# *AN INSIGHT INTO OTO-ACOUSTIC EMISSIONS : A QUESTION BANK*

*Register No. M 9413*

*AN INDEPENDENT PROJECT WORK SUBMITTED IN PART FULFILMENT FOR THE FIRST YEAR M.Sc. (SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE.*

***ALL INDIA INSTITUTE OF SPEECH AND HEARING***

***MYSORE - 570 006.***

***1995***

***DEDICATED TO MY MOTHER***

***"Mother and Love differ only in name,***
***For the miracles they work are one and the same"***

## ***CBRTIFICATE***

*This* is to *certify that this Independent Project entitled* ***"AN INSIGHT INTO OTO-ACOUSTIC EMISSIONS*** *: A QUESTION BANK" is the bonafide work in part fulfilment for the first year "MASTER OF SCIENCE (SPEECH AND HEARING)", of the student vith Register No. M 9413.*

*MYSORE*

***MAY, 1995***

**Dr. (Miss) S. NIKAM**
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## ***CERTIFICATE***

*This* is *to certify that this Independent Project entitled **"AN INSIGHT INTO OTO-ACOUSTIC EMISSIONS : A QUESTION BANK"** has been prepared under my supervision and guidance.*

*MYSORE*

*MAY, 1995*

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## ***DECLAMATION***

*I here by declare this Independent Project entitled "* ***AN INSIGHT INTO OTO-ACOUSTIC EMISSIONS : A QUESTION BANK"*** *is the result of my own study under the guidance of Dr. (Miss) S.* ***NIKAM,*** *Director , All India Institute of Speech and hearing, Mysore, and has not been submitted earlier at any university for any other Diploma or Degree.*

*MYSORE* ***(REGNO:M9413)***

***MAY, 1995***

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To Charu, Mehala, Monika, Vaishu, Vinki and Hardy : Thanks for being there for me, through good times and bad.

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To all my near and dear ones, who I may have not mentioned in my short-sightedness.

To "Precision- for the care with which they have added the finishing touches to this project.

**(REG NOM9413)**

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# INTRODUCTION

# CHAPTER 1

# INTRODUCTION

Oto-acoustic emissions today represent state-of-the-art advances in the realms of diagnostic audiology. Oto-acoustic emissions (CAEs) are defined as " Sounds generated within the cochlea, by the outer hair cells, which can be detected at the tympanic membrane by a miniaturized, sensitive microphone" - (NORTON AND STOVER, 1994) .

The oto-acoustic emission phenomenon is based on an active mechanism *in* the cochlea and was first described 10-15 years ago. For years together, the inner ear had been assigned a rather passive role as a hearing receptor. However, with the discovery of OAEs, the cochlea is considered now to be a highly sophisticated organ with bi-directional transduction properties. So, just as an old, horn-type hearing instrument can be turned around and blown like a trumpet, the human ear too, can both receive and generate sound energy - (KEMP 1990) . This bi-directional transduction property is known to be unique to human hearing.

The force responsible for OAE generation is the electro-motility of the outer hair cells. This outer hair cell electromotility was first demonstrated by BROWNELL (1983). This electro-motility is what sets the outer hair cells into oscillations at audible frequencies. These oscillations are magnified by the middle ear system and transmitted into the air as sound. So by sealing a receiver - microphone probe into the ear canal, sounds made by the cochlea can be evoked, even by external sound and recorded from almost any ear canal, with normal mid-frequency hearing.

OAEs have not only stimulated a radical re-think in auditory physiology but also represent a crucial landmark in the understanding of cochlear mechanics. The discovery and the first measurement of OAEs is credited to KEMP and associates (1978) from the Institute of Laryngology and Otology (ILO) in London.

Since the late 70's, when OAEs were first discovered, research has been actively on to:

a. Try and determine their various properties.

b. Design aPProprite instrumentation to record them.

c. Try and assess the external and internal factors which influence their generation.

d. Focus dn significant parameters of the stimulus used to evoke OAEs.

In India, research in the area of oto-acoustic emissions is still of fledgling status. But as the scientific work of audiologists, hearing scientists and other professionals all over the world has demonstrated, the OAEs represent a tremendous breakthrough in diagnostic audiology and are definitely here to stay. Therefore, it is vital for the audiologists of today and tomorrow to be well-acquainted with the basics and details ot OAEs. It is also essential, at this preliminary stage to tilter out every possible doubt that obscures our understanding of OAEs.

What follows is an earnest attempt to bring out any doubt, regarding OAEs into the open and thus dispel any misconception. This will certainly help to pave the way for a holistic understanding and proper appreciation of the phenomenon of OAEs. The potential use of this question bank could be:

a. its use in short-term and refresher courses.

b. its use to evaluate and monitor the student's or trainee's understanding of the subject.

Both short-answer and objective types of questions have been included. The different types of questions included are:

1. Crosswords

2. Match the following

3. Fill in the Blanks

4. Multiple choice questions

5. Expand the abbreviations

6. State True or False

7. Label the schematic diagrams

8. Short answer questions, etc.

# A CLOSER LOOK AT OAEs

# CHAPTER 2

# A CLOSER LOOK AT OAEs

The oto-acoustic emission response is not merely restricted to experimental situations, but is a natural physiological accompaniment to normal hearing. Moreover, OAEs can be measured non-invasively and are sensitive indicators * of cochlear status. Thus, they are a potentially valuable addition to the existing arsenal of (clinical audiology. Broadly speaking, the OAEs can be classified into two types:

**I. SPONTANEOUS 0T0-ACOUSTIC EMISSIONS (SOAEs):**

Spontaneous or unstimulated emissions occur in the absence of any external stimulation. SOAEs are pure tones of about 20 dB SPL found in the unstimulated ear canal in 40-60% of healthy ears. *They* are more or less continuous narrow band signals and relatively easy to measure. Their existence was first postulated by GOLD (1948) .

**II. EVOKED OTO-ACOUSTIC EMISSIONS (EOAEs) :**

EOAEs are oto-acoustic emissions, evoked in response to a sound stimulus and can be detected in 100% of all ears with normal hearing. Depending upon the nature of the eliciting stimulus, EOAEs are of three subtypes:

**a. TRANSIENT-EVOKED OTO-ACOUSTIC EMISSIONS: (TEOAEs)**

**TEOAEs were the first emission type to be reported in the** literature by KEMP (1978) . They are also referred to as click - evoked OAEs. They are frequency - dispersive responses, occurring in response to a transient acoustic stimulus, such as a click or a tone burst.

**b. ACOUSTIC DISTORTION PRODUCT EMISSIONS (ADPEs):**

These type of emissions are generated in response to two simultaneously presented pure tones (Fl and F2) , which are separated in frequency, by a prescribed difference (in Hz) . Technologically, the ADPEs are the easiest type of emissions to measure, bieing relatively artifact-free and requiring no post-hoc processing.

**c. STIMULUS FREQUENCY EMISSIONS (SFEs) :**

Stimulus frequency emissions are the most frequency specific and probably, the least clinically applicable of emission types. These emissions reflect the response of the cochlea, to a single, continuous, pure tone input occurring simultaneously with and at the same frequency as the eliciting stimulus.

The potential clinical applications of OAEs include:

1. Screening for peripheral auditory system dysfunction in newborn babies and infants.

2. Separating the cochlear and neural components of sensori-neural hearing loss.

3. Monitoring the effects of noxious agents, such as ototoxic drugs and intense noise exposure on the cochlea.

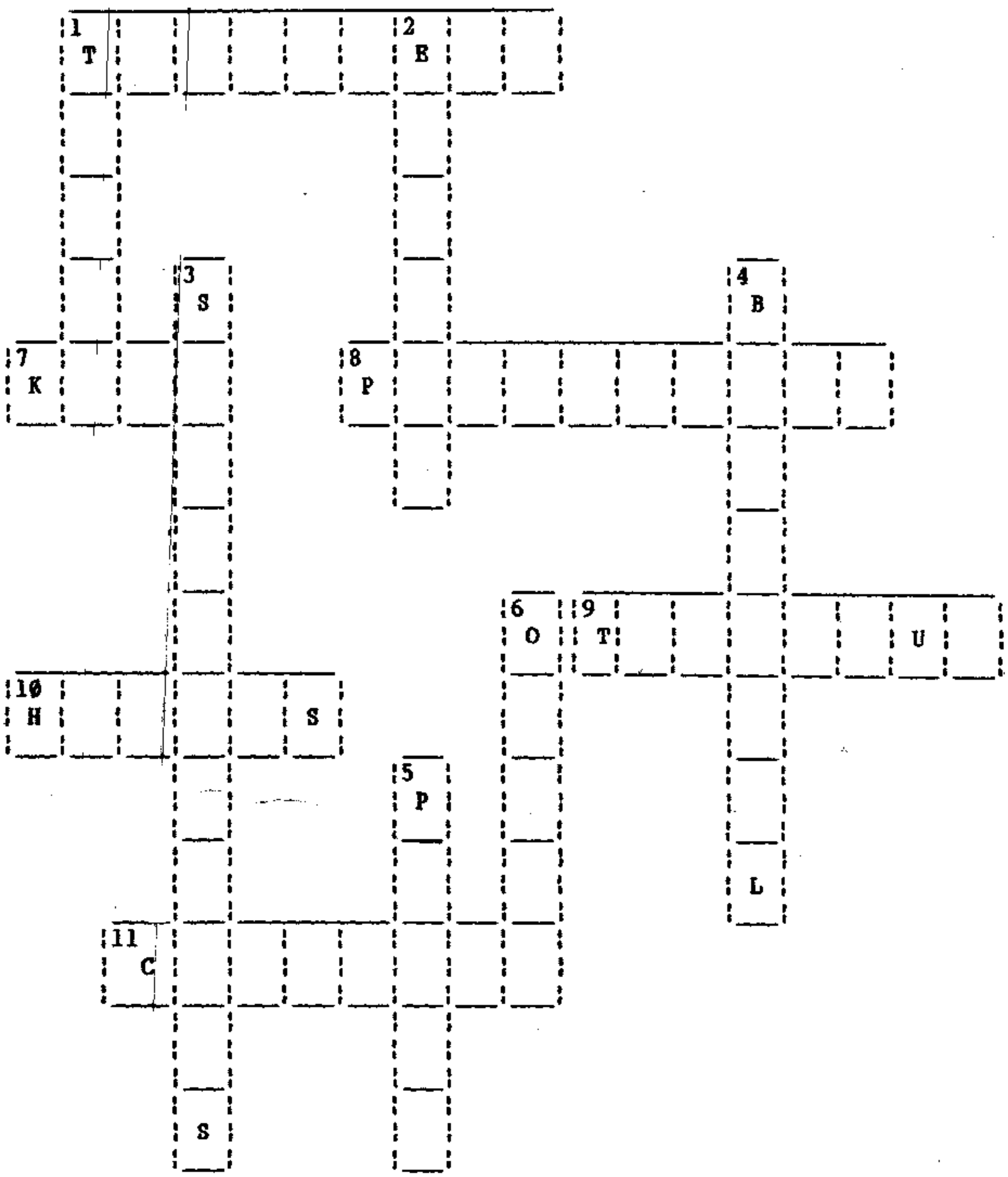
4. Assessing fluctuating hearing loss, with or without therapeutic regimens.

