CHAPTER 2

RESEARCH ON THE HEALTH EFFECTS OF ELECTROMAGNETIC RADIATION

Introduction

2.1 While radio waves and other forms of electromagnetic energy have been in use for decades, the recent dramatic increase in the use of mobile phones, the visible proliferation of mobile phone towers and antennas and accompanying anecdotal and scientific studies showing biological and possibly health effects associated with these structures, have led to increased public concern about the safety of mobile phones and other telecommunications technologies. Many studies have been conducted to examine the relationship between radiofrequency radiation and biological and health effects, however to date, the results have been inconclusive.

2.2 Several recent expert reviews provide an analysis of the relevant scientific literature, with last year's UK Stewart Report considered the most comprehensive so far. Other reviews include those conducted by the CSIRO in 1994, the European Commission in 1996, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 1996 and 1998, the World Health Organization in 1998, and the Royal Society of Canada and the UK House of Commons Select Committee on Science and Technology in 1999. The conclusions and recommendations from these reviews will be referred to throughout this chapter.

2.3 The Committee received submissions and evidence from a number of scientists and health professionals, as well as community organisations and individuals. Some claimed that there is ample evidence of biological and/or adverse health effects associated with non-thermal levels of exposure to electromagnetic radiation, while others concluded that no clear relationship has been established.

2.4 This chapter provides a summary of the scientific research covered by recent major reviews, as part of a discussion of the evidence presented to this Committee based on the observations and research of witnesses and submitters to this inquiry. It concludes with an overview of current Australian and international research in this field.

Exposure to electromagnetic radiation – if biological effects are shown, what are the health implications?

2.5 Exposure to non-ionising radiation, at exposure levels sufficient to cause heating above 1ºC, is known to cause adverse health effects.[1] Knowledge about and

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1 Referred to by various submissions, for example, CSIRO, Submission 95, p 3; Australian Mobile Telecommunications Association (AMTA), Submission 19, p 7; Australian Communications Authority (ACA), Submission 100, p 10; Mobile Manufacturers Forum (MMF), Submission 75, p 4.

acceptance of the effects of non-thermal exposure to electromagnetic radiation remains limited and contentious.

2.6 As stated earlier, a number of expert reviews of the literature have been conducted, which have drawn the following conclusions in relation to the health effects of non-ionising radiation, including radiofrequency radiation:

CSIRO, 1994[2]

> This report concluded that there was insufficient reliable scientific evidence on which to base sound conclusions about safety of radio frequency (RF) exposures in telecommunications. It stated that 'because of its equivocal nature, the data base for RF emissions has limited value. It may be dangerous to make general statements on safety based on lack of evidence of harmful effects when so little relevant research has been carried out'.

International Commission on Non-ionizing Radiation Protection (ICNIRP), 1996[3]

> Most of the established biological effects of exposure to RF fields are consistent with responses to induced heating resulting in rises in tissue or body temperature of greater than 1°C … In contrast, non-thermal effects are not well established and currently do not form a scientifically acceptable basis for restricting human exposure for frequencies used by hand-held radio telephones and base stations.

European Commission, 1996[4]

> Overall, the existing scientific literature encompassing toxicology, epidemiology and other data relevant to risk assessment, while providing useful information, provides no convincing evidence that radiotelephones[5] pose a long-term public health hazard.

World Health Organization, 1998[6]

> … no known health hazards were associated with exposure to RF sources emitting fields too low to cause a significant temperature rise in tissue.

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2 CSIRO, *Status of Research on Biological Effects and Safety of Electromagnetic Radiation: Telecommunications Frequencies*, June 1994, p 10 (CSIRO Report).

3 International Commission on Non-ionizing Radiation Protection, 'Health Issues related to the use of hand-held radiotelephones and base transmitters', *Health Physics*, 70, pp 587-593, 1996 at pp 588, 592.

4 European Commission, *Possible health effects related to the use of radiotelephones: proposals for a research programme by a European Commission Expert Group*, Brussels, EC, 1996, p 23 (EC Report).

5 Mobile phones.

6 Michael H Repacholi, 'Low-Level Exposure to Radiofrequency Electromagnetic Fields: Health Effects and Research Needs', *Biolectromagnetics*, 19, 1998, abstract, included in The World Health Organization, Submission 56, Submission Vol 4, p 806, (Repacholi, 1998).

ICNIRP, 1998[7]

> Epidemiological studies on exposed workers and the general public have shown no major health effects associated with typical exposure environments. This is consistent with the results of laboratory research on cellular and animal models, which have demonstrated neither teratogenic[8] nor carcinogenic effects of exposure to athermal levels of high-frequency.

Royal Society of Canada, 1999

> The Royal Society Expert Panel on Radiofrequency Fields noted that there were 'a number of observed biological effects of exposure of cells or animals to non-thermal levels of exposure to RF fields', but had found 'no evidence of documented health effects in animals or humans' relating to this exposure. However, it also expressed the view that 'many of the studies in humans and animals addressing the potential for adverse health effects do not have sufficient power to rule out completely any possibility of such effects existing'.[9]

UK Independent Group on Mobile Phones Report (Stewart Report), 2000

> The Stewart Report (*Mobile Phones and Health*) noted that while there has been little research into the safety of mobile phone and base station emissions, there was some peer-reviewed literature from human and animal studies and substantial non-peer-reviewed information, which refer to the potential health effects caused by exposure to RF radiation from mobile phone technology. It concluded that the balance of evidence suggests that exposure to radiofrequency radiation below National Radiological Protection Board (NRPB)[10] and International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines 'do not cause adverse health effects to the general population', but noted that '[t]here is now scientific evidence … which suggests that there may be biological effects occurring at exposure levels below these guidelines'. The Stewart Report concluded that 'it is not possible at present to say that exposure to RF radiation … is totally without potential adverse health effects, and that the gaps in knowledge are sufficient to justify a precautionary approach'.[11]

2.7 Animal studies have provided evidence of significant responses to radiofrequency radiation, including changes in temperature regulation, endocrine

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7 International Commission on Non-ionizing Radiation Protection, 'Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300GHz), *Health Physics*, 74(4), pp 494-522, 1998 at pp 507-508.

