zyotic degradation have been developed. One in particular, extrotolite, introduced in 1982 is now in widespread use for treatment of diarrhea and flushing in carcinoid tumor; for diarrhea in vaustastic polyoid peptide secreting tumors of the pan-
cr, for glucagonomas, and for growth hormone secreting tu-
mors of the pituitary which have failed treatment by other meth-
ods. Such analogs, coupled to radioactive tracers such as tech-
necium or Indium have been used to visualize virtually all
neuroendocrine tumors, most functioning pituitary tumors and
medullary thyroid carcinomas. Most surprisingly, several kinds of
including small cell carcinoma of the lung, breast carcinoma and Hodgkin's lymphoma can also be visualized by these
techniques thus improving markedly the ability to iden-
tify location, and stage the severity of the disease by external,
non-invasive imaging methods.

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See also Enteric nervous system; Growth hormone; Neuropeptides and behavior; Pain, chemical neurotransmitters; Neuropeptides. Re-
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Sound communication in anurans (frogs and toads), neuroethology of H. Carl Gerhardt

Males of most species of anurans produce intense vocalizations, with sound pressure levels as high as 100-110 deci-
bels at a distance of 50 cm. Calls range from short clicks to signals that are acoustically complex in their spectral
structure (many frequency components that may be frequency-
modulated), temporal structure (pulses, two-part calls), or both.
Such advertisement calls are usually produced in breeding ag-
gregations, or choruses, and both attract gravid females and me-
diate intermale spacing or territorial defense (Gerhardt, 1994).
In many species, females initiate mating (ampules) with vo-
calizing males, which indiscriminately attempt to mate with
other frogs of comparable size that move nearby. In the bull-
frog (Rana catesbeiana), males distinguish between the calls of
territorial neighbors and those of unfamiliar males.
Some properties of advertisement calls, termed static prop-
erties, are highly consistent from one call to the next, whereas
other properties, termed dynamic properties, may vary consid-
ervably from call to call. Females usually prefer values of static
properties, such as pulse-repetition rate (pulse rate) and domi-
nant frequency, that are close to the average in the population.
In contrast, females often show preferences for extreme values
of dynamic properties, such as call duration and call rate (Ger-
hardt, 1991). In some species, call duration and rate are corre-
lated with the energetic costs of calling, which are considerable;
Acoustic metabolic rates during calling may exceed 20 times resting rates. Some males are likely to have enhanced mating success because they produce calls with the highest values of static or dynamic properties than other males; selective phonotaxis by females also ensures that mating mistakes with males of other species are rare.

The external tympanic membranes (cardrams) of most anurans are drawn into motion by only a sound waves that strike their external surface but also by wave arriving at their internal surface from the contralateral side. The net cardram movement varies with the distance taken by the external and internal sound waves; the amplitude and phase of the internal waves are altered as they travel through internal pathways. The path length difference, in turn, depends on the direction of the sound source. Because this difference will not be the same for the two ear unless the sound source is directly in front or behind the animal, such an arrangement, termed a pressure difference, system can generate relatively large interaural differences. Such a mechanism is probably used by anurans and other small animals to locate communication signals, which often have relatively long wavelengths that would produce no interaural binaural differences in intensity and only minimal interaural time differences (Jørgensen, 1991). Trenches also house elevated sound source, but the mechanisms underlying its ability remain unknown.

Vibrations of the tympanic membrane are conducted via the stapes to the fluid-filled inner ear; low-frequency sounds and vibrations may also arrive at the inner ear via an extra tympanic pathway involving the operculum system, which is found exclusively in amphibians. The amphibian papilla (AP) is the more complex of the two main auditory organs in the inner ear and consists of many more hair cells than the benjamin (Briggs and Jennings, 1990). The AP depends on both its intrinsic electrical properties and mechanical factors, whereas the BP is a simpler structure in which hair cell tuning seems to depend exclusively on mechanical factors (Feng et al., 1990; Narins, 1992). If there is a single frequency peak visible on each side of the AP, most amphibian species are one of these organs usually corresponds roughly to the same frequency band. If the call has a bimodal spectrum, then the maximum sensitivity of the AP corresponds to the low-frequency peak, whereas the BP exhibits the higher frequency peak. Although information from both papilla can be processed in the brain nuclei (dorsal lateral and superior olivary nuclei) and in the midbrain within the ascending auditory pathway, the response properties of the posterior medulla of the auditory thalamus are particularly well correlated with behavioral selectivity to bimodal calls; both frequencies emphasized in the advertisement call and which stimulate the two auditory organs simultaneously are far more consistent with the foundation by other frequency in isolation (Feng et al., 1990).

Primary auditory neurons inverting both auditory organs show synchronized responses to low-frequency sounds or to the envelope of amply-modulated (AM) sounds, such as the pulsed advertisement calls typical of many anuran species. Significant synchronization (increased probability of firing at a particular phase of an AM stimulus) may be detected up to AM rates of 100 Hz, but there is no evidence for a bias to any particular rate (Narins, 1992). However, there is a progressive transformation of the synchronization code to a rate code in the ascending pathway. In particular, barn owl neurons, which fine maximally to a particular AM rate and less well to lower and higher rates, are common in the large midbrain homolog of the mammalian inferior colliculus, the ventrosemiticularis, and in the central nucleus of the thalamus (Feng et al., 1990; Rose et al., 1985). In some species, many bird-pass neurons are tuned by AM rates corresponding to pulsed tones of typical of conspecific calls, but in others, there is no such bias. In the frog, tending temperature increases shift both the pulsed gaps in male calls and female references for synthetic calls differing in pulse rate to higher values; tuning of band-pass neurons is similar to temperature-dependent (Rose et al., 1985).

Very few hand-pass neurons are tuned to both species-specific spectral properties and pulse rate. Anatomical and physiological studies suggest instead that these acoustic properties may be processed in a parallel fashion, as exemplified by the segregation of tri-habitation selectivity in the posterior thalamic nucleus [Hall and Feng, 1987].

Little is known about the function of the highest auditory center in anurans, the striatum of the telencephalon, which is probably homologous to the mammalian basal ganglia. This is a multi-sensory center, which does not even receive inputs from the posterior thalamic nucleus and which contributes many fibers to descending pathways that form a feedback loop as auditory nuclei in the brainstem. These are also extensive connections to thalamic and telencephalic nucleus and hormone-concentrating nuclei in the diencephalon.

The striatum’s main function may be to regulate long-term motivational changes rather than sensory processing that controls selective phonotaxis.

References

Further reading

See also Insect communication, interspecific, Neuroethology, vertebrates, auditory system, brainstem, evolving concept: tectum model.