# OAEs - THE BEGINNING

# CHAPTER 3

## OAEs — THE BEGINNING

**I. DO IT YOURSELF CROSSWORD:**



**CLUES**

I. DOWN:

1. The number of subtypes of evoked oto-acoustic emissions.

2. These emissions are identifiable in 96 - 100% of ears with normal hearing.

3. These are "unstimulated" emissions.

4. He first demonstrated the electromotility of outer hair cells

5. A type of EOAE detection device.

6. These hair cells are responsible for OAE generation.

**ACROSS:**

1. The first evoked emission type to be reported in literature.

7. The discoverer of OAEs.

8. OAEs have a potential use in. screening for auditory system dysfunction of this nature.

9. Initially, SOAEs were believed to result in this condition.

10. OAEs were first recorded in their ears-

11. OAEs are absent when this type of hearing loss exceeds 40-30 dB HL.

**II. EXPAND THE ABBREVIATIONS :**

1. OAE.
2. OHC.
3. SFE.
4. ILO.
5. ADPE.
6. MLS.
7. TEOAE.
8. POEMS.

**III. WATCH THE FOLLOWING :**

| | | | |
|---|---|---|---|
| 1. | OTO-ACOUSTIC EMISSIONS | A | WILLIAM BROWNELL |
| 2. | EASIEST EMISSION TYPE TO MEASURE | B | KEMP ECHOES |
| 3. | PRE-NEURAL SIGNALS | C | COPE AND LUTMAN |
| 4. | TINNITUS | D | ADPEs |
| 5. | BIDIRECTIONAL TRANSDUCTION | E | DAVID KEMP |
| 6. | OHC ELECTROMOTILITY | F | SPONTANEOUS OAEs |
| 7. | POEMS | G | COCHLEA |
| 8. | TEOAES | H | COCHLEAR MICROPHONICS |

***IV.* STATE TRUE OR FALSE** :

1. *OAEs* are a natural physiological accompaniment to normal hearing.

2. External and middle ear problems will affect OAE recording and measurement.

3. OAEs are not as frequency-place specific as the cochlear microphonic.

4. OAEs provide a physical communication channel to the cochlear transduction mechanism.

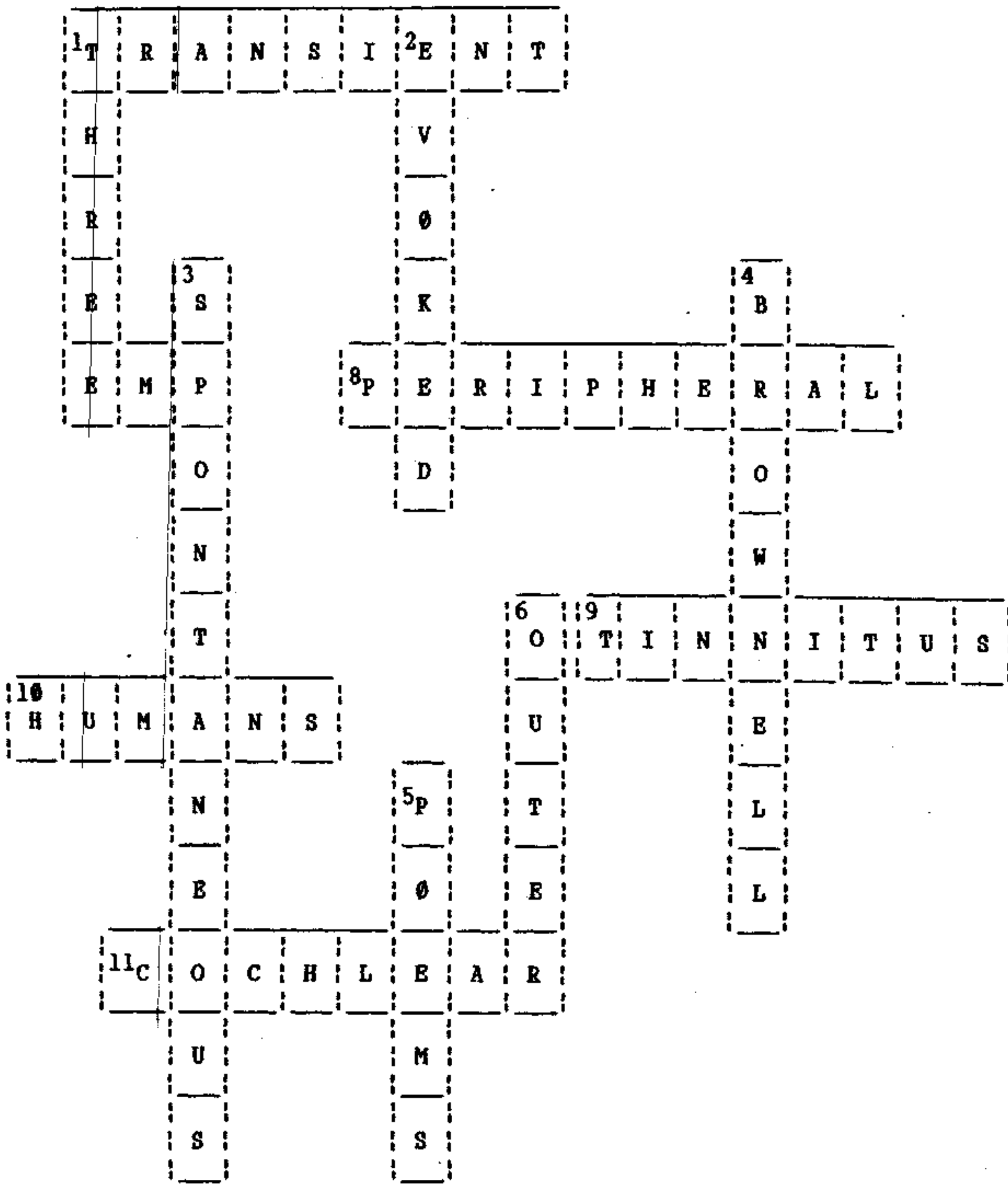
5. OAEs are mostly found at frequencies between 4000 Hz and **8000** Hz.

6. Latency of human oto-acoustic emissions decreases as the stimulus frequency is decreased.

# CHAPTER 3

# SOLUTIONS

**I. DO IT YOURSELF CROSSWORD:**



## II. EXPAND THE ABBREVIATIONS:

1. Oto Acoustic Emissions
2. Outer hair cells.
3. Stimulus frequency emissions
4. Institute of Laryngology and Otology
5. Acoustic distortion product emissions
6. Maximum length sequencing
7. Transient - evoked oto acoustic emission
8. Programmable oto-acoustic emission measurement system

## III. MATCH THE FOLLOWING:

1 - e

2 - d

3 - h

4 - f

5 - g

6 - a

7 - c

8 - b

## :IV. STATES TRUE OR FALSE

1 - True

2 - True

3 - False

4 - True

5 - False

6 - True

# THE SECRET OF OAEs

# CHAPTER 4

# THE SECRET OF OAEs - OHC ELECTROMOTILITY

## I- MATCH THE FOLLOWING :

| | | | |
|---|---|---|---|
| 1. | COCHLEAR AMPLIFIER | A | ENHANCE BASILAR MEMBRANE FUNCTION |
| 2. | OUTER HAIR CELLS | B | WILSON (80) |
| 3. | GOLD (1948) | C | MECHANICAL FREQUENCY ANALYSER |
| 4. | BASILAR MEMBRANE | D | ACTIN AND MYOSINE |
| 5. | VOLUME CHANGES OF SUPPORTING CELLS | E | DAVIS (83) |
| 6. | OUTER HAIR CELL STEREOCILIA | F | ACTIVE COCHLEAR FEEDBACK MECHANISM |

## II. FILL IN THE BLANKS :

1. ____________ are responsible for the sharp tuning of the basilar membrane.

2. Mammalian outer hair cells are motile in response to changes in ____________.

3. OHC electromotolity takes the form of a change in the ____________ of the hair cell.

4. OHC length ____________ under the influence of a depolarizing or excitatory stimulus.

5. The mechanical response of the cochlea in normals is known **to be__________.**

6. In the outer hair cell, normally found cytoskeletal organization is replaced by___________.

## IV FIND THE MISSING PEOPLE :

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| G | S | D | B | I | J | I | L | K | F | E | R |
| I | K | M | A | C | A | R | T | N | E | Y | |
| P | A | R | P | V | N | Q | P | S | 0 | H | A |
| T | Q | M | G | W | I | L | S | 0 | N | T | Q |
| 0 | E | D | O | H | R | S | V | N | C | K | A |
| K | T | I | L | N | E | Y | S | E | K | E | B |
| M | A | P | D | L | L | E | N | W | 0 | R | B |

The names of nine people who contributed to the understanding of the mechanism behind oto acoustic emission generation are hidden here. **CAN YOU FIND THEM ?**

**CLUES:**

1. Concept of Cochlear Amplifier'.

2. Outer hair cell stereocilia composition (2 names).

3. Hypothesized volume changes of supporting cells.

4. Experimental evidence for non-linear basilar membrane mechanics.

5. outer hair cell stereocilia composition.

6. Discoverer of oto acoustic emissions.

7. Demonstration of outer hair cell electromotility.

8. Travelling Wave theory.

9. Existence of active, cochlear feedback mechanism.

IV. STATE TRUE OR FALSE :

1. All medial efferent fibres of the auditory pathway respond to auditory stimulation.

2. The mechanism responsible for OAE generation is vulnerable to cochlear pathology.

3. Using OAE measurements, it is possible to assess the auditory pathways central to the cochlea.

4. OAE generation is dependent upon afferent synaptic transmission.

5. Outer hair cell length increases under the influence of a hyperpolarizing or inhibitory stimulus.

6. The "Cochlear Amplifier" is seen as a mechanism which maintains normal threshold sensitivity.

## V MULTIPLE CHOICE QUESTIONS:

PICK THE RIGHT ONE

**1. The normal auditory system** is:

a. linear, sharply tuned,and displays low sensitivity.

b. non-linear, sharply tuned and displays high sensitivity.

c. non-linear, broadly tuned and displays high sensitivity.

d. linear, broadly tuned and displays low sensitivity.

2. Non-linear basilar membrane behaviour :

a. is the result of OHC degeneration.

*b.* results in abnormal OAE behaviour.

c. indicates that active physiological mechanisms are involved in cochlear mechanics.

d. decreases the sharp frequency selectivity present in the normal cochlea.

3. Motility of outer hair cells has been demonstrated in response to :

a.___.___electrical stimulation.

b.___/___pharmacologic stimulation.

c.___/___Acoustic / mechanical stimulation.

d. ~ a11 of the above.

4. Outer hair cell electromotitlity forces are proportional to :

a. [ ] the current.

b. [ ] the applied voltage.

c. [ ] Both the current and the applied voltage.

d. [ ] stimulus voltage but not stimulus current.

5. The force generating mechanism for OHC electromotility is thought to be driven by :

a. [✓] **receptor potential.**

b. [✓] **cellular stores of ATP (adenosine tri phosphate).**

c. [✓] **Kreb's cycle.**

d. [✓] **resting membrane potential.**

6. Skeletal muscle cells differ from outer hair cells in :

a. [✓] being able to generate force only when contracting.

b. [✓] being dependent upon cellular stores of ATP for motility.

c. [✓] muscle cell elongation being a passive process.

d. [ ] all of the above.

7. As frequency increases, Magnitude of outer hair cell Movement:

a. [✓] also increases.

b. [ ] also decreases.

c. [✓] increases upto 8 kHz and then decreases.

d. [ ] shows no change at all.

8. When compared to cells of most organs.the cells of the Organ of Corti are :

a. [✓] very tightly packed.

b. [✓] placed apart but with loose attachments to adjacent cells

c. [✓] well separated by large fluid filled spaces.

d. [✓] widely separated at the basal end, closely packed at the apical end.

9. The outer hair cell has :

a. [✓] only tension resisting elements.

b. [✓] tension and compression resisting elements.

c. [✓] only compression resisting elements.

d. [✓] none of the above.

# CHAPTER 4

# SOLUTIONS

I. **MATCH** THE **FOLLOWING**

l-e, 2-a, 3-f, 4-c, 5-b, 6-d.