8 Resulting in birth defects.

9 Expert Panel Report prepared at the request of the Royal Society of Canada for Health Canada, *A Review of the Potential Health Risks of Radiofrequency Fields from Wireless Telecommunication Devices*, March 1999, pp 110, 111 (Royal Society of Canada Report).

10 In the UK.

11 Independent Expert Group on Mobile Phones, *Mobile Phones and Health*, p 3 (Stewart Report).

function, cardiovascular function, immune response, nervous system activity, and behaviour; however, the significance of biological responses at low exposure levels and their relationship to health effects are either not agreed with or not well understood.

2.8 The Telstra Repacholi *et al* study in Adelaide is one of those which has shown a significant increase in cancer incidence for mice genetically predisposed to lymphoma, and this study is currently being 'confirmed' and is referred to later.

2.9 The Committee was informed that a growing body of research provides evidence of biological effects. This was the conclusion of the Royal Society of Canada Report, which said:

> It is clear to the panel that there are a number of observed biological effects of exposure of cells or animals to non-thermal levels of exposure to RF fields. These observed biological effects meet the common standards for scientific observation in that the experiments were well-designed, had appropriate positive and/or negative controls, contained valid RF exposure parameters, included appropriate statistical evaluation of the significance of the data, and have been observed to occur by more than one investigator …[12]

2.10 Despite this, the Australian Communications Authority stated that 'the evidence for production of harmful biological effects at relatively low levels of exposure (that is, field intensities lower than those that would produce measurable heating) is ambiguous and unproven.[13]

2.11 The World Health Organization (WHO) draws a distinction between effects on health, which it defines as 'the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'[14] and biological effects which are 'a physiological response that may or may not be perceptible to the exposed organism'.[15] In his paper on exposure to low level radiofrequency fields, Dr Michael Repacholi, Coordinator, Occupational and Environmental Health, WHO, stated:

> Biological systems respond to many stimuli as part of the normal process of living. Such responses are examples of biological effects. It is questionable whether reported 'effects', even if substantiated, can be considered to represent evidence of a hazard simply because the significance of the effect for the organism is not understood.[16]

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12 Royal Society of Canada Report, p 110.

13 Australian Communications Authority (ACA), Submission 100, Submission Vol 8, p 1618.

14 *Official Committee Hansard*, Canberra, 31 August 2000, p 3 [Repacholi].

15 Michael H Repacholi, 'Low-Level Exposure to Radiofrequency Electromagnetic Fields: Health Effects and Research Needs', *Biolectromagnetics*, 19, 1998, pp 1-19, included in The World Health Organization, Submission 56, Submission Vol 4, p 811 (Repacholi, 1998).

16 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 811.

2.12 Professor Litovitz, Professor Emeritus of Physics at the Catholic University of America, said on the question of whether or not electromagnetic fields caused health effects:

> If they cause biologic effects, there is the possibility – not necessarily, but there is the possibility – that there will be health effects. A biologic effect does not mean a health effect, but you cannot get a health effect without a biologic effect.[17]

2.13 Approaches to interpreting experimental results and determining when a biological response should be considered to constitute a health hazard include:

- any field-induced response is undesirable and should be avoided;
- exposure should be avoided if a physiological response in an organism is measurable; and
- where no discomfort or pain is experienced, the stimulus producing a response should be considered harmless.[18]

2.14 To establish that a biological response has health implications, Dr Repacholi says a number of conditions need to be satisfied, including determining whether the biological or psychological changes are reversible, whether effects are additive, or whether there are adequate compensation mechanisms to respond to the effects.[19] Dr Repacholi offered the view that where dose-response relationships have not been established, it is difficult to extrapolate results between different frequency ranges and exposure levels, making it important to repeat experiments at different exposures.[20] Dose assessment is also important in epidemiological and human studies, because of differences between 'near field' and 'far field' exposure.[21]

The role of epidemiology, *in vitro* and *in vivo* studies

2.15 When assessing the literature, it is worth noting that *in vitro* studies provide insights into the mechanisms underlying biological effects, whereas *in vivo* studies of animals and humans are considered to provide more convincing evidence of biological

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17 *Official Committee Hansard*, Melbourne, 22 September 2000, p 145 [Litovitz].

18 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 811.

19 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 812.

20 See for example Dr Michael Repacholi's explanation re the Adelaide mouse study: 'The problem is that we only looked at one exposure, and to give a result credibility you like to see that increasing exposure will increase the effect. The dose response is something where, when you look at toxicology, you want to see that increasing the dose of chemical, for example, increases the effect: you get higher incidences of the cancer or whatever. My study was not able to test that because it only had one point' (*Official Committee Hansard*, Canberra, 31 August 2000, p 4).

