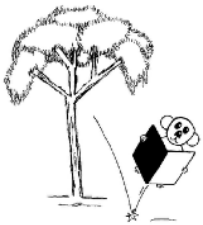
# Conversations for a Small Planet

## Volume 3:
## Biological Consequences of Low-Frequency Sound

Bruce Rapley PhD



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# Biological Consequences of Low-Frequency Sound.

*B. Rapley. PhD*

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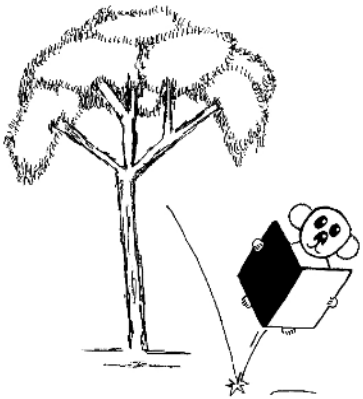


*Alicia Craig*

# *For Uncle Philip*

*This book is dedicated to Uncle Philip for his endless love and support which has made the creation of this narrative possible. His advice along the way has been invaluable.*

*Without his continuing support and encouragement, the research to create this work would have been almost impossible to complete. That he has subsequently spent countless hours correcting my prose is an indication of his dedication to education and a magnificent contribution to helping the many people who suffer from industrial noise pollution.*

*Thank you so much...*

# Acknowledgements

This book could not have been completed without the serious investment of time and energy from a number of colleagues and friends who read countless versions of the manuscript in order to arrive at a finished version.

In particular, two of my scientific colleagues were invaluable in providing a rich critique of the basic tenets, including the fine detail, of the manuscript including: Professor P.J. Dickinson (retired) and Dr. J.V. Podd (retired). Dr. A. Vieregg (retired) kindly stepped up to proof the 'final' draft of the manuscript for the purpose of translation. He found a plethora of minor errors, including French and Latin words and quotations that the other proofers had missed, for which I am truly grateful.

In addition, Mr. N. Jennings provided much editorial comment on the grammar and syntax as well as a good deal of moral support along the way.

My current colleagues, Misss. R. Summers, Dr. H. Bakker, Prof. Dr. M. Alves-Pereira, Dr. R. Thorne were generous with their support and timely comments. Further guidance and support was provided from a legal perspective by Ms. S. Grey and Mr. L. Hill for which I am eternally grateful. I could not forget my long-time friend, Ian B, who was always ready to step up and assist me with any request, and did so. Thank you so much for being there. Then there is Ann T, Bill M, Edele P, Chris, Colin W, David McB, Garth A, Gary R, Greg S, Greta J, Jason C, John D, John G, John R, Liam C, Lee M, Lilli G, Matthew V, Steve B, Terry S, Willy C. One can never underestimate the power of friendship. Thank you all for being my friend and having faith in me.

Of course I must also thank the many people suffering the adverse effects of industrial noise pollution for whom this work was created. I pray that this work will change the tide of greed and neglect.

Finally, I could not have completed this odyssey without the constant love and support of my dear partner, Rachel. She worked tirelessly to 'keep the home fires burning' while I spent thousands of hours sequestered in my office typing late into the night. I love you so much.

# Foreword

The purpose of writing this book is quite simple: To provide you, the reader, with a scientific understanding of how low-frequency sound and infrasound can and does affect biological organisms, including man.

Much of modern industry enlists the support of pseudo-scientists to try and dispel the facts with research that suits a particular agenda, as with the case of the wind industry in Australia and various pseudo-experts they use to promote bogus claims of nocebo effects. As an alternative, I want you to take a scientific journey of your own. I want you to look at the very interesting phenomenon of infrasound and low-frequency noise (ILFN), from the subtle sounds and gentle vibrations that nature provides, to sounds and vibrations that can stretch your nerves thin and drive you crazy, leaving you exhausted, as they attack your brain and bodily functions, adversely affecting your health.

This book is a dedication to the scientific journey that I and many others have been on for years to explore the truth about ILFN (hence the size and detail of this book). I have no doubt this enquiry will take us on further journeys over the coming years to fully understand the scientific mechanisms that cause these affects to manifest.

I ask you, the reader, as you journey through this book and take part in my conversations with you, to rely on your own judgement and take the initiative to make further inquiry for yourself. Do not rely on anything I say, check it out for yourself. This can then be the start of your adventure. An interesting journey awaits you. I am just providing the signposts. The mystery lies deep beneath…

Are you ready to take the plunge?

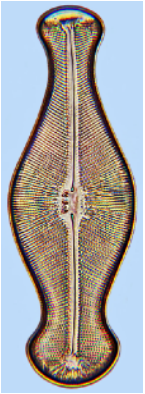
# About the Author

Bruce Rapley is a consulting scientist with a PhD. in Human Health and Cognition, an MPhil. in Technology and a BSc. in Biological Systems. He has worked in the secondary and tertiary education systems in New Zealand and is currently working for Atkinson & Rapley Consulting Ltd.

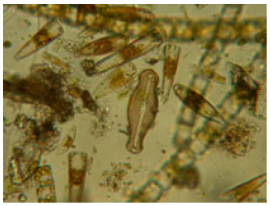
Bruce's primary research interest is in environmental factors that affect living systems. Much of his earlier research focussed on low-frequency magnetic fields and their effects on people and plants. Much of his pioneering research was conducted in this field which came to be known as ***bioelectromagnetics***.

Bruce's masters degree focussed on the design and testing of a magnetic biostimulator. He first tested the system on plants, focussing on mitosis or somatic cell division. He also tested the system on humans with Raynaud's Disease to investigate the effect of magnetic field treatment on peripheral circulation via nervous control of the arteriovenous anastomoses.

Bruce's PhD was conducted in collaboration with the New Zealand Military and the Defence Technology Agency investigating the effects of the acoustic environment of working soldiers relating to cognition and hearing. His thesis is indefinitely embargoed as a matter of national security.



Since 2005 Bruce has worked for Atkinson & Rapley Consulting Ltd. undertaking various research projects at local and national level. One major project concerned the effect of *Didymosphenia geminata*, a polluting diatom of clean rivers, in New Zealand.



Beginning in 1998, Bruce spear-headed the development of a new acoustic monitoring and analysis system for environmental noise control: **SAM** - Soundscape Analysis and Monitoring.

**SAM SCRIBE** is the latest development of the **SAM** technology. It is a small, portable USB, twin channel, broad-spectrum recording system that operates with a notebook computer. It utilises microphones manufactured by Atkinson & Rapley Consulting Ltd. that have a near flat frequency response from 0.1 Hz to 20,000 Hz., that facilitates research into the infrasound region. It can also be used in combination with a Class 1 microphone and preamplifier for compliance purposes.

