

A Glossary of Hearing

Appendix A

This Glossary is a record of the paradigm shift in the hearing sciences cataloged in the accompanying text. The definitions provided here take precedence over other definitions in the literature. Prior to the general glossary, the following table, expanded from Gulick, Gescheider & Frisina (1989), summarizes many of the terms used in Hearing based on their ancient language roots.

Roots of common anatomical terms

Root	Meaning	Example
Brachium (Lat.)	Arm	Brachium pontis
Caecum (Lat.)	Cavity with one opening	Vestibular caecum
Calyx	A cup-like feature	Calyx of Held
Cephale (Gk.)	Head	Cephalic
Cilium (Lat.)	Fine protein filled rod	Stereocilia of OHC & IHC
Cisternae (Lat.)	box or basket	Subsurface cisternae
Contra (Lat.)	Opposite	Contralateral
Corpus (Lat.)	Body	Corpus callosum
Cortex (Lat.)	Bark	Cerebral cortex
Dendron (Gk.)	Tree	Dendrite
Fenestra (Lat.)	Window	Vestibular fenestra
Fossula (Lat.)	Small niche	Cochlear fossula
Ganglion (Gk.)	Knot	Spiral ganglion
Hemi (Gk.)	Half	Hemisphere
Hyper (Gk.)	Over	Hyperpolarization
Hypo (Gk.)	Under	Hypopolarization
Inter (Lat.)	Between	Internuclear
Ipsi (Lat.)	Self, same	Ipsilateral
Lemniscus (Gk.)	Cord	Lateral lemniscus (tract)
Meatus (Lat.)	Passage	Internal auditory meatus
Medulla (Lat.)	Core	Medulla
Pedunculus (Lat.)	Stalk	Cerebral peduncle (tract)
Rete (Lat.)	Net	Reticular formation
Scala (Lat.)	Ramp, steps or ladder	Scala vestibuli
Soma (Gk.)	Body	Somatic
Stria (Lat.)	Streak, stripe	Stria vascularis
Syn (Gk.)	Together	Synapse
Villus (Lat.)	Fluid-filled rod	Projections of the mucous membrane

For terms not found in the following Glossary, the Glossary and Subject Index of Yost (2000) should be consulted.

2IFC & 3IFC– An n-interval forced choice procedure where a subject is required to make a choice between the n- options following a stimulus.

2TS– Two-tone suppression, a test protocol.

Acoustics– The study of the flow of energy through elastic media.

Acoustic impedance– The interference with the propagation of acoustic energy by a material. Given in several forms. See Impedance.

Acoustic wave– Any of a variety of waves involving the displacement of particles of matter in response to a local variation in pressure at a source. They occur as bulk effects in homogenous materials. They can also exist at surface effects at the interface between two materials. Acoustic wave theory is very complex and Lighthill (1978 & 1986) should be consulted.

1. The general case is a spherical wave originating at a simple (or monopole) source and propagating in

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three dimensions in a homogeneous bulk material. At a distance from the source, such a wave is known in the vernacular as a compression wave or pressure wave.

2. A plane wave is an approximation of a spherical wave at a large distance from the source.

3. A longitudinal wave is an acoustic wave restricted to a tube or channel where the components of material motion parallel to the axis of the tube or channel possesses far more kinetic energy than any transverse component. The wave propagates at a velocity determined by the bulk material.

4. A transverse wave is an acoustic wave restricted to a tube or channel where the components of material motion perpendicular to the axis of the tube or channel possesses far more kinetic energy than any axial component. The wave propagates at a velocity determined by the bulk material.

5. A special case is a one-dimensional acoustic wave excited at the interface between two materials and known as a surface acoustic wave. The wave propagates at a velocity determined by the properties of both material.

6. A Rayleigh wave is a surface acoustic wave where the bulk of the energy propagates with an intensity profile perpendicular to both the surface (a planar interface) and the direction of propagation.

7. A Lambert wave is a surface acoustic wave where the bulk of the energy propagates with an intensity profile parallel to one axis of the surface (a planar interface) and perpendicular to the direction of propagation.

8. A modified Rayleigh wave is a combination of a Rayleigh and Lambert waves on a curved surface.

9. A traveling wave is any acoustic wave containing a velocity related component in the argument of the function describing the amplitude of the wave. In the absence of any reflections, spherical, longitudinal and surface acoustic waves are traveling waves. Traveling waves in fluids are generally dispersive with respect to frequency. Traveling waves in solids and liquid-crystals are generally non-dispersive with respect to frequency.

10. Standing waves can result from the intersection of two traveling acoustic waves of the same frequency, with the second wave generally a reflection of the first.

11. The expression traveling wave is often used to mean a "slow wave" in hearing, a wave moving with a velocity considerably lower than the bulk speed of sound in the medium.

Activa– An active three-terminal biological device equivalent to a man-made transistor.

Adaptation– Generally defined as the change in performance of the adaptation amplifier, found in every Stage 1 sensory neuron, in response to stimulation level. The change usually exhibits a temporal profile. The profile changes during an adapting stimulus (peristimulus adaptation) and following an adapting stimulus (poststimulus adaptation). Peristimulus adaptation is frequently labeled "tone decay" in audiometry.

Peristimulus adaptation– The decrease in loudness of an on-going stimulus, usually measured as a function of time. Also a function of initial adaptation and initial stimulus level.

Adiabatic– A process carried out without a change in entropy.

Agnosia– Inability of a subject to perceive a sound pattern in spite of an apparently normal hearing modality.

Agonist– A drug which produces a response by a cell. Agonists exhibit three properties; selectivity, affinity and intrinsic activity.

Alloentric– A frame of reference centered on the external environment in psychology. Equivalent to the expression inertially centered in engineering practice.

Altricial– Helpless, naked, and blind when hatched: *altricial birds*.

Amphiphilic– Having one side that is hydrophilic and the other that is oleophilic.

Amnesia– Generally an inability to recall memories due to a failure in the perirhinal area of the hippocampal formation.

1. Anterograde amnesia– Inability to store declarative memories

2. Retrograde amnesia– Inability to retrieve stored declarative memories

Amusia–

1. a condition marked by inability to produce music – called also motor amusia

2. a condition marked by inability to comprehend music – compare to aphasia

Analytic signal– (Used in two distinct ways)

1. *Proper noun*; A function of a real variable composed of the real part of its response plus the imaginary operator times the Hilbert transform of that same real part. The resulting signal is limited to the right half of the frequency plane and has a unique value at frequency = 0 (de Boer & Nuttall, 1997, Appendix C).

2. *Noun plus adjective modifier*; any signal completely defined by a mathematical expression.

Anaphoria– A state of neutral feeling, neither euphoria or dysphoria.

Anodic stimulation– Stimulation by a positive potential or removal of electrons from a plasma.

Ansatz– An assumed form for a mathematical statement that is not based on any underlying theory or principle. A conjecture, hypothesis or proposition.

Antagonist– A molecule that can attach itself to a receptor but that does not cause a response by the cell. Its effect is to deny the receptor site to an agonist molecule.

AP– Used in two fields. (in music), absolute pitch.
(in neuroscience) action potential.

Aphasia– A deficit in the ability of a subject to either develop percepts, or to further process percepts, related to grammar and semantics. Both speech and (to a degree) music perception are affected.

Apodization– A method of diffraction control in acoustic wave propagation.

Archaic– Of, relating to, or characteristic of a much earlier, often more primitive period. No longer current or applicable.

Attention– A concept only now subdividing into distinct categories.

1. Sub-conscious attention as encountered within neuroscience. The focus of a subjects sub conscious cognitive powers on a specific aspect of its environment. Intimately involved with the awareness and alarm mode of neural operation.
2. Conscious attention as encountered in psychology. The focus of a subjects conscious cognitive powers on a specific aspect of its environment. Intimately involved with the analytical mode of neural operation.

Auditory brainstem response– A non-invasive electrophysiologically recorded response attempting to characterize the operation of the midbrain of the auditory system.

Autism– A complex medical syndrome frequently involving dysacusis.

Autocrine– A self regulating secretory capability in a biological cell.

Axon reflexes– A circumstantial situation described by de No in discussing potential signal architectures of hearing. He postulated the potential transmission of retrograde signals antidromically between groups of hair cells. de No did not pursue the concept and it is not supported here.

Bark– (*In honor of Barkhausen*) A numerical scale correlated with a set of frequency bands believed to approximate the bandwidths of the signaling channels associated with human hearing. (Zwicker, 1961)

Basal ganglia– A set of ganglia closely associated with the thalamus and particularly the cerebellum and responsible for implementing high level instructions received from the cerebellum.

Beat frequency– The difference in frequency between two simple acoustic tones.

Bel– A fundamental division of a logarithmic scale for expressing the ratio of two amounts of *power*. The number of bels denoting such a ratio is the logarithm to the base 10 of this ratio (see Decibel).

Best frequency– (or characteristic frequency). The frequency of maximum response for a single OHC or a signaling channel.

Binaural– The presentation of a different isolated stimulus to each ear. See stereophonic.