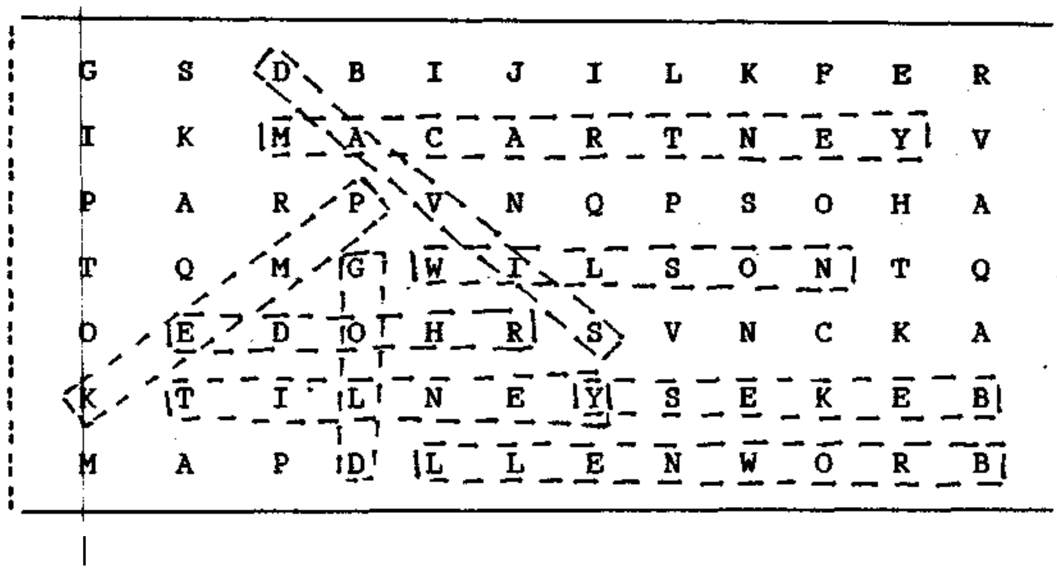
**II - FILL IN THE BLANKS**

1. Outer hair cell.
2. Cellular potential.
3. Length.
4. Decreases.
5. Non-linear.
6. Hydraulic skeleton.

**III. STATE TRUE OR FALSE :**

1. False.
2. True.
3. False.
4. False.
5. True.
6. True.

**IV. FIND THE MISSING PEOPLE :**




1. Davis
2. Macartney
3. Wilson
4. Rhod*e*
5. Tilney
6. Kemp
7. Brownell
8. Bekesy
9. Gold

V. MULTIPLE CHOICE QUESTIONS :

1-b, 2-c, 3-d, 4-d, 5-a, 6-d, 7-b, 8-c, 9-b.

# THE OAE FAMILY
# AND ITS MEMBERS

# SPONTANEOUS OTO-ACOUSTIC EMISSIONS

# CHAPTER 5

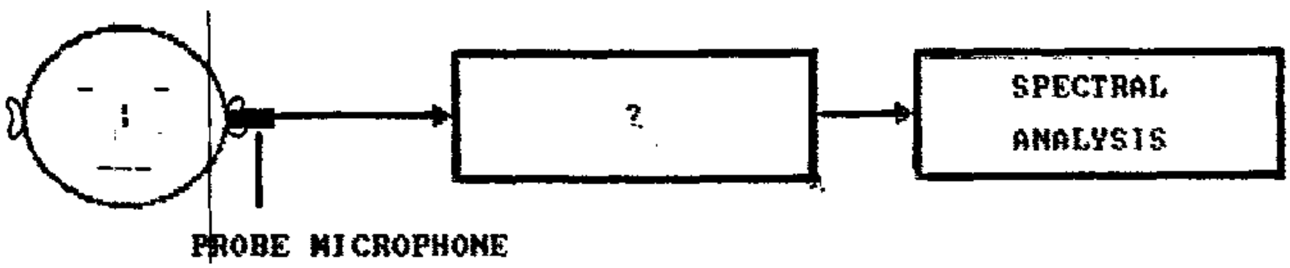
# THE OAE FAMILY AND ITS MEMBERS

PART A

A) SPONTANEOUS OTO-ACOUSTIC EMISSIONS

I. WHATS MISSING ?

Label the missing link in the schematic given for SOAE measurement :



II. MULTIPLE CHOICE QUESTIONS:

TICK THE MOST APPROPRIATE RESPONSE

1. Spontaneous oto-acoustic emissions:

a. [ ] are measured without external stimulation.

b. [ ] are more prevalent in males.

c. [ ] occur in 40 - 60% of unhealthy ears.

d. [ ] all of the above.

2. Spontaneous oto-acoustic emissions were first observed in:

a. [ ] dog ears.

b. [ ] chinchillas.

c. [ ] human ears.

d. [ ] rabbit ears.

3. Compared to other primates, incidence of spontaneous oto-acoustic emissions in human ears appear to be:

a. [ ] lower.

b. [ ] same as other primates.

c. [ ] higher.

d. [ ] inconsistently present.

**4. Spontaneous oto-acoustic emissions which are recorded fro* the external auditory canal:**

a. [ ] are only present in individuals who experience tinnitus.

b. [ ] :cur only after intense, acoustic stimulation.

c. [ ] :cur in 35 - 50% of normal hearing ears.

d. [ ] indicate cochlear pathology in neonates.

5.Spontaneous oto-acoustic emissions in children (5-12 years):

a. [ ] are similar in frequency distribution and amplitude, to those measured in adults.

b. [ ] are lower in amplitude than those measured in adult ears

c. [ ] are most commonly found in the 3000-5000 Hz range.

d. [ ] have the same frequency distribution as adults, but are higher in amplitude.

6. Incidence of spontaneous oto-acoustic emissions shows:

a. [ ] gender differences.

b. [ ] age differences.

c. [ ] racial group differences.

d. [ ] all of the above.

**III. WATCH THE FOLLOWING AND ARRANGE THE MATCHES IN CHRONOLOGICAL ORDER:**

| | | |
|---|---|---|
| 1. Investigation of the association between SOAEs and tinnitus. | A | BONFILS et al |
| 2. Posjtulation Of SOAE existence. | B | KEMP AND ZUREK |
| 3. Greater prevalence of SOAEs in infants | C | BILGER et al |
| 4. Racial group-related differences in SOAE prevalence | D | BURNS et al |
| 5. First measurement of SOAEs | E | GOLD |
| 6. Strong gender differences c | F | PENNER AND BURNS |
| 7. Existence of interactions among multiple SOAEs - the phonomenon of linked emissions | G | WHITEHEAD |

**IV. FILL IN WITH INCREASES / DECREASES:**

1. In subjects over age 50, prevalence and number of SOAEs ____________.

2. At frequencies between 1000 and 2000 Hz, the number of SOAEs-------.

3. In infants less than 18 months of age, prevalence of SOAEs.

4. Presence of SOAEs in one ear__________likelihood of SOAEs in *the* other ear.

5. When bompared to Negroes, the incidence of SOAEs in Caucasians the other ear.

6. If SOAEs are associated with normal, localized degeneration of hair cells, their incidence would be expected to __________ with age.

7. Stapedial reflexes and changes in the ear canal pressure are found to_____________the level and_____________the frequency of the emission.

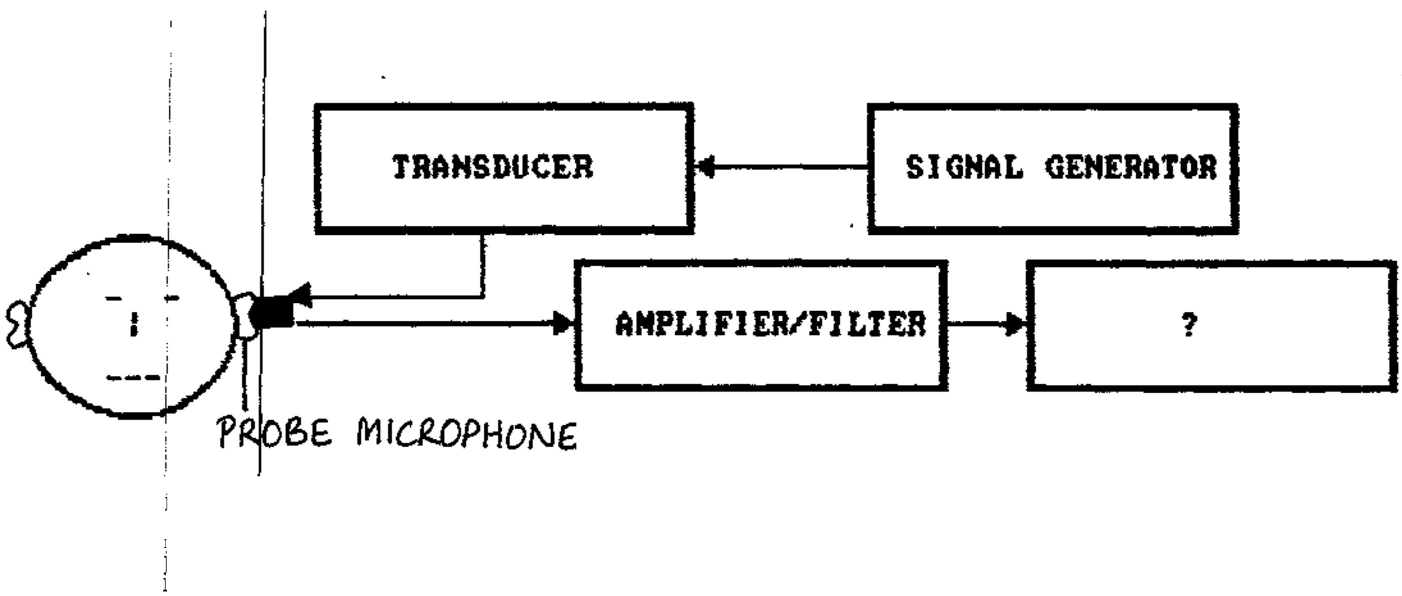
8. In ears with minimal cochlear hearing loss, possibility of finding SOAEs____________.

# EVOKED
# OTO-ACOUSTIC EMISSIONS

i I

PART B - EVOKED OTO-ACOUSTIC EMISSIONS (EOAEs)

Q.I. WHAT'S MISSING ? WHAT IS ITS FUNCTION ?




II.MULTIPLE CHOICE QUESTIONS : TICK THE RIGHT ANSWER.

1.Evoked oto acoustic emissions occur in response to:

a. !__! pure tones.

b. !__! clicks and tone bursts.

c. !__! pure tones and clicks.

d.______pure tones, clicks and tone bursts.

2. Evoked oto acoustic emissions:

a. ☐ display saturating input -output functions.

b. ☐ occur only at frequencies when there are SOAEs.

c. ☐ occur only in response to high-level stimuli.

d. ☐ are identical in all normal hearing ears.

3. Difference between individual evoked oto acoustic emissions occur mainly with respect to:

a. ☐ response latency.

b. ☐ wave form morphology and spectral content.,

c. ☐ peak-to-peak amplitude and number of emission bursts.

d. ☐ all of the above.

4. Evoked oto acoustic emission generation in response to low to moderate level stimuli is dependent on:

a ☐ integrity of the VIIIth nerve.

b. ☐ normal middle ear function.

c ☐ normal outer hair cell function.

d ☐ normal brain stem function.

5. Evoked oto acoustic emission may be present in cases where behavioral and neural responses are depressed or absent because:

a. ☐ mechanism responsible for OAE generation is peripheral to the VIIIth nerve.

b. ☐ they are an unreliable indicator of cochlear status.

c. ☐ actual tuning of auditory stimuli occurs central to the cochlear mechanisms.

d. ☐ evoked oto acoustic emissions are only elicited at high stimulus levels.

**6. Transient-evoked oto acoustic emission amplitude:**

a. ☐ increases with age.

b. ☐ decreases with age.

c. ☐ does not change with age.

d. ☐ is very difficult to measure in children.

***7.* Frequency specificity of transient-evoked oto acoustic emissions might be best described as:**

a. ☐ good only for high frequency hearing loss identification.

b. ☐ good for low and high frequency hearing loss identification.

c. ☐ excellent for all frequencies, 1000 Hz through 4000 Hz, if the ear has normal hearing sensitivity.

d. ☐ poor for both high frequency and low frequency hearing loss identification.

8. The pathological status of the Middle ear:

a. [ ] does not affect transient-evoked oto acoustic emissions

b. [ ] pay affect transient-evoked oto acoustic emission amplitude.

c. [ ] precludes transient-evoked oto acoustic emissions from being measured.

d. [ ] increases low-frequency transient-evoked oto acoustic emission amplitudes.

9. The prevalence of transient-evoked oto acoustic emission in normal hearing infants:

a.______is 50% less than that found in normal hearing adults.

b. [ ] is 80% less than that found in normal hearing adults.

c. [ ] is the same as that found in normal hearing adults.

d. [ ] is greater than that found in normal hearing adults.

