

Editorial

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S Stylis

Provoking thought for my ENT Colleagues

Stan Stylis FRCS
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It is astounding that, 50 years ago, the Duplex Theory of Hearing presented, with uncanny accuracy, a complete set of previously unthought-of factors essential in effecting the clarity of our hearing. This marked the end of 100 years of stubborn preoccupation with the basic concept of a Fourier analysis of the ‘travelling wave’. For years researchers have remained dismayed and sceptical of Dr Stylis’ bold pronouncements, but now this Treatise proves their validity.

Proof reading it for the first time, I have found it a fascinating journey; one that can hardly be denied.

It is my pleasure to introduce you to entirely new principles and slants that will provoke all your senses.

Mr. Joseph Scoppa

MB, BS, (HONS), Sydney Uni, FRACS

Emeritus ENT consultant, Royal Prince Alfred Hospital

Vice President, Australasian College of ENT Physicians

Dispute Resolution Workers Comp Commission NSW.

‘The human mind has first to construct form independently, before we can find them in things.’

Albert Einstein

1. Introduction

This paper is written in an 'easy' style. It is not meant to be a research paper as written by a physicist. The latter find it necessary to enter accurate figures, complicated mathematical calculations, constant interruptions specifying references, numerous undefined words and structures and principles of mathematics and physics long gone out of our clinical minds. All these clutter up a sentence and detract from the flow of a line of thought. Reading becomes difficult and taking time that the clinician cannot afford.

This explains why I have never found a clinical colleague ENT physician or surgeon who has any real idea of how the hearing is received, perceived and connected; even highly acclaimed cochlear implant surgeons have a very vague understanding of the theory of hearing.

For this reason, I have undertaken to write in narrative often provocative form and give some broad figures where a sense of perspective is required in understanding the matter under discussion and strict references rarely provided, though some helpful extras are provided in the Appendix at the end.

My four publications in this journal of *Laryngology and Otology* written in 1971 and in 1973 are provided here as they form a basis of my discussion and as they were written nearly 50 years ago, access to them would be difficult and by having them here on hand you could easily cast your eye on the relevant parts to which I refer, if you wish.

'*Nature is simple*', – I said to Professor Dixon Ward, the world-renowned American physicist who visited me in Australia in the late 1980s and discussed hearing with me. We were in my then home standing on the shore of Sydney Harbour and, tongue in cheek, I pointed out that the breeze arising in the evening was not a manifestation of the moving waves. It is purely due to the difference in the rate of cooling of temperature of the water versus that of land, leading to convection currents. '*Nature doesn't resort to a Fourier analysis of the waves!*', I said. He chuckled as he donned his red coat, eccentric to us Australians at that time. Being a real gentleman, he agreed. We kept in contact for some years until his death.

Subjects will be introduced with a few basic facts to refresh principles set you in the right frame of mind and then followed with matters of reasoning to clarify what is being put in the literature and finally presenting the way I see it. It is left for the readers to decide if what I am saying is reasonable and with such understanding that they will comprehend what is presented to us in a myriad of changing theories.

Unfortunately some repetition is unavoidable as the basic principles that are described, at some point will have to be repeated in the sequence of the actions in which they participate. In any case it relieves taxing your memory.

My prime aim is to justify how my Duplex Theory regarding the perception of frequency and intensity is well supported by the exciting new principles revealed in modern science. I would like to show that not only my theory can easily explain auditory function where no other does, but that there is no other explanation that would be possible.

Happily during my attempts to condense essential scientific points sufficiently so you can follow my final conclusions, I have formulated at least two personal concepts perhaps hitherto not thought of which could stir up the pundits worldwide.

One concept involves the quantum theory which even escaped the mind of Einstein who gave it up as 'spooky action'. The second concerns the so called 'the cochlear amplifier' which I feel should have a name change!

How it all began:

It would help if I relate how I felt compelled to turn my mind to cochlear function.

In 1971, having passed the first part of my FRCS, I found myself working at the standalone Ear Nose and Throat Hospital in Brighton, Sussex, and in the evenings I would be studying the discipline of ENT in preparation for my final fellowship. Knowledge regarding the middle ear disease was clear; chronic middle ear infection was very common, particularly in England where people, in those days, had been turning up as outpatients with chronic aural discharge to have the pus swabbed out and topical agents applied. The operating microscope was not available for adequate aural toilette. Microscopes were in use in the theatre and one learned the anatomy of the mastoid and all about cholesteatoma and fashioning shapes with bone or cartilage as implants in middle ear surgery.

When it came to considering 'nerve deafness' there was confusion. It was not possible to classify the various conditions (congenital deafness, deafness due to excess industrial noise, or to toxic antibiotics, virus infections and Meniere's disease and tumours). This confusing picture was solely because no one understood how the ear worked.

In the manner of our previous learning, one would understand how an organ functioned and then learn how this function was affected by each different disease. But with sensorineural deafness, we didn't know how the ear worked. One hundred and fifty years before these thoughts came to me, the main proponents in the theory of hearing were Helmholtz and later von Bekesy.

The real crux of the matter was to identify what element of the cochlea was actually tuned to receive the various frequencies, the primary consideration of all these theories and of mine.

Helmholtz originally thought that the arches of the organ of Corti were the vibrating elements tuned to the frequencies. He later changed his mind to the fibres of the basilar membrane but, again later ended up focussing on the wave motion on the basilar membrane, though he thought there was very little mechanical frequency analysis done in the inner ear. There were a number of variations along the road which are particularly discussed in the thesis of Andrew Bell, a senior researcher at the National Australian University in Canberra. *(AB)

Later, Georg von Bekesy arrived in the USA and was highly regarded. He worked constantly in examining the cochlear of all sorts of animals from fish and birds and humans. He used strobe photography and silver flakes to observe the wave movements of the basilar membrane when exposed to sound which he fed through a rubber tube poked into the external auditory canal at something like 120+ decibels. One would think that sound of this intensity would shake up the whole head and perhaps up the whole room in fact, but I suppose what else could he do?

Even until the 1980s the 'travelling' wave/Fourier analysis concept ruled strong and no one seemed to threaten the theory, I guess because of the respect and reputation of Von Bekesy. That is of course until I wrote my theory in 1971 where I stated

for the first time, quite strongly and clearly, that I could not accept the principle of the Fourier analysis as being capable of giving rise to the accuracy of our hearing and the ability to identify multiple frequencies simultaneously.

The ENT clinicians at the time were very reticent in discussing the mechanism of hearing as they were subjugated by the physicists who resisted any comments from the clinicians by bamboozling anybody with complicated mathematical formulae. I used to go into a library and see the walls filled up with hundreds of books written by physicists in which every page was covered with complex mathematical calculations. I told them I would lie on the floor and laugh my head off to think that all those calculations were based on a false premise.

Remember, this was only a few years after the electron microscope was invented. There was no other modern knowledge on cells which we knew as bags of cytoplasm with a few vacuoles and a nucleus. Albert Einstein once said 'imagination is more important than knowledge'. To such imagination I added physiology, the electron microscope scans (structure to function) and common sense.

This led to a coherent story and some eight or more novel features. It offered many explanations of clinical conditions. The then editors of the prestigious journal of *Laryngology and Otology* (Sir Jeffrey Bateman and John Ballantyne) had the perspicacity to accept them from a youngish doctor like myself embarking on an ENT career. Theories are rarely published in clinical journals, which speak highly of the editors. It testified to its value as they recognised the real need at the time to have some understanding as to what could be happening in the cochlea, so that some sense could be made in the nature and classification and causes of inner ear damage/disease.

The ENT clinicians were delighted and for the first time felt free to discuss and dispute how the ear worked. They had found a champion! As in most novel ideas, particularly in medicine, there is always resistance often for many years before the truth is finally revealed. The physicists are still trying to find it.

One such objection was proposed by a Professor Marples of Warwick University to which I responded. The reprint is provided *(SS 2 see Appendix). My response to this objection was happily supported by my clinical colleagues and the editors of the JLO demonstrated great confidence when two years later they published my further two articles built upon the more simplistic original one in 1971.

This act of support entitles them to high recognition for courageous contribution to the reasonableness and value of this Duplex Theory of Hearing. Someone reported to me of a colleague who cynically stated that '*he must of dreamt it all up*', but I didn't have an opportunity to ask him had he seen the little spaceship that Einstein had when he worked out his enormous Theory of Relativity.

The travelling wave/Fourier analysis theory still dominated for another 10 years before research took a turn in my direction. Meanwhile, the physicists have silently dropped all the objections, one after the other, that they originally launched against my theory. Professor Tony Wright, a young ENT surgeon (in early 1980s) measured the length of the cilia under electron microscopy and concluded that there was enough change in the cilia as I had suggested to account for eight octaves of hearing and thus being the first to lend support to my theory. Further support appeared in the thesis of Andrew Bell in Australia (AB). It accepted my revelation that there were two forces applied by the stapes footplate at the oval window in by air conducted sound, one being the near-field effect which actually pushed the basilar membrane and made it move and the second was the true sound wave (the long field effect).

Let us now discuss vibrations as a basic force.

Vibrations

The universe is made of vibrations. From the physical vibrations resulting in force (the gravitational force as described by Einstein) and a host of electromagnetic vibrations that permeate the whole universe, to the nano vibrations which form matter. These include smaller particles between the structures of an atom/molecules in the neutrons and protons and electrons (leptons) and the numerous forms of electromagnetic/energy forces between them (various bosons). All matter is made of these particles and forces.

Living beings can detect only those vibrations for which they have the sensors specifically designed to identify them. Differing species have sensors that can identify differing types or degrees of vibration. Every second of everyday, something like 6000 billion neutrinos coming off nuclear reactions in our sun whiz through our bodies and travel right through the earth without any interruption. Such a burst also occurs in space when stars explode as supernovae which lead to an enormous burst of neutrinos accounting for a thousand times more energy than any light that is emitted. It is said that one star explodes per galaxy every century. We do not have the senses to identify them.

Perhaps we have some remnant or vestige of a means to sense some hint of a different stimulus. Do not senses vary in sensitivity between one individual and another; are such senses experienced by people who have lost one sense and yet can identify some part of that sense by unexplainable means? (E.g. blind people who seem to sense visual events; deaf people who are aware of sounds ... just a thought ... so called brain plasticity is remarkable and probably involved.)

With respect to the cochlea, the key question over the last 150 years has been: 'what are the specific sensors that identify various frequencies of sound?' That is it! ... the main mystery!

Fifty years ago I proposed that such specific sensors are the cilia on the hair cells of the cochlea and nothing that has been said since has changed my mind. In fact I am reading this very moment a paper published on 16 January 2019 from the Massachusetts Institute of Technology,¹ which focuses on the structure of the tectorial membrane (TM). I did not want to interrupt my writing to delve any further as my own health has a sorry prognosis and I am pressed to finish this paper, but it caught my eye.

¹Massachusetts Institute of Technology. 'Mechanism helps explain the ear's exquisite sensitivity: A critical gel like structure in the inner ear moves according to a sound's frequency, researchers find'. *ScienceDaily*.

ScienceDaily, 16 January 2019. (www.sciencedaily.com/releases/2019/01/190116110945/htm)

It suggests that the TM is the detecting organ for sound.

But nevertheless it goes on to say the following. ‘The TM lies atop the tiny hairs that line the inner ear or cochlea. These sensory receptors are arranged in tufts that are each sensitive to different frequencies of sound, in a progression along the length of the tightly curled structure. The fact that the tips of those hairs are imbedded in the TM means its behaviour strongly affects the way those hairs respond to sound’.

But it is an example of the physicist’s continuing saga of reaching for an answer in 2019, already centred in this area as given to them in my writings of 50 years ago!

At last, after all this time, someone is focussing on the very area I proposed. This will be the area where all theories will end up eventually, exactly that pinpointed by the Duplex Theory of Hearing.

This is the only reason I mention this report from the University of Massachusetts. They describe vibration of water and gel in the TM with nanopores controlling the movement. But, as an accurate sensor for frequency it doesn’t make any sense. After all everything vibrates with sound.

Design

Let’s put it this way. If you were going to design a structure that would identify different frequencies, don’t tell me you would have fluid movement or pressure evoking a specific frequency reception; or little balloons full of fluid, such as the body of a living cell with all its factories working to keep the cell alive. Of course not!