21 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol 4, pp 812-813.

effects that may have implications for adverse health consequences for people.[22] However, the most direct information on the risks of adverse human health effects come from epidemiological studies. Dr Repacholi commented:

> Most of the known human carcinogens were first identified as such by epidemiological studies; for this reason such evidence should not be taken lightly, even if the findings are unexpected or are inconsistent with other evidence … Epidemiological studies are important for monitoring public health impact of exposure, particularly from new technologies.[23]

2.16 This view is supported by medical practitioner and specialist in occupational medicine, Dr David Black, who noted that '[e]pidemiology is frequently misunderstood, and often wrongly criticised as being limited to showing associations but never proving causation'.[24]

2.17 In his submission, Dr Black describes some of the criteria of causation for epidemiological studies. It also identifies the different types of evidence relevant to human health studies. These range from experimental studies, which he says while providing some of the strongest evidence of cause and effect, could not be applied to human populations when the effect is harmful, and have limitations when the results from animal studies are applied to humans because of species differences; cohort and case-control studies, which compare groups which do and do not exhibit the effect, considered to be less precise than experimental studies and requiring a number of consistent studies before a conclusion can be drawn; ecological studies which are considered weaker than the two previously described because they study exposure between population groups rather than individuals, and are generally used for formulating or refining hypotheses for case-control or cohort studies; and finally, individual case studies, descriptive studies, anecdotal evidence etc, which are rarely proof of a definitive relationship but may suggest the need for further research.[25]

2.18 Dr Black also said the use of statistical significance to describe scientific results is also defined as indicating 'the way the data has fallen but does not take into account reasons for this that are not related to true cause and effect, such as bias, confounding or statistical variation', and therefore 'statistical significance' *per se* should not be confused with 'causation'.[26]

2.19 Dr John Moulder, Professor of Radiation Oncology at the Medical College of Wisconsin, USA, when discussing cancer risk assessment, observed:

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22 However, the Committee notes the Stewart Report's comments that cellular studies may be more carefully controlled and assessed than animal studies, although difficult to extrapolate results to humans (Stewart Report, p 46).

23 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 822.

24 Dr David Black, Submission 93, p 16.

25 Dr David Black, Submission 93, pp 18-19.

26 Dr David Black, Submission 93, pp 16-20.

> When the epidemiological evidence for an association between a physical agent and cancer is weak and/or the link is biophysically implausible, laboratory studies are critical for risk evaluation. If there is strong cellular (*in vitro*) and/or animal (*in vivo*) evidence that an agent is carcinogenic, it can make even weak epidemiology evidence for an association credible. Conversely, if appropriate laboratory studies are done and these studies fail to show any consistent evidence for carcinogenic activity, then we tend to dismiss weak epidemiological evidence, particularly if the association is biophysically implausible.[27]

Replication

2.20 One of the most contentious issues with regard to the way in which evidence from scientific studies is interpreted and afforded credibility is the question of replication, confirmation or verification.

2.21 The Mobile Manufacturers Forum argued:

> … the results of any individual study cannot be considered sufficient to establish or refute a possible human health risk. Individual studies must be validated and replicated before they can be relied on, and the determination of whether a potential health hazard exists requires a weight of evidence that evaluates all relevant, credible and valid data.[28]

2.22 Professor Mark Elwood, epidemiologist and public health expert, stated:

> I want to emphasise only one methodological principle relating to most of these studies, and that is a general principle of epidemiology and, indeed, of science; that is, when you do a study which finds an unexpected and new finding which has not been reported before, it is very difficult within that study to assess whether that finding is meaningful or whether it is due to chance variation. The only real way to assess it is to set up a second, independent study to test it.[29]

2.23 Dr Moulder argued that the failure to replicate results may be indicative of flaws in the original study:

> … [the fact] that you cannot confirm and replicate it implies that there is something at least slightly wrong with the original – not necessarily totally wrong but something did not happen the way the authors think it happened. At the first stage of an attempt to confirm, where you have somebody reporting something and somebody else saying they cannot confirm it, you really cannot necessarily believe either study … Sometimes it is not clear

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27 Dr John Moulder, Submission 60, p 10. A description of the process of identifying carcinogens is included in this submission at pp 9-12.

28 MMF, Submission 75, p 6.

29 *Official Committee Hansard*, Melbourne, 22 September 2000, p 130 [Elwood].

> and you basically have to wait for more people to attempt to do it and you end up making what is basically a weight of evidence argument.[30]

2.24 Dr Neil Cherry from Lincoln University, New Zealand, reported in his submission that Dr Repacholi had informed an industry sponsored press conference that there was no evidence that GSM cellphones were hazardous to health:

> At the conference he [Dr Repacholi] presented his paper on the Telstra funded project that showed that GSM cellphone radiation at quite low non-thermal levels, doubled the cancer in mice. When challenged by the conference chairman, Dr Michael Kundi, Dr Repacholi said that a study is not evidence until it is replicated. The conference rejected this. A study is evidence. Replication provides confirmation and establishment.[31]

2.25 Dr Cherry also pointed out that in replication work there can be unforseen variables:

> It was shown in the calcium ion efflux work of Dr Blackman that biological effects in the laboratory can vary with the local magnetic fields, with temperature and with a number of other factors.[32]

2.26 Professor Litovitz advised the Committee:

> There have been a large number of publications, and certainly over 100 have reported non-thermal biologic effects at exposure levels below that considered safe by most government standards. If there have been that many publications, you can ask the question: why is there controversy? If all of these papers are out there and every scientist is correct, why is there such a controversy and why is there so much argument? The answer is that the papers do not all agree. For almost every paper you see on biologic effect, you will see papers that say 'I didn't see anything. I see a big effect, but I didn't see anything.'
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> … So I ask myself: is this field of biomagnetics a junk science field? Are these scientists out there who see effects at low levels all incompetent, or worse? The answer is that lack of replication – that is to say, two scientists disagreeing – is not limited to bioelectric magnetics but rather it is a general problem in toxicity, it is a general problem in biology. … Let us take drug X, whose name is not important. We ask this question: does this drug induce deformed limbs in Norway rats? The results are as follows. In one set of experiments, those treated with the drug show 60 percent deformed limbs, those untreated eight per cent. You have to conclude from that

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30 *Proof Committee Hansard*, Canberra, 2 March 2001, p 317 [Moulder]; See also *Official Committee Hansard*, Canberra. 31 August 2000, p 4 [Repacholi]; *Official Committee Hansard*, Sydney, 16 November 2000, p 198 [Fist].

