr>
<tr>
<td>6</td>
<td>Ears and one ear covered (controls with only the eye covered)</td>
<td>350</td>
<td>41%</td>
<td>390</td>
<td>26%</td>
</tr>
<tr>
<td>7</td>
<td>Mouth covered (controls with eyes covered, or intact)</td>
<td>549</td>
<td>35%</td>
<td>441</td>
<td>30%</td>
</tr>
</tbody>
</table>

(Review and think about treatments and results!)

Bats can assess:
- Target range
- Relative motion
- Size of target
- Shape of target
Doppler shift has information about relative motion.

Form (= Mechanism) and Function

Nose leaf and ear diversity

Call form fits foraging style
Some moths have ears that hear ultrasound.
Faint ultrasound causes them to turn away (right)
Loud ultrasound causes them to drop (middle)

Tiger moth emits ultrasonic clicks that jams the bat’s sonar.
A noxious moth emits ultrasonic sounds that bat learns to avoid.

A palatable moth emits ultrasonic sounds that mimic the sounds made by the noxious moth! = Batesian mimicry

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Not just moths! Some katydids hear the ultrasonic pulses of ‘gleaning bats’, and stop singing to prevent bats from eavesdropping.
Bats and insects seem to be evolving in response to one another. = coevolution

In this case, a coevolutionary 'arms race'

Can we demonstrate such evolution? How?

From Darwin's Voyage of the Beagle

One sub-family of day-flying moths has ears but has lost the ability to hear ultrasound.

Mechanism ↔ Development

Function ↔ Evolution

Bat echolocation research is proceeding on all fronts, and being integrated.