You would design something akin to antennas; like little tuning forks, which would vibrate sympathetically with any incoming frequency. Now when we talk about vibrate we don’t necessarily mean that this vibration occurs for a length of time before it dies down. You will see in my description later on, that it needs just a single nano movement quickly extinguished by the TM or by the nano scientific systems existing living cells ... again as will be described later. Nano seconds of movement is enough to depolarise the hair cell. Just think about it and tell me now, this very moment, what could be more efficient than that – what could be possible other than that?

Facts or Assumptions?

It is said that research involves standing on the shoulders of those who preceded us. Yes, that is so; therefore, we must not insult or demean previous researchers. This Treatise is not a frivolous rejection of modern concepts of the hearing mechanism or their proponents.

We are more or less obliged to accept the observations of researchers (particularly if they are repeatable by others) but, in the course of their description, it is natural that the researcher attributes certain functions to the structure they are examining. Both factors lending support to one another. The problem is that a casual reader will accept this mixture of observation of structure together with the purported reason for its existence.

In other words, the factual observations are intermingled with a presumption of what function that performs. It is this presumption that I cannot accept; particularly when there are more reasonable explanations available that fit the physiological facts.

A casual reader therefore is duped into accepting fact and fiction as being some new discovery.

That is what happened with von Bekesy and his ensuing disciples; he detected a wave and made assumptions. He then took up the rest of his career calculating around them and examined in detail a host of animal, until he read my debate and had second thoughts a year before he died (see footnote p55).

I am not asking anyone to accept all that I say. I am asking the reader to make up their own mind, consider the logic of my thinking and come to their own conclusion as to the real situation.

My articles are reprinted here in the Appendix (from S22 on) because they are vital to the understanding of this Treatise and affording immediate access to the reader as it is difficult to refer back to a publication of 50 years ago.

The conclusion is inevitable, that current painstaking research, using all the modern techniques, will all end up proving that my Duplex Theory of Hearing to be the correct one.

2. Prime References

In order to allow free flow of reading and understanding, references have been severely restricted. Reprints of my original publications written almost 50 years ago, are provided to allow immediate access to the reader as they afford a key premise for understanding the reasoning. Strict figures or formulae are avoided in order not to interrupt the thought process of the reader. Simple numbers as below identify in which reprint a matter under consideration is found.

- * SS 71 Stylis SC. A working theory on the mechanism of hearing. *J Laryngol Otol* 1971;**85**:481–91
- * SS 2 Stylis SC. In defence of the Duplex Theory of Hearing. *J Laryngol Otol* 1971:987–22
- * SS 73 Stylis SC. The Duplex Theory of Hearing – a new concept. *J Laryngol Otol* 1973;**87**:727–39
- * SS 4 Stylis SC. Unfair discrimination in the cochlea. *J Laryngol Otol* 1973;**87**:739–47.

There is no essential need for accessing other sources of information listed below. However, if the reader would like to follow up on my statements, the suggestions below are informative. That of my friend Andrew Bell is an easily read summary of all

theories from Helmholtz 1875 to about 2005 and also the subsequent development of the modern research. It gained him his PhD and requires only a click on the link given. No membership etc is required.

- * **AB Andrew Bell.** Senior Researcher, the National University of Australia, Canberra. PhD Thesis – <http://hdl.handle.net/1885/49307> (chapter 12 for historical) In 2005, he acknowledged my theory in his Thesis.
- * **NL Nick Lane.** Power, Sex, Suicide – (with about a hundred references)
Mitochondria and the Meaning of Life ... by Nick Lane PhD Professor of Evolutionary Biochemistry Oxford University Press (2005) ISBN 978-0192804815. This is a book every doctor should read. A fascinating and captivating narrative.
- * **Scientific American** (ISSN 0036-8733) PO Box 3187, Harlan, IA 51593-0378 has published in virtually all monthly issues as far back (last 30 years) as I remember on all nano science and Quantum Theory. Much of my information has been learned from this highly respected forum. I cannot possibly isolate specific references as I read from my old notes. scientificamerican.com
- * **AW Emeritus Professor Anthony Wright,** a researcher as well as an accomplished clinician and surgeon.
Dimensions of the cochlear stereocilia in man and the guinea pig. *Hearing Research* 13:89–98, 1984.
He will survive me and may be able to respond on my behalf as mentor.

Much of my material is from notes I have taken over many years and mingled with my own comments so I am unable to quote specific references. As the material is of educational value rather than commercial, I can only make general reference where possible. I am not a plagiarist, the entry is a compliment.

3. Introduction to Reprints Pertaining to The Duplex Theory of Hearing

Though my articles are easy to read, I summarise the key points here to enable the reader to proceed with the matters presented in this Treatise, without any interruption in reading the articles in detail.

The original publication *(SS 71) in 1971, stated clearly that this was an attempt to categorise, explain symptoms, signs and pathogenesis of many hearing disorders associated with the inner ear. It also stated ‘we are concerned only with the primary mechanism, namely, how pitch and loudness can be received concomitantly and how rapid changes in these qualities can be appreciated’.

I claimed firmly that the movement of the stapedial footplate gave rise to two separate wave motions, one being called the ‘near field effect’, which gave a physical push to the basilar membrane, and the other being the ‘long field effect’ or the true soundwave, which travels throughout the cochlea. This had never been applied to the cochlea before. In his thesis of 2005 Andrew Bell (AB) was particularly impressed by this now obvious fact of physics. The Duplex Theory of Hearing was thus named and these two waves play an all important role in the whole mechanism of hearing as unfolds in my discussions in the latter part of this Treatise. Whilst no direct reference to this fact has appeared in subsequent literature, I notice it has been used in recent times when required by some researchers to explain their assumptions.

The first paper (SS 71) described in simple terms some absolutely novel proposals and, in addition, a list of the types of theories that existed until then.

In the paper titled Unfair Discrimination in the Cochlea *(SS 3), other proposals appeared in the text which also have never been considered before.

An overall summary of the novel features is as follows:

1. Two wave motions are produced by the stapes footplate – important
 - (a) True sound waves (the ‘far field’ effect – a molecular oscillation)
 - (b) Gross pressure waves (a ‘near-field effect’) – See details in article.

Yet no one had postulated that true sound waves existed in the cochlea. The basilar membrane is deflected by the latter wave, which causes the ‘travelling’² wave of Von Bekesy. This carries the hair cells to and from the TM.

²Please note that the term ‘Travelling wave’ is used in my articles to refer only to the movement of the BM which is of a wave-like manner and at the time understood by all. I am not referring to a wave that was the subject of a Fourier analysis ... it is the movement by the BM that is most important not the presence of any wavelike element.

The travelling wave moves at a rate of about 1000 cm/s at the base, reducing to 300 cm/s by the time it reaches helicotrema. This cannot compare with the speed of true sound waves in fluids, for example, 143 000 cm/s in water. Naftalin (1964) demonstrated by mathematical calculations that, with regard to hearing, scientific observations on a temporal basis cannot be explained by the slow speed of the ‘travelling’ wave.

Important find:

In any case, von Bekesy whose knowledge and reputation ruled supreme, died in June 1972 and the timing suggests he had read my theory of September 1971 and wavered in a ‘confession’ which he wrote and which was published posthumously in 1974.

(Georg von Bekesy (1974) ‘Some Biophysical Experiments from Fifty Years Ago’. *Annual Review of Physiology*, 36: 1–16, Doi:10.1146/annurev.ph.36.030174.000245, ISBN 978-0-8243-0336-5, PMID 19143520 ...

Bekesy wrote:

‘In time, I came to the conclusion that the dehydrated cats and the application of *Fourier analysis* to hearing problems became more and more a handicap for research in hearing, referring to the difficulties in getting animal preparations to behave as when alive, and the misleading common interpretations of *Fourier analysis* in hearing research ...’

I only uncovered this recently on searching for his personal history ... no one seems to have mentioned this publication at all!

Did the ‘wave’ hitting the wall in the JLO’s open mind and confidence in the logic of my theory in 1971 finally convinced him to express his doubts? The wave movement he witnessed would not in itself explain the physiology.

2. The cilia of the hair cells are not fixed to the TM.
 3. The cilia act as tuned resonators to receive the frequency of the true sound waves.
 4. Two factors are necessary for the transduction of sound vibrations to electrical energy.
 - (a) Exposure of the cilia to endolymph.
 - (b) Vibration of cilia.
 5. The function of the TM is that of dampener as well as that of a protective medium for the cilia from the hostile endolymphatic environment.
 6. Loudness is a complex function of the following factors:
 - (a) Amplitude of movement of the cilia.
 - (b) Degree of freedom from the gelatinous layer of the TM.
 - (c) The various relationships revolving about the type of movement of the basilar membrane and the rods of Corti, and the relative exposure of the various rows of hair cells.
- I wrote, 'the ionic basis of hair cell action is unknown and speculation of it is outside the scope of his paper. Suffice it to say that a different electrolyte mechanism must exist than that in the studied neural mechanisms involving sodium–potassium pump systems; possibly a chloride pump related to an ionic sync with a reverse charge pattern'. (p. 734 of SS 73).
 - I emphasise that the vibrations need not reach its full amplitude: in other words, it suffices that the movement is initiated in the specific tuned elements (cilia); build up and decay thus become unimportant.
 - At the time I suggested that the cilia of the hair cells exposed to the endolymph would experience an enormous gradient across the cell membrane in the form of chloride ions and also of electric potential. The vibration of electronegative cilia (−70 mV) in an electropositive endolymph medium (+80 mV) surely forms the basis of a triggering mechanism for discharge potentials; the ultimate transduction of mechanical energy (vibration of cilia) to electrical energy (change in membrane potential). Is not this the obvious basis of oxygen-dependent cochlear microphonics? We will see there are other factors and ions involved.

This second article *(SS 73) in addition separates out the different types of theories and puts them into categories.

The correspondence *(SS 2), which appeared later in 1971 was instituted by Professor V. Marples, of Warwick University, who raised objections based on a model that he had built. This was purely of a straight membrane; that is, it did not take a two and a half times curl as does our cochlea. It is a relatively weak argument as it is commonly suspected that when one builds a model they build into it the very things they want to show.

Furthermore, remarks made have since been proved these objections were incorrect. In keeping with his contemporaries he wrote '*it is not possible to initiate and terminate vibrations instantaneously as implied by Stylis*', but then of course nano-science had not been fully appreciated. My response printed immediately after his letter was very convincing to my colleagues who then felt emboldened to enter the fray, as well may your goodselves. It took 10 years before physicists began to change their direction my way.

Other theories could not explain the clear hearing of a frequency and a rapidly recurring one at that, let alone a number of frequencies (e.g. an orchestra), even clicks of a fraction of a second. No where anywhere near that.

Unless a theory can provide that, it cannot be considered as valid.

I thanked Dr Marples for taking time to study my article and taking the trouble to publish his views but that I had hoped he would '*consider a broad concept of my theory with a mind uncommitted to prior ones*'.

This is a difficult thing to do, but I have a feeling that, as his physicist colleagues have since all dropped their objections quietly with the further research over the last 35 years this might have happened.