SAM SCRIBE is now used inNew Zealand, Australia, Belgium, Canada, France, Germany, Portugal, the UK and USA. Key features include portability, USB interface to a notebook computer and twin microphones that allow comparison of two soundscape environments simultaneously, such as inside versus outside measurements.

The power of the SAM SCRIBE system is that it records broad spectrum sound for post-capture analysis utilising a number of different software packages and strategies. The raw data is always available as uncompressed wav files that are encoded for security and chain of evidence for court proceedings. The system utilises satellite global positioning technology for proof of recording location with time/date.

Currently, Bruce continues to focus on using the SAM technology to conduct environmental acoustics and public health research, producing scientific papers for publication, presenting at conferences, giving seminars and talks, and writing books on topical aspects of science. He also manages the production and manufacture of the SAM SCRIBE technology, distributing it around the world.

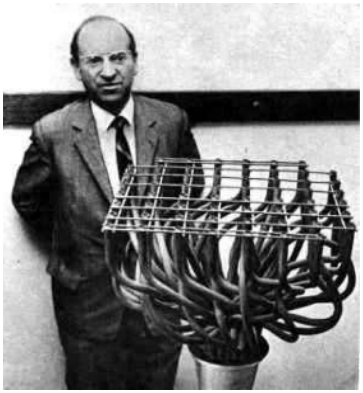

# Preface

The term **"infrasound"** is one that is relatively new to our language. We can trace the origins of the word back to 1960 when research was carried out on the potential use of infrasound as a weapon. Google has a great feature, ngram, that allows us to trace the usage of any word in the English language. If we type "infrasound" into the search window it produces the following graph.


It is interesting to note that from the early 1970s, usage of the term plummets until around 1980. Just what could cause such a sudden rise in the popularity of a word followed by such a sharp decline, only to rise again into the next century? Well, I might have one answer.

In the early 1960s, a French scientist by the name of Vladimir Gavreau started investigating why people felt ill in a certain building. Gavreau, born in Russia, became interested in infrasound while working in France when his lab assistants experienced pain in their ear drums and reported shaking lab equipment, but no audible sound was picked up on his microphones. He concluded that it was infrasound which was to become a consuming interest for the remainder of his life.

Gavreau discovered that the experience of his laboratory assistants was not novel; other people in different buildings also suffered from the same weird effects. He found that opening or shutting windows affected the mysterious 'sound' which led him to the conclude that it was infrasound. In reality, what he had discovered was that low-frequency sound, often as a result of internal structural resonance, was a widespread phenomenon. In my PhD I even quote the experience of one of New Zealand's prime ministers, David Lange, who suffered from exactly this problem in his office on the top floor of parliament buildings. Changing the fans and their speed of rotation solved the problem. So really, Gavreau had simply stumbled onto what has become a common problem in recent decades, frequently as a result of heating, venting and air conditioning systems (HVAC).



The problem was, Gavreau reasoned, that if such low-frequency sound could adversely affect people, perhaps there was a potential military application for it as a weapon, see left. Thereafter followed much research and speculation, fuelled by a news-hungry media. Anything that stirred the blood of the readers was fair game. All the better if a little exaggeration could be added, just to 'spice things up'. And so it was that much misinformation was published, and after his death, much disinformation. Gavreau soon became a laughing stock of history. Unfortunately, he was right about many things. In fact he was right about one cause of sick building syndrome and the potential for infrasound to be used as a weapon.

I am privy to this fact because one of my close colleagues not only knew Gavreau but was also involved with military research in the United Kingdom around the same time. Indeed, a real infrasound weapon in the form of a low-frequency sound generator was suspended underneath a

helicopter which was then flown over a rioting crowd in Northern Ireland, during the time of 'The Troubles'. When it was switched on, immediately about one-third of the crowd collapsed with epileptiform attacks. The weapon was banned by the Second Geneva convention 1976 and never used again.

There is one other salient fact that I am aware of due to contacts I met in the course of my PhD studies with the New Zealand Defence Force. Gavreau died as the result of his own infrasound experiments. He died of empyema as a result of vibrating his internal abdominal organs against their suspensory integuments (connective tissue) leading to septicaemia. It is interesting to note that Wikipedia cannot state exactly when this happened, but I am led to believe it was in 1972, shortly after Gavreau attended a meeting in London at which my colleague was present. Sadly, 24 hours after Gavreau died, so did his lab assistant who was working with him in the lab at the time.

Upon his death, the military confiscated all his papers and equipment and it has never been seen or heard of since. We have little on the internet, save a couple of genuine pictures, such as the one on the previous page, purporting to be a prototype for his proposed infrasound military weapon.

As far as I am aware, no such weapon was ever built, and if it was, it was never used. Today the military are more interested in high frequency weapons.

So that may account for the ngram showing the term infrasound coming into vogue in the 1960s, only to die immediately after Gavreau's death. Its rise in usage in the 1980s has another cause: large fans and rotors, including wind turbines.

From the early 1980s, wind turbines again became a topic of serious research for the purpose of power generation, coming as they did on the heels of the 1970s oil crisis. What history tends to forget is that from the time of these early experiments, industrial, large-scale

wind turbines were known to produce significant amounts of infrasound! The standard argument is that this only resulted from what are known as down-wind turbines, where the blades are on the down-wind side of the tower. Thus the wind hits the tower first, causing turbulence, this in turn causes low-frequency infrasound emissions. However, **up-wind turbines also produce infrasound and low-frequency sound**, albeit less than down-wind versions, but **it is ratio-metric**. That is, large up-wind turbines produce significant amounts of infrasound and low-frequency sound and they are growing in size with every new model. The ubiquitous small wind turbines used for generations on farms caused no problems, but with the larger industrial turbines, the larger the turbine the greater the output of low frequency and infrasound.

And so it was against this background of ever-increasing numbers of wind turbine generation facilities being built closer and closer to human habitation that the complaints began to emerge from near neighbours. This has become one of the most contentious public debates of current times. As a result of investigating some of these apparently 'wild' claims of adverse health effects, I became convinced that wind turbines could produce some form of acoustic and vibratory 'pollution' that could affect people. So how did I become involved?

In 2011, after 13 years of development, I managed to produce the first version of a new pc-based technology to monitor and analyse environmental sound: SAM - (Soundscape Analysis & Monitoring.) Since then, my now international team have continued to develop this technology that is now being sold worldwide. Special pricing exists that allows those directly affected by any form of industrial noise pollution to measure and record their own soundscapes then correlate this with their health diaries.

My team continue to progressively evolve this technology in addition to carrying out research around the world, publishing the results in scientific papers and presenting at conferences. As a result of international interest in the topic and a stream of questions via the

internet that exceeded my ability to reply, I decided to write a book (one of a series) that answers many common questions. So what you are reading is my solution to a strong demand for answers regarding the effects of low frequency and infrasound on animals (and people) as a result of industrial noise pollution.