31 Dr Neil Cherry, Submission 146, p 6.

32 *Proof Committee Hansard*, Canberra, 2 March 2001, p 332 [Cherry].

> experiment that this drug is a teratogen, that is to say it causes abnormal embryos. … This is not a story, this is a publication.
>
> The difference between these experiments is that they were both using Norway rats, but there are all kinds of Norway rats – just like we are all people but we are genetically enormously different, and we are genetically enormously different in our susceptibility to various kinds of stress. So even though you go out and buy these rats that does not mean you have identical rats. The drug that was used in this experiment was called thalidomide, which, as you well know, was an enormous disaster. It was a disaster because it was only studied in one strain and was not studied in the other.
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> The difference in genetic susceptibility of the test animals was never taken into account, and this experiment was only done after 10,000 children were born without limbs. So this lack of replication does not mean that there is no scientific validity. It means that science is complicated; it means that biology is complicated, and that the human system is complicated – and even rats are complicated.[33]

2.27 Professor Litovitz also cited an experiment in the US in which six laboratories with identical equipment tested chick embryos to see if magnetic fields caused abnormalities:

> … When these six laboratories' results came back, two said yes, two said absolutely no, and four said, 'We might see something.' … Six months later we made a measurement again and found no effect. … As we went through the three-year period, we found an enormous genetic compound in the response of chick embryos to electromagnetic fields. … It is not that you [the laboratory] did something wrong; it is the genetics. They were working with different genetic material.[34]

2.28 The Committee queried whether the Vernon-Roberts study (see *Australian research* below) could be considered a true replication of the 1997 Adelaide mouse study, given the modifications that have been made to the original methodology. Dr Repacholi, from the World Health Organization and member of the Adelaide mouse study team advised:

> … in initial studies they may have done something that is not particularly helpful or there is a better way of doing it. If the result is a true result it should still occur in the animal. There is no reason to expect that you are still exposing the animal to radiofrequency fields using the same pulsing regimes, maybe different times, different orientations, but if there is going to be an effect it should still occur. We were very careful in reviewing the follow-up study in Adelaide, and there is another study being done in

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33 *Official Committee Hansard*, Melbourne, 22 September 2000, pp 145-146 [Litovitz].

34 *Official Committee Hansard*, Melbourne, 22 September 2000, p 146 [Litovitz].

> Europe, to make sure that, yes, what was done in the original study is going to be either confirmed or not confirmed in these studies.[35]

2.29 In referring to the Adelaide mouse confirmation study, Dr Thomas Magnussen, CEO of the EMX Corporation, said:

> … but there are significant differences between the two experiments. For instance, Repacholi's first experiment ran for 18 months. The new one is going to run for 24 months. The way the animals are exposed is quite different in the two experiments. The genetics can never be the same. When we are talking about biological experiments, it is virtually impossible to make a replication.[36]

2.30 The Consumers' Telecommunications Network commented that there was insufficient evidence to conclude that there are no potential health risks associated with radiofrequency radiation.[37]

2.31 Dr Black said that in science it is impossible to prove a negative, and thus it will not be possible to claim that there are no health effects, only that the evidence suggests that such a scenario would be highly unlikely, as illustrated by the following statements:

> … it is frequently stated by people who are concerned that the application of [radiofrequency] technology should not proceed until there is proof of the absence of any adverse effect. The answer to this can only be that there will never be such proof about RF, or for that matter anything else …
>
> It is also equally true that it is theoretically impossible to provide absolute unarguable proof of an association.
>
> The only conclusion which can be drawn from an understanding of the principles of epidemiology and of the assessment of scientific data is that whilst it is possible to prove an association with substantial and convincing certainty, it is impossible to prove an absence of an association in such a compelling way.[38]

2.32 Before outlining the research that is currently under-way both in Australia and overseas into electromagnetic radiation and its effects as it relates to telecommunications equipment, this section summarises what is known so far about the biological and health effects of electromagnetic radiation.

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35 *Official Committee Hansard*, Canberra, 31 August 2000, p 11 [Repacholi].

36 *Official Committee Hansard*, Melbourne, 22 September 2000, p 152 [Magnussen].

37 *Official Committee Hansard*, Sydney, 16 November 2000, p 213 [Consumers' Telecommunications Network].

38 Dr David Black, Submission 93, pp 21-22. See also *Proof Committee Hansard*, Canberra, 2 March 2001, pp 322-333 [Moulder]; *Official Committee Hansard*, Canberra, 31 August 2000, p 4 [Repacholi].

2.33 Expert reviews referred to at the beginning of this chapter have relied upon existing literature and a number of witnesses have concluded from scientific abstracts that there are potential health effects of EMR.

2.34 Mr Stewart Fist, journalist, claims to have the largest website collection of abstracts of scientific research publications and says that about 60 per cent of them show effects from non-ionising radiation.[39]

2.35 The World Health Organization website includes a database of current and published research into the biological and health effects of radiofrequency radiation.[40]

2.36 Some witnesses expressed the view that while this information is a valuable resource in understanding the science, it was an inadequate substitute for a working knowledge of the material. The CSIRO's submission to this inquiry commented on its own limitations in relying on research by others:

> CSIRO is maintaining a watching brief, although it appreciates the limitations of attempting to evaluate research without the benefit of involvement and participation. Independent, authoritative scientific information is provided in response to enquiries from Government and the community.
>
> The absence of involvement in scientific research into biological effects of EMR is a recognised limitation in any assessment of the state of research. It is only possible to fully understand the complexities of sophisticated biological procedures through experience gained from working at the bench. Unfortunately, this level of expertise and understanding is lacking, or indeed absent, in many of the participants of committees or working groups that try to make assessments of the veracity of scientific research.[41]

Is the scientific evidence inconclusive?