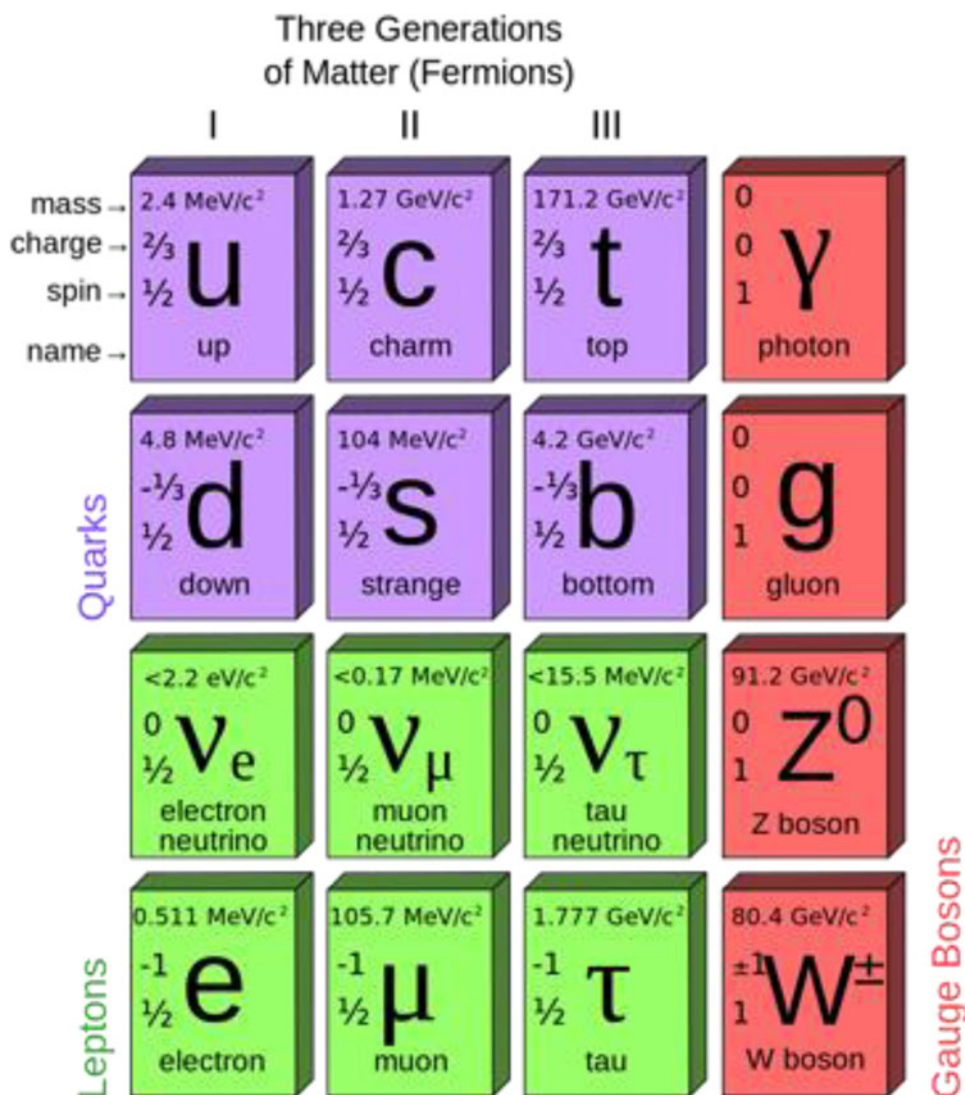
The papers are very easily read, the explanation simple and straightforward. I reprint them here so that you can refer to them at anytime. (p S22 on)

4. Essential Modern Physics

A. Quantum Theory

We cannot by any stretch of the imagination discuss this in any detail. The concept has been worrying scientists since about 1930. It caused great worry to Einstein in his attempts to correlate it with his Relativity Theory and no one has been able yet to really understand it. However in attempting to condense it for you, I have gained a new concept, as I will outline below. (It is recommended you read pS18 re the UNIVERSE).

Quanta are the smallest particles or amounts of energy that form all matter (the total components). I have copied below a diagram that lists all the particles discovered. The activities of these smallest particles in mass and energy appear to be involved in unbelievable association (entanglement) and proven so. (Diagram from A Chaudhuri)



Photon and phonon quanta are Bosons; they have no mass but carry energy. A phonon, in condensed-matter physics, is a unit of vibrational energy that arises from oscillating atoms within a crystal. A packet of these waves can travel throughout the crystal with a definite energy and momentum, so in quantum mechanical terms the waves can be treated as a particle, called a phonon. A phonon is a definite discrete unit or quantum of vibrational mechanical energy, just as a photon is a quantum of electromagnetic or light energy (Encyclopaedia Britannica).

As in my enlightenment as to the events in the cochlea, I found starting at the end point and working back is more revealing. Physicists involve themselves in mind-games when trying to ascertain how their current observations work, without considering the end-point facts. They conjure up complex and unbelievable explanations that confuse even the greatest minds. Raw basic thinking has resulted in my vision of quantum activity as a ‘universal dynamic equilibrium’, an idea not been suggested before. It will serve your understanding well if you think of it in this way.

As medical specialists, we are all aware of the principle of dynamic equilibrium that exists in the metabolism within all cells; when one action/process occurs, another immediately restores the status quo of that action in a normal cell. Failure to restore that status quo will lead to damage to the cell, eventually causing it to perish. This is the principle of homeostasis – the ‘milieu interieur’ – established by Claude Bernard (1813–1878).

Moving to a larger example, the whole body for instance, we need to imbibe water so the body can carry out its metabolism in all cells. In addition, nutrients require transport and waste products need to be excreted by the kidneys. Perspiration plays a key role in temperature control. If the intake of water does not balance the output, the effect will be on the one hand oedema or on the other dehydration, either affecting every organ with eventual death if not corrected. An equilibrium has preferably to be maintained. You could regard this activity as ‘**entanglement**’ ... a set formula, which, if it breaks down (**decoherence**) leads to adverse effects.

Now, consider a larger system still; go to a household. Just as in a cell or a body unwanted elements need removing, rubbish accumulates and if not removed disaster can follow ... disease, cockroaches, rats etc. Other parameters can be used. Again, why not spread the principle to neighbours or suburbs? The next door drainage runs into your property ... immediately your entangled counterpart drains the excess away until the matter is resolved. If the counterpart is defective then you are flooded out and a larger entanglement may be in the background (e.g. a drain further down the road).

The process can be extended as far as you like. If it can’t be resolved then a new set of circumstances has arisen.

For instance, where there is a major flood disaster in a low lying country, government evacuation of the area perhaps with a redrawing of the map if it cannot be remedied; new quantum decoherences and entanglements are self formed.

All these examples are coming to mind as I write and perhaps there are better examples but I do not wish to enlarge further ... just throwing some thoughts for you to consider so, in a way, the concept of a form of a '**universal dynamic equilibrium**' develops. An event will cause a restorative event in another place as appropriate, if possible.

We are only a part of the universe, just as an arm is part of us, so why would the relationships of existence be any different?

It appears we have been born with the universe, or developed from the same source; of particles and forces of the same mother ilk!³ (If interested, see Appendix, pp. 47–52 for a summary of the Universe, our place in it and basic contents). As we are a part of the universe with the galaxies and planets etc. we are like part of the universe 'body', like an arm or a kidney. Except that in relative size, our whole self is like one cell in that universe ... that is, like one cell in our own body. So that all the contents of the universe act in unison – as one whole being – obeying the same scientific laws to maintain equilibrium as does each part of our body ... within the ambit of our body and in each organ and in each cell in our body. And as it is with our cells or an organ or the whole body, the (unknown) 'forces' maintain equilibrium as far as they can but, if they can't, no big deal, the affected unit dies. The universe remains with new circumstances and a **new quantum state** exists.

Therefore, whatever 'force' is working to maintain our dynamic equilibrium is working over all the universe as well ... or vice versa. No one knows what form this takes. This is what they have been trying to find out, but in the laboratory. But the principle of entanglement and decoherence is readily accepted.

May I also point out that within our bodies we have other beings such as resident bacteria in our gut perhaps invaders like worms, even dormant viruses inside our bodies. Just as we are born inside the Universe they are also and exist inside us. All thus with a quantum relationship. Perhaps an 'understanding' that if 'this happens' then, 'that reaction occurs' (i.e. **entanglements**). Perhaps the gut bacteria have entanglements so that if gastric acid is present they move further down the bowel; or have an 'agreement' with the intestinal villi to assist them and they will supply nutrients.

Quantum activity can be shown to happen with more coherence in the microworld (i.e. small particles) than with larger things (namely it is obviously more apparent and more important in the cell which is the basic unit, than the larger body which has more ways with which to counteract/restore/adjust).

I emphasise, that with my '**Principle of Universal Dynamic Equilibrium**' goes the acknowledged concept that matter and energy is not lost or destroyed ... It is a matter of metamorphosis.

So what do the physicists tell us?

'**Entanglement**' is the prime state which gives rise to the strange consequences. Individual particles bind with others in an indivisible relationship and behave as a single unit. Even at a distance they behave according to their relationship as a single entity without any proven connection. (With respect to the size of the unit body, ratio of the nano distances in a cell is perhaps greater than the ratio in the larger body of the planet or the universe. A matter of relativity. So what's different?)

This quantum thinking displays peculiar puzzling events which cannot be really comprehended. Great minds like that of Einstein and Schrodinger, were so baffled that Einstein labelled them 'spooky events', pity I cannot debate with them with my '**Concept of Universal Dynamic Equilibrium of Quantum Action**'.

These particles can act as a wave or a particle at the same time.

For instance, it has been definitely proved in recent years, by extensive and repeated laboratory research, that two particles (or a number of '**entangled**' particles) separated by any length of distance from inches to metres and miles, purportedly perhaps even years away, can move in a preset condition in complete unison with one another. (But remember, these distances in a massive body as the universe is only equivalent of the inside of one cell or maybe two of our cells beside one another ... if you get the picture! ... again as perspective, if one nanometre was as big as your foot, the distance between Australia and New Zealand would be one centimetre; if 1 nm was as big as a football, a red cell would be the size of a football field).

It has definitely been shown in the lab for instance, an electron is made to spin in one direction, it can cause another electron miles away in another laboratory to change it's spin to the opposite direction. If one particle suddenly turns upside down, another particle in another place will turn itself upright. Yet there is no obvious detectable connection of any sort between the two. It is virtually instantaneous.

Interfere with one lot of particles and the entangled particles elsewhere will also react!

To all this I say, so isn't this the same as expanding one of our cells to an increasing larger size with the same sort of natural equilibrating forces at play? The physicists are trying to explain something they can't understand by beginning with their understanding of classical physics with which it all merges; and applied to a very 'local' area. They acknowledge that it doesn't always work out (60–80 per cent), but don't realise that it all sorts itself out only if it can ... but if the circumstances cannot, then a new state has now developed with new entangled relationships. There is no law against the impossible.

A University in the Netherlands is still doing such experiments and claims that by the year 2020, it will use this technology to produce a quantum internet which will do amazing things.

The protons and neutrons consist of quarks and gluons (each of several varieties) regarded as particles, the electron has its own mass and charge, and there are bosons (of different types) which are not particles of mass but units of energy.

Do not confuse a **photon** which is the smallest discrete amount or quantum of **electromagnetic radiation** carrying X-rays, microwaves, radiowaves, visible light with an electron. A photon has **no mass**. An **electron** has mass and it's own charge and

³I really believe you will find my discourse on our Galaxy interesting as well as consolidating its relevance in proving the workings of the hair cells as discussed above.

Don't get excited ... it is just a thought, an exciting thought ... but it illustrates that there are *forces that exist beyond our anticipation*, so that the probability of my proposals 50 years ago being valid is increasing by the day.

There are more factors to come.

when it falls from a higher energy orbit to a normal one, it emits a photon – *a packet of energy*. Photons carry such energy differences between states and are both a massless particle and a wave. The higher it's frequency, the higher it's energy. In the opposite situation, when an electron gains/absorbs a photon, it moves into a higher energy level and the photon, which provided/carried the energy to it, disappears.

Why have I tried to try to explain in brief this difficult but **proven** Quantum science? Because I wanted to ask, under the proven scientific observations, how can anyone deny such apparent miraculous activity is occurring in our cells, bodies and the environment.

We can specifically apply them to reaction by the cilia of the cochlear hair cells to a nano movement/vibration in an organised ionic environment and/or depolarising stimulus. How entangled are the elements in this situation? A 'tickle' here can cause an immediate reaction in a related quantum particle beside it or in an entangled particle elsewhere. Is that not causing an action (e.g. depolarisation) and an immediate restoration so maintaining an equilibrium?

B. Nano Science and Protein 'Engines'

Nano science is a study of how matter behaves when it is configured on a scale of nanometre.

Atoms are the building blocks of matter. Having electrons enables them to bond with other atoms to form materials and structures.

Of course the discussion on Quantum effects has discussed the basic structure of matter and energy but on another platform. I now focus briefly on the relevance of such small size in the activities of the cell and the 'machines' that perform all the functions required to perform their function as well as keep the cell alive.

Electrons although discreet and countable in number have a spatial extent, like the springs of a guitar. The media to which electrons are tethered can be tuned in size and shape, changing their resident frequency. As I understand it, the electrons do not have to stay restrained to their particular atom or molecule but can run all over the accumulated mass exchanging energy but maintaining a neutral electrical charge and maintaining dynamic equilibrium. The material's size programmes whatever forces they absorb.

In nano scale, the surface area becomes largely vastly larger and more important compared to volume. Remember this ... Surface area provides an expanse for connections and intercourse with other forces.

Perspective regarding size

A millimetre (mm) is a thousandth of a metre 10^{-3} m.

A micrometre (μm) is a millionth of a metre 10^{-6} m.