Binaural localization– The determination of the time delay related to a sound source in object space and the conversion of that information into coordinates useable by the CNS. Processing of data above and below a characteristic frequency appear to be handled differently.

Bipolar neuron– A common morphological terminology for the three-terminal neuron where the poda terminal is not ramified and can only be seen with an electron microscope. The description does not say anything concerning the function of the neuron. Functionally, the neuron is capable of addition of multiple input signals but not subtraction. May

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also be used to describe a stage 3 encoding neuron described herein as a ganglion cell.

Bleb--A (probably) pathological structure seen extending from the periphery of the sensory neuron surrounding the cuticular plate. Frequently found to contain mitochondria, ribosomes and vesicles. (Tilney, et. al., 1982)

BLM--Bilayer membrane. A frequent abbreviation for a cell membrane. Usually consisting of two liquid crystalline films consisting of phosphoglycerides with their hydrophobic surfaces facing each other and separated by a space as observed with an electron microscope. Frequently labeled a three-layer membrane in other literature because of the dark-light-dark appearance in the electron microscope.

Bulla-- The ovoid prominence below the opening of the ear in the skulls of many animals; also the tympanic bulla or auditory bulla.

Caecum of the vestibule--(sê' kern) The sac-like pouch protruding into the vestibule from the cochlea and containing the initial portion of the tectorial membrane. Also labeled the cul-de-sac of the scala media.

Calyx of Held-- An unusually large synaptic area found among some of the neurons terminating in the cochlear nucleus.

Canalicular - relating to or like or having a canaliculus.

Canalicular reticulum-- A complex structure immediately adjacent to the cuticular plate of the sensory neuron and extending entirely across the cross-section of the sensory neurons.

Canaliculi are small, microscopic canals between the various lacunae.

Capture bandwidth-- The bandwidth corresponding to the physical capture area of an OHC in contact with the tectorial membrane.

Cathodic stimulation-- Stimulation by a negative potential or injection of electrons into a plasma.

Caudal-- a. Of, at, or near the tail or hind parts; posterior: the caudal fin of a fish.
b. Situated beneath or on the underside; inferior.

Cent-- the interval between any two sound waves whose frequency ratio is the twelve-hundredth root of 2. One hundred cents constitutes an equally tempered semi-tone.

$$\text{Number of cents} = 1200 \log_2 f_1/f_2$$

Center frequency-- The high frequency component generated by the mixing of two tones given by the formula, $(f+g)/2$ (the result of a trigonometric identity).

Centriole-- The name given to the rudimentary structure found in some species where a more robust kinocilium might be expected in other species.

Cerebrum--The total brain of a species. Alternately the cephalon.

Central branches-- The axons of the neurons proceeding from the spiral ganglia to the cochlear nucleus. A term used by early morphologists.

Characteristic delay-- The occurrence of maximum spike rates define a characteristic delay in individual amplitude-channel neurons of the binaural localization system. Delays as small as 100 microseconds have been recorded in cat.

Characteristic frequency (CF)-- The center frequency of the passband of either an individual OHC sensory neuron or of the auditory nerve fiber connected to one or more OHC. Also called the best frequency.

Chugging-- A perceived variation of hearing sensitivity observed in quiet locations and related to the pulse of the individual. The broadband background appears to rise and fall in amplitude in cadence with the pulse.

Chord-- The simultaneous production of two or more compound tones by a single musical instrument.

Chronaxie-- A theoretical time required for an injection current of twice the threshold current required to generate an action potential. See Rheobase.

Cilia— Fine cylindrical structures protruding from the sensory neurons at the end opposite to the location of the synapses with the neural system. Generally described in terms of the kinocilia and the stereocilia which serve different functions.

1. **Stereocilia**— The primarily protein-filled fine rod-like structures protruding from the cuticular plate of a mechanico-receptor sensory neuron. The protein structure exhibits piezoelectric properties. The proteins are replaced every 48 hours in a very dynamic process in humans.

2. **Kinocilia**— Consists of a closely spaced group of primarily plasma filled dendritic conduits projecting from the mechanoreceptor sensory neuron from near the cuticular plate. The 9 or 9+2 individual conduits are frequently described as microtubules. The kinocilia is a degenerate nerve analogous to the dendritic structure protruding from a photoreceptor cell and contacting the disks of the outer segment. The protein content of kinocilia is usually insignificant. Kinocilia are significantly more fragile than stereocilia.

ciliary rootlet— The portion of the (stereo) cilia extending down through the majority of the cuticular plate.

Closed-ear method— Measurements made with an earphone placed tightly against the pinna of the ear and obstructing other sound sources. See open-ear and inserted source methods.

Cochlea-o-topic— Having a neural organization traceable to the cochlea.

Cochlear action potential—CAP— (aka, compound action potential) Generally a misnomer. Historically used to describe the waveform captured as a cochlear microphonic. Typically contains both analog (generator potential) and phasic (action potential) components.

Cochlear amplifier— A hypothetical mechanism within the cochlear partition that increases the sensitivity of basilar membrane vibrations to low-level sounds and, at the same time, improves the frequency selectivity of these vibrations (Kim, et. al., 1980—Allen & Neely, 1992). The concept is archaic.

Cochlear microphonic— (*singular*) An AC voltage measured as a function of time and acoustic stimulation by a probe located near the round window and an arbitrary ground. Other investigators have used the term to refer to differential signals derived from one electrode in the scala media and the second in the scala tympani (Sokolich, 1976). Like any other evoked potential, it is a single voltage measured at a single point due to voltages arising at a large number of distributed remote points. In this case, the elements of the waveforms are usually due to generator waveforms (analog) from the pedicles of sensory neurons and subsequent amplified and/or inverted copies of these signals.

Cochlear Partition— The overall structure separating the cylinder containing the scala vestibuli from the cylinder containing the scala tympani. Contains the Organ of Corti supported by the basilar membrane acting as a structural member, the tectorial membrane, Reissner's membrane and the endolymph.

Colliculus— *plural* col-lic-u-li An anatomical prominence ; *especially* any of the four prominences constituting the corpora quadrigemina.

Combination tones— Tones perceived when an observer is presented with an acoustic stimulus consisting of two component frequencies, f_1 and f_2 ($f_1 < f_2$) that both fall within the passband of a single OSC.

Commensurable— Measurable by a common standard. Developed from a common conceptual foundation.

Complex tone — The sound generated by two or more sources at a given time. Generally consisting of two or more compound tones. When using two separate instruments, the sources have generally been tuned to the same perceived pitch, but not necessarily the same acoustic frequency, and are not phase-coherent.

Compliance— That coefficient which, when multiplied by 2π times the frequency, gives the reciprocal of the magnitude of the imaginary part of the impedance. See also Impedance.

Acoustic compliance— That compliance which results from the volume displacement per unit pressure. The unit is the centimeter to the *fifth power* per dyne.

Mechanical compliance— That compliance which results from the linear displacement per unit force. The unit is the *cubic* centimeter per dyne.

Compound action potential— A misnomer. A waveform frequently measured at the round window and containing summed elements of both analog and phasic waveforms originating at the outputs of the sensory neurons (analog portion) and cochlear neurons (phasic portion). See cochlear microphonic.

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Compound tone– The set of tones generated by a single source at a given time and generally harmonically related.

Computational anatomy–A descriptor referring to anatomical features that contribute to the computational task by introducing delay or spatial reorganization among neural signals.

Condensation click– A click that causes an initial motion of the tympanic membrane toward the inner ear. (See rarefaction click)

Conduction of sound– Described using at least four adjective modifiers:

1. Air (tympanic) conduction.
2. Bone conduction.
3. Fat conduction (the melons and ear horns of cetacea)
4. Liquid crystal (surface wave) conduction within the cochlear partition.

Conductive hearing loss– Hearing loss of non-neural origin. Usually evaluated in terms of air-conductive loss (associated with outer and middle ear) and bone-conductive loss (associated with cochlea).

Cone of confusion– A coarse term for the error circle, in azimuth and elevation, of the subject's source location capability.

Confidence interval– For a very large population, the true mean of the population 95% likely to be within 1.96 standard errors of the sample mean. This region is called the 95% confidence interval. Confidence intervals are the most useful measure of the dispersion of a distribution. They are derived from the standard error of the mean. See Standard error.

Consciousness– A state of awareness in an animal. A condition shared with the states of unconsciousness (not conscious) and subconsciousness (an internal state of awareness not explicitly perceived by the subject).

Consonance– A perception of pleasantness or smoothness when two or more simple or compound tones are presented simultaneously.

Consonance-dissonance– Subjective expressions associated with the fusion of chords consisting of multiple tones. Generally used in the vernacular but poorly defined in the scientific context. Used differently in music and psychology.

1. Psychology– Consonance results when two tones are presented together and the resultant perception is pleasing. If unpleasant, the tones are considered dissonant.
2. Music– Consonance is produced by frequency intervals which are small integer ratios. Non-integer ratios are considered dissonant, even in the absence of roughness.

Consonant– A speech sound produced by a partial or complete obstruction of the air stream by any of various constrictions of the speech organs.

