Review of Important General Concepts from Crickets

1) Sound production involves interactions between peripheral sound-generating structures and CNS control over these structures.

2) Sound motor output is hierarchically organized. Decision $\rightarrow$ command $\rightarrow$ pattern generation $\rightarrow$ muscle contraction.

3) Stereotyped motor output is often under the control of central pattern generators (CPGs) that operate in the absence of any additional input. (CPG is a cellular/circuit oscillator)

4) CPGs may be activated by 'command neurons', which are defined as both necessary and sufficient for production of the behavior.

5) Vocal communication signals may be genetically controlled and tightly linked to the genetics of the auditory system.

6) Cricket sound production is used to attract mates and recognize conspecifics, but singers are vulnerable to parasitism.

Birdsong: The vocal apparatus

- A description of song
- Function of song.
- How songs are made
- Neural control of song production
- Neural correlates of motor control
Birdsong Rationale

- Birdsong is stereotyped behavior.
- Repetitive. Easily recorded, can be quantified.
- Has been an ethological tradition since William H. Thorpe (1951, 1954, 1958) made thorough review of song learning and introduced Chaffinch as an early model system of learning.
- Peter Marler.
- Is controlled by specialized neural circuits.
- Is learned (among passerines, parrots, hummingbirds).
- Is sexually dimorphic. Sexually dimorphic neural circuits/brain areas.
- Is controlled by gonadal steroids which affect song development.
- Is plastic, even amongst adults, which show extensive neurogenesis (birth of new nerve cells).
- Is species specific: comparative studies are de rigueur for studies of birdsong.
### Songs
- long (>2 s)
- repetitive
- loud
- spontaneous
- from song perches
- usually males
- mostly passerine

### Calls
- short
- bursts, not repetitive
- loud or soft
- stimulus specific,
- anywhere
- male or female
- all birds

The sound spectrograph shows a hierarchy of song elements.

- **notes**: continuous trace on sound spectrograph
- **syllable**: natural collection of notes.
- **phrase**: repeated syllables.
- **song**: series of phrases taken together.

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**Song Function**

**Territorial defense**
- announce territory ownership for purposes of aggressive exclusion.
  - muting lowers success in deterrence
- both sexes may sing

**Mate Attraction**
- song is more common during breeding season, and prior to mating.
- song stimulates female reproductive responses

**Song Repertoires**

<table>
<thead>
<tr>
<th>Bird</th>
<th>Repertoire</th>
</tr>
</thead>
<tbody>
<tr>
<td>White-crowned sparrow</td>
<td>1 song type</td>
</tr>
<tr>
<td>Bewick’s wren</td>
<td>10-20 song types</td>
</tr>
<tr>
<td>Winter’s wren</td>
<td>100-200 songs</td>
</tr>
<tr>
<td>Long-billed marsh wren</td>
<td></td>
</tr>
<tr>
<td>western population</td>
<td>150</td>
</tr>
<tr>
<td>eastern population</td>
<td>75</td>
</tr>
<tr>
<td>Brown thrasher</td>
<td>2000+</td>
</tr>
</tbody>
</table>

**What is the repertoire of bird sounds?**

White crowned sparrow
- 1 song
- many notes, many of uncertain function
How do birds make sounds?

Vocal organ is the syrinx, located at the junction of trachea and bronchi. Recall, in birds, lung is a 'flow-through' organ (air taken into air sacs is expelled through the lung.).

Sound and the Syrinx

Specialized junction between two bronchi.

**Old Theory:** medial tympanic membranes vibrate when air sacs exert pressure and there is air flow.

Old Theory of Sound Production

Medial tympanic membrane, under pressure from the interclavicular air sac, stretches into the bronchus, partially restricting air flow. Air flow induces vibration in the membranes (generates the sound). Tension on muscles, tighten the membrane, increasing the vibration frequency. But... if membranes touch opposite wall, vibration will not be sinusoidal, thus overtones (H. C. Greenwalt believed that vocal tract does not act as a resonant filter).

6 pairs of Muscles of the syrinx:
- **extrinsic:** ST (sternotrachealis) TL (tracheolateralis)
- **intrinsic:** 4(9) pairs that all originate on the tympanum, and insert on various bronchial rings.

OLD MODEL of Syrinx Function
A new mechanism of sound production

Goller, F and Larsen ON (1997).

Lesion of the medial tympaniform membrane has no effect on song.

Endoscopic visualization shows the importance of the lateral labia and medial labia in vocal production.

Goller and Larsen (2001)

Endoscopic visualization shows movements of lateral and medial labia.

a) respiration
b) strong stimulation
c) labia near close aperture
d) respiration again
e) respiration
f) stimulated
g) stimulation of on vTB

Endoscope shows movements of lateral and medial labia.

Larsen & Goller (2002) JExpBiol. 205(1) 25

Does the vocal tract act like a resonator?

Q? Does the vocal tract of bird act like a resonator (like a tuned pipe)

If yes, then two different resonant frequencies are impossible (unless harmonically related).

Helium experiments (Nowicki) uncovers higher harmonics when singing in light air (implies some filtering in normal air)

Birds are capable of singing two unrelated notes at once (implies no resonance)

Vocal tract resonances in oscine bird sound production: evidence from birdsongs in a helium atmosphere.