A nanometre (nm) is a billionth of a metre 10^{-9} m.

A picometre (pm) is a trillionth of a metre – 10^{-12} m

- A grain of sand equals one **mm**. (one million **nm**).

A sheet of paper is 75 000 nm thick

- Human hair is 50 000–100 000 nm thick
- A red cell is 7000 nm thick
- Viruses can be up to 100 **nm**
- Most atoms are 0.1–0.2 nm wide
- 10 hydrogen atoms side by side are 1 nm long
- 10 base pairs of DNA = 1 nm of DNA and strung end to end would amount to 2 m of DNA in each cell if not condensed into tiny particles – so it fits in a small space.

There are 15 trillion cells in our body each about **10 000 nm across**. Obviously, many structures/organelles can fit inside and can measure up to hundreds of nanometres in size.

For example, the pumps that move molecules in and out of our cells are about 10–20 nm or more. The proteins that keep our cells going are typically about 10 nm and the DNA molecules that programme our genetics measure only 2 nm across.

So, we can see that a great number of protein machines and inclusions can be easily accommodated within a cell.

Cellular contents, proteins and activity

There are a hundred billion new cells made in the body everyday. All three billion bases in a human genome need to be copied each day.

Proteins are a major class of bio molecules that can connect biology directly with a lot of nano technology. All functions in a living cell are carried out by protein structures.

Proteins are composed of amino acid which are **no more than 1 nm in size**. The order of the amino acids within the protein has a strong effect on structure. That order is determined by information of the DNA, each gene being essentially the code for a single protein. With the direction of *messenger* RNA, other RNAs amass the various proteins required in the **ribosome** which joins them together. The ribosomes are thousands of protein building factories in the cytoplasm of a cell which translate the message encoded in the messenger RNA, assisted by specialised proteins called *transcription factors*.

All 'machines' in the cell are made of proteins. Proteins can be very different in that there are 22 different amino acids providing a selection used to manufacture protein, depending what its function is going to be. 'Proteins make possible all the physical attainments of life, from metabolism to movement, from flight to sight, from immunity to signalling. Probably the most important group are the enzymes, biological catalysts which speed up the rate of biochemical reactions by many orders of magnitude, with an astonishing degree of selectivity for their raw materials'. (*NL)

The cells need a variety of proteins because they perform so many different functions within the cell, making hormones and their receptors, immune proteins like antibodies etc. Some proteins have evolved to very specifically recognise other proteins or even DNA or other molecules. **Their structures are designed to find and bind partners.**

Helical sections that we find in proteins are rigid, so they are good at grabbing chemical functionalities or other molecules. The linker regions are quite flexible and are good at allowing a protein *to change shape to give off a signal*. In this way, proteins can tell a cell whether it is cold or hungry so that the cell can respond.

One of the most ubiquitous functions of protein is to **catalyse chemical reactions**. Proteins are **good at making unreactive molecules do something special**. They do this by bonding molecules in special pockets where they can bend the molecule to put it under stress and break a bond or they can use one of their own functionalities to cut or replace a chemical bond.

Each protein machine function is carried out by the use of energy. This function may be triggered off by some signal – a movement, a change in its immediate environment, the presence of another ion or molecule designed to provoke a reaction.

Not all proteins have what we consider active functions, some of these passive functions are present to provide structure to a cell or a tissue, for example collagen which is the main component of connective tissue, representing 30 per cent of the total protein in our body. This exists in a triple helical structure about 1.5 nm in width and 300 nm in length. These triple helices of collagen are wound into tight bundles that can be hundreds of nanometres thick and they provide a guide that tells the cells where to grow. The ability to tell cells how to position themselves have been mimicked with other nano materials.

The windows or ‘pores’ at the cells surface are protein engines formed to detect specific substances on the surface which then causes them to contract and open a space allowing ion exchange to occur. ... acting as **a gatekeeper** ... receptors deciding what to let in or out. They are inactive, but once they bind something they trigger a chain of events, forming pockets to allow the receptor to bring material into the cell.

Other ‘nano machines’ open the window to expel other ions or materials.

Nerve cells have certain duties whereas muscle cells have other duties. Specific protein engines (protein molecules) are present to perform those specific actions. They are constantly being replaced. If for some reason replacement is tardy or inhibited then the cell will die and a process of replacing it with another cell occurs (apoptosis).

All these processes are in a dynamic state and ‘humming’ all the time until a stimulus, to which they have been especially made to detect, triggers them off to ‘do their thing’. Similarly, in the instance of my Duplex Theory of Hearing, a specific type of movement in the cilia of an inner hair cell (IHC) would be enough to trigger off the process of depolarisation. This latter state may be direct or it may involve a multistage reaction before actually stimulating the neurone. Such stages can lend themselves to modification (viz. suppression or sensitisation).

These actions occur in split seconds. I keep emphasising the words ‘dynamic equilibrium’. There is a continuous activity of this sort occurring with electrons passing from one to the other continuously but still resulting in a zero balance until the specific stimulus is given that pushes a pulse reaction in the one direction resulting in the depolarisation and proceeding to the effect they were designed to produce.

In nano scale magnitudes, changing the surface area of a material maximises the density of energy that can be stored in it. Optimal angles and odd orientations facilitate the triggering of reactions and/or amplifying the effects.

The energy required

All matter is extremely active at all times, yet maintaining its overall equilibrium. Forces both internal and external will alter this state momentarily until the forces of equilibrium reverse it back.

To effect this, energy is required. Energy is essentially produced by the movement of electrons. This is done by using the energy obtained by the movement or transference of electrons from one atom to another atom (during the specific action of the protein engine, the atom that has given up an electron to provide the fuel/energy for the action, is said to be oxidised).

This atom then has to be recharged again or reconstituted (**redox**) by receiving those electrons back again. This latter energy is provided by the **mitochondria** (NL see Apx, p. 35), which uses oxygen and glucose to do so. They contain a multifolded membrane affording an expanse of surface to effectively and rapidly break down nutrients to glucose through the citric acid cycle to produce ATP.

These mitochondria have their own DNA/RNA system (*independent of the cellular nucleus*) to strictly reproduce mitochondria which probably form the most numerous item within the cell (from very few in skin and blood cells up to a several hundred mitochondria which might exist in the cell and may take up 40 per cent of the cytoplasm). A billion of them can fit in a grain of sand. These are constructed **solely** to produce energy.

The ‘fuel’ of oxygen and nutrients are allowed in the cell by the protein pore-opening machines on the surface of the cell to supply the mitochondria which contain a multifolded membrane affording an expanse of surface to effectively and rapidly break down nutrients to glucose. As aforementioned, they pass the glucose down the chain by electron carriers in the Krebs cycle (citric acid cycle), passing, gaining or surrendering an electron at each step every 5–15 ms; these *redox reactions* release energy. The mitochondria move round the cell where needed to ‘keep up the charge in the cells ‘machines’”.

So all energy-generating reactions of life are redox reactions.

It is the transfer of electrons that is the criterion, so oxygen isn’t always necessary.

There is no need to go into any further detail except to reiterate that all vital processes of life are a continuous movement of the electrons and electrical charges by the protein engines and the energy to do this is immediately replaced by the mitochondria; so this dynamic process is an ongoing process resulting in a ‘dynamic equilibrium’. This is occurring in every cell in the body continuously at all times.

Nano tubes

A carbon nanotube is a nano-size cylinder of carbon atoms. Imagine a sheet of carbon atoms, which would look like a sheet of hexagons. If you roll that sheet into a tube, you'd have a carbon nanotube.

This is not related to hearing, but I bring it up here to illustrate how a single carbon nano tube, less than a micron long and only 10 nm wide protruding from an electrode begins to vibrate vigorously when a radiowave of specific frequency impinges on it. They are able to respond to vibration albeit *electromagnetic* (radio waves). They are not like the standard fixed antennae of radios that merely pick up the electromagnetic radio waves and transmit them as electric current. The nano tube itself actually vibrates mechanically and serves simultaneously as all essential components of a 'radio – antenna, tunable band-pass filter, amplifier, and demodulator' said physicist Alex Zettl, the inventor. It could fit inside a living cell.

In 2007, I watched in awe the website of a nano tube viewed under electron microscopy, watched the tube vibrate and being able to select a number of songs or classical orchestral music which were rendered as one would hear them on a standard radio or CD. In fact I teased my anaesthetist for a year challenging him to bet me \$100 that I could let him hear a selection of songs on an invisible radio. I eventually did show him to his amazement.

Reminds me of the nano-sized cilia of the hair cells which also vibrate and instigate reactions by various means as will be described in due course.

5. Basic Hearing Factors

Anatomy

You all know the basic anatomy of the cochlea. I will select various parts of this for comment as it might apply to our discussion.

But first, why is the cochlea shaped the way it is? Because mammals have eyes on the front of their heads they rely on hearing to detect unexpected, unexplained sounds coming from behind. They can see danger ahead they have to hear it coming from behind. Everything in the auditory system is, therefore, geared towards sensitivity and anything that helps improve this can only be an evolutionary benefit.

'Whispering walls' of the bony cochlea

This thought came to mind whilst I was considering the question of the cochlear modifier, to be discussed shortly, acting in instances where the sound waves were of minimal intensity but sufficient to stimulate the cilia of the outer hair cells (OHCs). I wondered then whether the curved shape of the bony cochlea would play a role in directing such waves around the spiral towards the apex (helicotrema).

This principle has been playing on my mind from the very first article in 1971. It didn't quite fit in then as a vital factor, and, as a theory consolidated in my mind, it wasn't taken further. However, I was pleasantly surprised when reading my 1971 paper again after such a long time and noting the possible advantages the shape of the bony cochlea offered. Faced now by the concept of the 'Cochlear Modifier', one function involving the need for the most minimal of sound waves, not strong enough to cause adequate vibration of the stapes footplate, to reach and to stimulate the OHCs, the thought came that there may well be some advantage in this spiral shape.

Because of the impedance caused by the relative density is of cochlear fluid in comparison to that of the bony cochlear wall, one could imagine a reflection of the sound waves in a manner akin to the 'Whispering walls' as occurs at St Paul's Cathedral in London and in other places.

After consecration, in 1704, of the cathedral built by Architect Sir Christopher Wren, people in the gallery circling the wall just below the dome, picked up unintentional conversation even if they were on the opposite side of this circular walkway more than 33 m away, and beyond the reach of a regular whisper.

One would think that a loud conversation or shout would create a much more powerful sound wave than a whisper with a better chance of being heard a long way away. In fact, the qualities of the whisper were much more audible; being of low intensity it seemed to avoid less interference from echoes and other distortions.

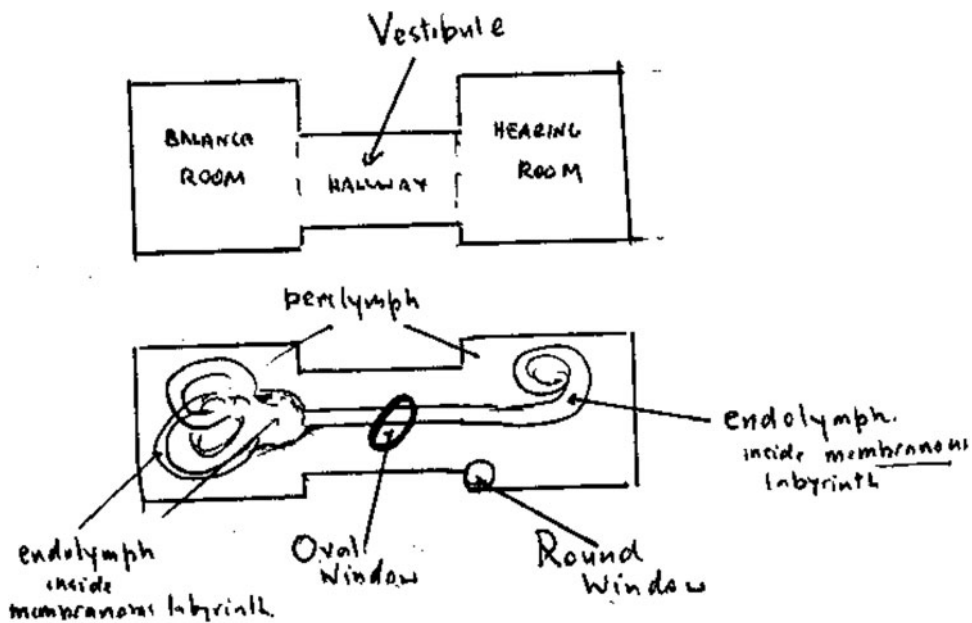
The phenomenon was investigated by Lord Rayleigh in the late 1870s. He concluded that the waves underwent repeated reflection and 'crept' horizontally around the inside of this circular gallery. This was very much like the diagrams I postulated in my articles of 1971 and 1973.