Contralateral– *Biology*: Situated on, pertaining to or affecting the opposite side.
Vision: Affecting the opposite side of object space relative to the body.

Correlate tones– Tones perceived when an observer is presented with an acoustic stimulus consisting of two component frequencies, f_1 and f_2 ($f_1 < f_2$) that both fall outside the passband of the OSC corresponding to the perceived frequency.

Cortex– The outer shell of the brain (cerebrum) or cerebral cortex. The major part of the telencephalon. Alternately, the neo-cortex where the inner brain is labeled the paleocortex.

Cortifugal fibers– Neurons originating in the temporal cerebral cortex and proceeding to the thalamus. Concerned with delivering second level (or higher) interps back to the thalamus. Similarly, neurons originating in the parietal lobe and projecting volition commands to the thalamus.

Cortilymph– The fluid filling the tunnel of Corti, the space of Nuel, the outer tunnel and the spaces around the hair cells.

Critical band–

1. A term introduced by Fletcher, 1953 and adopted by Zwicker, 1957, as a translation of the German, frequenzgruppe. Essentially used in the vernacular. Does not correspond to any technical use of the term critical bandwidth defined below. The frequencies involved are usually much wider than the critical bandwidth measured at the 20 dB down level.

2. That bandwidth at which subjective responses rather abruptly change (Scharf, 1977).

Critical bandwidth— The effective bandwidth, at a given response level, of an individual frequency channel associated with a single sensory neuron, or with a group of closely related sensory neurons if measured after the stage 3 encoder of a frequency-sensitive channel. Usually measured at 10% response (20 dB down from the peak) in audiometry.

Critical frequency— The center frequency of the frequency response of a frequency-sensitive channel usually measured after the stage 3 encoder of that channel. See critical bandwidth.

Cross modulation— The generation of spurious frequency components due to passing a complex signal through a nonlinear signaling network, frequently, but not necessarily, an amplifier.

Cubic difference tone— A specific beat tone obtained through cross-modulation involving the second harmonic of one tone and a second tone ($2f_1 - f_2$). See beat tone and cross-modulation.

Cuticular plate— A specialized filamentous section of the sensory neuron devoid of cytoplasmic organelles and interfacing with the cilia of the neuron.

Cytoarchitecture— The organization of the brain as studied at the microscopic anatomic (cellular) level.

Cytology— The study of the interior structure of cells in relation to their function. See histology.

dB-A— A weighted scale measuring the intensity of sound relative to the threshold of hearing, independent of the frequency of the sound.

DC potential— A quiescent electrical potential of a circuit element measured with respect to a specified common reference, "ground," location. A distinctly different potential than the pedestal generated at the output of a sensory neuron and frequently labeled a DC potential erroneously.

Deafness— (clinical term, Anacusis) Defined variously according to the discipline being discussed. Total deafness describes the inability of the subject to perceive any of the characteristics of acoustic energy presented to the auditory system from an external source. Generally considered to be a permanent condition. See also hearing loss.

Decibel— (dB) One tenth of a bel. The number of decibels denoting the ratio of two amounts of *power* is 10 times the logarithm to the base 10 of this ratio. When describing *scalar* quantities *at the same impedance level*, the formula becomes 20 times the logarithm to the base 10 of the ratio between the two quantities. These scalar quantities include current, voltage, pressure and velocity.

Declarative memory— memory associated with "knowing that" (the knowledge of abstract facts and events). See also non-declarative memory.

Decussation— Anatomical term describing a neural tract originating on one side of a bilateral organism and terminating on the opposite side.

Detection limen— (abbrev. DL) The smallest detectable change in frequency at a specific frequency. Similar, if not identical in concept, to the just noticeable difference in frequency. See JND.

Deterministic— (Antonym of Stochastic) A result that is precisely predictable on an instantaneous basis based on the operational rules of the circuit or mechanism involved.

Dichotic— Binaural stimulation in which the acoustic stimulus at each ear differs in one or more parameters. See diotic.

Difference limen (DL)— A just noticeable difference (JND) as a function of frequency under specified conditions.

Diotic— Binaural stimulation where the stimulation to both ears is identical in all parameters.

Dissonance— A perception of unpleasantness or roughness when two or more simple or compound tones are presented simultaneously.

Double Boltzmann function— The normalized sum of two generic Boltzmann functions. See Boltzmann function.

DPOAE— Distortion-product otoacoustic emissions.

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Driven response– In a PST histogram, the total number of spikes per second during stimulation minus the average number of spikes per second in the absence of stimulation, the SR rate.

Dynamic range recruitment– A term used to describe the loss in dynamic range due to damage to the sensory neurons. (page 396 Jahn & Santos-Sacchi, 2001)

Dysacusis– A general clinical term for a broad range of hearing disorders (other than those due to a quantitative decibel hearing loss).

Dystrophy– Abnormal or impaired functioning, especially of a bodily system or social group.

Ectoderm– One of the three germ layers of the higher animals. The epithelium and the nervous system derive from ectoderm, as does the gut and digestive tract. The muscles and skeleton generally derive from the mesoderm.

Ectotherm– (syn. poikilotherm) An animal dependent on his environment to establish his core temperature.

Eikonal equation– The square of the gradient of a scalar expressed in all relevant dimensions.

Electrophonic Effect– Sound perceived following electrical stimulation of the peripheral neural system of hearing. Usually refers to stimulation applied to non-neural tissue of the inner ear but may apply to stimulation of the middle or outer ear. See also sensoriphonic.

Emulation– The process of assembling and operating a *physical* device or circuit having the same or similar performance characteristics as the prototype.

Endotherm– (syn. homeotherm) An animal that maintains its own core temperature independent of its environment.

Ephapse– A term used in the 1950's to distinguish an electronic synapse from a chemically-based synapse. (Davis, 1961)

Epithelium– Forms the covering, the lining surface of the body, and much of the glandular tissue. The coverings are thin and permit the easy passage of water, salts, gases and small molecules through the various membranes. Derived from the ectoderm.

EQ-NL Theorem– A theorem of de Boer applicable to a specific class of cochlear function models not supported here. Abbreviations are for equivalence and nonlinearity. See de Boer & Nuttall, 2000.

ERB– Equivalent rectangular bandwidth. Found occasionally in the hearing literature, usually without the criteria used to establish equivalence.

Evanescence– Means "tending to vanish."

Evanescence wave– 1. An electromagnetic wave observed in total internal reflection, undersized waveguides, and in periodic dielectric heterostructures. While wave solutions have real wavenumbers, k , k for an evanescent mode is purely imaginary. Evanescent modes are characterized by an exponential attenuation and lack of a phase shift.

2. A non-energy transporting field resulting from total internal reflection. The field(s) are found on the opposite side of the reflecting surface from the incident and reflected waves. The fields decay exponentially with distance (significantly within one wavelength) and do not propagate.

Excess gain– A misnomer. This gain is absolutely mandatory for the proper operation of the auditory system at low stimulus levels. The concept is more properly described in terms of the maximum gain (achieved throughout the mesotopic region).

Excitatory postsynaptic potentials (EPSP)– A largely conceptual description of the axonal potential of a two-terminal neuron.

Extinction– A term from behavioral neurology referring to the loss of information from an otherwise intact sensory hemifield when a double-simultaneous stimulation technique is used. Extinction in dichotic listening is dependent on a second poorly understood phenomenon referred to as ipsilateral suppression.

Falsification– Used contrarily at different times and in different communities.

1. To demonstrate a hypothesis is not defensible and is therefore falsified, based on the German equiv.
2. To tailor the data released to eliminate outliers and therefore strengthen the hypothesis.

Fatigue– A temporary loss of sensitivity to one stimulus following exposure to *another* stimulus, as opposed to adaptation which involves the same prior stimulus. Fatigue may persist for over 24 hours.

Fermat's principle– The original statement of Fermat's principle was, "The actual path between two points taken by a beam of light is the one which is traversed in the least time." Snell's law and the law of reflection follow directly from this statement. A generalization of the principle applies equally well to elastic (acoustic) energy. It may be reformulated slightly in terms of optical path length as "Light, in going between two points, traverses the route having the smallest optical path length." In its original form however, Fermat's principle is somewhat incomplete and even slightly in error. Its modern form is "A light ray, in going between two points, must traverse an optical path length which is stationary with respect to variations of the path." In this formulation, the paths may be maxima, minima, or saddle points.

Fine-structure– The repeatable variations in the audiogram occurring at intervals of less than 10% of the local nominal frequency. Generally associated with bond breaking in a liquid crystalline material under flexure.

Flexoelectric material– A piezoelectric material that exhibits a significant output when a bending force is applied.

Fontanel or fontanelle– A membrane-covered opening in bone or between bones.

Fonticulus– See Fontanel.

Formant– One of the fundamental elements of speech, frequently characterized by either a voiced or unvoiced element followed by a vowel sound.

Formant frequency– The dominant frequency in a sound produced during speech. Typically a harmonic of the fundamental frequency generated by the larynx.

Fourier Analysis– The technique of mathematically separating a complex waveform into its constituent orthogonal (usually sinusoidal) components. Not used within the biological auditory system but useful for understanding that system.