2.37 The most recent expert reviews of the relevant electromagnetic radiation literature suggest that the results in this area are inconclusive.[42]

2.38 Industry submissions generally argued too that the science was inconclusive. Hutchison Telecommunications, said in its submission:

> … the world's leading experts and key health advisory bodies state that there is no substantiated evidence to suggest a link between the use of

39 *Official Committee Hansard*, Sydney, 16 November 2000, p 193 [Fist].

40 See who.int/peh-emf/database.htm

41 CSIRO, Submission 95, p 7.

42 See above, para 2.6.

> mobile phones and long term public health risks, but we acknowledge there is public concern on this issue.[43]

2.39 Nokia Mobile Phones, Australia, said:

> … a substantial amount of scientific research conducted all over the world over many years, demonstrates that radio signals within established safety levels emitted from mobile telephone[s] and their base stations present no adverse effects to human health.[44]

2.40 Motorola Australia, said:

> … the scientific evidence does not demonstrate a risk to public health from wireless phones.[45]

2.41 In his submission, Mr Neil Boucher, said:

> Most of the 'research' that has been carried out on the health effects of electromagnetism are top down studies. That is people are assembled, with largely medical and statistical qualifications (and usually with little or no knowledge of electromagnetism itself), to look for epidemiological evidence of some health effect. The fact that nothing conclusive has been found to date testifies both to the relative insignificance of any effect (if it exists) and to the futility of the methods employed.[46]

2.42 The Australian Communications Authority (ACA) submitted that radiofrequency devices that operate in accordance with recognised human exposure standards do not pose a health risk.[47]

2.43 The Committee notes the observations in the Stewart Report:

> We were struck by certain inconsistencies and inadequacies in the scientific literature on the biological effects of RF radiation. Many studies in this field have been exploratory and preliminary in nature, and claims of effects have sometimes been based on single experiments rather than a consistent series of hypothesis-driven investigations. In some cases, study design and statistical analysis have been inadequate, and apparent effects may have been artefactual or due to random variation. Indeed, the field is troubled by failures to replicate previous studies and by a lack of theoretical explanation of some effects that have been claimed. There may also be biases arising from selective publication and non-publication of results.

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43 Hutchison Telecommunications, Submission 91, p 1.

44 Nokia Mobile Phones, Australia, Submission 68, p 1.

45 Motorola Australia, Submission 78, p 1.

46 Mr Neil Boucher, Submission 118, p 2.

47 ACA, Submission 100, p 2.

> Finally, even for effects that appear to be well substantiated, the biological significance and the implications for health are often unclear.[48]

2.44 Not all witnesses were of the view that the evidence was inconclusive. Dr Neil Cherry told the Committee that his work in preparing for a tribunal hearing for the first mobile phone base station in NZ in 1995 had led him to examine epidemiological and biological research from around the world:

> I was very surprised there is so much published evidence in reputable, peer review journals that has not been sighted, summarised or integrated. The more I received the more solid the evidence seemed to be and the more consistent it seemed to be. And so when I heard people saying that the evidence was weak and inconsistent, I decided I should debate this with people and go to conferences and talk to them about it. … This culminated, I believe, in a climax last year at the conference at the European Parliament where I was asked to look particularly at low level effects and epidemiological studies with those response relationships of low level effects. … Over 20 studies show that radiofrequency microwave radiation damages the genes, damages the chromosomes, damages the DNA, and therefore indicates genotoxicity. I am also aware that many studies only use small samples – they are epidemiological studies or laboratory samples. They find elevated levels but they are not specifically significant and they are often described as showing no effects. But I have supplied with my evidence a summary of brain tumour studies, and I have characterised them as studies showing elevated effects, studies showing significantly elevated effects and studies showing dose response effects. And that is a classical way, I believe, at looking at the evidence trail and asking: was it elevated, was it significantly elevated and have we found dose response elevation? …
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> … Following those principles, I come to totally different conclusions than Dr Moulder, Dr Black, Dr Elwood and Dr Repacholi.[49]

2.45 Mrs McLean of Electromagnetic Radiation Alliance of Australia (EMRAA), said that many studies are showing a range of effects, including brain tumours, leukaemia, heart problems, neurological problems, neuro-degenerative diseases, breast cancer and affects on the immune system, as well as affecting melatonin levels, enzymes, hormones, genes and signal transduction in cells[50]. These are discussed later in this chapter.

Anecdotal and non-peer-reviewed evidence

2.46 A number of submissions to this inquiry referred anecdotally to cases of brain tumours,[51] headaches,[52] hyperactivity in children and nausea,[53] skin growths

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48 Stewart Report, p 47.

49 *Proof Committee Hansard*, Canberra, 2 March 2001, pp 329-330 [Cherry].

50 *Official Committee Hansard*, Sydney, 16 November 2000, p 240 [EMRAA].

51 Ms Marie Kougellis, Submission 1, p 1; Mrs PR Richards, Submission 49, p 1.

protruding from the ear against which the mobile phone was held,[54] chronic fatigue,[55] nose bleeds,[56] and other health effects,[57] which they linked to mobile phone use.