In this manner, and, as low-frequency waves seem to travel better, the sound waves could be gently angled to travel towards the apex of the cochlea and so to stimulate the OHCs in the low-frequency areas, thus perhaps assisting the 'jolt' to the basilar membrane.

So, the softness of a whisper and its lower frequency would be perfect to take advantage of the presence of the acoustic interface impedance of this curved shape, which might have evolved to be yet another way of enhancing the hearing so vital in mammals who can see danger in front but have to hear danger coming from behind their restricted line of vision.

1. Housing of the mastoid labyrinth

It is essential to understand the anatomy of the labyrinth. This can be described as two large rooms separated by a hallway as depicted below. All this area is filled with perilymph. Within this perilymph lies (consider it for the moment as 'floats') the fully enclosed membranous labyrinth. This consists of the balance organ (semicircular canals etc.) in the one room, and the membranous labyrinth with the hearing organ lies in the second room. The hallway (passageway **or** *vestibule*) allows the ductus reuniens to connect the endolymph between the balance organ and the hearing organ.



The oval window (and thus the footplate of the stapes) is located in the anterior wall of this vestibule. The effect of the stapes vibration occurs on the perilymph and not directly on the cochlear duct or Scala media. The round window also exists in the wall of this perilymph collection.

Finally, imagine the bony walls of the two rooms contracting to follow intimately the shape of the membranous labyrinth and leaving only a small amount of perilymph between the bony wall and the membranous labyrinth itself, except in the vestibule which has a relatively larger amount. It is reported that the cochlea has only about 0.2 ml in volume.

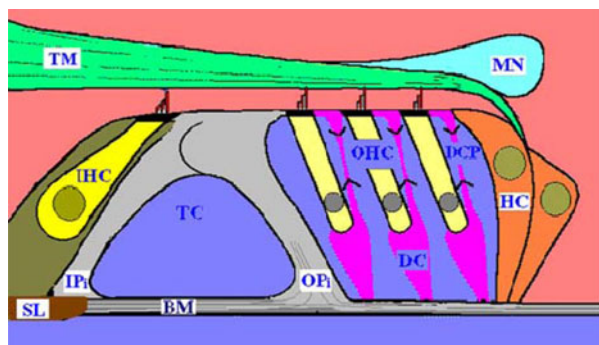
Vibration of the stapes footplate causes pressure variations in the perilymph. If there were no round window to allow some flexibility of this pressure, there would be no movement occurring in the cochlear duct. Because of the round window, such pressure is directed to this area causing deformity of the endolymphatic scala media. This results in movement of the basilar membrane (and of the TM though not symmetrical) which thus initiates the process of hearing conducted by air.

Not only then is this anatomical structure of basic importance, but it also must play a role in the perception of intensity of sound as I will bring in later.

The hydraulic factors obey the rules of physics. Pascal's law states that pressure exerted on a fluid in an enclosed space is distributed equally throughout that fluid. Fluids are not compressible.

The conventional picture of a cross section of the organ of Corti is shown here.

- TM Tectorial membrane
- MN Marginal net. This is now thought to anchor to the Hensen's cells
- SL Spiral lamina (bony)
- BM Basilar membrane
- IHC Inner hair cell
- OHC Outer hair cell
- TC Tunnel of Corti
- HC Hensen's cells
- DC Deiter's cells



2. The tectorial membrane

This is of hard but elastic structure ideal for transmitting sounds by bone conduction. It's dry weight is composed of 50 per cent collagen and is covered with a gelatinous layer which is much more complex than other acellular gels. In the absence of the air conducted sound or in moving back and forth as the basilar membrane moves, the tips of the cilia are restrained by this gelatinous covering.

3. The basilar membrane

The basilar membrane is not a membrane per se, but rather is composed largely of extra cellular matrix materials. It is just a sheet-like barrier between the scala tympani and the cochlear duct, upon which the Organ of Corti sits. It has no fibres set individually that will respond to frequencies as some earlier physicists had proposed. If a surface like that is shaken, pushed or blown, wave-like movements occur, depending on the strength and frequency of pushing or shaking. The degree of movement is said to be in the degree of picometers [at threshold, one minus 12th part of a cm (minus 9th part of a nanometre)].

The only important thing as far as I am concerned is that movement is created and not so much as to whether it takes any shape or not. Movement will move the hair cells back and forth up against the TM; whereas, if the BM does not move, the cilia would be touching and restrained in the gelatinous layer of the TM and not free to move in response to air conducted sounds.

4. When I wrote the theory in 1971, there was some argument whether the cilia were attached firmly to the basilar membrane or not. By reasoning it would not seem possible as there is no such other example in our anatomy. They are too fragile and any movement back and forth would tear them and that doesn't seem to happen. In any case I have described the findings in my publications and the matter has been ignored any further except in recent times there is talk of a firmer connection with distortion of the cilia 'bending' in a shearing-type action. I can't accept that sort of scenario, what with no firm attachment and a gelatinous layer.

Picture it in your mind. If the tip of the cilia are retracted out of the gelatinous layer, they become free to move and so to allow the sequence of depolarisation to occur. If they were just 'bent' by TM movement (as many claim), how would a sound wave stimulate a specific cell tuned to a particular frequency? The cilia of **all** the hair cells (or a large number of them) would be bent!

There are many modern descriptions of the various cells in the Organ of Corti, but the essential cells to our interest are the single line of IHCs and three or more lines of OHCs. I would think that there are three lines of OHCs in order to rustle up enough strength to move the TM as will be described. There are about 12 500 OHC in the average human cochlea.

There is perilymph around the bodies of the OHCs. There is a contractile protein (**prestin**) within the OHCs which contracts when the hair cell depolarise. The inner cells don't do this. The inner cells purely provide the brain with signals denoting specific frequencies and intensity (95 per cent of the afferent nerves to the brain are from the IHC). The OHC is supposed to participate in what they call the cochlea amplifier which I will discuss next.

5 Descriptions indicate a **vascular supply** running up the modiolus but I guess you wouldn't want vessels of any size carrying pulsations into the cochlea as that would cause a lot of interference. The nutrients coming from the stria vascularis line the surface in the external wall.

Some researchers have based their theories on specific **frequency** perception on the squishing and squashing of the OHCs. I can't for the life of me believe that if you wanted to pick something as a strict detector of frequency, you would pick on little balloons of fluid. The OHCs obviously detect sound but detecting strict frequency is not required.

And if there is muscle in the side walls, of course 'it will pull up its knees' when it gets depolarised. How would you like an electric shock to run from your head to your feet all of a sudden, and if you had muscles, you would squash and expand a bit yourself! With that thought, I will discuss this when coming to talk about the 'cochlear amplifier'.

Depolarisation of a Hair Cell

There is no need to go into great detail here except to say that

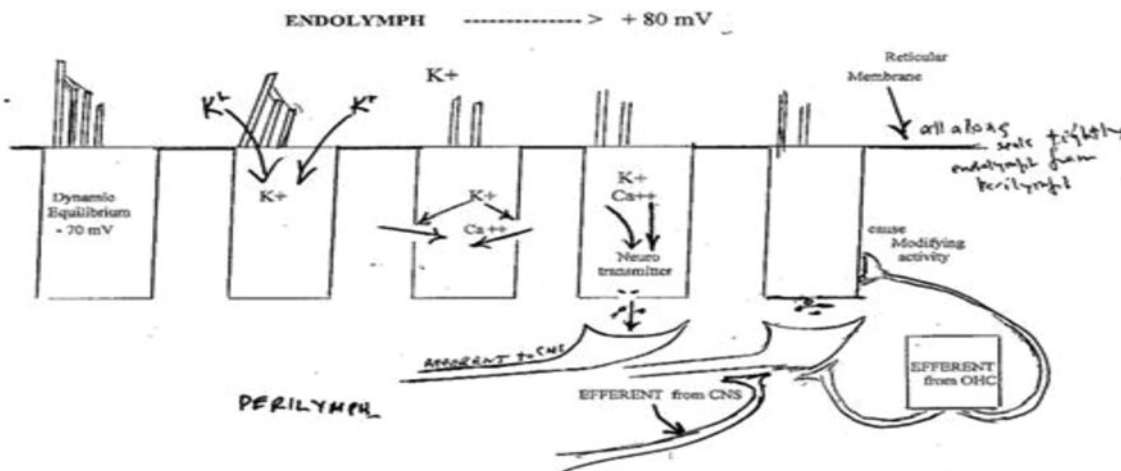
- The **endolymph** has a high potassium concentration and an electrical potential of about 80 mV. It has less sodium and calcium ions than extracellular fluid elsewhere in the body.
- The **perilymph** in the scala tympani has a low potassium concentration.
- The cilia themselves have an electronegative potential of minus 70 mV.

Keep in mind that the perilymph actually percolates into the canal of Nuel that is in the Tunnel of Corti by small pores in the basilar membrane and also into the intracellular area surrounding the OHCs. It is protected from mixing with the endolymphatic fluid by the reticular lamina covering the OHC area and with a tight junction system. The supporting cells assist to circulate the potassium ions extruded from the hair cells to get them to the stria vascularis.

I believe that the 'pumping' activity of the OHC actually helps the circulation of this perilymph in constant restoration of the ionic differences as I will be describing further on.

When the tip of the cilia are free of the gelatinous layer of the TM, they are able to vibrate or really move like a stick hinged onto the surface of the hair cell. More a waving action than a vibration I guess. This movement causes a response (whether by quantum relationships or protein machine triggering, or tethering strings from the adjoining cilia is neither here nor there) opening up pores which allows the ionic transfer of potassium into the cell from the endolymph leading to depolarisation and a receptor potential. The latter opens calcium channels and these trigger the release of neurotransmitters which diffuse across the space between hair cell and the nerve terminal. The positive ions diffuse into the perilymph which has a low concentration of positive ions. I have given an idea of the steps involved only to show that there are a number of means available to alter responsiveness. For instance, the calcium influx plays an important role in allowing humans to ignore constant sounds that are no longer new whilst allowing other acute sounds to be heard.

BASIS of DEPOLARISATION of HAIR CELLS



The diagram above is to illustrate simply, step-by-step, how the IHCs depolarise and how the OHCs influence their depolarisation. The OHC is different in that it has contractile elements and I expect does not require stepwise depolarising system seeking to quickly modify the action of the IHCs.

The IHC depolarisation can be affected/modified by influences on the potassium ion of the calcium influx or the end transmitter across the cell cellular/neural junction with the afferent fibre. This CNS afferent nerve fibre carrying the sound message to the CNS itself can be influenced by if current CNS messages and efferent fibres are from the OHCs.

All these actions occur in nano science/quantum mechanics conditions. That is, requiring only a nano movement in the cilia and restored again in nano seconds; in a scientific manner/mode discovered and proven by modern science as I have already discussed. Therefore, there can be no argument about whether the cilia are capable of being responsible for the specific reception of frequency.

Based on classical physics and not anticipating such a possibility is probably the reason why the physicists have shied away from accepting my theory outright from the beginning. No one attempted to look at the cochlea with that in mind but instead sought solution in complex ways. Intensity would be a factor of the strength of this vibration as well as the modification by the activity of the OHCs which are described below and the factors mentioned in Cochlear Hydraulics (p. 12).

The ‘Tuning’ of The Hair Cells – an Important Concept

As I had reasoned that the specific tuning of the hair cells rested in the size of it’s cilia in 1971, I purposefully went into sufficient detail here in order to introduce the limitless expanse of possibilities in the physics, chemistry, biology applicable to previous puzzling activities in our scientific ambit.

It is possible, in my mind most probable, that the specific tuning of each hair cell (at least the IHC) is embedded in the DNA and ‘entanglements’ or nano structure of the cellular proteins and ‘soul’.

We can discriminate 10 or many more pitches per semitone. With 3000 or more IHCs this can be accommodated. Some people have a great skill at appreciating different frequencies whereas some are tone deaf. Have they not inherited the same degree of specificity? No problem with hearing speech but can’t sing. Never really thought about it ... leave it to you.

How can one cell be determined to produce insulin and another to carry oxygen? Why could not the tuning of the cochlear xylophone be of basic genetic essence? Try and disprove that!