Fricative– A consonant, such as *f* or *s* in English, produced by the forcing of breath through a constricted passage. Also called *spirant*.

FTC– Frequency-tuning curve. Used in discussing the frequency response of OHC neurons relative to the overall frequency response of a given cochlear partition. See **STC**.

Fundamental frequency– The frequency generated by the larynx in the process of generating speech.

FWHM (full width at half maximum)– An expression used to describe the width of a spectral distribution or other profile expressed as a graph. The units are usually nanometers in vision research but Hertz in audio and other temporal frequency domains.

GABA– γ -amino butyric acid. The primary reaction residue from the electrostenolytic process providing electrical power to the neurons. See glutamic acid.

Ganglia– *Plural*. Following morphological usage, a group of cells located remotely from the CNS and apparently used in signal manipulation. May contain only phasic, stage 3, interconnections or may contain stage 2 signal processing in electrotonic (analog) mode.

Ganglion cell– The generic name for any Stage 3 neuron used to encode analog (electrotonic) signals onto a carrier consisting of a stream of action potentials. *Preferred plural*, ganglion cells, rather than ganglia (see ganglia).

Gel– A liquid-crystalline material at or below the temperature where large scale lateral motion of the molecules within the material ceases.

Glutamic acid– The primary reactant in the electrostenolytic process powering the neurons. It participates in a stereo-specific reduction on the outer surface of each conduit of a neuron that generates a free electron on the inner surface of the conduit. The reaction releases carbon dioxide and GABA. See **GABA**.

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Gravity waves– A term used in geophysics to describe waves formed at the surface between two fluids of different density. Their existence involves a relationship between their internal inertia and the force of gravity. Not the gravity waves of astrophysics. Gravity waves exist in at least two forms:

- Surface gravity waves– at an interface between two fluids of distinctly different density.
- Internal gravity waves– found within fluids with a continuously varying density.

Gyrus– A surface area of the outer cerebral cortex surrounded by indentations described as sulci.

Habenula perforata– A series of holes in the bony spiral lamina enclosing the cochlea that allow the axons and neurites of the spiral ganglia innervating the IHC and OHC to enter the basilar membrane.

Hamulus– The apical hook of the cochlea.

Hardesty's membrane– A name sometimes applied to the gelatinous surface of the tectorial membrane facing the sensory neurons.

Harmonic– A tone with a frequency that is a multiple of a lower frequency tone. The order of the multiplier gives the tone its name. The second harmonic is at a frequency of two times the lower frequency.

Head-related transfer function– HRTF; the ratio of the free-field stimulus as a function of frequency next to the head to the signal reaching the eardrum. [Wightman & Kistler, 1989]

Hearing Level– (HL) A logarithmic scale used in audiometry to compare the hearing in individuals relative to a standard consisting of 18 year-olds. Scale is similar to the phons scale. The baseline for HL is independent of frequency.

Hearing loss– (Clinical term, hypacusis) Generally an impairment that is potentially correctable, either medically, surgically or through the use of amplification.

Helicotrema– The passage between the scala vestibulari and scala tympani at the apex of the cochlear partition.

Heterophonic– (synonym, multi-frequency)

HRTF– The head-related transfer function component of the outer ear performance characteristic.

Hemicochlea– A cochlea sectioned by a plane including the mid-modiolar axis.

HHLL– The Hellman & Hellman Loudness Limen of 1990.

Histogram– A statistical representation of data used commonly in audiometry. Usually used in a "folded" mode. Data is collected for long periods of time that may or may not be related to the frequency of the stimulus. The time of occurrence of each signal is assigned a bin interval with respect to the time of the stimulus that may or may not be related to the stimulus frequency.

1. **Period histogram**– The above histogram where the horizontal axis is normalized to the duration of one cycle of the stimulus. Each response to subsequent periods of the stimulus are overlaid onto this first period of the histogram is usually shown. Also known as a folded PST histogram. When the stimulus has a complex shape, the reference point is frequently taken as a zero crossing of the sub-harmonic waveform. Such a form may be labeled a post-zero crossing histogram (Goldstein & Kiang, 1968)
2. **Interval histogram**–
 - (1) Similar to the period histogram but plotted for multiple periods on the horizontal axis (with the time usually given in ms instead of periods and fractions thereof.
 - (2) A histogram of the probability of a second response pulse occurring within a specific time interval following an initial response pulse.
3. **Interspike interval (ISI) histogram**– A plot of the number of occurrences of time intervals between successive action potentials (spikes) as a function of the length of the interval. (Rose, 1968; Javel, 1986, page 217)
4. **Peristimulus time histogram**– (PST histogram) A histogram showing signal activity during the period of an extended stimulus. Frequently shifted in time to accommodate any latency associated with the signal.
5. **Post stimulus time histogram**– (PoST histogram) A histogram showing signal activity following an impulse stimulus. (Smolders & Klinke, 1986) The collection interval should be delayed to reflect the physiological delay between the stimulus and the point of recording.

6. Compound histogram– A construction formed from two separate histograms to relate the responses to rarefaction and condensation clicks. (Goblick & Pfeiffer, 1969) Not a realizable histogram in the laboratory. Not required if the conforming ordinate scale of the histogram is used as proposed here.
7. Conforming or corrected PST– (C–PST) A peristimulus time interval histogram that has its ordinate corrected to represent pulse-to-pulse time delay rather than instantaneous frequency.
8. Probability histogram– Any histogram where the bin count for each bin has been normalized by dividing it by the total number of events counted.
9. Sweep frequency histograms– Histograms where the horizontal scale represents frequency intervals rather than time intervals. Used to define the critical frequency and critical bandwidth of a sensory channel. (Sachs & Kiang, 1968)

Histology– The study of cell types, primarily from a morphological perspective. See cytology.

Hologram– Derived from Greek roots meaning "complete writing." The idea is that every part of "the writing" contains information about the whole.

Hopf bifurcation– A condition where one or more astable oscillators are biased to just below their stability threshold. A slight change in bias causes them to begin continuous oscillation.

Horn– a rigid, non-porous duct of which the cross-sectional area increases progressively from the small end (or throat) to the large end (or mouth).

Hydronium– Used in three closely related contexts.

1. Hydronium ion– H_3O^+
2. Hydronium crystal– A room temperature lattice of $(\text{H}_2\text{O})_n$. Believed to exist in liquid-crystal form.
3. Hydronium bridge– A monolayer hydronium crystal hydrogen-bonded to two asymmetric lemmas of individual neurons resulting in the formation of an Activa.

Hydrops– A clinical description of an excess fluid in the cochlear duct (scala media). Distension of the scala media (or Reissner's membrane).

Hyperacusis– exaggerated sensitivity to sounds at all intensities. Hyperacusis is a reduced tolerance to normal environmental sounds caused by loss of feedback within the sensory neurons. Ears lose most of their dynamic range. Frequently used synonymously with dysacusis, oxylacusis, and hypersensitive hearing. Compare to recruitment.

Hypoacusis– A general term suggesting a broadly based loss of sensitivity to sound.

Impedance– The interference with the propagation of energy by a material. Beranek defines four primary and a host of secondary forms of impedance. In acoustics, several different mathematical definitions of impedance are used. The principle definitions are:

The acoustic impedance, Z_a : $Z_a = p/Su = p/U$ in dyne-sec/cm⁵

The specific acoustic impedance, Z_s : $Z_s = p/u$ in dyne-sec/cm³

The mechanical impedance, Z_m : $Z_m = pS/u$ in dyne-sec/cm

where p is the sound pressure in dynes per square centimeter, u is the linear velocity in centimeters per second and S is the area for which the impedance is being defined, in square centimeters. $U = Su$ = volume velocity, in cubic centimeters per second. Notice the difference in units for these three forms. The electrical impedance is defined entirely separately. *The units of electrical impedance are different from each of the above definitions.* Ref: Beranek, 1949, pp15-36, and International Bureau of Weights & Measures, Paris (www1.bipm.org/en/si/derived_units/2-2-2.html).

The acoustic impedance is most commonly used in applied acoustics. The specific acoustic impedance is most often used in theoretical acoustics. The mechanical impedance is frequently used when the interface between mechanical and acoustic systems is of primary interest. The type of impedance selected by the user must be explicitly named. The specific impedance of air is 415 Pascal/m². The specific impedance of water is nominally 1.5×10^6 Pascal/m² (roughly 3600 times greater). Based on the above units, the acoustic ohm is related to a volume propagation velocity in the medium in cm³/sec. Alternately, the mechanical ohm is related to a linear propagation velocity in the medium in cm/sec.

Inferior colliculus– One of two morphological structure involved in the extraction of acoustic signals related to source

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location. Generally passes its output to the superior colliculi that are known to be involved in pre-motor command signal generation activity.

Infrasonic sound– Typically, sound at frequencies below 15 Hertz.

Inhibition– A term widely used in psychology but poorly defined. Typically described in the context of an all-or-nothing event. Not generally applicable to the analog processing found within the sensory neurons or feature extraction engines of hearing where signal reduction by subtraction is a more appropriate concept.