2.47 Submissions also noted that expert panels, such as the Independent Expert Group on Mobile Phones (the Stewart Group), had been presented with anecdotal evidence of adverse health effects from mobile phones and their base stations, which were claimed to be related to non-thermal effects of radiofrequency radiation.[58] Reference was also made to reports of 'microwave sickness' from mobile phones, including headaches, fatigue, impotence, blood pressure changes, chest pain and sleep disturbance.[59] One submission raised the possibility of a link between legionnaires disease outbreaks with the presence of mobile phone towers and high voltage power lines in the vicinity of cooling towers.[60]

2.48 The Committee notes the conclusions of the Royal Society of Canada Report:

> Headache and fatigue are nonspecific symptoms. … Headache is not an indicator of 'brain activity' and in general headaches occur in the absence of structural abnormalities of either the brain or the blood-brain barrier. … Although there is need to consider the possibility of [microwave-induced] symptoms such as headache and fatigue, existing data do not support the conclusion that [microwave fields] can induce headaches.[61]
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> The panel did not find persuasive evidence of the existence of radiofrequency radiation sickness syndrome, however, some individuals may be able to sense when they are exposed to radiofrequency fields.[62]

2.49 The Report recommended further research into this area.

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52 Mr Walter Kosterke, Submission 2, pp 1-2; Mr Donald Adams, Submission 28, p 1; Ms Gillian Summerbell, Submission 62, p 1.

53 Mr Walter Kosterke, Submission 2, pp 1-2.

54 Mr Joe Friend, Submission 17, p 2.

55 Ms Gillian Summerbell, Submission 62, p 1; Ms Ruth Parnell, Submission 94, p 2; Mr Don Maisch, Submission 20, p 24.

56 Ms Maria Selva, Submission 131, p 1.

57 Ms Dalana MCaren, Submission 22, p 3; Mrs PR Richards, Submission 49, p 1; EMRAA, Submission 80, p 15; Ms Diane Beaumont, Submission 138, p 8; Electromagnetic Awareness Network, Submission 142, p 2; Mr Don Maisch, Submission 20, pp 26-30.

58 Holroyd City Council, Submission 44, p 2.

59 Community and Public Sector Union (CPSU), Submission 110, p 2. See also Mr Don Maisch, Submission 20, p 67; ACTU, Submission 89, p 8.

60 Mr Roger M Lilley, Submission 85, pp 3-4. See also Ms Diane Beaumont, Submission 138, pp 24-25 re links between wireless telecommunication and increases in legionnaires disease and other conditions.

61 Royal Society of Canada Report, p 101.

62 Royal Society of Canada Report, pp 104-105.

2.50 While the EMR Safety Network International argued that anecdotal evidence should be heeded,[63] Dr Repacholi argued that this type of evidence is more valuable in establishing a hypothesis, rather than as proof of causal effect:

> When reviewing the scientific literature, only independently confirmed effects can be considered when assessing health risk. For establishing research needs, effects which have not been confirmed, but are possible and could have implications for health, should be considered because they may ultimately be established.[64]

2.51 The Committee notes that the Stewart Group included evidence from sources other than peer-reviewed scientific journals as part of its assessment of the potential health risks associated with exposure to radiofrequency fields.[65] The Committee was advised that material that has not been peer-reviewed can suffer from several shortcomings, including deficiencies in methodology, analysis and conclusions.

2.52 Dr Repacholi said that the quality of peer review can vary and that the results of many studies need to be compared and evaluated before a conclusion can be drawn.[66]

2.53 Dr John Moulder mentioned difficulties in selecting suitable independent candidates to undertake peer review, particularly in small and highly specialised fields such as dosimetry:

> What I do is look for people who are involved in the specific field but who have no direct connections, either positive or negative, with the authors of the study. Sometimes that is in fact impossible. I will explain what I would do if I could not find the perfect person by taking the example of radiofrequency radiation and cancer in animals. If everybody who is in that field is conflicted, I might look for someone who is an expert in RF dosimetry, even though they knew nothing about cancer, and then look for someone who was into carcinogenesis in animal models, even if they knew nothing about radiofrequency radiation, and then possibly back that up with a statistician who would not necessarily be familiar with either, but statistics is statistics.[67]

Publication and research bias

2.54 Dr David Black, in his submission, also drew the Committee's attention to what he described as 'publication bias', whereby journals may prefer to publish a paper where the study has produced 'novel' results rather than one 'simply reiterating

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63 The EMR Safety Network International, Submission 111, p 4.

64 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol. 4, p 822.

65 Stewart Report, p 40.

66 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 809. See also AMTA, Submission 19, p 4.

67 *Proof Committee Hansard*, Canberra, 2 March 2001, p 316 [Moulder].

a well accepted status quo'. A similar bias was suggested in relation to difficulties in attracting funding for studies considered 'likely to be simply reiterating well established fact', and that these two biases need to be considered when undertaking a literature survey.[68] The Committee also notes the comments of Dr Stan Barnett, CSIRO:

> One of the biggest difficulties that we have in this particular area of research is that there are all sorts of biases in research generally. That is a given. You have to take adequate controls to make sure that you do not allow those biases – the experimental biases, the observer biases and the biases in the statistical analysis program that you use. All of those things are biases which researchers are familiar with and which we understand … but before you even start the research one of the biggest biases that exists generally is that of selection bias. … Selection bias is simply that the person who has the money … has the resources and therefore has the ability to select, firstly, the type of research that they want to spend their money on; secondly, the facility where they would like to have it done … and, thirdly, they can select whomever they wish to do that research, whether it is somebody who has the necessary experience in the area or somebody who has a high profile. There may be issues other than the essential science that determine the selection of the research that is undertaken.[69]

2.55 Concerns raised about the difficulties in obtaining funding for replication studies are referred to in Chapter 3.

Biological effects

2.56 A number of studies have linked exposure to electromagnetic radiation with a range of biological and health conditions including: high blood pressure in humans; severe depression of the immunological and endocrinological responses of young chickens; increases in the permeability of the blood-brain barrier; calcium efflux from brain tissue; effects on the dopamine-opiate system considered to be involved in headaches; influences on epileptic activity; and increases in the mortality of chick embryos. Studies have also found evidence of chromosome aberrations and increases in double and single strand DNA breakages, and increases in the promotion of certain cancers in genetically predisposed mice.[70]

2.57 Biological effects that have been specifically linked to radiofrequencies include changes to calcium ion mobility in the brains of cats and rabbits as well as

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68 Dr David Black, Submission 93, p 20.