10. Transient-evoked oto acoustic emission screening tests:

a [ ] show high sensitivity, but low specificity compared to auditory brain stem response screening tests.

b. [ ] show low sensitivity, but high specificity compared to auditory brain stem response screening tests.

c. [ ] show high specificity and sensitivity compared to auditory brain stem response screening tests.

d. [ ] are mere time consuming than auditory brain stem response screening tests.

11. As a clinical **tool with adult** patients, transient-evoked oto acoustic emissions are best for identifying:

a. ☐ pseudohypacusis.
b. ☐ low frequency, cochlear hearing loss.
c. ☐ multiple sclerosis.
d. ☐ acoustic neuromas.

12. Research evaluating the use of transient-evoked oto acoustic emissions for newborn hearing screening has shown that, in comparison to Auditory Brain Stem Response screening, transient-evoked oto acoustic emission screening:

a. ☐ is cheaper and faster, but not as effective.
b. ☐ has substantially better accuracy.
c. ☐ has substantially poorer accuracy.
d. ☐ can be used effectively only with neonatal intensive care unit (NICU) babies.

13. The best transient-evoked oto acoustic emission responses in infants are seen:

a. ☐ when infants are 4-6 weeks old.
b. ☐ between 48 and 72 hours of age.
c. ☐ immediately at birth.
d. ☐ at the age of 3 months.

14. For clinical screening purposes, thresholds for trans Lent-evoked oto acoustic emission are not generally deter lined because:

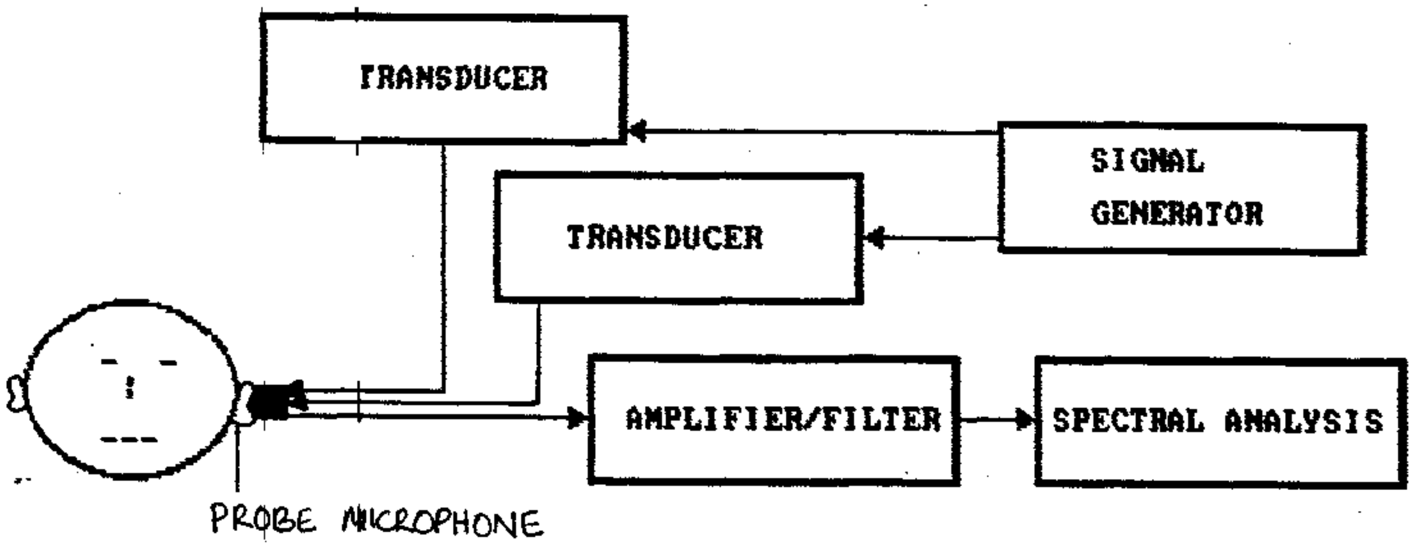
a. ☐ test time is too long.

b. ☐ presence of spontaneous emissions might lower thresholds .

c. ☐ thresholds for transient-evoked oto acoustic emissions are affected by the patient's age.

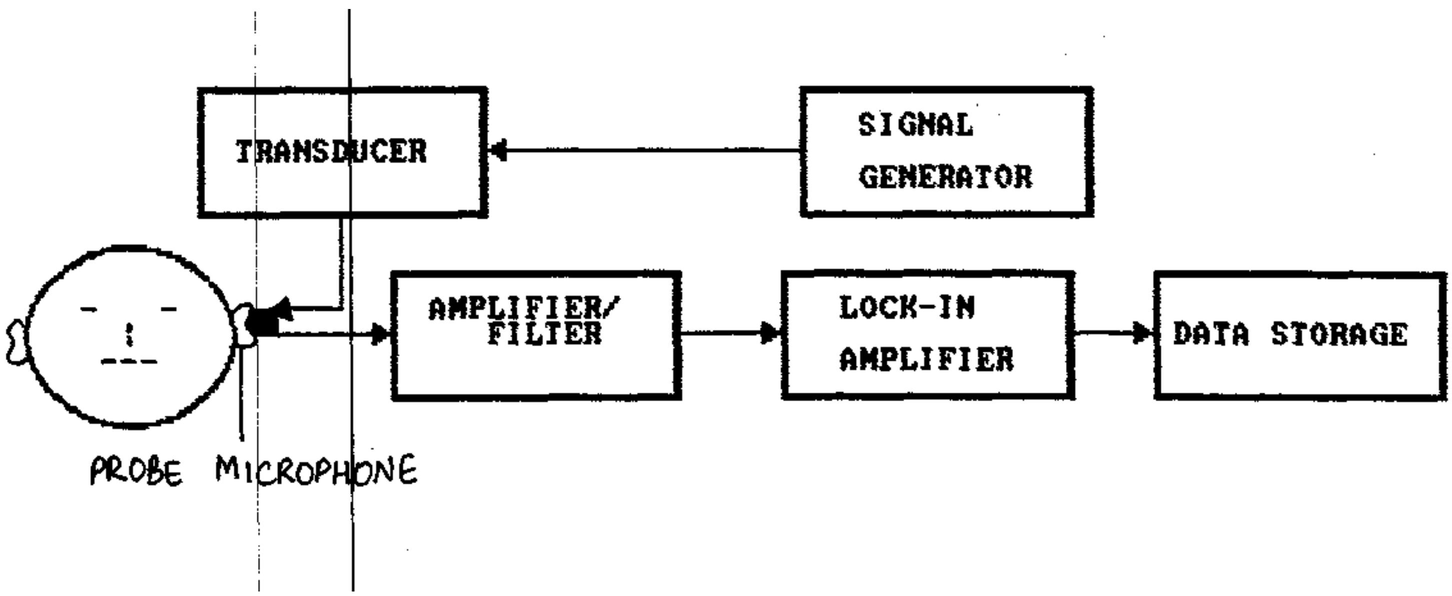
d. ☐ all of the above.

III A) WHAT TYPE OF EVOKED EMISSIONS ARE MEASURED USING THIS APPARATUS ? HOW IS THIS APPARATUS DIFFERENT FROM THAT USED TO MEASURE OTHER EVOKED EMISSIONS ?



B) WHAT TYPE OF EMISSION CAN BE MEASURED USING THIS SYSTEM?

IN THE GIVEN SCHEMATIC, WHAT IS THE FUNCTION OF THE LOCK-IN AMPLIFIER ?




IV. MULTIPLE CHOICE QUESTIONS

1. Which type of oto acoustic emissions are not generated at the cochlear location associated with the frequency of the emission?

   a.______Spontaneous oto acoustic emissions (SOAEs).

   b.______Transient evoked oto acoustic emissions (TEOAEs).

   *c.*______Acoustic distortion product emissions (ADPEs) .

   d.______Stimulus frequency emissions (SFEs) .

2: Distortion product emissions were first demonstrated in human ears by :

a. ☐ LONSBURY - MARTIN, et al.

b. ☐ KEMP et al.

C ☐ BONFILS et al.

d. ☐ THORNTON et al.

3. When hearing levels across frequency exceed 30 dB HL,

a. ☐ transient-evoked oto acoustic emissions are present more often than distortion product oto acoustic emissions.

b. ☐ both transient-evoked oto acoustic emissions and distortion product oto acoustic emissions are always present.

c. ☐ distortion product oto acoustic emissions are present more often than transient-evoked oto acoustic emissions.

d. ☐ Both transient-evoked oto acoustic emissions and distortion product oto acoustic emissions are always absent.

4. Parameters which are known to affect distortion product oto acoustic emissions are:

a. ☐ stimulus frequency.

b. ☐ stimulus level.

c. ☐ separation between primaries.

d. ☐ all of the above.

5. wiich of the following is considered an ideal subject for the study of distortion emissions ?

a. Chinchilla.
b. Guinea pig.
c. Rat.
d. Gerbil.

6. Compared to the difference tone distortion product (f2 - fl), the c\bic difference tone:

a. is more robust.
b. is more vulnerable to cochlear insult.
c. is easier to detect.
d. all of the above.

7. Particularly strong correlations between physiological tuning curves and OAEs have been observed at :

a. 1 kHz.
b. 4 kHz.
c. 2 kHz.
d. 500 Hz.

8. Distortion product emissions with an intensity less than the noire floor :

a. can be easily detected.
b. can not be detected.
c. are artifacts.
d. may be sometimes detected.

9. Maximal distortion product oto acoustic emissions have been reported using F2/F1 values of :

a.____1

b. 1.25

c_2

d.______0.5

10. Stimulus frequency emissions (SFE's) are also called :

a.______Kemp echoes.

b.______linked emissions.

c.______synchronous evoked emissions.

d.______cochlear echoes.

11 . The frequency seperation betveen adjacent peaks in the stimulus frequency emission wave form increases with :

a.______decrease in frequency.

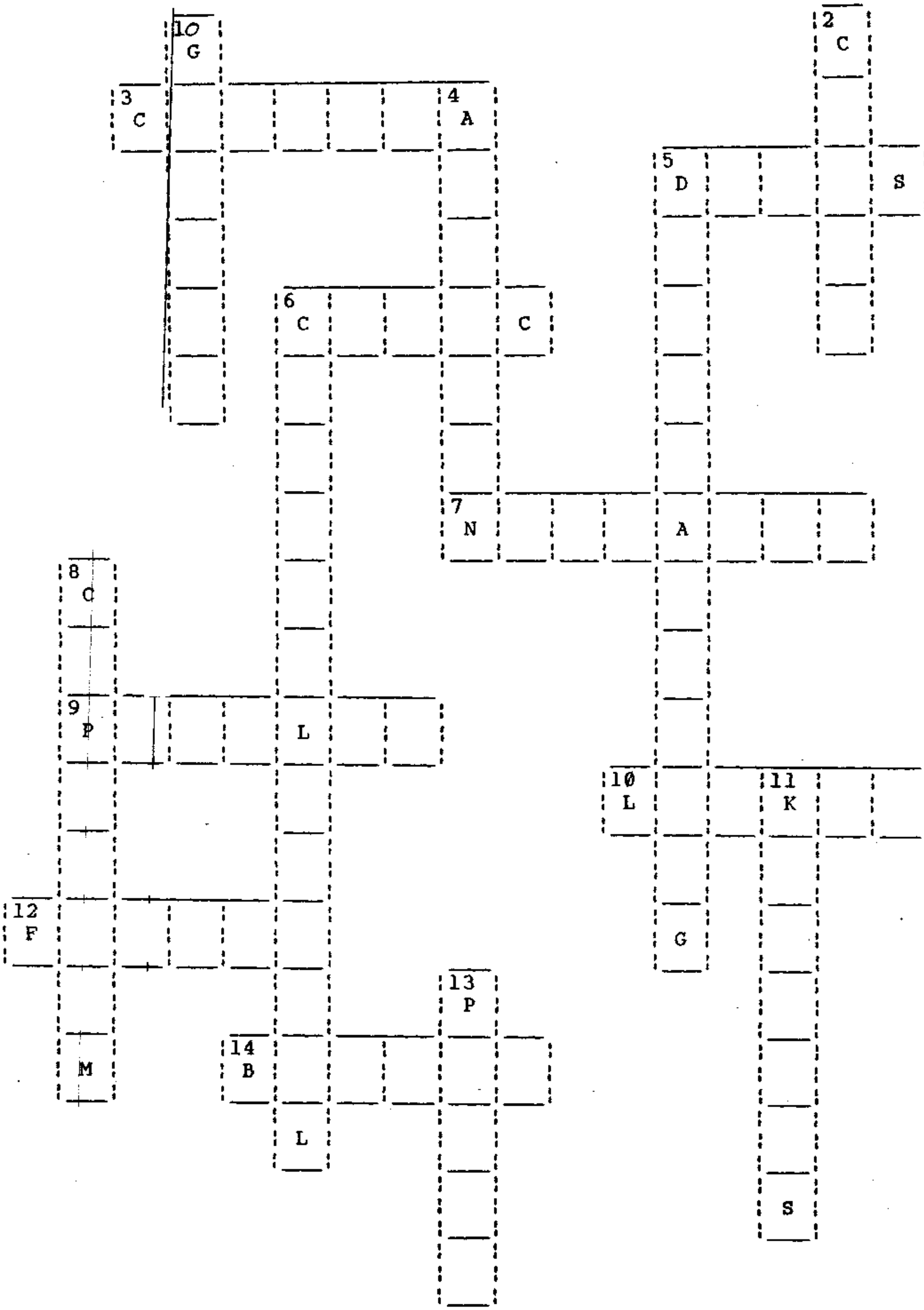
b.______increase in intensity.

c.______increase in frequency,

d.______decrease in intensity

of the evoking stimulus.