Inion– The most prominent projecting point of the occipital bone at the base of the skull.

Innervation– The process of interconnecting two neurons by a neural conduit. The expression does not imply the direction of the signal over the conduit. Nor does it imply the nature of the conduit.

Inserted-source method– Measurements where an acoustic source is introduced into the outer ear canal, generally near the tympanic membrane. See open-ear and closed-ear methods.

Intensity– Used variously in science.

1. In acoustics, sound intensity is equated to AC power density in Watts/meter².
2. In electromagnetics, field intensity is equated to electric field strength in Volts/meter.
3. In antenna theory, radiation intensity is equated to the power per unit solid angle, W/steradian.

Intensity Level (IL)– Generally a shorthand for the intensity level expressed in SPL.

Interaural differences– Differences in time (ITD, interaural time differences), level (ILD, interaural level differences or IID, interaural intensity differences) or frequency or spectrum (ISD, interaural spectral differences).

Interval– In music, the difference in frequency between two notes, the frequency interval.

Ionotropic– Used in McGeer et al., 1987.

Ipsilateral– *Biology:* Situated on, pertaining to or affecting the same side.
Vision: Affecting the same side of object space relative to the body.

JND– Just-noticeable difference. Can be used with respect to any parameter, particularly intensity, frequency or angle discrimination.

Kanamycin– A pharmaceutical frequently used to artificially damage IHC and OSC cells (Lieberman & Dodds, 1984)

Kimura's membrane– Occasionally used to describe the gel layer on the inner surface of the tectorial membrane.

Kinocilium– A single unique cilium found in some types of mechanoreceptors. It is morphologically separate from the other cilia (stereocilia). Not usually found in mammalian auditory sensory neurons beyond the neonatal period. The 9+2 arrangement of interior filaments suggests the kinocilium is degenerate neural tissue.

Labyrinth– A term used to describe the entire inner ear mechanism and includes two principle portions, the vestibule and semicircular canals superoposteriorly, and the cochlea inferoanteriorly. (Goodhill, 1979, pg 36). The former is believed to have evolved 400 million years ago. The latter is believed to have evolved 200 million years ago (Brownell, 9th Workshop, 2006).

Bony labyrinth– A synonym for the labyrinth described above.

Membranous labyrinth– The epithelial spaces of the above labyrinth that are filled with endolymph. The cochlear duct or the scala media, within the cochlea.

Perilymphatic labyrinth– The portion of the labyrinth filled with perilymph and for the most part surrounding the membranous labyrinth.

Larynx– (the laryngeal pharynx) The voice box of the human containing the vocal cords.

Laser tweezers– A technique wherein the minute force levels associated with bending a collimated laser beam via a spherical refracting element are applied to a cilia (that is attached to the spherical element).

Latency– The delay following an impulse stimulus consisting of the component due to the Phonodetection/de-excitation, P/D, Equation

Lateral olivocochlear complex (LOC)– The area of the trapezoidal body of the medulla dedicated to the processing of the intensity (and time delay) sensitive portion of the auditory signaling channels. See also the MOC complex.

Lateralization– Used variously.

1. The perception of a source as located along a line between the two ears when signals are presented binaurally via earphones. See localization.
2. The process whereby certain embryological asymmetries of structure are ordained phylogenetically, coded genetically, and realised ontogenetically.
3. Localization of function attributed to either the right or left side of the brain.

Limbic system– Named the limbic lobe by Broca based on his observation that it surrounded the brainstem. Following the projection of the cerebral cortex onto a plane surface, the limbic system describes the outer edge of the cerebral cortex (Cook, 1986).

LIP– A posterior area of the parietal lobe identified in studies to discover the saliency map of the brain.

Localization– The perception of a source relative to a circle in the far field when the sound is presented stereophonically using speakers. See lateralization (1).

Loudness– The subjective intensity of a given magnitude of sound through a conscious experience. Expressed in units of sones. See sones.

Loudness recruitment– What is described in the literature as an abnormal growth of loudness (Jesteadt, 1997pg 213) because of a failure to model the auditory system adequately. See recruitment.

Loudness time constant– The perceived time constant of the auditory system, which includes both the attack time constant of the adaptation process and the correlation time required by the perceptual and cognitive processes. Estimates of the adaptation component are about 80 msec.

Love waves– Surface acoustic waves with amplitude in the plane of the surface and perpendicular to the direction of propagation. See also Rayleigh waves.

M.A.F– Minimum audible field pressures. These pressures are a function of the type of sound involved, tones, speech, noise, etc. The type must be specified. The measurements involve the use of a microphone placed where the external ear of a human would be within the free-space acoustic environment. See M.A.P.

M.A.P– Minimum audible sound pressure. The measurements involve the use of a microphone placed near the tympanic membrane (eardrum) of a human. The measurements are usually made based on pure tones. See M.A.F.

Masked threshold– Similar to the classical absolute threshold based on JND but measured in the presence of both a test stimulus and a masking signal that must be precisely defined.

Masking– The loss of sensitivity to one acoustic stimulus in the presence of a second stimulus. The difference in structure between the two stimuli is significant. Masking significantly modifies the capabilities of the interpretation and perceptual processes in hearing. See also suppression.

1. Tone masking–
2. Noise masking–
3. Temporal masking– See also adaptation
4. Dichotic masking– Masking is applied to one ear while the test stimulus is applied to the other.
5. Remote masking– Masking by noise well outside the critical band associated with the test stimuli.
6. Forward masking– Masking by noise terminated before the signal is applied. A post stimulus adaptation phenomenon. Also called residual masking or post stimulatory threshold shift.
7. Backward masking– Masking by noise terminated after the signal is applied. Also called precedent masking.

Meatus– a natural body passage, a canal or duct.

1. Internal auditory meatus– a short auditory canal in the petrous portion of the temporal bone through which pass the facial and auditory nerves and the nervus intermedius. Also called the internal acoustic canal or internal auditory canal.

Mechanoreceptor cell– A class of sensory neurons found within the labyrinth. Different optimizations are found within the vestibular system and the auditory system.

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Medial olivocochlear complex (MOC)– The area of the trapezoidal body of the medulla dedicated to the processing of the frequency sensitive portion of the auditory signaling channels. See also the LOC complex.

Medley– A sequence of chords played at a specific musical interval.

Medulation– Archaic, use myelination.

MEL– A psychological unit of pitch assigned an arbitrary value of 1000 mels at 1000 Hz. It is claimed that the units represent a quantification of the subjective experience of pitch. A pitch of 500 mels is defined as twice as high as a pitch of 250 mels. However, the frequencies generating these values do not bear the same numerical relationship. See pitch.

Melody– A sequence of chords.

Meniere's disease– A syndrome characterized by vertigo, hearing loss and tinnitus. (Goodhill, 1979 chapter 7)

Metabolism– The complex of physical and chemical processes occurring within a living cell or organism that are necessary for the maintenance of life.

Metabotropic– relating to or being a receptor for glutamate as part of the electrostenolytic process.

Minimum audible angle, (MAA)– The threshold in degrees of arc that is correctly discriminated from the standard in 50% of the trials.

Minimum audible field–MAF– Thresholds measured by the open-ear method where the pressure is measured at the place of the ear with the head removed.

Mixing– (Used variously in different fields) In the audio context, it usually refers to the linear combining of two or more signals.

Missing fundamental– An ephemeral concept based on an erroneous concept of information extraction.

MLD– Masking level differences.

Modiolus– the inner rim of the Organ of Corti.

Monochromator– A device for delivering a beam of energy of narrow spectral (frequency) bandwidth to a given exit aperture.

Morpheme– The smallest meaningful unit in the grammar of a language.

Music– A acoustic composition consisting of the superposition of complex groups of tones(chords) presented in succession according to an equally complex rhythm, where the individual tones may exhibit a temporal variation within each individual interval of the rhythm.

Musical scales– A system of designating harmonically related acoustic frequencies where an octave describes a factor of two difference between two notes. A semitone is one-twelfth of an octave on a logarithmic scale. A semitone is usually divided into 100 cents in music or into fractions of a semitone based on the reciprocal of powers of two, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, etc.

Musical tone– (*In earlier times*) A sensation excited within the ear according to Helmholtz (page 56).
(*In modern times*) A compound tone generated in the external environment by a musical instrument.

Nasion– The point in the skull where the nasal and frontal bones unite.

Nelson's notch– A null in the FTC spectral response near the junction of the response generating the tip and the response generating the tail due to a phase reversal at that point of equal amplitudes due to each underlying mechanism.

Nerve VII– The facial nerve containing the efferent neurons innervating the cochlea of the auditory system, the vestibular system and the face.

Nerve VIII– The nerve of the membranous labyrinth. The vestibulocochlear nerve containing the afferent neurons of

both the vestibular system and the auditory system.

Neurophysiology– (synonym, neurology) The study of the function of the neural system.

Noise– An undesired sound.

Pink Noise– Noise that does not exhibit a uniform energy density as a function of frequency. Pink noise is occasionally defined more specifically within specific disciplines. These designations include “Brown noise,” and the various spectral weightings such as the A, B & C curves. In this last set, the C weighting is actually white noise.