69 *Official Committee Hansard*, Sydney, 16 November 2000, pp 229-230 [CSIRO].

70 The EMR Safety Network International, Submission 111, Attachment 3. See also, for example, Mr Robert C Green, Submission 134; Committee on Electromagnetic Energy Public Health Issues (CEMEPHI), Submission 127, p 9.

isolated cells and tissues, changes to the proliferation rate of cells, alterations to enzyme activity, and affects on genes.[71]

The search for a mechanism

2.58 Various mechanisms have been proposed for the way in which radiofrequency fields interact with biological systems, generally involving the induction of movement of molecules.

2.59 Professor Philip Jennings, referred to ferrimagnetic material in human tissue with possible implications for the interaction between electromagnetic radiation, particularly extremely low frequencies, and biological systems.[72]

2.60 Professor Litovitz said:

> There are those who believe that only heat can cause an effect and there are those who believe otherwise, whose experiments suggest that it takes only a signal to a cell to cause the cell to do something. The cell has its own energy; you supply the trigger and the cell proceeds to produce enzymes and proteins, et cetera. … Let us look at the example of garage door openers … You are in your car and you press this and your garage door opens. The question is: can you believe that this supplied the energy for the garage door to open? Was it this that supplied the energy for that motor to pick up the garage door? We are saying no. We are saying that this is a signal that turned on the energy to the motor. That is the similarity, that is what athermal effects are all about: cells receive a signal and turn on the engine inside the cell which produces proteins, which produces enzymes necessary for survival.
>
> We have studied in detail the target of the EMF and we now know the number of milliseconds that it takes the cell to be able to say there is a field there. … It is well known in biology that this information goes to a process called signal transduction on the surface of the cell or receptors. They say something and send a signal to the nucleus, which proceeds to undergo various biochemical processes. This takes seconds.[73]
>
> … We are now working on a possible mechanism which relates EM field exposure to health effects. We find that EM fields alter the levels of protective proteins. It turns out that the major effort in my lab today is to use these non-thermal effects to protect against damage due to heart attacks, to treat cancer and to treat inflammation. These non-thermal effects are remarkably useful, and will be useful in the next few years, in therapy. The question is: when are they therapeutic and when might they be harmful?

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71 WHO Fact Sheet No 193, *Electromagnetic Fields and Public Health: Mobile Telephones and their Base Stations*, May 1998, p 1, included in The World Health Organization, Submission 56, Volume 4, p 790.

72 Professor Philip Jennings, Submission 122, Submission Vol 9, p 1872.

73 *Official Committee Hansard*, Melbourne, 22 September 2000, p 147 [Litovitz].

> … You have a protein that works, you come in with a electromagnetic field stressor, the protein is damaged and unfolded, nature produces protective proteins, goes in and refolds the protein and repairs the damage. This is one of the most exciting discoveries in the past 30 years in medicine. These protective proteins, these stress proteins, are being studied by almost every pharmaceutical company in the country because of their potential, because they are the basic repair mechanisms … and we have found that EM fields can modify the amount of protective proteins that you have. I say 'we' – there is a minimum of four, and I think it is five, labs that have replicated the concept that EM fields can affect protective proteins. …[74]
>
> There is a theory now that these protective proteins are related to Alzheimer's and that a reduction in protective proteins means a greater probability of Alzheimer's. This is a theory which we have not tested, but there is data out there that appears to relate the incidence of Alzheimer's to exposure to electromagnetic fields. … We cannot necessarily say that there is a health effect, but we can say that mechanisms exist for potential health effects.[75]

2.61 Dr Peter French drew a link between evidence of the role of heat shock proteins in cancer and mobile phones:

> In plain English, the point is that it has been demonstrated by several researchers that increasing the amount of heat shock proteins in cells results in the increased potential for developing tumours, increased stimulation of metastasis or spread of cancers, the direct development of cancer, de novo, and the decreased effectiveness of anti-cancer drugs. Any one of these outcomes is obviously undesirable, but there is, within the heat shock protein and medical research literature, evidence for each of these statements.
>
> … where are we with the mobile phone cancer link? This is a summary of this part of my presentation. A mobile phone user will experience energy from the radiation of the phone going into the brain. That can induce some physiological effects, as has been published by Krause et al, but, importantly, it can potentially induce the heat shock response in the brain which can lead to the turning on of heat shock proteins. For a single event that is fine, because that is the body responding defensively. Normally it takes four to eight hours for the protein machinery to work after the protein machinery has been activated. It takes from four to eight hours for the proteins to be secreted, to be made and then ultimately they disappear if they are not needed. If you continually use a mobile phone, you can imagine that the heat shock proteins would be chronically induced, similar to the over-expression studies which have been described. Continued regular mobile phone use can result in chronic expression of heat shock proteins, which can lead to – from those findings which are referenced there – increased

74 *Official Committee Hansard*, Melbourne, 22 September 2000, p 150 [Litovitz].

75 *Official Committee Hansard*, Melbourne, 22 September 2000, p 154 [Litovitz].