I would like to give you a couple of riding instructions before you go any further, unless, of course, you have skipped this preface like many readers do. I never read the preface, I like to read the book! But if you are one of the few who do read prefaces, there are a couple of gems that you should be aware of before you launch into it more deeply.

This is a book. More than that, it is part of a series of books I am writing called: **Conversations for a Small Planet.** These books discuss contemporary issues that affect the planet. The intention is that I will provide controversial and entertaining information in a conversational style that will hopefully encourage the readers to start conversations of their own with people around them. These conversations are intended to raise topics that are important to our environment and the general health of the planet and its occupants. What I ask is: Don't talk to me, talk to each other. Start lots of conversations and let's generate interest that will hopefully raise awareness of issues that are important to everyone and our future wellness.

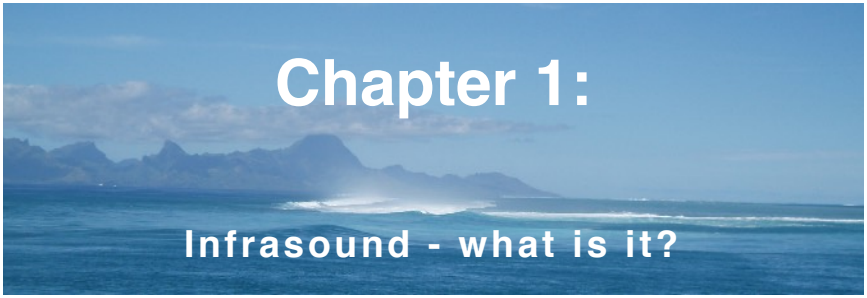
As this is a book, and an attempt to start many conversations, I have not written it in the style of an academic paper, a thesis or a text book. Therefore, there are virtually no references. I challenge the reader to find references for themselves, and others I have not found. This must be a journey of discovery for you, the reader. What I am doing is providing topics for the conversations including background information and simple explanations of the complex science involved.

Hopefully, these conversations will result in increasing enlightenment regarding issues that could affect our quality of life, indeed, potentially our ability to survive our own science and technology as we continue to pollute our environment.

So, I hope that this books prompts you to start your own journey. My journey was in conducting the science and developing the technology that brought me to where I am now. I am sharing the results of my journey with you, like a sort of travel guide so that you might be inspired to undertake your own journey. My job is to provide the signposts. I hope you enjoy the trip. I enjoyed mine.

P.S. Why not take a friend?

# Contents

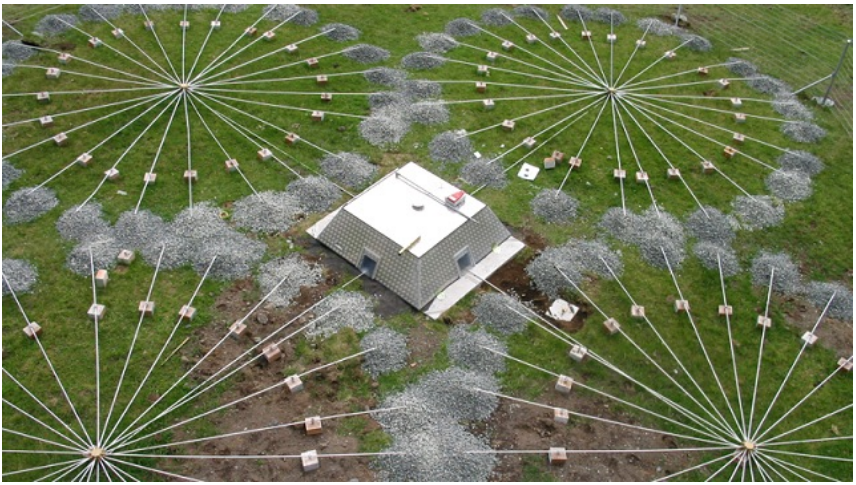


# Chapter 1:

## Infrasound - what is it?

The term INFRASOUND is one that is becoming increasingly common in today's language, largely as a result of the association of infrasound with the low-frequency emissions from industrial-scale wind turbines. But the term certainly predates the proliferation of large-scale wind turbines for electricity generation that grew out of the international oil crisis of the 1970s.

Infrasound was known as far back as WW1 where it was used to locate explosives used by the enemy. It became even more important as a result of WW2 where the world was to see the first nuclear bombs, devastating Hiroshima and Nagasaki in Japan, hastening the end of the conflict. Atomic bombs are orders of magnitude more destructive than any previous weapon. Accordingly, they generate enormous amounts of infrasound that can be detected around the world. Below is the infrasound detection array at Tristan da Cunha.



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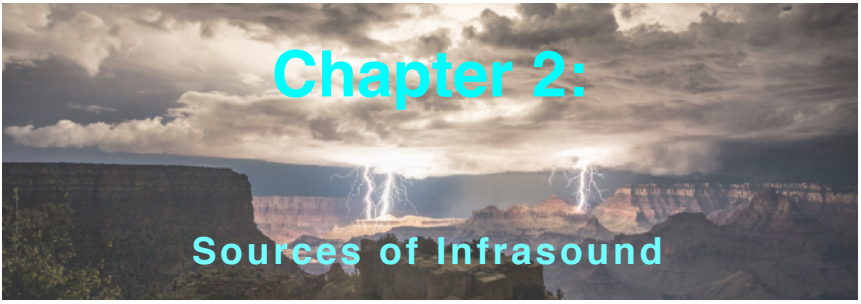
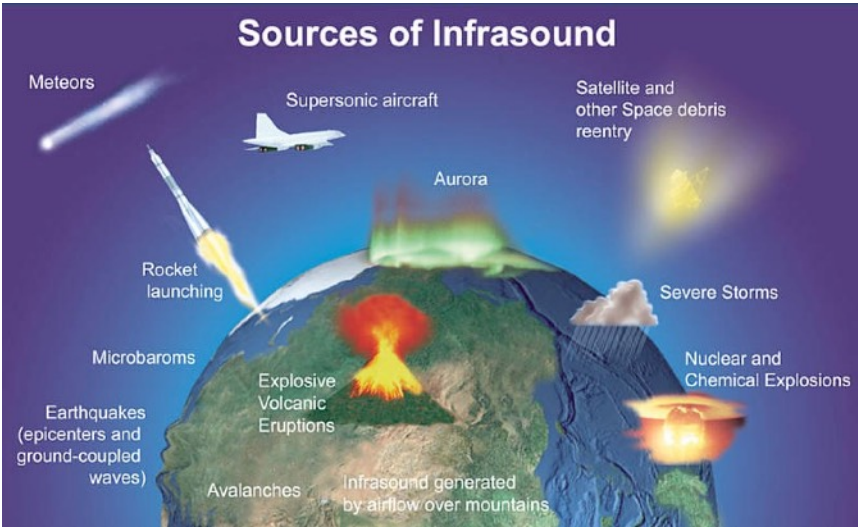



***INFRASOUND*** is all around us, all the time — *it's omnipresent.*




Infrasound is a form of energy that you cannot get away from. The figure above gives an excellent overview of just how many sources there are[1]. While some of the sources of infrasound are manmade, such as transport, explosives and industrial equipment, this is still only a small part of the total soundscape (sound environment in relation to human perception).