Random Noise– A sound or electrical wave whose instantaneous amplitudes occur, as a function of time, according to a normal (Gaussian) distribution curve. Random noise need not have a uniform frequency spectrum.

White Noise– A sound or electrical wave whose spectrum is continuous and uniform as a function of frequency. White noise need not be random.

Non-declarative memory– memory involved in “knowing how” (as in the knowledge of motor skills). See also declarative memory.

Nuel’s space– The fluid filled space between the reticular lamina and the basilar membrane containing the outer hair cells.

Octave– (adj., consisting of eight) A term used to describe the original 8-note musical scale known as the Just Scale. Now used to describe the expanded (added the black keys on the piano) 12-note Tempered Scale.

(Acoustic) The interval between two tones, one of which has twice the frequency of the other.

(Music) An interval of 12 half-steps or semitones.

Octave span– The distance along the cochlear partition equivalent to one octave of frequency. The span varies with location. It can be as much as 3.5 mm in the mid-frequency range of cat, but as little as 0.3 mm at both low and high frequencies.

Ohm’s Acoustic Law– An extension of Fourier’s analysis of gas waves to sound waves.

Open-ear method– Measurements made using a loudspeaker at a specified distance from an unimpaired ear. See closed-ear and inserted-source methods.

Operating range– the overall operating range of the hearing system is conveniently divided into four regimes, the kaumotopic, mesotopic, phonotopic and hypertopic regimes.

+ The kaumotopic regime extends below 20 dB SPL. It is characterized by signals at or below the ambient noise level of the neural system.

+ The mesotopic regime extends from 20 to about 45 dB SPL. This regime is characterized by performance that improves significantly with stimulus level.

+ The phonotopic regime extends from about 45 dB to about 90 dB SPL. This regime is characterized by performance that is largely independent of stimulus level.

+ The hypertopic regime extends about 90 dB SPL to the point of pain. This regime is characterized by degrading performance with stimulus level until pain is encountered.

These terms were chosen to be compatible with similar conditions related to the visual system.

Organ of Corti– Defined variously over time as the field of microscopy has improved. Generally, the elements mounted on the side of the basilar membrane facing the tectorial membrane and between the inner sulcus and Hensen’s cells (not membrane).

Otic capsule– The bony structure surrounding the labyrinthine system (containing the vestibular and cochlear systems). Anson & Donaldson (1992, page 39) describe it as the most unusual skeletal element in the body for a list of reasons.

Paradigm– Universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners (Kuhn, 1962). Kuhn also argued that rival paradigms are incommensurable—that is, it is not possible to understand one paradigm through the conceptual framework and terminology of another rival paradigm.

Parsimony– Adoption of the simplest assumption in the formulation of a theory or in the interpretation of data, especially in accordance with the rule of Ockham’s razor.

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Partial– Used variously in hearing research.

1. A physical component of a complex sound. Its frequency may be either higher or lower than the fundamental or driving frequency and may or may not bear an integral relation to that frequency.
2. A physical component of a complex sound. A Fourier component of that complex sound.

Pectinate– Having projections resembling the teeth of a comb; comblike.

Pedestal– The short duration pulse generated at the pedicle of an auditory sensory neuron as a result of integration of the stimulus applied to its dendrite. It may be combined with an AC waveform related to the input stimulus to form the total response.

Perceived timbre– A single sensation produced by the PGN/pulvinar as an interp and representing a specific timbre distribution in hearing in response to an acoustic stimulus.

Perception– Used variously:

(Psychology) Recognition and interpretation of sensory stimuli based chiefly on memory.

Perceptual learning– An increase in the ability to extract information from the environment, as a result of experience and practice with stimulation coming from it. (Gibson, 1969, p. 3)

Peripheral branches– The neurites (primarily dendrites) of neurons extending from the spiral ganglia to the sensory neurons. A term used by the early morphologists.

Period histogram– See histogram.

Periodicity pitch– The frequency given by the reciprocal of the repetition interval (if any) of a complex waveform. Such a frequency exists only if the ratios of all of the frequencies present can be expressed by an equivalent set of ratios of integers.

Perstimulatory– During the stimulus interval.

Peristimulus time histogram– See histogram.

Phasic– A term used in the biological and medical community to describe a neuron that exhibits action potentials, or other impulse-type signals unrelated to the shape of the external excitation.

Post stimulus time histogram– See histogram.

Pharynx– The morphological volume associated with the upper throat and the oral and nasal cavities.

Phon– The loudness (perceived intensity) of any tone judged to be equal in loudness to the intensity in dB SPL of a 1000 Hz tone. See Sone. (Fletcher, 1953, pg 193)

Phonation– The contribution of the larynx to speech formation, creation of the initial acoustic energy packets prior to their tailoring by the aural cavity. Consists of the voiced (tonal) and unvoiced (atonal or fricative) elements.

Phoneme– The smallest phonetic unit in a language that is capable of conveying a distinction in meaning, as the m of mat and the b of bat in English.

Phonotopic– The regime within the overall dynamic range of hearing wherein performance is essentially independent of input stimulus level. See operating range.

Pinna– The soft tissue forming the external ear in animals.

Pitch– Used in three distinctly different contexts.

1. A term used by musicians to describe the equivalent frequency or musical designation for a real sinusoid of a given frequency.
2. A psychological perception based on the weighted average of the signature amplitude distribution at the output of the PGN. For an exponential series of harmonics, the pitch corresponds to a single note of the musical scale. If other harmonics are present, the perceived pitch may consist of multiple notes.
3. A calculated value based on various assumptions but generally assuming the hearing modality operates as a broadband Fourier Analyzer. These calculated values are associated with the names periodicity pitch,

residue pitch, subjective pitch, etc. The calculations frequently suggest a "missing fundamental."

Poisson's ratio– The ratio of the transverse contraction per unit dimension of a bar of uniform cross-section to its elongation per unit length, when subjected to a tensile stress. The range is typically 0.3 to 0.6. Polyethylene = 0.54 to 0.61.

Polarization– Used variously within the biological sciences.

<cytology> Used in place of the term orientation to describe the preferred direction of molecules, particularly proteins (of unspecified electrical polarization) found *in-situ* within a cell.

Presbycusis– A lessening of hearing acuteness resulting from degenerative changes in the ear that occur especially in old age

Pressure– (*In acoustics*) The average sound pressure is the time integral over a period or longer of a rectified sound wave. Either half- or full-wave rectification may be specified. The unit is the microbar (dyne per square centimeter).

Pressure waves– See Acoustic wave.

Propagation– The transmission of energy by a vectorial process involving either electromagnetic or acoustic fields.

Proprioception– Sensing for determining the configuration of the skeletal system and soft tissue (such as the pinna).

PST histogram– (or PSTH) See peristimulus time histogram.

Psychoacoustics– The field of psychophysics where the stimulus is of acoustic origin.

Psychometric curve– A representation of the statistics related to a psychophysical experiment, usually displaying the percentage of correct responses to a test.

Psychophysics–

1. That branch of experimental psychology, including especially its methods, devoted to the establishment of relationships between psychological and physical measures of sensory events.
2. The scientific field devoted to the study of the subjective psychological response evoked in an animal by an objective physical stimulus.

Pyramid cell– A designation of a morphological type of neuron with a long history. Physiologically, it refers to a neuron of triangular cross section with substantial apical (dendritic) and basal (poditic) arbors and an axon exiting from the nominal center of the base. There are frequently multiple poditic arbors arranged around the maximum circumference of the cell.

Quality Factor (Q)– The quality factor usually associated with a tuned circuit, but frequently applied to any frequency selective circuit. The formula is the center bandwidth (on a logarithmic scale) divided by the full (band)width at half maximum, FWHM, (6 dB below the maximum). An alternate designation for this Q value would be Q_6 . A special case of the quality factor is frequently used in audiometry. It defines Q_{10} as equal to the center frequency divided by the full (band)width at the one-third maximum (FWOM) points. The one-third maximum level is equivalent to 10 dB below the center frequency value. This is a more demanding measurement that gives lower Q values. Occasional quality factors of Q_{20} (full bandwidth at ten percent of maximum) and Q_{30} (full bandwidth at three percent of maximum) are seen in the audio literature.

Quiet adaptation– The state of maximum sensitivity of the hearing system in response to the adaptation amplifier within each sensory neuron operating at maximum gain.

Rarefaction click– A click that causes an initial outward motion of the tympanic membrane (Kiang, 1965). The earliest action potentials are formed in response to the rarefaction click.

Rayleigh function– Used variously in different scientific disciplines.

1. (*Statistics*) Used to describe a single term expression
2. (*seismology*) Used to describe a two term approximate equation for an argument much larger than 1. The wider field of wave mechanics assigns the name Rayleigh equation to this expression. See Rayleigh equation.

Rayleigh equation– (*Wave mechanics*) A two term equation of broad application. The equation is an approximation

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only good for an argument much larger than 1. It can describe the critical wavenumber at the limit of Rayleigh wave (surface wave) propagation.