# DO IT YOURSELF - CROSSWORD II



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**CLUES :**

**I. ACROSS:**

1. The cochlear emissions analyzer acquired by AIISH.

2. He made the first attempt to explain SOAE generation.

i

3. He demonstrated greater SOAE incidence in subjects with mild cocnlear losses with respect to normals.

4. The differences tone which is the most frequently observed distortion product.

5. He introduced the concept of "Cochlear Amplifier" .

6. TEOJLES are especially useful for hearing screening in this population.

7. These emissions are the results of interactions among multiple SOAEs.

8. The software for DPOAE analysis was developed at this college of medicine.

II. DOWN:

9. A highly sophisticated technique of measuring EOAE group latencies.

10. The rodent species which has highest DPOAE levels at low frequencies.

i ^

11. The drug which has been shown to abolish SOAEs.

12. This type of auditory stimulation decreases the amplitude of all types of OAEs.

13. Potassium, within the outer hair cell acts as a stimulus of this nature.

14. A stimulus which elicits the most information in the shortest time.

15. The EOAE detection device designed at "The Institute of Hearing Research".

16. A commonly used probe-microphone for EOAE recording.

# CHAPTER 5
# SOLUTIONS

PART **A**

**I. WHAT'S MISSING ?.**

**ANS: AMPLIFIER**

**MULTIPLE CHOICE QUESTIONS: TICK THE RIGHT ANSWER**

II. 1-A 4-C
2-C 5-A
3-C 6-D

**III MATCH THE FOLLOWING AND ARRANGE THE MATCHES IN CHRONOLOGICAL ORDER:**

III. 2e - 1948
5b - 1981
7d - 1984
If - 1987
3a - 1989
6c - 1990
4g - 1993

**.IV. FILL *IN* WITH INCREASES / DECREASES:**

| | |
|---|---|
| IV. 1. Declreases | 5. Decreases. |
| 2. Increases | 6. Increase. |
| 3. Increases | 7. Increase, Decrease. |
| 4. Increases | 8. Increases. |

PART B

I. WHAT'S |MISSING ? WHAT IS ITS FUNCTION ?

ANS: TIME DOMAIN AVERAGER.

It helps to improve the signal to noise ratio, which is essential because the evoked oto acoustic emissions intensity is usually less than 20 dB SPL.

II.MULTIPLE CHOICE QUESTIONS : TICK THE RIGHT ANSWER

ANS - 1d.

ANS - 2a.

ANS - 3b.

ANS - 4c.

ANS - 5a.

ANS - 6b.

ANS - 7c.

ANS - 8b.

ANS - 9d.

ANS - 10a .

ANS - lla.

ANS - 12b.

ANS - 13b.

ANS - 14d.

III A) WHAT TYPE OF EVOKED EMISSIONS ARE MEASURED USING THIS APPARATUS ? HOW IS THIS APPARATUS DIFFERENT FROM THAT USED TO MEASURE OTHER EVOKED EMISSIONS ?

ANS: Acoustic distortion product emissions (ADPEs). This apparatus is different because it has two transducers, needed to present the two primaries fl and f2.

B) WHAT TYPE OF EMISSION CAN BE MEASURED USING THIS SYSTEM ? IN THE GIVEN SCHEMATIC,WHAT IS THE FUNCTION OF THE LOCK-IN AMPLIFIER ?

ANS|: Stimulus frequency emissions- A lock-in amplifier is needed to seperate the emission from the evoking stimulus.

## IV. MULTIPLE CHOICE QUESTIONS

1 - c-

2 - b (in 1979)

3 - c (PROBST et al 1993)

4 - d

5 - d (KIM and HUMES 1980)

6 - d

7 - c (MICHEYL et al 1994)

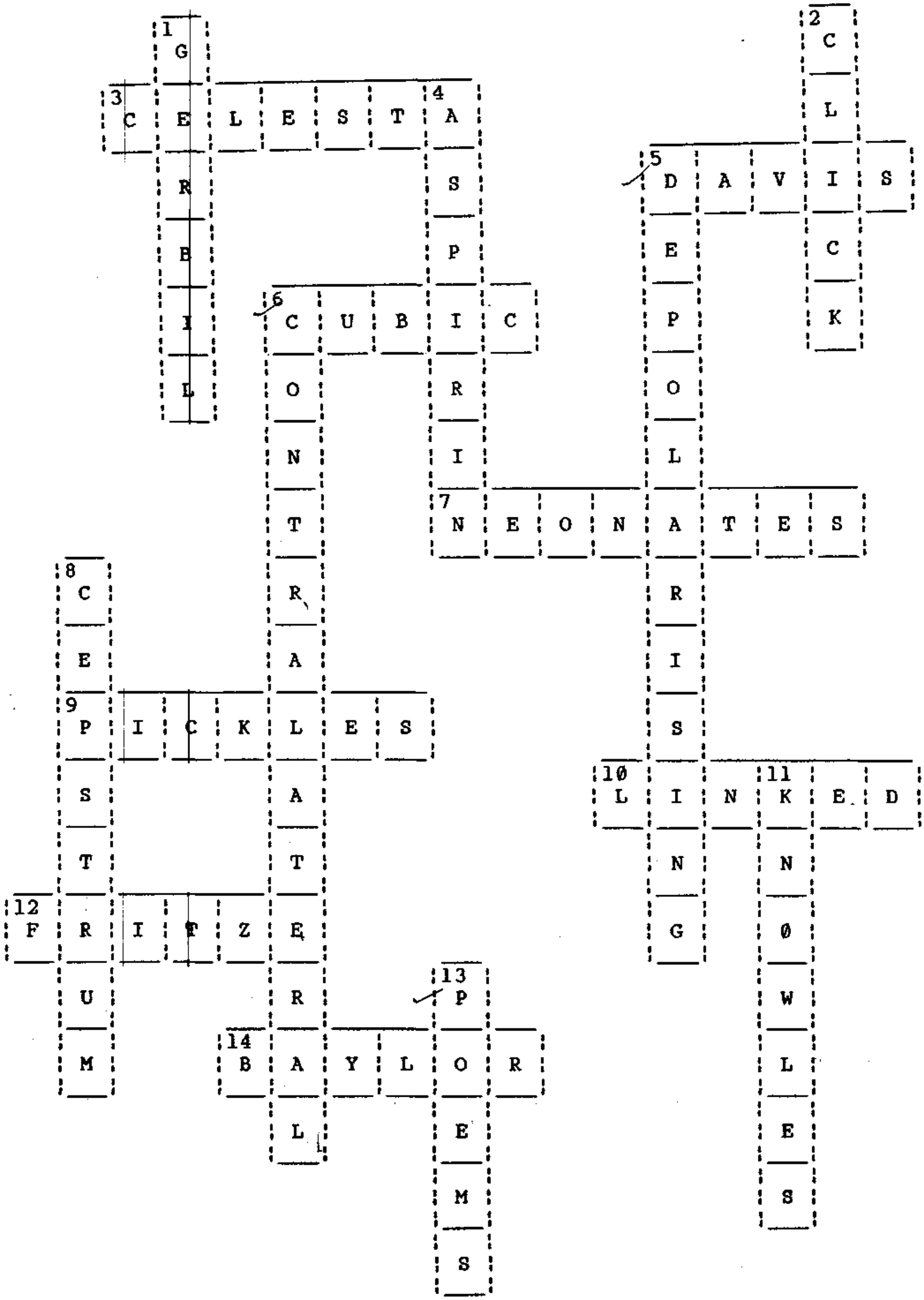
8 - b

9 - b (KEMP and BROWN 1983)

10 - c

11 - c

DO IT YOURSELF - CROSSWORD II



# INSTRUMENTATION IN OAEs

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# CHAPTER — 6

# INSTRUMENTATION IN OAEs

**I. MATCH THE GIVEN INSTRUMENTS TO THEIR PLACE OF ORIGIN:**

| | | | |
|---|---|---|---|
| 1. | POEMS (Programmable Oto-Acoustic Emissions Measurement systems) | A | Portland, Oregon. |
| 2. | PETERS AP 200 OAE PROCESSOR | B | Bio-logic systems, corporation |
| 3. | CELESTA 503 | C | Institute of Hearing Research, Nottingham, U.K. |
| 4. | RANGER SYSTEM (CUBE DIS) | D | Oto Dynamics Ltd, U.K. |
| 5. | VIRTUAL MODEL 330 | E | Etymotic Research, Illinois. |
| 6. | ILO 88 | F | Institute of Audiology, Netherlands. |
| 7. | SCOUT DPOAE SYSTEM | G | Madsen Electronics, Denmark. |

II. **KNOW YOUR NUMBERS:**

1.1 An evoked oto acoustic emission screening test is best aimed at detecting thresholds below__________________dB HL.

2. A late oto acoustic emission response is one which is recorded .___ms after stimulus onset.

3. The average evoked oto acoustic emission intensity is usually less than_____________dB SPL.

4. The mean testing time needed to record an evoked oto acoustic emission response is_____________minutes.

5. A transient-evoked oto acoustic emission response is easily observed in_____% *of* normal hearing adults.

6. *The* best transient-evoked oto acoustic emission responses in neonates are recorded______________days after birth.

7. Stimulus frequency emissions are generally absent in ears with cochlear hearing loss exceeding_____________dB HL.

8. During distortion product oto acoustic emission testing, one of the criteria to decide whether a recorded response is an emission, is that the response should be___________________dB above the noise floor.

9. Spontaneous oto acoustic emissions are found only in about __________% of normally hearing ears.

10. A two stage screening procedure using OAEs followed by auditory brain stem response for detection of hearing loss has a specificity of____________%.

III. STATE TRUE OR FALSE : CORRECT THE FALSE ONES.

1. POEMS has a flatter microphone frequency response peaking than ILO 88.

2. The 'CHECK-FIT' feature helps to optimize response measurement aft each oto acoustic emission frequency.

3. The use of high-level stimuli to evoke oto acoustic emissions increases the problem of stimulus artifacts.

4. The technique for oto acoustic emission measurement resembles tympanometry more than either subjective or evoked response audiometry.