Significant contributors include: storms; waves and surf; avalanches; earthquakes; volcanic eruptions; waterfalls; wind; the aurora; lightening; bolides and meteors; icebergs breaking off — the list goes on.

1 http://neuroresearchproject.com/2013/02/19/1289/

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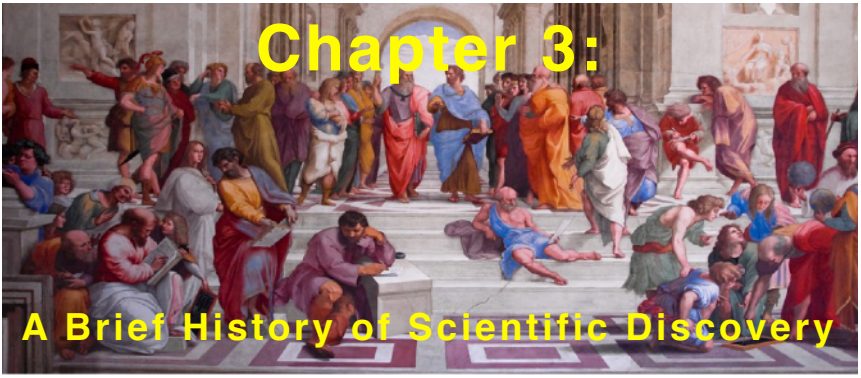

# Chapter 3:

## A Brief History of Scientific Discovery

There is an old Chinese proverb:

"IF YOU WANT TO KNOW WHERE YOU ARE,
YOU MUST FIRST KNOW WHERE YOU HAVE BEEN"

So at the risk of reminding you of boring history lessons at school, I will embark on a short whirlwind tour of scientific discovery through the ages so that you can see where we came from and where we are now.

The brain is arguably the most complex system in any animal. It has defied description and understanding since man began to study biology back in the mists of time, before recorded history began.

Today, many scientists consider that understanding the brain is in its infancy, yet surgery on the skull, and brain, dates back to the Neolithic period, some 10,000 years ago. Trepanation, as it was called, involved drilling a hole in the skull to expose the brain. Often history texts claim that this was done to release demons, but the truth is, we will never really know. Ten thousand years ago, such surgery was not well documented. But at least those primitive humans never had to suffer the anguish of a photocopier or printer paper jam! But you might get a few cuts from your chisel as you tried to record history on your cave wall.

There are cave paintings from the late Stone Age which suggest that people believed the practice of brain surgery would cure epileptic

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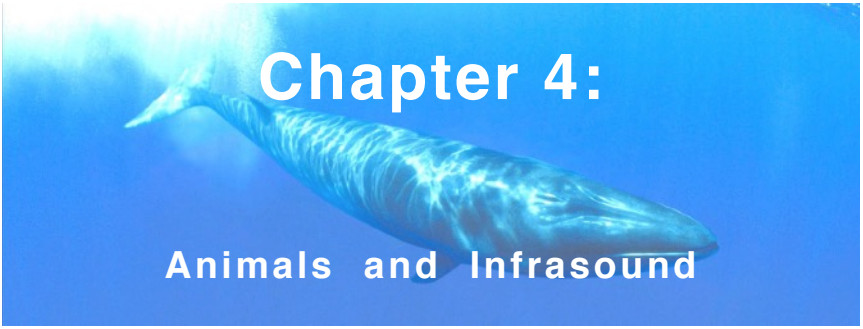

# Chapter 4:

## Animals and Infrasound

Life on earth has evolved in the presence of natural sources of infrasound. So if infrasound is sound that is below the accepted range of human hearing, is this so for all animals? The simple answer is no. There are two outstanding examples that we know of, whales and elephants. It is important to make the point that this is as far as we know. Our knowledge is not exhaustive and the science of biology is continually expanding on many fronts. There may be other animals that can hear into the infrasound region that we simply do not know about yet. There is one other problem: Where does hearing stop and vibration sensation begin? All animals sense vibration.

To understand this point, we need to understand how the hearing response of animals is determined. It is not as simple as giving them a hearing test as you and I would get if we went to an audiologist. Animals are far less cooperative and do not answer questions nearly as well, at least to humans who are asking them!

Animal hearing is determined in a number of ways. The first, and perhaps oldest technique is to take an animal into the laboratory and wait for it to settle down and be calm. Then a sound is introduced, usually a pure tone in the form of a sine wave[1]. The experimenter then observes the animal to see if it reacts. It might jump, in which case we have just caused the **startle response**. This is a good indication that the animal heard something, if everything else in the environment has remained the same. One of the problems of using this approach is that it

1 The closest approximation to a sine wave is the sound produced by a flute.

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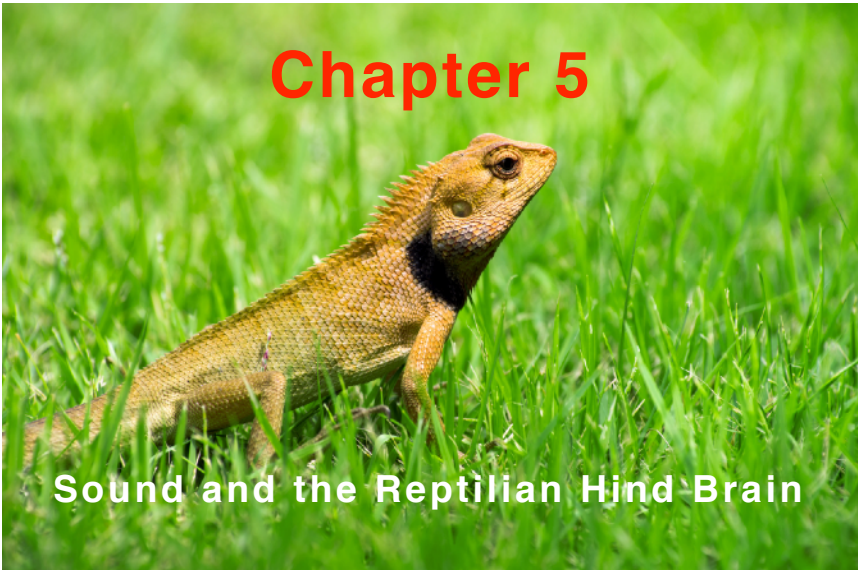
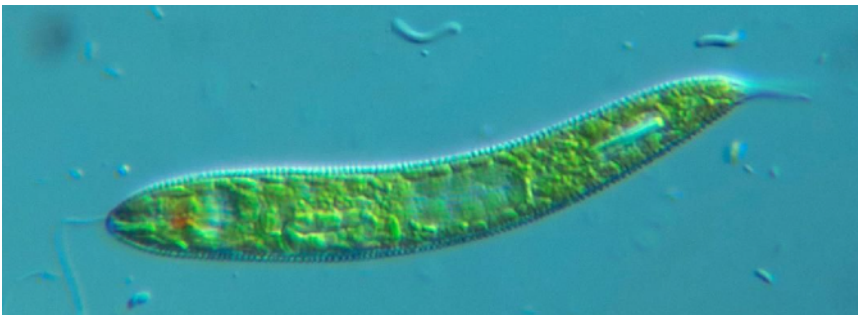