The length of the cilia may not be related to appreciation of specific frequency, but more to the increasing distance from the origin of the stapes footplate, the movement of the wave as it falls off toward the low tones and/or other architectural factors. Professor Wright examined the length of hair cells under the scanning electron microscope* and found some irregular sizes and irregular organisation ... ‘extra inner hair cells, missing outer hair cells and, in places, no strict demarcation between ranks of first, second and third row outer hair cell stereocilia at any one point in the cochlea’. These factors may not be important if the whole mechanism existed in the cell itself.

Another interesting comment was ‘The stereocilia stand in a fluid medium which will exert a damping effect on their resonance. This damping, however, whilst considerably altering the amplitude of their vibration causes only a very small alteration in the frequency of the vibration.’ Well? The cell is tuned only to that frequency.

So, my theory will be modified to include these factors, as it still conforms to my original proposals as the modern science was not known at that time and ignored as yet elsewhere except in the Treatise.

So I claim that the theory of 1971 and 1973 is not only absolutely possible but it is almost certainly the only way that the specificity of accurate reception is obtained. What the various neuronal circuits do in informing the brain and the intricate reflexes and variety of manifestation and meaning is entirely another issue not concerning this basic one dealing with reception of sound in the cochlea.

The 'Modifier of Cochlear Sensitivity' – A Duplex Action

Before proceeding to the action of OHCs, one must keep in mind other factors modifying reception of intensity of sound input. This would include the more basic effect of the cochlear hydraulic factors introduced on page 12 and which must affect the OHCs, which are also 'doing their own thing'. Furthermore, Andrew Bell (AB, p. 8) describes the **intratympanic muscles** prolonged contraction in response to loud noise. This can reduce the middle ear contribution of 30 dB to the intensity of the sound.

The cochlea is a precise frequency analyser, effectively discriminating closely related tones. The appreciation of sound occurs within tens of microseconds.

An amazing thing is that the ear through the activity of the membranes and the hair cells in the cochlea not only detects but they can also amplify the softer sounds so that an extraordinary wide intensity range is covered. At threshold, the ear detects signals with intensities less than one billion that of atmospheric pressure.

In recent times the idea of a '**Cochlear Amplifier**' has been widely held on the basis of observations on microanatomy of the OHC and such ability to effect the hearing of soft sounds. But consider my following discussion.

1. It appeared to me from 1971 that the basilar membrane is there only to move the organ of Corti back and forth so that the cilia can be stimulated one way or another. I have explained how the near-field force initiated by the stapes footplate strikes the BM and a wave can follow.
2. The strong claim in the 1971 was that I could not accept a Fourier analysis as having any direct use for frequency reception. Such process would possess so many problems of its own; the anathema of build up of vibrations and again on the decay of vibrations. In particular, try and explain how this can fit in with the occurrence of very short bursts of sound of different frequencies with different harmonics and relationships ... and simultaneously. Already I discussed the differing speeds of sound waves striking the hair cells and the very slow speed of the 'travelling' wave, in comparison. This matter was pointed out by researchers before but they seem to have just shrugged their shoulders whilst they scratched their heads!
3. In any case, Bekesy himself, most likely after reading my 1971 article, wrote that he was having second thoughts and then died in 1972 (footnote p55). His article was published posthumously in 1974 and no one commented on it, or else they failed to see it, but kept working on it for some years later before quietly dropping the subject. Just because I couldn't borrow Einstein's spaceship.
4. With **air conducted** sound, the tips of the IHCs **have** to move away from the mucus-like surface of the TM, in order to allow freedom for the movement of the cilia in a tilting fashion hinged at the top of the hair cell. They don't wave around like whips, but the tips need to be free to allow them to move. If they were flexible hairs, able to move freely along the length of the cilium, tip anchoring would still allow some wiggling if not quite free of the TM. That is why the TM works well. It does not have to envelope the cilium deeply.
5. The hair cells and cilia would benefit from systems protecting them from excess noise. The hair cells are in constant use; they are not ever really turned off. So there is a high metabolic need for the provision of oxygen, nutrients and ions to the cells and surrounding environment and the removal of waste products.
6. These latter functions are augmented by the OHCs as follows:
If the air conducted sound is very weak, there may not be sufficient force at the stapes footplate to move the BM to a degree enough to free the tips of the IHC cilia from the TM to allow them to vibrate.

The **OHC** are said to react to weak sound waves and, via the contracting and expanding action as described by various researchers, to cause movement of the BM which frees the tips of the IHC cilia to enable very soft sounds to be heard. In animals that don't require to hear very soft sounds, there is no elaborate middle ear apparatus; only mammals have OHCs.

I suggest that the movement of the **OHC** can only cause a limited movement of the BM. After all they are not strong enough to move a brick! ... we are talking of nano movements ... and in any case they are not attached to a solid point to pull themselves 'up'. Their action is like standing in a bucket and trying to lift yourself off the ground! They can only pull together the upper layer ('cuticular surface') and the bottom layer sitting on the BM, really compressing the content in between; but at least causing a movement.

The reduction in size of the OHC and pressure on the (perilymph) fluid surrounding them would squeeze some to escape back into the general perilymph (e.g. via the space of Nuel) thus setting off a sudden movement.

At the same time, the efferent nerves from OHC to the IHC can effect a sensitising or stimulative effect on the IHC's energy status so also modifying its response; (or it may be reducing any OHC inhibiting activity). ... note a few paragraphs down re central inhibition.

All this adds to the better sensitivity of the IHC for very soft air conducted sounds, thus earning the title of 'cochlear amplification'.

On the other hand, if the noise is intense, the weaker OHC movement cannot match the relative strength of the movement of the BM but, by the contraction of the OHC, a 'stiffening' of the basilar membrane occurs reducing its deflections. That is, when the BM is not moving (or hardly so), the resulting responses of the OHC is enough to cause a movement. But when the BM is already moving, the stiffening effect on the BM by the OHC contractions become inhibitive. Thus preventing excessive movement adding to other factors to protect the IHC. Concurrently this pumping action helps the circulation of nutrients and waste products between the cells in the BM and the stria vascularis.

Again, perhaps at the same time, the efferent signals from the OHCs to the IHCs may influence the excitability of the hair cell in a protective way.

Namely, the presence or absence or modification of the signal by a neural message from the OHC may make the IHC more sensitive to stimulation or less sensitive to stimulation. (I guess by opening or closing ionic channels, or by some direct effect akin to 'depolarisation' so to speak. I don't mean that it actually depolarises the cell but may cause a change either to 'encourage' or 'inhibit' full depolarisation or ion movements.) As described before, there is more than one step in the depolarisation mechanism in the IHC. Such effects can be also explained by Quantum mechanics.

This inhibition to intensity response is not absolutely clear in that the Medial Olivary Complex in the brain sends inhibitory fibres to the synapses of its afferent nerves at the IHC.

The Lateral Olivary complex sends its inhibitory messages by direct contact with the OHC observed with reduction of BM movement.

Having said all the above, I would think that there is activity over this pathway continuously with complex effects as yet not clarified.

Though I have been talking about the total cochlear 'xylophone', I could imagine that the effects of the Cochlear Modifier are more constant with respect to its 'amplifier' action in the apical (low tone area) of the cochlear, as the BM wave loses power.

It may occur at different areas at different times; it probably does and is acting at all times to variable degree. I don't know if this has been mooted in the literature.

Thus, the OHCs are modifiers of cochlear sensitivity, a dual action consistent with a Duplex Theory!

7. The squish-squash OHC movements may well play a part in circulating the fluid (perilymph) that surrounds them, like a pump causing it to run up and down between the cell bodies and in and out of 'escape routes'. There are pores in the BM linking the perilymph of the scala tympani and the pericellular fluid of the OHCs and in the space of Nuel between the arches of the Organ of Corti. It thus ensures circulation of this fluid directly onto the cell surfaces so that there is a constant exchange of nutrients, ions, waste and oxygen and so on via the stria vascularis. After all these hair cells are working all the time unless one is in very quiet environment or asleep, and even then are on alert for any noise ... the ticking of a clock, someone snoring, the fall of rain, a passing car, the clicks and knocks of ghosts in the house!

The stria vascularis has marginal cells highly active in convoluted mitochondrial packed folia rich in sodium and potassium ions and ATP'ase. Guess what they do. Descriptions of details of pathways and many methods involved in recycling the ions (particularly potassium and electric potential) abound in the literature but not essential for our understanding here.

This mechanism avoids the use of pulsating sounds or other disturbing effects in having larger blood vessels running through the cochlear duct itself.

8. The modification involves **only air conducted sound**. With bone conduction, the sound travels to the cilia via the TM whose hard elastic structure is ideal for transmitting sound waves. The cilia tips in contact with and to some extent restrained in the mucus-like surface of the TM are stimulated directly. Any significant air conducted sound would reduce the intensity of bone conducted sound by withdrawing the cilia from the TM when the BM moves. This has a role to play in explaining the Rinne and Weber tests.

I feel then that this type of duplicity of the OHC function is a brilliant one for a thriving healthy and normal cochlea.

I have not seen any theory published so far to throw light on all these enigmatic factors. My new analysis of the recent phenomena are adding strong support to my Duplex Theory of 50 years ago.

6. Summary

We have discussed the following facets.

1. The quantum theory was discussed with a personal concept that the universe is like a giant body and the galaxy, the planets, the moon, the stars and any of the contents of these structures are all different parts of its body ... and so are we.

The principle of trying to maintain a dynamic equilibrium from the smallest environment and each of their components at **all levels** – from quarks to animal bodies, the planets and galaxies. If the entanglements are not sufficient to effect equilibrium, a path may become permanently injured/damaged or die/disappear which then just results in a different mix in the entanglement chain.

The forces themselves are not understood, but that such immediate effects must also exist in hair cells and supports the Duplex Theory of Hearing

2. Multiple nano-size protein engines and their functions.
Again, the organisation and nano timing of reactions and restitution accounts for the rapidity and accuracy of the hair cells in response to movement of the cilia.
3. The hair cells are individually tuned to a frequency from development; this is embedded in the protein engines and quantum forces.
4. We have looked at nano tubes only to indicate a similar process in the electromagnetic wave reception with a nano structure resembling the cilia of the hair cells in the cochlea.
5. We have looked at the production of energy with mitochondria being the essential elements maintaining life. They produce energy from food and continuously recharge the electrons of the protein engines immediately.
6. The principle of 'dynamic equilibrium' at all levels has been emphasised. Matter and energy is not lost; it is a matter of **metamorphosis**.

7. We have discussed a microscopic anatomy of the cochlea which has been the source of intense research since I published the Duplex Theory of Hearing. This led to a discussion and a statement of the process that has been called 'cochlear amplification' which I have called the '**Cochlear Intensity Modifier**' which has a role in both amplifying the hearing for very soft sounds and in dampening the hearing to protect the cochlea in very loud sound intensities.
8. The different functions between the IHC and the OHC have been examined

Overall, the application of modern science indicates that the Styli Duplex Theory of Hearing is quite feasible and is not matched or threatened by any other in its entirety. One must note it has a '**Duplex**' character in many facets ... a **dual** character e.g. Features of both a Resonance Theory as well as a Place theory as outlined in 1973; two forces entering the cochlea; cochlear modification by OHC action both for amplification and for dampening; dynamic equilibrium.

The Past 50 Years

Over the past 50 years the physicists have shown great ingenuity and detailed research into the question of the Cochlea, in particular to identify tuned elements responsible for identifying in frequency and intensity. I suspect that they could not believe that all the processes involved in depolarisation and subsequent restoration could occur in such nano-size movements and nano time frames. I can understand that. Perhaps the reputation and hard work on many animal species by von Bekesy with a strong extended acceptance of the theory of Fourier analysis and the absence of modern investigative method stilted objection. *My theory was the first to raise a serious doubt about its veracity.*

There has been a struggle to explain the following phenomena.

- a. The discrepancy between the speed of the Bekesy travelling wave in comparison with the extremely faster speed of the sound wave (Naftalin in 1964).
- b. The anathema with respect to the time involved in the build-up of vibrations and again in the decay of vibrations with respect to the speed of reception.
- c. The specificity and clarity of frequency reception.
- d. The clarity of a microsecond click.
- e. No one seems to have recognised the presence of two type of forces produced by a vibrating source. This formed a basic element in my Duplex theory and which have a great influence on what occurs in the cochlea.
- f. No one really challenged what I had written, except for the early objection by Dr Marples on Warwick University (reprinted with my response in the Appendix), and all such objections have been quietly dropped in the ensuing years.