5. The possibility of altered middle ear pressure or the presence of fluid has no effect on the emission energy.

6. Fitting the probe is not a very important aspect of acoustic emission measurement.

7. The key parameter of evoked oto acoustic emissions is peak-to-peak amplitude.

8. Extraction of the stimulus frequency emission by vector subtraction requires the use of a lock-in amplifier.

**IV. MATCH THE GIVEN OAE TESTING EQUIPMENT WITH THEIR CHARACTERISTIC FEATURES:**

| | | | |
|---|---|---|---|
| **1-** | 03 | **A** | Advanced digital signal processing (DSP) hardware U.K. |
| 2. | RANGER SYSTEM (CUBE DIS OAE TEST INSTRUMENT) | B | Flat microphone frequency response. |
| 3. | VIRTUAL MODEL 330 | C | Middle ear analyser option. |
| 4. | ILO 9(2 SYSTEM | D | Improved ER-10C low noise DPOAE probe. |
| 5. | POEMS | E | "ANALYSER" option to measure SOAEs. |

V. MULTIPLE CHOICE QUESTIONS : TICK THE CORRECT ANSWER .

1. The only type of evoked oto acoustic emissions which are not seperated from the evoking stimulus either spectrally or temporally are:

a.______distortion product emissions.
b.______click-evoked oto acoustic emissions.
c.______stimulus frequency emissions.
d.______tone-burst evoked oto acoustic emissions.

2. The degree of correlation between two seperately determined temporal averages of the click-evoked oto acoustic emissions, would be best estimated by the measure of:

a.______emission amplitude.
b.______number of emissions.
c.______reproducibility value (%) .
d.______slope of the input-output function.

3. The only oto acoustic emission measurement system, which comes with a middle ear analyzer option is:

a. _ ILO 88.
b. - CELESTA 503.
c. - ILO 92.
d. - POEMS.

4 The term "noise floor" refers to:

a.______contralateral noise stimulation.

b.______ambient noise in the test setting.

c.______physiological noise (from the subject).

d.______background noise in the recording system.

5. The PETERS AP 200 oto-acoustic emission processor is especially designed for quick and easy measurement of:

a.______Spontaneous oto acoustic emissions.

b. __ Click-evoked oto acoustic emissions.

c.______Distortion product oto acoustic emissions.

d.______Stimulus frequency emissions.

6. The distortion product oto-acoustic emission measurement technique performed by the VIRTUAL MODEL 330 was developed at:

a.______Institute of Laryngology and Otology, England.

b.______Institute of Audiology, Netherlands.

c.______Cochlear Function Lab., Baylor College of Medicine, Houston, Texas.

d.______Institute of Hearing Research, Nottingham, England.

7. For distortion product emissions, the rate at which the emission grows as a function of increased level of primaries is represented by:

a.________s Lope of the input-output function.

b.________maximum amplitude of the emission.

c.________dynamic range of the emission.

d.________detection threshold.

8. Neonatal transient-evoked oto acoustic emissions differ markedly from adult recordings. Neonatal data are generally:

a.________of a greater duration.

b.________contain more high-frequency elements.

c.________of a larger amplitude.

d.________all of the above.

9. The mechanisms which could possibly explain the contralateral suppression effect are:

a.______, middle ear stapedial reflex.

b.________inter-aural cross talk.

c.________direct effect of lateral efferent fibres.

d.________all of the above.

10. The evoked oto acoustic emission response reverses when:

a.________stimulus intensity is increased.

b.________stimulus repetition rate is increased.

c.________the polarity of the stimulus is changed.

d.________stimulus frequency is changed.

# CHAPTER 6

# SOLUTIONS

## I. MATCH THE GIVEN INSTRUMENTS TO THEIR PLACE OF ORIGIN:

**1-C,** 2-F, **3-G, 4-E, 5-A, 6-D, 7-B.**

## II- KNOW YOUR NUMBERS:

1. 30 dB HL.
2. 10ms (ELBERLING and JOHNSEN 1982)
3. 20 dB SPL.
4. 12 minutes (STEVENS et al 1989).
5. 96-100 %.
6. 3-4 days (MEREDITH et al 1993).
7. 40-50 dB HL (LONSBURY-MARTIN et al 1990).
8. 3 dB (7AN DIJK et al 1987).
9. 50% (NORTON and STOVER 1994).
10. 99% (KENNEDY et al 1991).

## III. STATE TRUE OR FALSE : CORRECT THE FALSE ONES

1. True
2. Flase. The unique "check-fit" feature assures probe-fit accurecy before testing.
3. True.

4. True.

5. False. Middle ear pressure imbalance has the effect of reducing emission energy below about 2 kH2.

6. False. Fitting the probe is one of the most important parts of making an acoustic emission measurement.

7. False. The key parameter of an evoked oto acoustic emissions is group Latency because peak-to-peak amplitude and frequency content are defined only for a specific latency.

8. True.

IV. MATCH THE GIVEN OAE TESTING EQUIPMENT WITH THEIR CHARACTERISTIC FEATURES :

1-c, 2-d, 3-a 4-e, 5-b.

**V. MUTIPLE CHOICE QUESTIONS : TICK THE CORRECT ANSWER:**

**1 - c**

**2 - c**

**4 - a**

**5 - b**

**6 - c**

**7 - a**

**8 - d**

**9 - d**

**10 -**

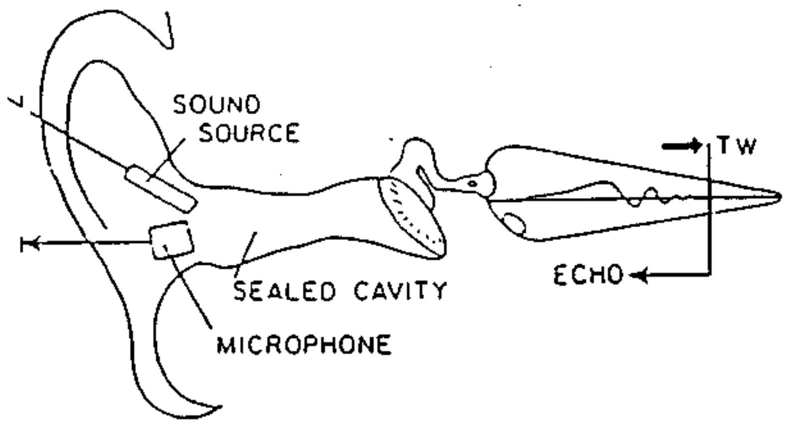
# NORMATIVE FINDINGS IN OAEs

## CHAPTER — 7

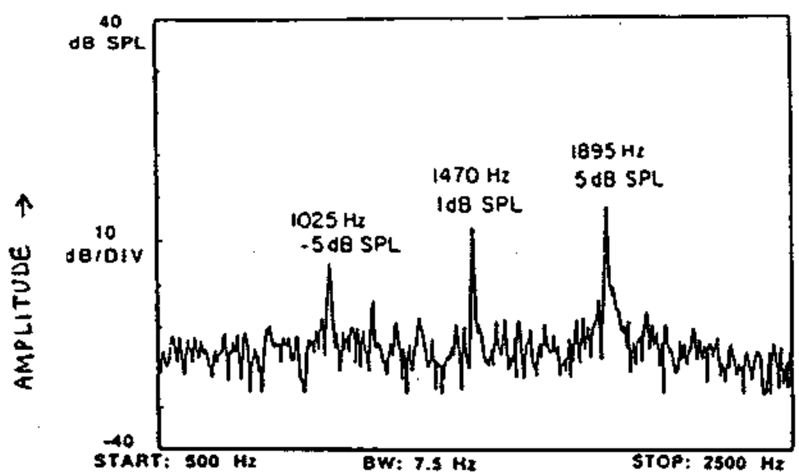
# NORMATIVE FINDINGS OF OAEs

### I. LOOK AND LEARN:

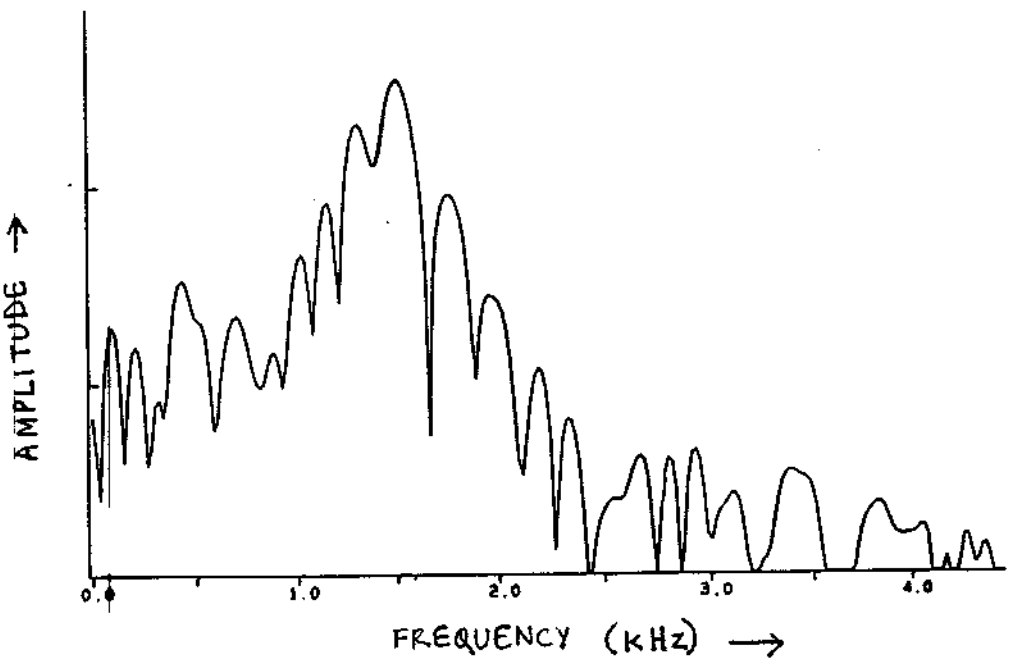
1. The given schematic illustration represents the———.————of oto-acoustic emissions.



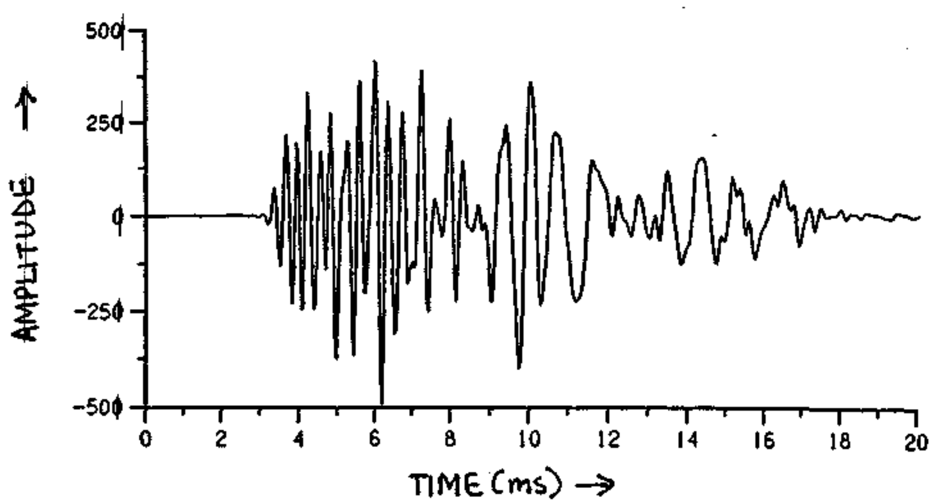
2. The above is a recording of a ________ oto acoustic emission response.