There is little doubt that evolution is the mechanism that best explains the process by which life forms developed on earth. One of the major reasons for this is that we can clearly see a progression from the simple to the more complex. Aided by the fossil record, patchy though that may be, there is strong evidence that one development led to another. From the primitive, red, light-sensitive organ in the flagellate green algae, Euglena[1], see below, to the complex eye of an octopus, a clear succession is evident.



1 Euglena is a member of the single celled group known as Protists. They contain aspects of plants and animals.

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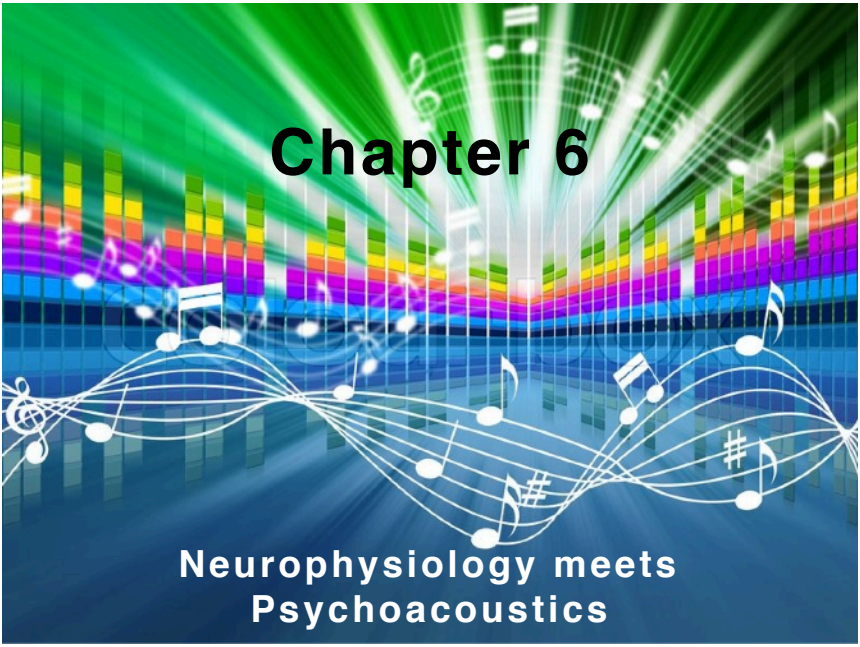


Psychoacoustics is the scientific study of sound perception while audiology is the clinical/medical aspect of hearing. More specifically, it is the branch of science studying the psychological and physiological responses associated with sound (including noise, speech and music). It can be further categorised as a branch of psychophysics. Psychoacoustics received its name from a field within psychology—i.e., recognition science—which deals with all kinds of human perceptions. It is an interdisciplinary field of many areas, including psychology, acoustics, electronic engineering, physics, biology, physiology, and computer science.

In simple terms, sound from the environment that impacts on your ear drum is transmitted via nerves to the brain where it is processed, resulting in instructions to your body to perform specific behaviours (actions). It is behaviour as a result of hearing sound (psycho-acoustics).

In this chapter I want to look at music and neuroscience, bringing together sound perception and brain function. But let's get back to

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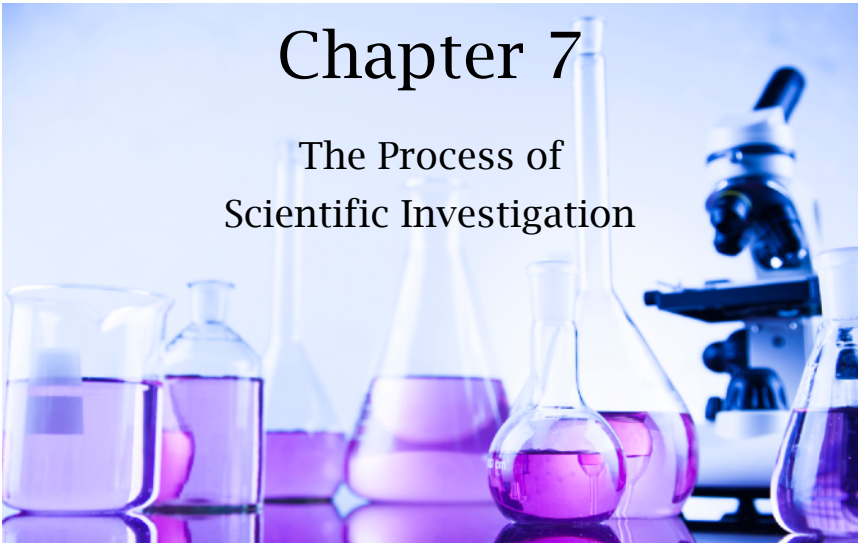

# Chapter 7

## The Process of Scientific Investigation

The way that science progresses begins with a question that arises from an observation. This leads to the construction of a hypothesis, an explanation of the 'how' something happens. This becomes our theory. That theory is then tested in the real world and the results examined to see if our theory is supported. If it is, then that is simply more evidence that we have come up with a very plausible idea. If the experiment disproves our hypothesis (or null hypothesis[1]), then we have to go back to the drawing board and come up with another explanation.

The way that you ***do not*** conduct science is to observe something, then come up with an idea that correlates to a partial data set of those observations and then not test it. This does not even have as much kudos as a 'thought' experiment. While thought experiments can be of great value - Einstein used these to create his special theory, and later his general theory of relativity - their use is rather limited. Einstein could not do the experiments that he wanted, such as sitting on a beam of

[1] In a statistical test, the hypothesis that there is no significant difference between specified populations, any observed difference being due to sampling or experimental error.

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Denmark has embraced wind energy arguably more than any other country and is often touted as an example to the rest of the world. Denmark embarked on a program of using wind as a renewable green source of electricity generation early in the 1970s. Today Denmark boasts 39% of electricity production is produced by wind turbines. Denmark is the home of Vestas and many other component manufacturers. In 2012, the Danish government committed to raise the percentage of electrical energy from wind to 50%.