Rayleigh waves– Surface acoustic waves with their amplitude normal to the surface and perpendicular to the direction of energy propagation.

Receptor– A specialized region of the cell membrane that reacts with external chemicals (Bradley, 1989, pg 3). Both pre and post junction receptors are recognized.

Reciprocity Principle– A source at P must produce at Q the same field as an equal source at Q would produce at P. The principle is the same as in optics, except more modes are possible in acoustics (elastics).

Recruitment– Defined variously and usually imprecisely.

– (Clinically) an abnormally rapid increase in the sensation of loudness with increasing sound intensity that occurs in deafness of neural origin and especially in neural deafness of the aged in which soft sounds may be completely inaudible while louder sounds are distressingly loud.

– Physiologically an abnormal sense of expanded loudness due to operating on the portion of the auditory response curve below the region described by Stevens' Law ($\gamma = 0.3$). The phenomenon is present in the mesotopic regime of normal subjects.

Rectification– an archaic term in hearing used to describe the presumed rectification occurring within the signal channel of the sensory neurons. Perpetuated by an error in the graphical coordinates used to create many audio histograms. Effect in question actually relates to the sensory neurons operating as class A amplifiers below and integrators above a critical frequency (typically 600 Hz in humans).

Resonance– A condition arising in any physical system when the positive and negative reactive components become equal resulting in zero reactive impedance in a series resonant circuit or a nominally infinite reactive impedance in a parallel resonant circuit. The effect is most prominent when the resistive component of the circuit is small relative to the individual reactive impedances.

Resonator– Any physical system combining two specific features. It contains both positive and negative reactive impedances that can be made equal at a specific frequency. It has a port or pair of terminals that allows exchange of energy between the resonator and an outside energy source or sink.

Residue– (or residue pitch) A term popularized by de Boer to explain the “fundamental frequency” paradox. His 1976 analysis did not produce a unique definition of the term.

Response area– An area on a graph of stimulus intensity versus frequency that contains all intensities and frequencies capable of producing a detectable response. (Kiang, 1965)

Reticular lamina– The surface of the basilar membrane through which the sensitive features of the sensory neurons protrude. Formed of, and/or supported largely by, the pyramidal arches.

Reverberation– The persistence of sound due to repeated reflections within a chamber.

Rheobase– The theoretical minimum current injected into a plasma required to generate an action potential in the absence of any refractory time period. Defined by Abbas & Miller in Zeng, Popper & Fay, 2004.

Rheology– The study of the surface characteristics of materials.

Ringer solution– A man made aqueous solution of the chlorides of sodium, potassium, and calcium that is isotonic to animal tissue (but species specific for accurate scientific work) and is used topically as a physiological saline and, in experiments, to bathe animal tissues. Unless specifically modified by an investigator, it contains no nutritional or metabolic components.

Root-Mean-Square– (RMS) A shorthand notation describing a mathematical calculation involving statistical quantities. The value given is derived from the square root of the sum of the squares of several means. The calculation gives the equivalent amount of work done by a force described by an arbitrary waveform. Most frequently used to describe the effective amplitude of a sinusoidal force in terms of its peak value. The RMS amplitude of a sinewave is 0.707 of the peak amplitude.

Roughness– A psychological perception generally associated with the introduction of extraneous frequency

components into the perceived tone. The specific site where this phenomenon is introduced remains unknown.

Segregation– The ability of a subject to identify a tone as separate from a group of other tones.

Semantics– (Used in the general sense) The science of the meaning and sense development of any stimuli, including words, images, etc.

Semit– (abbrev. for semitone) One twelfth of an octave divided logarithmically. A ratio between semitones of about 1.059:1.

Sensorineural deafness– Deafness generally associated with the neurons of the cochlea. Other names for this kind of deafness include “sensory”, “cochlear”, “neural” and “inner ear deafness.”

Sensation– A perceived psychological response resulting from stage 4 information extraction from one or more signatures derived from acoustic stimuli, or a dysfunction within the auditory system.

Sensoriphonic effect– The perception of sound by a subject as a result of direct electrical stimulation of the sensorineurons of the peripheral nervous system of hearing. See also electrophonic effect.

Short increment sensitivity index– (SISI in audiometry) A measure of the degree of recruitment. Uses an alternating series of 1dB and 5 dB tones, of one second duration, added to an ongoing 20 dB SL base level (and following a synchronizing tone of +25 dB) at various frequencies.

Signature– A description of a stimulus as created within the neurological system, usually corresponding to the envelope of the stimulus expressed in logarithmic units.

Simulation– The process of preparing and plotting the performance of an *equation* or assembling and running a *computer program* designed to describe the performance characteristics of a prototype.

SL– *Sensation Level*– The stimulus sound pressure in dB relative to the perceived threshold level at a specific frequency. A relative parameter. See SPL. (Gulick, pg 50)

SOAE–Spontaneous otoacoustic emission (Probst, et. al. 1991 for a review)

Sone– A unit of loudness or psychological intensity. One sone is defined at 1000 Hz as 40 dB above threshold. Now an ISO Standard (ISO Resolution 131-1959). The loudness function (in Sones) is defined as the sound pressure raised to the power of 0.6 for intensities above 40 dB. Below 40 dB, the exponent varies significantly.

Sound– An alteration in pressure, stress, particle displacement or particle velocity which is propagated in an elastic material.

Sound intensity– The amount of energy flowing per unit time through a unit area that is perpendicular to the direction in which the sound waves are traveling.

Sound Level Meter– An apparatus for estimating the equivalent loudness of sound by an objective method. Typically averages the half wave rectified sound energy over a period longer than that of the lowest frequency of interest. Includes the early “VU meters.” See also the more precise Sound Pressure Meter.

Sound Pressure Meter– An instrument including a calibrated microphone and compensation amplifier with a “flat” overall response in the desired frequency range. It indicates the rms value of the sound pressure in a complex sound wave. See also the less precise Sound Level Meter.

Spectral response curves– Curves representing the amplitude response of a circuit as a function of frequency.
1. FTC: Frequency tuning curves, electrophysiological responses obtained under constant output conditions.
2. IIC: Iso-intensity based curves, electrophysiological responses obtained under constant amplitude stimulus conditions.
3. PTC: Psychophysical tuning curves, obtained under low stimulus levels (typically 10 dB above threshold) using masking techniques. [Moore in Malmearca & Irvine, 2005]

Spectral segregation– Ability of a subject to delineate between tones that do not belong to a large set of tones.

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Spectrometer– A device for dispersing the energy applied to it on the basis of the frequency (or wavelength) of that energy. The total spectrum may be recorded simultaneously or a moving aperture may be used to determine the energy density along the dispersed energy pattern. If a narrow region of the dispersed energy, with respect to frequency, is passed through a single fixed aperture, the device is called a monochromator.

Spectrum Level– A term used by Gelfand to describe the power *density* of an acoustic signal in dB (the power level per one cycle bandwidth). Spectrum level = intensity level minus $10 \log(\text{bandwidth})$.

Speed of sound– The velocity of sound waves within a medium. Approaches infinity in an incompressible fluid. Is zero in a vacuum. Typically 344 meters/sec in air at 20° Celsius and sea level. Typically 1437 meters/sec in fresh water. In petrous bone, it is about 3013 meters/sec.

SPL– *Sound Pressure Level (Archaic: Specific Pressure Level)*– The RMS intensity (pressure) level of a stimulus based on a standard using 20 micropascals as a reference. A reference parameter in ISO documents. See SL.

Spontaneous rate– An average frequency on the ordinate scale of a histogram due to all uncontrolled neural activity, and potentially asynchronous stage 3 activity resulting from a stimulus.

Standard deviation (SD)– Usually an estimate, s , of the true standard deviation, s (sigma), based on a limited sample size. It is the square root of the variance, and expressed in the same units as the original measurement.

Standard error (SE or SEM)– An abbreviated form of the Standard error of the mean (i.e., the standard deviation of a distribution of means for repeated samples from a population).

STC– Spatial-tuning curve. Used in discussing the location of an OHC neuron of specific CF along the cochlear partition. See FTC.

Stellate cell– Any biological cell exhibiting multiple protuberances lacking any obvious physical arrangement.

Stellate neuron– Any multipolar neurological cell exhibiting multiple protuberances lacking any obvious and more specifically definable physical arrangement. Frequently contrasted with the pyramid neuron that exhibits a distinct apical neurite as well as one or more neurites emanating laterally along with an axon emanating from the surface opposite the apical neurite. See also stellite neuron.

Stellite neuron– A neurological cell used to decode action potential streams associated with stage 3 signal projection in chordates (vertebrates). The output of a stellite neuron is an electrotonic (analog) voltage. The stellite neurons are usually found in laminae IV of the cerebral cortex and a similar laminae in other signal manipulation engines of the neurological system. They can be identified by the fact they are the termination point for the axons of ganglion neurons and interneurons arriving at an engine via either (inter-engine) projection nerves or (intra-engine) association nerves. These projection and association nerves may be called commissure in some contexts. The physical shape of a stellite neuron is not defined but they are frequently described as large stellate neurons when found in laminae IV.