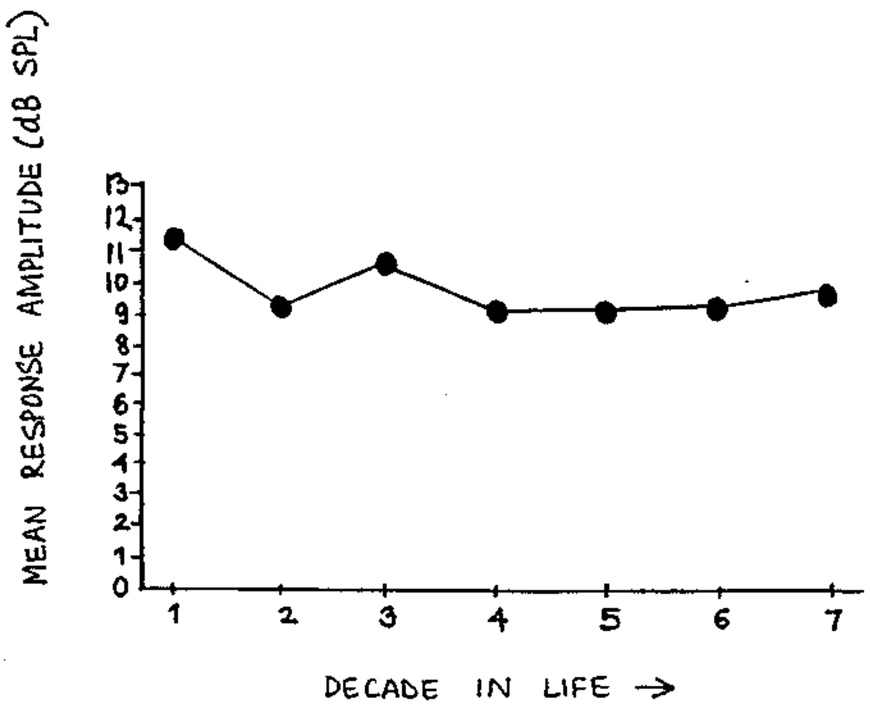
3 This is the frequency spectrum of an evoKed oto acoustic emission. It is obvious that the majority of energy is in the frequency range of_________KHz.



4. The OAE response shown is decaying rapidly with time. Such response is called a_______________response.

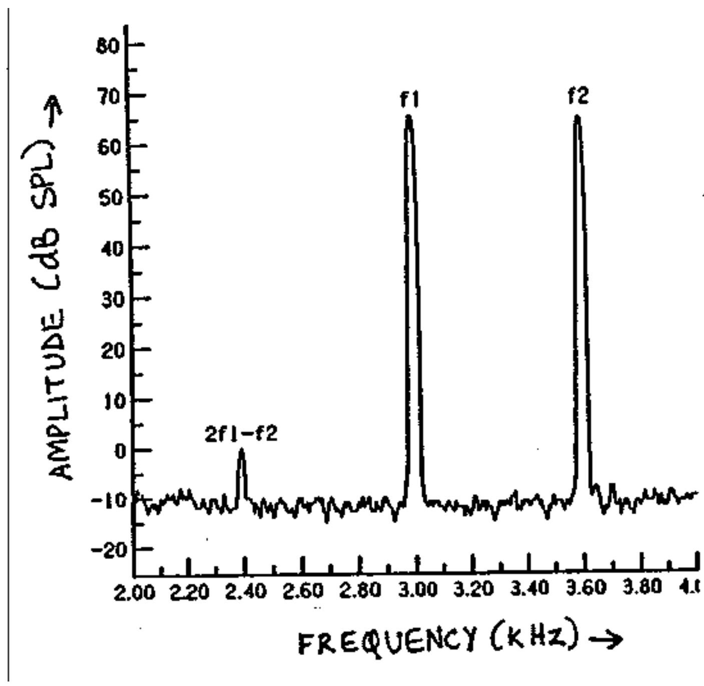


5. This graph shows the transient evoked oto acoustic emission response amplitude in normally hearing ears. Trasient-evoked oto acoustic emission response amplitude is the greatest upto_____________years of age.



6. The oto acoustic emission response shown in the graph is the

_______emission.



## II. KNOW YOUR NUMBERS:

1. In normals, the characteristic frequency range of spontaneous oto acoustic emissions extends from____________ to_________________KHz.

2. Transient-evoked oto acoustic emissions can be detected in all the ears of normally hearing subjects who are less than_______________years old.

3. *In* normally hearing ears, evoked oto acoustic emission detection threshold is generally lower than the subjective threshold by____________dB HL.

4. The transient-evoked OAE in normally hearing ears lasts for about____________ms.

5. The frequency range within which acoustic distortion products can be reliably detected is from____________________to ______________kHz.

6. The amplitudes of stimulus frequency OAEs in normally hearing ears vary between_____________and________________dB SPL.

**III. MULTIPLE CHOICE QUESTIONS :TICK THE APPROPRIATE ANSWER:**

**1. The amplitudes of spontaneous oto acoustic emissions in normally hearing subjects generally do not exceed:**

a.______12 dB SPL.

b.___20 dB 8PL.

c.___40 dB SPL.

d.____10 dB SPL.

2. In normals, the characteristic frequency range of transient-evoked oto acoustic emissions extends front:

a.______0.5 - 6 KHZ.

b.___0.5 - 4 KHZ.

c.______1 - 2 KHZ.

d.____**4 - 8 KHZ.**

3. For individuals above 40 years of age, transient-evoked oto acoustic emission threshold increased linearly at a rate of:

a.______8 dB HL/ decade.

b.______4 dB HL/ decade.

c.______10 dB HL/ decade.

d.______15 dB HL/ decade.

4. Above a critical age limit (60 years), prevalence of transient evoked oto acoustic emissions in normally hearing subjects is reduced by:

a.______50%.

b.______25%.

c.______> 50%.

d.______40%.

5. For distortion product oto acoustic emissions between 1 and 8 khz, the detection thresholds (3 db above noise floor) in normals is:

*a.*______35 - 45 dB SPL.

b.______10 - 15 dB SPL.

c.______0 - 05 dB SPL.

d.______20 - 40 dB SPL.

6. In humans, distortion product emission responses have dynamic ranges of approximately:

a.______20 dB HL

b.______10 dB HL

c.______30 dB HL

**d.______40 dB HL**

# CHAPTER "7

# SOLUTIONS

## I. LOOK AND LEARN :

I. GENERATION.

2. SPONTANEOUS.

3. 1-2 kHz.

4. TRANSIENT.

5. TEN.

6. DISTORTION PRODUCT.

## II. KNOW YOUR NUMBERS:

1. 0.5 kHz - 6kHZ (MARTIN et al 1990).
2. 60 YEARS (BONFILS et al 1988).
3. 10 dB HL.
4. 20 ms.
5. lkHZ - 8kHZ (PROBST et al 1989).
6. -20 dBSPL AND +10dBSPL (DALLMAYR et al 1987).

## III. MULTIPLE CHOICE QUESTIONS :TICK THE APPROPRIATE ANSWER:

1 - b

2 - b (PROBST et al 1986)

3 - a (BONFILS et al 1988)

4 - c (BONFILS et al 1988)

5 - a ( LONSBURY-MARTIN et al 1990)

6 - d ( LONSBURY-MARTIN et al 1990)

# CLINICAL APPLICATIONS OF OAEs

# CHAPTER — 8

# CLINICAL APPLICATIONS OF OAEs

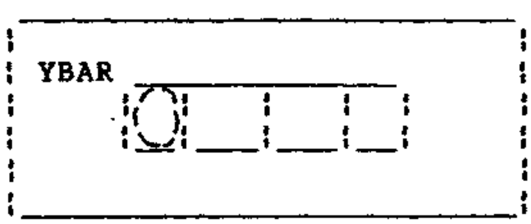
## I. MATCH THE FOLLOWING:

| | |
|---|---|
| 1. Infant screening for hearinq loss | A Normal OAE response |
| 2. Noise-induced hearing loss | B Bone-conduction stimulated OAEs. |
| 3. Central auditory nervous system disorders | C Poor OAE efficiency |
| 4. Tinnitus | D Main application of TEOAEs . |
| 5. Otospongiosis | E Prolonged OAE duration |
| 6. Cerebello-pontine angle tumor detection | F No relation with OAE presence. |

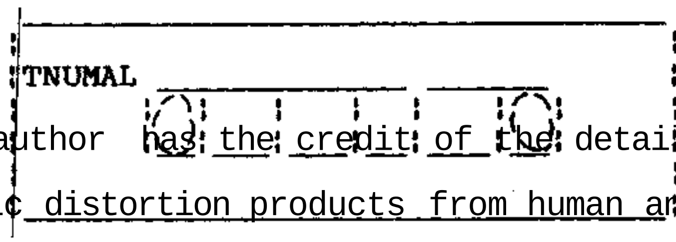
## II. SCRAMBLED WORD GAME:

USE THE CLUE GIVEN TO UNSCRAMBLE THE GIVEN JUMBLES, PUTTING ONE LETTER TO EACH SQUARE, TO FORM THE NAMES OF FOUR AUTHORS WHO HAVE INTENSIVELY STUDIED CLINICAL APPLICATIONS OF OAEs:

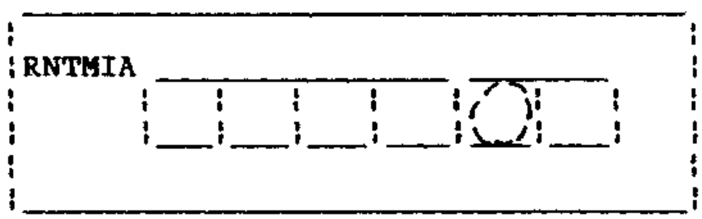
1. Along with Kemp, he was responsible for designing ILO 88 in 1987.



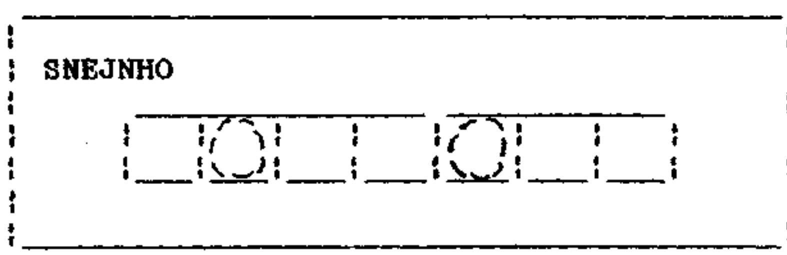
2. He and COPE in 1987, brought out an evoled-oto acoustic emissions detection device - the POEMS.




3. This author has the credit of the detailed investigation of acoustic distortion products from human and animal ears.




4. This author has studied the evoked oto acoustic emissions from human ears and made a systematic investigation of the various parameters affecting them.



**NOW** ARRANGE THE CIRCLED LETTERS TO FORM THE SURPRISE ANSWER TO THIS FINAL CLUE:

This author has the unique distinction of having the maximum number of published articles on OAEs and their clinical applications.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | F | | | |

: **RATE THE EFFICACY OF OAE'S IN IDENTIFYING THE GIVEN AUDITORY DISORDERS AS**

**VERY GOOD.**

-> PROMISING.

-> DISAPPOINTING.

1. NOISE -INDUCED HEARING LOSS____________.

2. HIGH - FREQUENCY COCHLEAR HEARING LOSS______________.

3. HEARING LOSS IN INFANTS (SCREENING) ________________.

4. PSEUDOHYPACUSIS____________.

5. ACOUSTIC NEUROMA (VIIIth NERVE TUMORS)_______________.

6. LOW FREQUENCY HEARING LOSS_______________.

IV. MULTI CHOICE QUESTIONS :TICK THE APPROPRIATE ANSWER:

1. Spontaneous oto acoustic emission responses are affected by:

   a.______aspirin intake.

   b.______cochlear hypoxia.

   C.______alteration of middle ear/external canal pressure.

   d.______all of the above.

2. When spontaneous oto acoustic emissions are present,behavioral thresholds will usually be less than:

   a._____40 dB HL

   b._____20 dB HL.

   C.___10 dB HL.

   d._____55 dB HL.

3. In cases of central auditory nervous system disorders, evoked oto acoustic emissions are:

   a.______sometimes normal.

   b.______always normal.

   c.______sometimes absent.

   d.______always present, but never normal.

4. Absence of evoked oto acoustic emissions in infants could be due to :

   a._______pure cochlear pathology.

   b._______retro-cochlear pathology.

   c._______middle ear pathology.

   d._______pure cochlear pathology and/or middle ear pathology.

5. The main parameter to be used for all clinical applications using evoked oto acoustic emissions is:

a .______latency.
b.______duration.
*c.*______detection threshold.
d.______input-output function.

6. As a consequence of aging, changes seen in the transient evoked oto acoustic emission response are:

a._______decreased amplitude.
b._______shift of energy spectrum to lower frequencies.
c._______increased latency.
d._______all of the above.