Spurred on by the calls to reduce carbon dioxide emissions to curb global warming, the closure of coal-fired power stations was called for. Following the Chernobyl nuclear disaster of 1984, Denmark passed new legislation in March 1985 forbidding the construction of nuclear power plants. Denmark, not to put all its 'eggs in one basket,' also invested in solar which amounts to 548 MW. While Denmark appears to have significant electricity generation from carbon-free, renewable sources, it is anathema that they also have the highest cost per kWh in the European Union, proving that all that glitters is not green. The debate about Denmark's ability to utilise this potential production is a vast subject and worthy of another book for its own right. But for the moment, let us return to the title of this chapter and investigate the alleged carnage that resulted from low frequency (and possibly

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The story beings with a mysterious death in 1983 at the Portuguese aircraft maintenance, repair and manufacturing plant, OGMA, at Alverca, just 25 km north of Lisbon. OGMA, originally Oficinas Gerais de Material Aeronáutico is now rebadged as Indústria Aeronáutica de Portugal. It is a specialist aviation company with a long and distinguished history. They have been manufacturing aircraft and engines since 1918 and are a major centre for aeronautical maintenance.

Originally owned and operated by the Portuguese government, it was privatised in 2003 whereupon a major drive was initiated to make the company efficient on a world scale and expand into even more markets than those already explored. In three years the turnover was doubled and this led, in 2005, to the present position with the government of Portugal retaining one-third of the shares with private ownership, predominantly from EMBRAER and EADS, owning the remaining two-thirds of the company share capital.

OGMA is fully qualified in both civil and military aviation, with certification as a repair station to FAR 145 and EASA 145, with AQAP 2110 and ISO 9001-2000 Quality Management. The company is an established and authorised maintenance centre for several Original Equipment Manufacturers, including Lockheed Martin, Embraer, Rolls-

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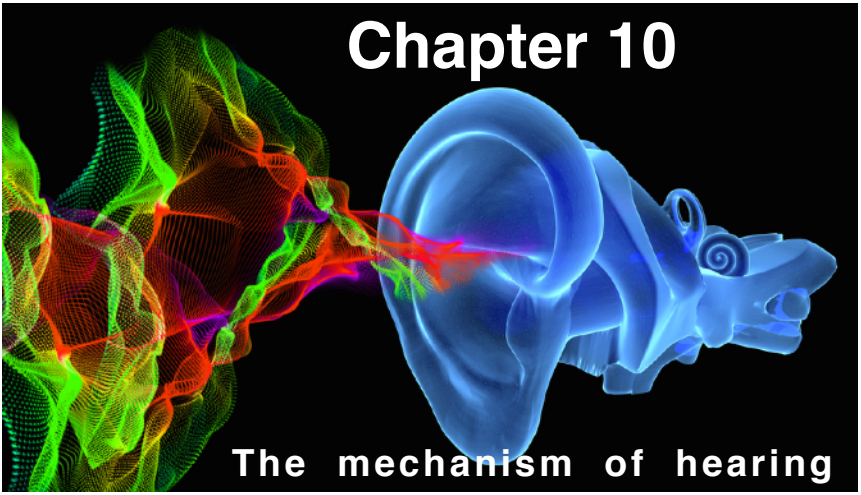


To understand the insidious effects of low-frequency sound and infrasound, it is important to understand the way in which sound is transformed into nerve impulses and transmitted to the brain for conscious interpretation (processing). So let's take a look at what we know about human hearing.

Sound is simply variations in air pressure. It is generally accepted that if these oscillations occur in the frequency range of 20 Hz to 20,000 Hz, they are said to be within the hearing range of a healthy, young adult. It is important to note that this range is an average, originally determined by Fletcher and Munsen back in the 1920s. The tests were undertaken using ear-occluding headphones and pure tones, known as sine waves. They used just 23, healthy young adult volunteers.

The equipment of the 1920s was crude by today's standards and their accuracy is certainly something we should question. We should also consider that the purpose of Fletcher and Munsen's research was to improve the quality of sound in the relatively new invention: The Telephone. From a biological point of view, there are many problems with how Fletcher and Munsen carried out their work. They did the best they could at the time. Remember this was "new" research in the 1920s.

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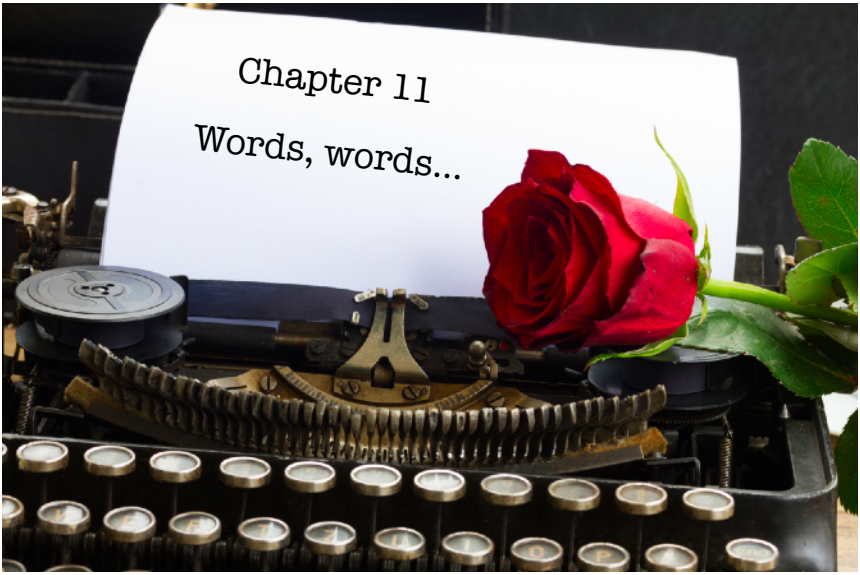


Infrasound and low-frequency noise is becoming a topic of discussion across the globe in response to the proliferation of industrial wind turbines for electricity generation. Touted as a Green alternative to fossil fuels, wind farms are becoming a popular bandwagon for the couch-greenie and the public activist alike. It is easy to hitch your wagon to such a popular star because the world, we are told, is suffering from global warming and it's all our fault.

