The cochlear nucleus is the site of termination of fibres of the auditory nerve.
Each auditory-nerve fibre responds only to a narrow range of frequencies.

Evans 1975
There are many overlapping single-fibre tuning curves in the auditory nerve.
Tonotopic Organisation

Anterior Base Cochlea Basilar Membrane Hair Cells Apex Spiral Ganglion Auditory Nerve Posterior Cochlear Nucleus

Characteristic Frequency

Posterior Cochlear Nucleus Auditory Nerve Axon Apex

Evans 1975

Tonotopic projection of auditory-nerve fibers into the cochlear nucleus

Ryugo and Parks, 2003

The cochlear nucleus: the first auditory nucleus in the CNS

Evans 1975

Position along electrode track (mm)
Physiological Classification of Cochlear Nucleus Neurones
LATERAL INHIBITION IN THE DORSAL COCHLEAR NUCLEUS

Inhibitory side band

Palmer 1977

Stabler 1991

Stabler 1991
Fig 4.4. Distribution of best thresholds of auditory nerve fibres in one cat. Fibres with high spontaneous firing rates (\(S > 35\)) have low thresholds, and those with low spontaneous firing rates (\(S < 0.3\)) have high thresholds. Fibres with intermediate spontaneous firing rates (between 0.3 and 35) have thresholds in between. The behavioral absolute threshold of the cat, expressed in terms of the intensity at the ear, is just below the lowest thresholds of the auditory nerve fibres. Neuronal data from Listerman and Kiang (1978, Fig. 2). Behavioral data from Elston et al. (1990).
At each frequency, auditory nerve fibres differ in their spontaneous rate, input/output function and dynamic range - these covary.

Winter and Palmer

Sachs and Abbas 1974

Galambos and Davis 1943
Timing
Peri Stimulus Time Histograms
When a novel stimulus occurs within a frequency channel the discharge rate is immediately increased and then falls (adapts) over a few tens of milliseconds.

Kiang et al. 1965

Winter and Palmer
Temporal Responses of the Principal Neurones of the Cochlear Nucleus to pure tones

Types of neurones in the cochlear nucleus
To medial superior olive: information about sound localization using timing (and possibly time coding of speech).

To inferior colliculus: information about pinna sound transformations.

To lateral superior olive: information about sound level and voice pitch.

To inferior colliculus: information about complex sounds (possibly place coding of speech).

Input from cochlear nerve.

To lateral nucleus of the trapezoid body: information about sound localization using interaural intensity.

To inferior colliculus: information about complex sounds (possibly place coding of speech).

Osen 1969
The discharges of cochlear nerve fibres to low-frequency sounds are not random; they occur at particular times (phase locking).

Evans (1975)

Enhancement of synchronization in Globular Bushy Cells

Joris et al. 1994
Enhancement of synchronization in Spherical Bushy Cells

PARALLEL PROCESSING OF INFORMATION IN THE COCHLEAR NUCLEUS

To medial superior olive: information about sound localization using interaural intensity

To lateral superior olive: information about sound localization using interaural intensity

To medial nucleus of the trapezoid body: information about sound localization using interaural intensity

To inferior colliculus: information about complex sounds (possibly place coding of speech)

Either commissural or to inferior colliculus: information about sound level and vocal pitch

To inferior colliculus: information about pure sounds

Input from cochlear nerve

Type T Multipolar Cells

Lorente de Nó
Generation of vowel sounds

At low sound levels steady-state vowels are well represented in the mean discharge rate of the population of auditory nerve fibres.

Sachs and Young, 1979

At higher sound levels the representation of the formant frequencies becomes less distinct.

Sachs, Young and Colleagues
Theoretical computations, based on optimally weighting the different spontaneous rate populations, reveal that mean rate alone may contain sufficient information even at high sound levels.

Delgutte, 1996

Selective listening

Two populations of cochlear nucleus stellate cells retain vowel formant information in their discharge rate at high sound levels.

Lai, Winslow and Sachs, 1994

Blackburn and Sachs, 1990
To medial superior olive: information about sound localisation using timing (and possibly time coding of speech)

To inferior colliculus: information about pinna sound transformations

To lateral superior olive: information about sound localisation using interaural intensity

Either commissural or to inferior colliculus: information about sound level and voice pitch

To inferior colliculus: information about complex sounds (possibly place coding of speech)

Input from cochlear nerve

To lateral superior olive: information about sound localisation using interaural intensity

To medial nucleus of the trapezoid body: information about sound localisation using interaural intensity

Type D Multipolar Cells (commissurals)

Physiological Responses before injection

Onset-C Unit BF 6.29 kHz
Onset-C Unit BF: 6.29 kHz

Kim and Leonard, 1988

Onset unit
Chopper unit
Primarylike unit
Cochlear nerve fibre

Kim and Leonard, 1988
To medial superior olive: information about sound localisation using timing (and possibly time coding of speech)

To inferior colliculus: information about pinna sound transformations

To lateral superior olive: information about PARALLEL PROCESSING OF INFORMATION IN THE COCHLEAR NUCLEUS

Either commissural or to inferior colliculus: information about sound level and voice pitch

To inferior colliculus: information about complex sounds (possibly place coding of speech)

Input from cochlear nerve

To lateral superior olive: information about sound localisation using interaural intensity

To medial nucleus of the trapezoid body: information about sound localisation using interaural intensity

Pinna Cue Pathway

Dorsal Cochlear Nucleus

Bipolar

Large Multipolar

Giant

Dorsal Cochlear Nucleus

Oertel and Young, 2004
Temporal Responses (PSTHS) in Dorsal Cochlear Nucleus

Moore and King 1999

Monaural spectral localization cues

Moore and King 1999

Responses of a Type IV DCN units to sharp spectral edges

Reiss and Young 2005
Cells sensitive to sharp spectral notches

Input from somatosensory system possibly involved in compensation for pinna and head position
Summary of Cochlear Nucleus Responses

The cochlear nucleus consists of three parts each of which is tonotopically organized.

The cochlear nucleus contains several major cell types that project to other brain areas.

As a result of their interconnections, biophysics and input from the auditory nerve these cell groups reprocess the auditory nerve activity for different features of the incoming sounds.