7. Transient-evoked oto acoustic emissions are known to be altered in frequency and/or amplitude composition by:

a.______noise exposure.
b.______ageing processes.
c.______contralateral acoustic stimulation.
d.______all of the above.

8. The high frequency range of the transient-evoked oto acoustic emissions response is typically first by:

a.______aging processes.
b.______ototoxic influences.
c.______noise exposure.
d.______Meniere's disease.

9. **Tramsient-evoked oto acoustic emission measurements can provide valuable physiological information in diagnosing with nerve tumors, when used in conjunction with:**

a.________acoustic **reflex** testing

b . _ __auditory brain stem response and acoustic reflex testing.

c.________pure tone audiometry.

d.______, pure tone audiometry and acoustic reflex testing.

**10.** In **normal hearing subjects, as frequency increases, the slope of the input-output function of distortion product oto** acoustic emissions

a. __ increases rapidly.

b.______decreases rapidly.

c. —- increases slightly, then decreases.

d.______shows no change.

11. **At frequencies having hearing loss, distortion product** emissions are:

*a.* __ prolonged in duration.

p.______absent.

c.______decreased in amplitude.

d.______absent or decreased in amplitude.

12. Stimulus frequency emissions are absent in ears with cochlear hearing loss exceeding:

a._____20 - 25 dB HL.

b._____30 - 40 dB HL.

c._____40 - 50 dB HL.

d._____50 - 60 dB HL.

# CHAPTER 8

# SOLUTIONS

**I. MATCH THE FOLLOWING:**

1-D, 2-E, 3-A, 4-F, 5-B, 6-C.

II. SCRAMBLED WORD GAME:

1. BRAY
2. LUTMAN
3. MARTIN
4. JOHNSEN
5. FINAL:

| | | | | | | |
|---|---|---|---|---|---|---|
| B | O | N | F | I | L | S |

III. RATE THE EFFICACY OF OAE's IN IDENTIFYING THE GIVEN AUDITORY DISORDERS AS:

1. Very good (KIM et al 1992).
2. Promising (ROBINETTE 1992).
3. Very good (KEMP AND RYAN 1993).
4. promising (ROBINETTE 1992).
5. disappointing (ROBINETTE 1992).
6. Disappointing {ROBINETTE 1992).

## IV. MULTIPLE CHOICE QUESTIONS : TICK THE APPROPRIATE ANSWER :

1 - d

2 - b

3 - b

4 - d

5 - c

6 - d

7- d

8 -b

9 -b

10 - a

11 -b

12 - c

LET'S GET

OAE - ORIENTED ! !

# CHAPTER — 9

## LET'S GET OAE — ORIENTED 11

The phenomenon of OAE's undoubtedly represents a veritable breakthrough in diagnostic audiology. How much do you know about this new and exciting discovery ? Take this quiz and find out. GOOD LUCK :

1. Who is credited with the discovery of OAE's ?

| | |
|---|---|
| Bekesy | GO TO 5 |
| Gold | GO TO 9 |
| kemp | GO TO 13 |

2. The outer hair cells, believed to be the site of OAE generation, are coupled to the basilar membrane via:

| | |
|---|---|
| Outer Phalangeal cells | GO TO 10 |
| Stereocilia | GO TO 14 |

3. Not exactly. OAE's can be recorded anywhere between 500 Hz and 3000 Hz. It is only the wave form response energy that peaks between 1000 - 2000 Hz.

RETURN TO 7

4. Wrong On the contrary, distortion product emissions are found to be stronger in laboratory animals than in man. (BRAY and KEMP 1987).

TAKE ONE MORE CHANCE AT NO : 33

5. I'm afraid that's a disappointing start. Bekesy in 1960 put forth the 'TRAVELING WAVE THEORY' and provided experimental evidence for the mechanical frequency tuning of the basilar membrane.

**BACK TO 1**

6. NO- PICKLES (1982) was the one who volunteered an explanation for this mechanism behind SOAE generation. He suggested that if the *OAC* membrane were to malfunction such that increased influx of calcium ions was allowed, contractile responses of the stereocilia might result, causing SOAEs.

**GO BACK TO NO: 20**

7. OAEs are known to be much more frequency-place specific than the cochlear microphonic. At what frequencies are OAEs observed ?

Between 500 Hz and 3000 Hz - GO TO 11

Between 1000 Hz and 2000 Hz - GO TO 3

8. Absolutely right. RUGGERO et al (1982) did propose that spontaneous oto acoustic emissions may be associated with localized regions of damaged outer hair cells, which are surrounded by normal functioning outer hair cells. However, this hypothesis was later disproved by STRICKLAND et al (1985).

RUSH ON TO NO. 27

9. No, that's incorrect! Gold in 1948 was the first to suggest that a purely passive type of basilar membrane filtering action could not wholly account for the sharp frequency selectivity, measured in humans.

GO BACK TO 1

10. That's right! The OHC's, at their base are connected to the basilar membrane via the outer phalangeal cells, also known as DEITER's CELLS.

ONWARD TO NO. 12

11 Good going. OAE's are mostly found between 500 Hz and 3000 Hz and are seldom found at frequencies above 4000 Hz.

BACK UP TO 2

12. Clinical work and research on OAEs has largely focussed on which particular type of OAEs ?

SPONTANEOUS OAEs GO TO 25

TRANSIENT EVOKED OAEs GO TO 30

13. Great start: It was indeed Kemp and his associates at the Institute of Laryngology and Otology in London, who in 1978,

**JUMP BACK TO 7**

14. That's a major faux pas !. The OHCs are coupled to the tectorial membrane above, and not the basilar membrane via their tallest stereocilia.

**RE-ATTEMPT NO. 2**

15. where was the EOAE detection device - the "Programmable oto-acoustic Emissions Measurement System (POEMS)" developed?

The Cochlear Function Laboratory GO TO 17

Institute of Hearing Research. GO TO 23

16. Terrific! Clinical studies have shown that, in comparison to auditory brain stem response screening, transient-evoked oto dcoustic emissions screening required lower ambient room noise by 10 dB SPL.

**ADVANCE TO NO: 39**

17. WRONG. It was the software to measure distortion product 0AEs that was developed at the Cochlear Function Laboratory at the Baylor College of Medicine.

RETURN TO 15 AND TRY AGAIN

18. No. Stimulus frequency emissions occur as a synchronous response to a continuous pure tone stimulus which is at the same frequency as the stimulus. Because of these two factors, it is not easy to separate the response from the stimulus, and the response extraction process is more complex.

**AS FOR NO:35, TRY AGAIN**

19. YOU'VE HIT THE NAIL ON THE HEAD!. Females not only have a greater incidence of SOAEs, but also have a greater incidence of bilateral recorded SOAEs and a greater tendency to demonstrate multiple SOAEs (Strickland et al 1985)

**GO ONTO 33**

20. Who hypothesized that the presence of SOAE's might be associated with varying degrees of outer hair cell damage?

| | |
|---|---|
| PICKLES (1982) | GO TO 6 |
| RUGGERO et al (1982) | GO TO 8 |

21. No. In fact,it is females who have ben experimentally shown to have an incidence of spontaneous oto acoustic emissions twice as great as seen in males.

**BACK AGAIN TO 29 FOR YOU**

22. Yes indeed! It is the transient evoked-oto acoustic emissions which are relatively the easiest to measure. It is this ease of measuring which makes the transient evoked emission, an attractive tool for clinical use.

**RACE AHEAD TO WRAP IT ALL UP WITH NO. 40**

23. YOU'RE RIGHT. POEMS was designed at the Institute of Hearing Research in Nottingham, U.K. by Cope and Lutman in 1988.

**TRY NO : 20 NOW**

24. Yes,it is the spontaneous oto acoustic emissions which are rarely present in normally hearing laboratory species and are therefore, studied primarily in humans.

**MOVE AHEAD TO NO. 35**

25. WRONG The clinical utility of spontaneous oto-acoustic emissions is still being investigated. The spontaneous oto acoustic emissions are found in 35-40% of healthy ears only. Moreover, the particular internal cochlear feedback conditions needed to sustain SOAE's are not always present, nor are they important for normal hearing. Hence, their limited clinical application.

**BACK AGAIN TO NO. 12**

26. NO, not quite. While it is true that DPOAE's are relatively artifact-free, and do not require any post-hoc processing, the complexity of equipment and technical parameters far obtaining DPOAEs is greater than TEOAEs (for eg: The probe must contain two sound inputs to deliver fl and f2 stimuli).

**BACK AGAIN TO 35.**

27. Acoustic Distortion Product Emissions (ADPEs) are generated in response to auditory stimuli, which are :

| | |
|---|---|
| PURE TONES | GO TO 31 |
| CLICKS/TONEBURSTS | GO TO 38 |

28. No way! One of the main advantages of transient-evoked oto acoustic emissions screening is that, on an average, transient-evoked oto acoustic emission testing took 9 minutes less than the time needed for auditory brain stem response testing. (STEVENS et al 1989).

**BACK ONCE AGAIN TO 37**

29. Strorg gender differences in spontaneous oto acoustic emission incidence have been observed. Research has shown that :

| | |
|---|---|
| FEMALES HAVE GREATER INCIDENCE - | GO TO 19 |
| MILES HAVE GREATER INCIDENCE - | GO TO 21 |

1

30. ABSOLUTELY RIGHT. The transient-evoked oto acoustic emissions have been shown to have varied clinical applications as they provide broad-band, cochlea-wide information. In clinical situations, this means the 'most information in the shortest time. Also, transient-evoked oto acoustic emissions are present in 98-100% of normal ears and hearing thresholds less than 30 dB HL.

**MOVE AHEAD TO 37**

31. BINGO!. THAT IS THE RIGHT ANSWER. ADPEs are generated in response to two simultaneously presented pure tones (fl and f2) , which are separated in frequency, by a prescribed difference.

**NO. 29 IS YOUR NEXT STOP**

32. In the spring of 1993, the National Institute of Health (NIH) ojfficially made hearing testing for all infants using evoked oto acoustic emissions mandatory.

**WITH THIS, WE COME TO THE END OF OUR QUIZ**

33. Which type of oto acoustic emissions are rarely present in laboratory animals ?

| | |
|---|---|
| DISTORTION PRODUCT OAEs | GO TO 4. |
| SPONTANEOUS OAEs | GO TO 24. |

34. ABSOLlTELY RIGHT! It is CELESTA 503 which consists of an oto acoustic emission analyzer complete with a middle ear analyzer option.

35. Technologically speaking, which of the three evoked oto acoustic emission subtypes is the easiest to measure ?

| | |
|---|---|
| DISTORTION PRODUCT EMISSIONS | GO TO 26 |
| TRANSIENT EVOKED OAEs | GO TO 22 |
| STIMULUS FREQUENCY EMISSIONS | GO TO 18 |

36. NO. ILO 88 was designed to serve as an OAE screening device for neonatal screening and does not have the middle ear analyzer option.

**TRY 39 AGAIN**

37. Compered to transient-evoked oto acoustic emission screening, Auditory brain stem response screening

| | |
|---|---|
| IS LESS TIME CONSUMING | GO TO 28 |
| CAN BE DONE IN GREATER AMBIENT NOISE. | GO TO 16 |

38. That's not right, I'm afraid- Transient acoustic stimuli like clicks and tone bursts are used to elicit the transient-evoked oto-acoustic emissions (TEOAEs) or the click-evoked OAEs (CEOAEs).

BACK TO 27

39. Which of the following OAE measurement systems comes with an included "MIDDLE EAR ANALYZER" option ?

CELESTA 503 (MADSEN ELECTRONICS) GO TO 34.

ILO 88 (OTODYNAMICS LTD) GO TO 36.

40. WELL THEN, THAT'S IT! THE FASTEST ROUTE TOOK 25 STEPS

--> 1-13-7-11-1-10-12-30-37-16-39-34-15-23-20-8-27-31-29-19-33-24-35-22-40

ONE CONCLUDING QUESTION : When was hearing screening for all injfants officially recommended using eoae testing ?

CHECK 32 FOR THIS ANSWER

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