Protagonists, undaunted by the continual failure of climate models, have changed their banner from "Global Warming" to "Climate Change". This subtle but significant change has still not been sufficient for a large percentage of the population to reconsider their stance. Easier to jump on the bandwagon and flag-wave innovative ways to save the planet. And it makes us feel good too. Creating wind farms seems a no-brainer, but there are hidden costs. In order to progress this topic, first we need to introduce a few new concepts before we can answer the key questions: a) i**s infrasound harmless because it is ubiquitous in the environment?** and b) **is all infrasound the same?**

In order to do this, it is necessary to hold a mirror to ourselves:

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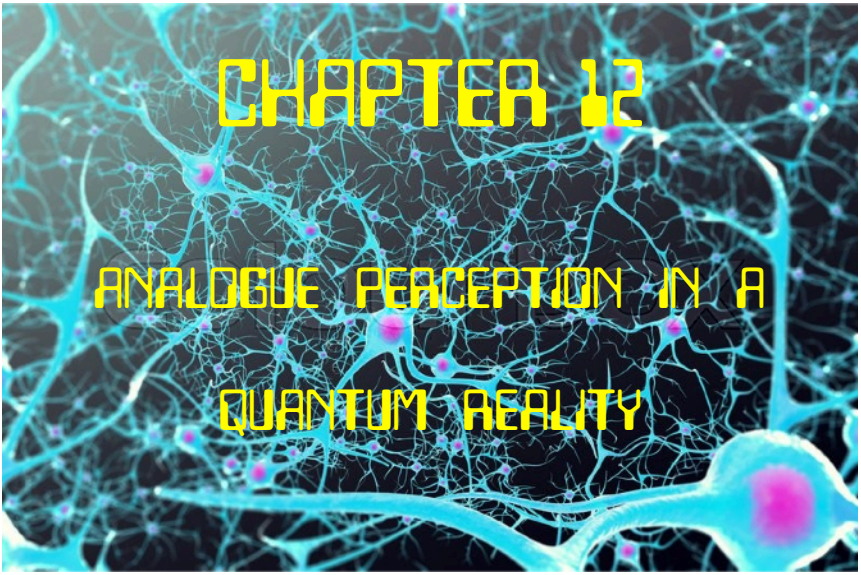

# CHAPTER 12

## ANALOGUE PERCEPTION IN A QUANTUM REALITY

The world, as we perceive it, is analogue. That is, there is an infinity of progression between big and small. There are no steps in largeness. Some things are small and get bigger, not in jumps, but by a process of continual expansion. Plants are a perfect example where growth appears to be a continual process of progressive enlargement. There are, of course, various organs (parts) of determinate size, like leaves, flowers and fruit. They grow to a certain size then stop. (Grasses are a bit of an exception, but eventually grass blades stop growing.) Even invertebrates that have to shed their hard exoskeleton to grow to the next size, do so by puffing up a soft second exoskeleton underneath the one being shed. Thus they grow 'linearly,' not in binary jumps.

It is only when we get down to the nano-scale, that the true quantised nature of the universe becomes apparent. Energy jumps in specific sized lumps: Quanta. Photons of light emitted from an atom do so in specific-sized amounts. This is due, in part, to the stability of electron orbitals around atoms. Atoms can absorb a quantum of energy, like a high-energy photon, resulting in the electron orbital jumping up to a new, stable or semi-stable level (size). If the new energised orbital, having absorbed its 'meal' of a photon, is stable, it will remain in a high

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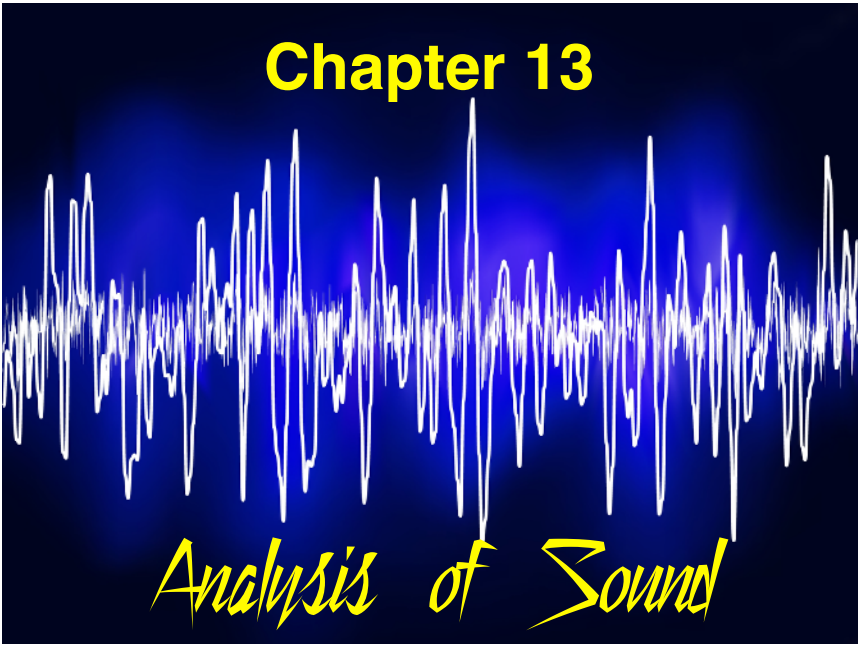


There are many different ways to analyse sound. One simplistic approach is to measure the sound pressure level (equivalent of loudness), using the dB scale, but this statistic has little relevance on its own. Imagine trying to describe a piece of music by using just a single statistic. What would that statistic be for Beethoven's Fifth Symphony? Would that value have any meaning? No. Of course not.

A single loudness level is of virtually no value whatsoever. Neither is any average value. Interpretation of sound is not about loudness alone, nor can that even be sensibly described by a single statistical, a numerical value. Imagine trying to quantify the take off of a jet aircraft using a single statistic: Loudness. As we all know the takeoff starts off quietly, gets louder and then gets fainter as the plane flies away. Which value of loudness do we use? The maximum? The mean? The median? There is no sensible answer.[1] Let's take a look at another example to see how really stupid this concept is.

1 For the problem of repetitive noise, the EPNL metric exists. There is also the use of a rolling average over 90 days to trap repetitive sounds on a daily/weekly basis.

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# Chapter 14:

# SOUND AS INFORMATION

Sound has always had the potential to cause physiological injury. While such sound pressure levels in prehistoric times were likely minimal, perhaps restricted to volcanic eruptions and very loud thunder or avalanches, by and large, mankind evolved in an environment that was generally benign as far as ballistic (physical) damage from sound was concerned. But while the natural environment was only to provide very minor physical damage to humans as a result of sound energy, mankind was to change all that in a variety of innovative ways.

The first serious threat to animals in terms of auditory damage was gunpowder, invented in China more than a thousand years ago. The exact date of the invention which saw sulphur, charcoal and salt-peter (potassium nitrate) mixed together, is unknown. From a chemical point of view, the sulphur and charcoal acted as the 'fuel' source while the potassium nitrate ($KNO_3$) acted as an oxidising agent. The chemical reaction that results has such rapid burning and expansion that it soon became useful as a propellant to hurl projectiles at the enemy.