Another relevant consideration which has really cemented my original presentation:

Prof Anthony Wright, my mentor over the last forty years, informs me that in recent times, research on single afferent nerve fibres from specific inner hair cells has shown that each cell responds 'best' to a specific frequency. That is there is critical frequency (cf) at which that cells respond to a very low sound level and not to adjacent frequencies.

However, the cochlear 'keyboard' caters for a spread of some 10 to 15 'notes' for each semitone; The ear has no labelling of Doh Ray Mee! The cilia have a much more sensitivity than the crack on a piano, so the Doh Rah Mee is our brain's interpretation of the highly specific number of frequencies (as picked up by the specifically tuned hair cells) that are actually presented, perhaps affected by intensity, damaged areas, etc.; and we have labelled what we hear.

7. The Styli Duplex Theory of Hearing – Update 2019

1. Two wave motions are produced by the stapes footplate (never considered before this theory in 1971).
 - (a) *True sound waves.* (the 'far-field' effect – a molecular oscillation)
 - (b) Gross pressure waves (a 'near-field effect').
2. The cilia of the IHCs are not fixed to the TM.
3. The hair cells and its cilia act as specifically tuned resonators to receive the frequency of the true sound waves.
4. The IHCs are formed with capacity to respond to a specific frequency as an inbuilt characteristic by the provision of the necessary nano structures and protein engines specific for each cell along the acoustic xylophone. The IHCs and the OHCs have different structures and different functions.
5. Two factors are necessary for the transduction of sound vibrations to electrical energy.
 - In air conduction, the tips of the cilia must be withdrawn from the confines of the surface of the TM by movement of the BM.
 - The cilium must move (for nano seconds and to a nano degree) in the environment of endolymph to experience ionic exchange.
6. The function of the TM is to hold the cilia still in the absence of air conduction; it also acts as a soft surface for the apposition of the tips of the cilia which could be damaged by repeatedly striking a bare surface. It acts as a dampener rapidly suspending a movement of the cilium, after the nano fast depolarisation, so allowing depolarisation for the next tonal stimulus if applicable.
7. Releasing the cilia from custody of the TM does not cause depolarisation. It just frees the cilia so those that are tuned to a frequency can react if that specific frequency is present.
8. The BM is influenced by important actions of the cochlear hydraulics and at the instigation of the associated OHCs in the modifier of cochlear sensitivity mechanism.

9. The contractibility of the OHCs assist in the circulation of the cochlear fluids in order to maintain the metabolism and activity of all the cells in the cochlear duct by the function of the stria vascularis.
10. Loudness is a complex function of the following factors (all basically dependent on intensity of the sound reaching the cochlea)
 - Amplitude of movement of the cilia and any inherent 'settings'.
 - The actions of the modifier of cochlear sensitivity.
 - Inhibitory nerve impulses from the OHC to the IHC.
 - Inhibitory CNS efferent nerve impulses.
11. Depolarisation involving ionic exchange of potassium ions and calcium ions as described.
12. All reactions occurring at nano levels and at nano speeds with nano speed restoration of the dynamic equilibrium.

8. Final Statement

By explaining the amazing nature of modern physics, I have indicated that what I claimed 50 years is not only quite possible but most likely. Sympathetic resonance is a principle behind everything from quarks to quasars.

At the time, the amazing modern advancement of science was not available to us, but common sense, gut feeling and the process of exclusion of other possibilities gave me confidence to express my views. I am now very confident that I was correct and cannot see how such accuracy in frequency reception can otherwise occur.

The absolute details, step by step, are not critical to accepting the overall principle.

Furthermore, effects outside of the cochlear duct are a separate issue. Delayed effects such as gangliopathy and other disorders affecting the multiple and complex sensorineural connections from cochlea to brain and their psycho acoustic details are again a separate matter.

In this Treatise we have been concerned only of the question of what are the tuned elements of receiving frequencies and intensities in the cochlea.

Who knows what each of us are hearing? Are we hearing **exactly** the same thing? Obviously not! Why are some people so brilliant in musical matters? How can some people identify the exact note on the keyboard just by hearing it? Why are some people 'tone deaf?' why is it that many people can't sing? We all have our own interpretation with the sounds that we hear as if learning a different language. After all, different language sounds are interpreted in each country and tribe to mean the same thing. People with cochlear implants learn to understand the meaning of sounds they hear by developing their own language and using their other senses.

Nevertheless, all these things begin with the identification of frequencies, intensities, modulations, suppression of background noise and so on. That is why it is important to understand how the cochlea works and how science sheds light on the nub of the receptor mechanism.

Many questions remain to be clarified though I have given you enough to think about and to use as a basis in assessing propositions put to you about hearing.

It would be remiss of me not to emphasise the support of the Editors of the JLO who, with an open mind and perspicacity, changed the direction of research by having the confidence to publish my papers 50 years ago. This support again may direct the research to the cilia themselves and thus once again advance our knowledge. They should share the honour.

It remains in your hands to make up your own mind as I soon will be subject to a rearranged part of quantum physics.

Stan Stylis FRCS.

9. Appendix

THE UNIVERSE

GALAXIES; EARTH; ELEMENTS; BLACK HOLES; QUANTUM SPOOKY ACTION

Where do our hair cells, our bodies and molecules fit in?

If you really want to know how the Quantum Theory fits in, this discussion is not only valuable for understanding what I have already written in the body of the treatise but it should be of great interest to many of us who have been too busy to keep up. It is what I understand of it all.

I intend to cover briefly, but in an overall fashion, the question of the universe, the galaxies, the chemical elements that exist and to round off my concept of quantum theory by including Black Holes.

The Universe is *all of space and time and their contents*, including planets, stars, galaxies, and all other forms of matter and energy. No one knows the exact size of the Universe, because we cannot see the edge – if there is one. All we do know is that the visible Universe is at least 93 billion light years across. (One light year is the distance light travels in one year – about 9 trillion km.) Galaxies began at the Big Bang 14 billion years ago. Space is expanding at 72 km/s.

From here it helps if we start with a description of a *galaxy*. It is simply a huge collection of gas and dust and billions of stars and their solar systems, occurring at once, all held together by gravity. There are thought to be as many as 100 billion galaxies in the universe, of differing age. If there are many galaxies close to one another (in cosmic terms) they are called super clusters ... largest known structures in the universe. Our galaxy, the *Milky Way Galaxy* is part of the local group *L&G Galaxy Group* which contains more than 54 galaxies and which in turn is part of the *Laniakea super cluster LS*. The local group is part of the election called the Local Group Galaxy. The observable universe is estimated to contain 200 billion to 2 trillion galaxies.

Our galaxy is classified as a spiral galaxy, with relatively loosely wound arms. Hundreds of billions of stars in our galaxy are arranged in a flattened disc (like a coin) with a central bulge. It stretches about 100,000 light years⁴ from one ill-defined edge to the other. Our galaxy contains globular star clusters each of which consists of roughly a million stars.

Our sun is about one third of the way from the edge of this thin disc. At the very centre of our galaxy there is a 'Super Massive Black Hole' about 4 million times the mass of our sun, but housed within a region not larger than our own solar system. It is about 27,000 light years away from the planet Earth.

⁴A light year is the distance that light travels through a vacuum in one year, that is, 10 trillion kilometres (6 trillion miles).

Our sun is a star about 150 million kilometres from earth. (This is used as the size of one Astronomical Unit – AU.) Stars consist of a luminous spheroid of plasma held together by its own gravity. They shine due to thermonuclear fusion of hydrogen into helium in its core which releases energy that traverses the stars interior then radiates out into space. This plasma makes up 90 per cent of the sun.

Stars are formed from massive clouds of dust and gas (a nebula) coming together and atoms of light elements squeezed by the force of gravity depressing the atoms until the fusion reactions begin, the lifetime of a star depends very much on its size. Also if a star explodes (such as a supernova) it also results in a nebula which exists in the space between the stars and are known as ‘*interstellar space*’. Our sun is a perfectly ordinary star, we presume that all stars have planets and it is difficult to ‘see’ outside our own Milky Way galaxy because of limited technology. In 2013, astronomers have reported that there could be as many as 40 billion earth size planets orbiting in the habitable zones of the sun – like stars and red dwarfs within the Milky Way Galaxy. Eleven billion of these estimated planets maybe orbiting sun-like stars. It is estimated that there are at least two *rogue planets* for every star in the galaxy (2017) which just move around the galaxy themselves without rotating around. They even have moons rotating about them and retain heat and retain a hydrogen-dominated atmosphere. Though they are not associated with stars, they are incredibly difficult to find because they don’t reflect any starlight.

Our sun has a mass of 330 000 times the mass of earth and forms 99.86 per cent of all the mass in our solar system. It is one of about 400 billion stars in our Milky Way galaxy. Other solar systems can have more than one sun.

The earth is estimated to be 4.5 billion years old. The earliest undisputed evidence of life on earth dates from at least 3.5 billion years ago, the fossils of anatomically modern humans are from the Middle Palaeolithic, about 200 hundred thousand years ago, though human-like life appeared on earth about 66 million years ago.

Outside our own particular solar system but *within our galaxy*, there are 4000 known planets (*exoplanets*). It is also estimated that there could be as many as 40 billion earth size planets in habitable zones of sun-like stars and red dwarfs in the Milky Way, 11 billion of which may be orbiting sun-like stars (a red dwarf is a sun that is on the way out and becomes very red in colour). The nearest such exo planet maybe as close as 12 light years away from earth. Proxima Centauri is the closest star to Earth (not counting the sun) and is 38 million, million km (4.2 light years away). The nearest to earth size planet in a habitable zone (Kepler) is about 1400 light years away.

The planets are kept in their orbit by gravity. Centrifugal force would tend to force the planets away but gravity keeps them in check. The speed at which the moon is moving away from earth, could affect life on the planet but this could take billions of years to happen. It is thought that the moon was formed when a proto planet (Theia), about the size of Mars, collided with the earth about 4.5 billion years ago and the residual debris coalesced to form the moon. The moon is kept in orbit by the gravitational force on earth but in itself exerts a gravitational force on our planet causing the tidal bulges (rise in tides). Because the tidal bulge is affected by the spinning of the earth, which tends to drag ahead of the sluggishly orbiting moon and keeps pushing it into a higher orbit and this accounts for a move of 3.8 cm (1.5 inches) per year away from its current orbit around the earth. So the effect is that the earth rotation slows down. The earth is tilted towards the sun at an angle of 23.5° on its axis which results in the sequence of the seasons by virtue of this tilt.

Now having described all that, we can understand what is happening in each galaxy. We can understand that new galaxies are being formed and there are all ages of galaxies. Nevertheless, they all arise in the same manner from the same ‘mother’ if you wish. I liken them to children, siblings, all composed of the same particles, energies of different sorts and electromagnetic forces and therefore likely to go through the same history as we have uncovered on Earth. The same formation of planet and development of living beings as the elements come together. So now we can discuss these matters having the concept of the whole universe and its ongoing progress in mind.

Within the sun, hydrogen atoms are fused together to produce helium. In a process known as the proton-cycle (PP), the amount of energy released during the fusion reaction can be precisely quantified. Four hydrogen nuclei (protons) and two electrons form a helium nucleus, two neutrinos, and six photons. This fusion is the process that powers the sun (and stars in general) inverting some of the hydrogen mass through an inexhaustible source of energy.

The hydrogen is squeezed so tightly so that four hydrogen nuclear are combined to form one helium atom for the release of energy in the form of heat and light as the sun fuses 600 million metric tons of hydrogen every second. So, helium in the universe is created by the fusion of hydrogen nuclei either in the early universe (at the Big Bang) or in the stars. After converting the hydrogen to helium, the internal core collapses and heats up until it is hot enough to fuse helium into larger atoms. They can combine three helium atoms into carbon. At the same time some helium will fuse with that carbon to produce oxygen. Outside the core is what is called the envelope where there is still enough hydrogen to fuse into more helium.

In time, the core begins to fuse heavier nuclei and this eventually causes a *transition from a normal star into a red giant* when the sun will gradually cool. In the largest star, one process leads to another and the star collapses, heats up again and starts fusing carbon and oxygen; if massive enough, this keeps happening until some point arises where the hotter core cannot fuse any further and the star collapses and explodes forming a supernova or a neutron star or a stellar black hole (2019).