Stereausis– Source location within the hearing modality. Analogous to stereopsis in vision.

Stereocilia– The cilia found protruding from the cuticular plate of mechanoreceptors. Stereocilia of an individual mechanoreceptor are generally arranged into a recognizable geometric grouping. The grouping is characteristic of the type of receptor cell and is separate from any kinocilium present. See kinocilium.

Stereophonic– Literally, multiple complex sound sources (phonations) at different spatial locations in the far field environment. The sound from each source can travel to both ears. See binaural.

Stevens' Law– Given a tonal stimulus at the ear drum, the loudness is given by $L = L(f, x, I) \approx I^v$ where (f, x, I) are frequency, place, and intensity of the tone respectively, over the phonotopic range. v is typically between 1/3 and 1/4. Frequently described as the cube root rule. Stevens' Law fails over more extended ranges in favor of the diode law.

Stochastic– (Antonym of deterministic) A result that is not precisely predictable on an instantaneous basis based on the operational rules of the circuit or mechanism involved. The process exhibits a random component.

Subjective tone– A tone perceived by the subject in the absence of any component of that frequency in the original stimuli. Can be defined within three classes, tones generated by passage through a nonlinear process, tones such as beats generated within linear channels, and tones such as periodicity pitches that do not appear anywhere in the tonal

portion of the hearing system. The latter are primarily perceived following training as to their significance.

Subsurface cisterna– The structural cage immediately within the plasmalemma along(at least) the cylindrical portion of a sensory neuron. It appears to rigidize the sensory neurons against significant electromotility due to the change in potential associated with the axoplasm.

Sulcus– A valley or fissure between the surface areas, gyri, of the outer cerebral cortex.

Superior colliculus– One of two morphological features known to be involved in motor command signal generation and formatting.

Suppression– The loss in sensitivity of the hearing system to a signal following the application of a preceding signal. Suppression is a function of the intensity and duration of the preceding signal. It is also a function of the frequency difference between the two signals and the time between the beginning of the test interval and the end of the preceding signal. The duration of the test signal is a factor in suppression experiments. See also masking. (See Delgutte, 1990).

Surface acoustic waves– Acoustic waves traveling at the interface between two materials of different density. they are characterized by their localization at the interface surface and their slow propagation velocity compared to the longitudinal conduction waves normally associated with the bulk characteristics of either material.

Surface of local reaction– An ideal surface where the motion of each elemental area is independent of adjacent elemental areas. Relied upon by Allen and Sondhi in the late 1970's.

Synaptic ribbon– (alt. synaptic bar) The termination of the internal conduit between the Activa and the pedicle of a neuron. Frequently associated with a synaptic arc formed parallel to the exterior lemma of the axon.

Synesthesia– A condition where one perceives a sound in response to a visual stimulus or vice versa.

Synchronism– The term used in hearing research to describe the ability of sensory neurons to faithfully amplify their stimulus at frequencies below their low-pass frequency limit of about 600 Hz.

Synchronization index– Used variously in the exploratory research phase of hearing. Delgutte, 1980; the magnitude of the Fourier component at the tone frequency divided by twice the discharge rate of the response found in the auditory nerve.

Tectorial membrane– A delicate, flexible, gelatinous membrane overlying the rest of the sensory receptive mechanism; it is an epithelial derivative, cuticular in nature. (Anson & Donaldson, pg 179)

Tempo– defined as the speed of the rhythm in music. Generally described in words rather than a specific rate or velocity.

Temporary Threshold Shift– (TTS)– A postulated post stimulatory auditory fatigue. (Elliott & Fraser, 1970)

Timbre– The perceived distribution of energy in a chord or other complex sound when processed by the two-dimensional correlator of the PGN.

Tinnitus– The awareness of a sound percept not caused by external acoustic sources, and generally not audible to a clinician due to the generation of sound waves by the middle or inner ear.

Tip and tail– The narrow and broad components of the frequency response measured for chromatic channel neural signals.

Tone– (*In earlier times*) A sensation excited within the ear by any periodical motion of the air (Helmholtz, page 56). A perceived psychological sensation is the result of a signature (derived from a stimulus) in this work. (*In modern times*) A periodic, generally sinusoidal, vibration in the external medium and the stage 0 elements of hearing. See also compound and complex tones.

Tonotopic– A term used loosely to describe the topography of any nerve or neural engine if that topography displays an orderly distribution of frequency sensitive neurons relatable to the cochlear partition.

Tonotopicity– 1. The systematic mapping of frequency into physical location within the cochlear partition.
2. The systematic distribution of acoustic energy into physical locations along the tectorial membrane

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monotonically as a function of frequency.

Top down, bottom up– Used in hearing to distinguish between signals arriving at the midbrain from the peripheral hearing modality (bottom up) and mechanisms associated with pattern matching using the higher centers of the brain (top down). [Malmierca & Irvine, 2005]

Trabecula– The diminutive of the Latin "trabes", a beam or plank of wood, as might be used in a supporting structure. Frequently a pole supporting an axial load.

Transfection– infection of a cell with isolated viral nucleic acid followed by production of the complete virus in the cell; also the incorporation of exogenous DNA into a cell

Trapezoid body– The region of the medulla containing the cochlear nuclei and the trapezoid nucleus.

Trapezoid nuclei– A symmetrical pair of neural engines within the trapezoidal body and connecting the contralateral cochlear nuclei with ascending neural paths. (Wever, pg 231)

Traveling wave– An acoustic wave with a velocity related term in the argument of the function describing the amplitude of the wave. Frequently used in hearing as synonymous with "slow wave." See Acoustic wave.

Traveling wave theories– A group of archaic and largely conceptual theories relying upon the presence of an (undiscovered) low velocity surface acoustic wave associated with the basilar membrane.

Tremolo frequency– (alt. Vibrato frequency) The frequency of the amplitude variation of the center frequency component generated by the mixing of two tones (the result of a trigonometric identity).

Tritone– A superfluous, or augmented fourth, containing three whole steps. The two notes span a half octave.

Tuning curve– A graph of the sound pressure at the tympanic membrane as a function of frequency in a signaling channel for a change in the pulse rate that is an arbitrary level above its spontaneous rate (typically 10 pps). (Kiang, et. al., 1986) Obviously indicative of a channel with a spontaneous rate.

Ultrasonic sound– Typically, sound at frequencies above 15,000 Hertz.

Umbo– The attachment point of the malleus to the tympanic membrane.

Velocity– A vector quantity describing the amplitude and the direction of energy flow. Used with multiple adjective modifiers.

1. **Propagation velocity**– The rate of propagation of a specific phase of a sinusoidal wave along a medium.
2. **Phase velocity**– The velocity of a point of constant phase associated with a sinusoidal traveling wave. The point of constant phase is characterized by the expression $x + vt = \text{constant}$ in the wave equation.
3. **Group velocity**– The apparent rate of propagation of a specific feature of a complex acoustic signal within a medium. In a non-dispersive medium, the group velocity equals the phase velocity (Kraus, 1953). In a normal dispersive medium, the group velocity is less than the phase velocity of the mean frequency. In an anomalous dispersive medium, the group velocity is greater than the phase velocity of the mean frequency.
4. **Particle velocity**– (at the molecular level) The RMS amplitude of the random vibration of a molecule in three dimensions.
5. **Particle velocity**– (at the macro-level) The motion of a particle within a liquid or liquid crystalline material subject to acoustic excitation. Typically elliptical or ellipsoidal. Frequently resolved into the component along a specific axis of interest. The average displacement associated with such short term particle velocity is usually zero.

Vibrato frequency– The perceived modulation frequency within a single tonal channel resulting from the stimulation of a sensory channel by two closely spaced frequencies. The vibrato frequency is one half the value of the beat frequency.

Villus– (pl. villi) A small slender vascular process.

Waveguide– A structure for directing acoustic or electromagnetic energy along a specified path.

1. **Open waveguide**– A dielectric waveguide in which the external field decays exponentially but extends to great distances.
2. **Closed waveguide**– A waveguide where the external wall is totally reflective of the energy

enclosed.

Wavenumber– Used variously

1. (Acoustics, vibration and visible light), wavenumber = the reciprocal of the wavelength.
2. (Theoretical physics), wavenumber = $(2 \cdot \pi) / \text{wavelength}$.

White noise– See noise.

WKB–Wentzel-Kramers-Brillouin method– A phase integral method of approximation used in complex structural analysis. It makes an assumption that allows the separation of variables. It is considerably faster than competing finite element or finite difference computations but of limited precision.

Word–A sound or a combination of sounds, or its representation in writing or printing, that symbolizes and communicates a meaning and may consist of a single morpheme or of a combination of morphemes.

Zeitgeist– The habits of thought that characterize a scientific discipline at the time of a new discovery. (Gulick, pg54)

Zombie– A mythical animal that is identical to a human but lacks consciousness (the ability to reason).

Zona arcuate– The area of the basilar membrane structure including the Arches of Corti. (Anson & Donaldson, III-56)

Zona pectinate– The structures of the basilar membrane between the Arches of Corti and the spiral ligament.

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