As the story goes, the Taoists in China were attempting to create a potion to confer immortality. Unfortunately, the rapid progression of the chemical oxidation reaction that resulted could certainly have propelled those in the near vicinity into an alternative existence: the question of immortality conferred as a result, or not, is still a matter of debate and belief.

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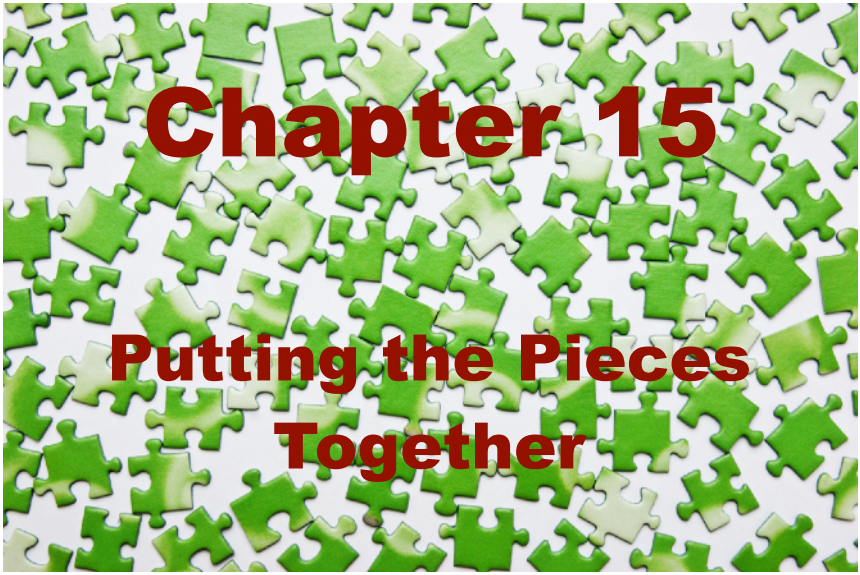


This has been quite a long journey, but I hope, a worthwhile one. It is not easy considering a new paradigm, otherwise some of the major crises of history, such as the Copernican Revolution, would not have happened.

Throughout history new ideas have challenged traditional thought and this has inevitably led to arguments. From the dawn of human history, academic thinkers and philosophers have challenged the status quo. Over time, philosophers slowly morphed into scientists. Some of the outstanding scientists whose ideas were once revolutionary but have survived the test of time include (in approximate chronological order according to date of birth):

Thales, Socrates, Plato, Euclid, Archimedes, Aristotle, Copernicus, Gilbert, Brahe, Galilei, Kepler, Harvey, Descartes, Boyle, Malpighi, Huygens, Van Leeuwenhoek, Euler, Linnaeus, Kant, Herschel, Lavoisier, de Lamarck, Laplace, Dalton, Gauss, Davey, Faraday, Liebig, Darwin, Joule, Helmholtz, Galton, Mendel, Pasteur, Kirchhoff, Lister, Kekule, Maxwell, Wundt, Mendeleev, Haeckel, Koch, Boltzman, Roentgen, Tesla, Meyr, Kamerlingh Onnes, Ehrilch, Freud, J.J. Thomson, Binet, Sherrington, Curie (Maire & Pierre), Bayliss, Hunt Morgan, Curie,

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***Typical!*** You just get the final touches to all the chapters done and the comments back from the proofers / editors and ***whammo!*** Out of left-field comes some scientific news so staggering that it has to be squeezed in somehow. Well, this is exactly what happened.

Having taken a year to write this book and 8 months for proofers and editors to niggle about syntax and punctuation, not to mention the scientific advisors all wanting to have their say, I got the manuscript ready to ship to the printers and then a paper hit my desk:

> **Altered cortical and subcortical connectivity due to infrasound administered near the hearing threshold - Evidence from fMRI**.

What could I do but sit down at the keyboard and try to translate this critical piece of work into a lingo that the lay reader could have a chance of understanding. And that wasn't easy!

If the title of the paper by **Markus Weichenberger and his team**[1] was not difficult enough, reading the fine detail really required a

1 Markus Weichenberger, Martin Bauer, Robert Kuhler, Johannes Hensel, Caroline Garcia Forlim, Albrecht Ihlenfeld, Bernd Ittermann, Jürgen Gallinat, Christian Koch and Simone Kuhn.

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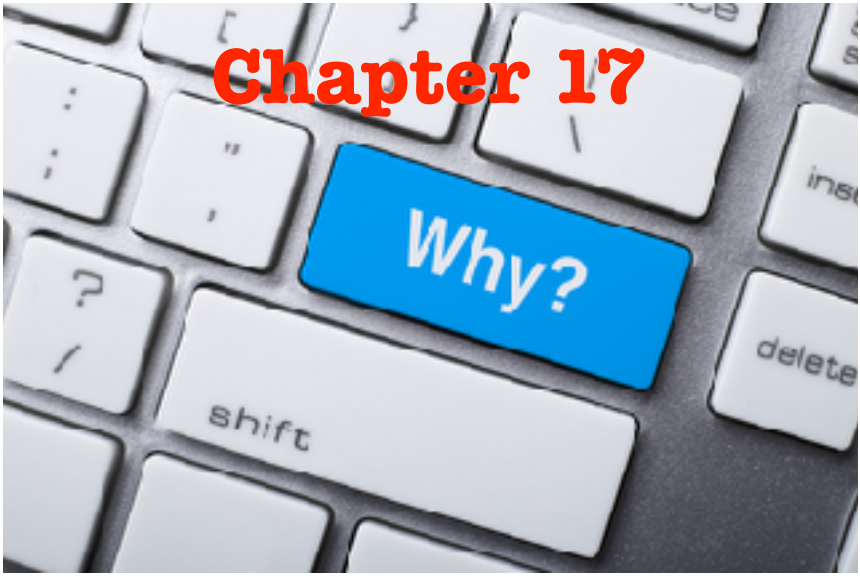


The purpose in writing this book is quite simple: **To provide a greater understanding of how low-frequency sound, and infrasound, can and does affect biological organisms, including man.** To fulfil that basic requirement, it was necessary to paint a broad picture, to draw together many apparently disparate observations and facts. Understanding such a complex topic necessitates drawing knowledge from many disciplines. To paint our *Big Picture*, we need to use a lot of paint and many colours.

To bring together all the necessary elements of the 'plot' has been a large and daunting task. I am grateful for my broad education in the sciences that also extends into areas of technology and engineering. It has taken a lifetime to accumulate. This diverse education has allowed me to stand back and look at the big picture: To form a Gestalt, if you will. This book is simply my attempt to share that journey with you in the hope that it will encourage you to undertake your own journey of discovery.

What I have asked you to do is not take any of the information I have provided on face value, rather you should become cognisant of it, then investigate it independently for yourself so that you can reach your own conclusions.

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# APPENDIX

## Experimental Design

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