The helium and hydrogen forms an overall big percentage of the sun and other heavy elements are in smaller amounts. The total mass of the sun is such that only a relatively small fraction is used for nuclear reactions and it can live for about 10 billion years. The Sun consists (by mass) 70 per cent hydrogen, 29 per cent helium, 1.5 per cent carbon, nitrogen and oxygen and 0.5 per cent all other elements (iron, nickel and a few lighter elements).

Hydrogen is the most abundant element in the universe originating in the first few moments after the Big Bang. It is 10 times more abundant than helium. Oxygen is a thousand times less abundant in the universe than hydrogen. Hydrogen is the third most abundant element on the earth’s surface after oxygen and silicon.

Helium, the second most abundant element in the universe (25 per cent) is transformed into carbon in the sun. Carbon is the sixth most abundant element and iron the 10th in the universe.

Earth’s most abundant mineral is a highly dense form of magnesium iron silicate.

Almost 99 per cent of the human body is made of the six elements – oxygen, hydrogen, nitrogen, calcium, and phosphorus. Only about 0.85 per cent is composed of another five elements – potassium, sulphur, sodium, chlorine, and magnesium. All 11 are necessary for life.

Having described what is happening in our own galaxy, it is obvious then that all galaxies have been born from the same source. They are living a very simple analogy, and as mentioned above, we can regard this source as a mother having children. The galaxies are all of different ages and all made in the same way from the same source and the same energies, power and constituents and will be released in the same environment and cooling off to presumably go to the same places producing similar elements as I discussed with our own galaxy. They are all in various stages of development which we can apply to our own galaxy. It is just that all the parameters are of such enormous magnitude being those of time, of distance, and of energies.

Simple as my concept may be, it provides a new viewpoint which may in fact explain observations which may otherwise appear more mysterious than they are. And that is why I explained it in my chapter of Quantum Theory, which latter appears to apply to these astronomical considerations. I wrote these particular and more detailed sections in this Appendix to avoid interrupting the main thought and aim of my Treatise. Writing this section explains briefly what went through my mind.

By calling upon our reader’s knowledge of the human body and the Principle of ‘dynamic equilibrium’, perhaps interesting advances or possibilities may trigger new thoughts in the research of astronomers and physicists.

After all, I have seen statements such as the following in the literature.

Energy and matter in the universe is constant.

The ‘zero-energy universe hypothesis’ proposes that the total amount of energy in the universe is exactly zero; its amount of positive energy in the form of matter is exactly cancelled out by its negative energy in the form of gravity.

The ‘law of conservation of mass’ or ‘principle of mass conservation’ states that for any system closed to all transfers of matter and energy, the mass of the system must remain constant over time, as system’s mass cannot change, so quantity cannot be added nor removed. Hence, the quantity of mass is conserved over time.

We as medical practitioners understand the dynamic equilibrium of our body forces and situations. We have already discussed this in the Quantum Theory section (p. 11). Therefore, if we regard a *galaxy* as being a ‘human being’, then all its parts are related and conformed to the above two quotations. The principle of dynamic equilibrium (which is the simpler way of stating the above two quotations) applies at all levels and over the whole.

And this principle exists in every little part of every little part ... in my quote that 'big fleas have little fleas', all having their dynamic equilibrium. So the known physical forces we apply to our human physiology and which are understood in terms of our standard physics and chemistry, are one aspect in maintaining equilibrium; e.g. the connections of nerves and electrical type forces and of hormones and other means of communications exists.

However, there are connections and forces that exist which we don't understand. And these include the 'spooky connections' of Einstein, and all those referred to in the Quantum Theory of 'entanglement' and others.

When something changes, as for example a star implodes, there is a 'change' in the various gravitational and the forces which obviously have effects and reactions. Stars may join in associations or reach black holes for metamorphosis. Galaxies begin to die or coalesce, as Earth and Andromeda are doomed to do in about 3.75 billion years. The moon is moving away from Earth each year affecting tides and gravity, etc. We can't stop this. The Universe has its own equilibrium reactions and entanglements; so what is 'spooky' about that? This is reflected in 'everything' as in our own body.

So there is no reason to be confused, these relationships exist whether we know exactly how they work or not. Thus, we have to accept this line of thought rather than deny their presence. This supports the accepted validity of Quantum Theory.

I have thus expressed my vision of the relationship of Universe, Quantum theory and Nanoscience in order to support my personal opinion of cochlear hair cell function and nanosecond response (action and reaction) of the cilia to sound frequencies and their specific tuning capabilities. I had expressed this functional sense from basic instinct 50 years ago, but further scientific advances now provide strong unifying evidence to help convince reluctant physicists.

For completion I make this note about 'Dark Matter' which 'fills up the void' between matter.

Dark matter is called dark because it *does not appear to interact with observable electromagnetic radiation*, such as light, and is thus invisible to the entire electromagnetic spectrum, making it extremely difficult to detect using usual astronomical equipment.

The density of dark energy is very low ($\sim 7 \times 10^{-30}$ g/cm³) much less than the density of ordinary matter or dark matter within galaxies. However, it dominates the mass-energy of the universe because it is uniform across space (fills all the spaces between everything else).

In a way it could be considered like connective tissue in our body.

The galaxies are siblings. New ones can arise either from the original source or from causes secondary to these initial galaxies.

Thus, we see that all atoms and molecules can exist on earth and in the universe and its planets and contents, have arisen from incredible strength of power, temperatures, pressures and gravity released by the Big Bang. From this the atoms and hadrons have been structured. If the forces can compel such particles to be so dense that an item the size of a marble cannot be lifted because of its weight, then one can imagine anything; any substance with any size nucleus and electrons can result. Who knows what happens in the evolutionary process from then on?

Using the earth as an example, what forms of life can exist using elements and environments made of different atoms and different energy forms than we have on earth? What form can this life take? Who knows? However, it is reasonable to suppose, in the billions and billions of planets, the chances of reformation of atoms and elements as we have on earth must be replicated in many planets. They will undergo the type of evolution that has happened here on earth, where life appeared 3.5 billion years ago and human life perhaps 66 million years ago and homo sapiens (anatomically modern humans) about 200,000 years ago.

Can't we believe that in the 200 billion to perhaps 2 trillion galaxies occupying space, that we can doubt the existence of life? It is estimated that even in our Milky Way Galaxy there could be 11 billion planets orbiting in the habitable zones around sun-like stars. A matter of 40 billion earth size planets orbiting such stars and red dwarf stars within our Milky Way Galaxy. The mind boggles.

Black Holes

With no big stretch of the imagination taking it further, there is a need within that galaxy to have some means of dealing of debris in space; or of matter that is losing its energy and thus moving away from any gravitational 'pull' and any other body with which it has been associated.

All galaxies have a 'super massive black hole' at their centre.

A mass, losing energy due to age or other reason, may well be attracted by the energy from a Black Hole drawing it into its ambit. It is then remodified or perhaps recharged by merging with other particles or mass within the black hole, then to return in a different form.

Keep in mind –

Energy and matter in the universe is constant.

The 'zero-energy universe hypothesis' proposes that the total amount of energy in the universe is exactly zero. Its amount of positive energy in the form of matter is exactly cancelled out by its negative energy in the form of gravity.

The 'law of conservation of mass' or 'principle of mass conservation' states that for any system closed to all transfers of matter and energy, the mass of the system must remain constant over time, as system's mass cannot change, so quantity cannot be added nor removed. Hence, the quantity of mass is conserved over time.

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Personal Farewell



Mr. Stanley C. Stylis

MB, BS, (HONS), BSc (Med) (HONS), FRCS (ENG), DLO (RCP & S)

P.O BOX 5145, MARRICKVILLE 1475, Sydney, NSW, AUSTRALIA

Born in Sydney on the 10th of May 1932 of Cypriot parents in mid great depression before antibacterial agents. Education: Crown St. Public School; Sydney High School; Sydney Uni and Sydney Hospital, first built in Australia in the developing English colony. Then as GP for 12 years (proper doctors then not bitser specialists) delivered 500 babies; minor surgery Ts & As; appendicectomy; hernias etc. whole families grew up with us.

Went to the UK in 1969 to obtain FRCS in ENT. Returned as Chairman ENT Illawarra Hospital Group; owner/director of private hospitals.

As my time is limited by cardiac amyloidosis recognised as a wild cardiac form only in the last 2 years, I am now past my use-by date, and the JLO has allowed me to list personalities who have supported my thoughts on many subjects. Also it offers an opportunity to apologise to my family in Australia, Cyprus, UK and USA whom I have neglected with respect to time with them due to the demands of our profession. I have listed the professionals and others who have supported me in ineffable manner. My sense of humour and contempt at following unreasonable rules precluded accepting public honours or positions.

Private Acknowledgements. (+ indicates deceased) – probably unaware of their lasting influence.

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- Ben Chifley+, Australian Prime Minister who introduced three University bursaries for Medicine 1948. This enabled me to attend Uni.
- Jacques Miller, who discovered the immunological function of the thymus, whilst I shared time doing my own project in BSc research.
- Joffre Cowle+ Ophthalmology; I regard him as a genius for his widespread inventions, ex Prof Pharmacology and dozens of publications.
- Albert Khan+ FRCS, ENT consultant Wollongong Hospital; prime consultant of Aust. Hearing who taught me early ENT surgery.
- Paul Wadsworth+ FRCS, my boss at the stand alone Sussex ENT Hospital who answered my numerous questions tirelessly.
- Henry Shaw+ FRCS of the Royal Marsden Hospital who befriended my wife and I, taught me head and neck surgery; co-wrote a paper.
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- Professor Dix Ward+ ENT and physicist who knew Bekesy and visited me in Australia to discuss hearing. and wrote regularly till he died.
- Professor Joseph Sataloff MD, DSc of Pennsylvania, read my early papers and invited me over to speak and dine. (I never made it).
- My fellow founder executives of Aust College of ENT Physicians (Dr J Scoppa and Dr B Williams) with the cooperation of ASOHNS. We lectured on non-surgical ENT disease and advised government on such matters and on workers compensation and wrote the WorkCover guidelines. We served as approved officers in resolving disputes and upgrading the laws. Close personal friends with whom I socialised and whose skills were vital in maintaining the standard and reputation of my clinical practice; Dr Louis Klein with deep family relationship and my unequalled 20 years long Anaesthetist; Joe Ross; Professor Paul Fagan; Dr J Vaughan and Elizabeth; Dr R Kirk, the Cypriot Brotherhood; Greek Orthodox Clergy; I was treasurer building the first Church in Wollongong.
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- My senior audiologists, Susan Helfand Dubb, earlier a lecturer at Witwatersland University in South Africa, patiently carried out unusual audiometric testing at my request in order for me to test the various aspects of my thoughts on the cochlea. I constantly posed unexpected ideas on hearing, in order to evoke responses from the point of view of the audiologists and their understanding.
- The most prominent man in public life with respect to radio and television comment, having achieved an unprecedented 264 top awards, and having politicians and activists constantly on the hop, was Alan Jones OA, recently retired, with an open mind and a fearless honesty influencing government and citizens alike. He has assisted in introducing me to various parties involving medical matters, e.g. flaws in industrial deafness laws, public hospital defects etc. My Treatise and respect will please him for his confidence and trust.
- Dr George Miller left medicine to become a world famous movie director introducing me to this industry as a director of the company after raising funds from our colleagues when he began with the series of Mad Max films then to many other successes. A great man.
- Mr Peter Erman, a solicitor and friend, always listened to my opinion regarding key medical emphasis in court cases; we often responded about the result of cases in humorous poetic rhyme. He encouraged my art and suffered my pranks. A pleasant relief.
- I have also been blessed by loyal staff, in all my years (up to 22 staff in my clinic), particularly those in Wollongong who still regularly check on me despite me ceasing work in Wollongong 30 years ago. They meet regularly like family.
- My five god-daughters, all of a different religion (unintended), who have recommended me to St. Peter at the Pearly Gates.
- Finally, since my wonderful wife passed away, my clever son Andrew, born and educated in the UK at Millfield and then Cardiff University, has been my saviour, maintaining my feeble strength during the final completion of this Treatise.

I could not have survived without my own genetic relatives and friends giving all their uninterrupted support, but it is not possible to list them all, especially in any order. They are well identified in any case. The personnel listed above stand aside and this occasion offers an opportunity for them or their relatives to accept my acknowledgement. I bid them all farewell and share with them my legacy.

Stan Stylis