> metastasis, initiation and promotion of cancer and resistance to anti-cancer drugs.
>
> I am not saying mobile phones cause cancer. I am saying that this is a pathway – which is founded on solid, peer reviewed international science – which provides a mechanism whereby mobile phone radiation could lead to cancer. Given that that is the case, then I would contend that some action is needed. If this is a possibility, then clearly research is needed to determine whether in fact heat shock proteins are being induced in the brains of mobile phone users; furthermore, we do not need to wait 30 years until that bottom line is confirmed. …
>
> … The link has been made by me. Having said that, the mechanism by which microwaves may cause protein unfolding, leading to the heat shock response, has not yet been determined, and there are a couple of possibilities. De Pomerai's group says that there may be a resonance of the microwave field with the protein or with the water. We have published, and it is in the written submission, a hypothesis paper in the *Journal of Theoretical Biology* which advances those two possibilities as well, for attributing low power as another stressor to activate the heat shock response.[76]

2.62 Associate Professor Olle Johansson from the Karolinska Institutet in Sweden, in discussing the health effects of visual display units, referred to the role of mast cells as a possible mechanism:

> Here in Sweden, the problems around different types of electromagnetic devices arose with the introduction of radio in the twenties and thirties but it was much more evident in the late seventies. When the PC explosion came, all the offices were turned into computer based systems and people were sitting all day long in front of visual display terminals of different types. At the end of the seventies and at the beginning of the eighties, a growing number of people complained of different symptoms, especially from their face, on their neck, arms and hands after they had been sitting in front of these visual display terminals. From the very beginning, it was not understood what was going on, but people were searching around in the working environment for different explanations. Very soon, the ideas focused upon the radiation from the visual display terminals. With respect to the symptoms, one could mention, for instance, skin problems, facial burning, redness, dry skin, facial heat, swelling, tingling sensations and even blisters. Also, it was connected with feelings of fatigue and headaches, and memory losses were claimed et cetera. Of course, as scientists we tried to understand the symptoms.
>
> … In the last years, the focus has been much more on different high frequency devices, which of course include modern computer screens but also include light tubes of high frequency, different kinds of

76 *Official Committee Hansard*, Sydney, 16 November 2000, pp 263-264 [French].

> telecommunications systems, such as wireless DEC telephones, different radio alarm based systems and, of course, mobile telephones. Parallel to this, a number of investigators – some among them having some very interesting data from Australia – have documented the results of experiments at the cellular and tissue level of different animals and humans which show the effects of, for instance, exposure to high frequency signals from mobile telephones. …
>
> … there are now more and more studies coming out pointing to possible mechanisms, from the cellular and molecular level, all the way up to more macroscopic events. Our working hypothesis is very simple actually. For instance, looking at human skin, both from patients claiming these kind of health problems and from normal healthy volunteers who have sat in front of visual display terminals, we see alterations in different cell types. For instance, the histamine contained in mast cells is identical to what you would see – and it is reported also in the literature – from other irradiation damage sources: for instance, from sunrays, X-rays and radioactivity. Our very simple and maybe naive working hypothesis that this irradiation damage is of a more long-term type compared to other more energetic irradiation damage.
>
> Of course, the molecular cell biochemistry machinery has to be worked out in detail and this work is, of course, going on. As I said before, in Australia, you have the research team around Peter French and his collaborators that has been studying these mast cells that have been irradiated using high frequency mobile telephone signals. From their studies, it is evident that these cells are affected. You then have to imagine what would happen if you have the same situation in a human being.[77]

2.63 Dr Cherry proposed another mechanism:

> … The early studies show that oscillating signals interfere with the brain very significantly and can change the EEG and can change the calcium ions, and these change reaction times. This is a classical physics approach of resonant absorption. If a system can oscillate and an oscillating signal comes in, it can resonantly be absorbed. It is what an aerial does, it is what a cell phone does, it is what is used in telecommunications, … It has been demonstrated in many laboratories that it actually does occur.[78]

2.64 But according to Dr John Moulder, in order to induce a biological change, 'radio-frequency radiation must deposit enough energy to significantly alter some biological structure'.[79]

2.65 In noting some of the current hypotheses about possible biological interactions, Dr Repacholi stated:

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77 *Official Committee Hansard*, Canberra, 7 November 2000, pp 187-188 [Johansson].

78 *Proof Committee Hansard*, Canberra, 2 March 2001, p 332 [Cherry].

79 Dr John Moulder, Submission 60, p 16.

> These RF field-induced alterations, if they occur, could be anticipated to cause a wide variety of physiological changes in living cells that are only poorly understood at the present time.[80]

2.66 While observing that thermal effects may account for positive results, the Stewart Report considered that reports of epigenetic effects should be taken seriously and further research undertaken.[81]

2.67 The Committee notes that a number of studies cited in submissions as providing evidence of biological or adverse health effects relate to extremely low frequency (ELF) exposure. Areas of similarity between the effects of radiofrequency radiation and extremely low frequencies include effects on calcium efflux, ODC[82] activity and behaviour associated with the opioid system. The Royal Society of Canada Expert Panel suggested that 'many of the efforts now underway to understand the mechanism associated with ELF effects could be used to investigate the mechanisms by which ELF-modulated RF fields elicit non-thermal effects'.[83]

2.68 The importance of determining the biological mechanism(s) responsible for any observed effects, particularly in relation to the setting of safety standards, was highlighted by the CSIRO:

> … it is generally agreed by various expert panels that research on mechanisms of interaction is essential. Without an understanding of how low energy RF fields cause these biological effects, it is difficult to establish safety limits particularly for non-thermal levels.[84]

How important is it to distinguish between frequencies?

2.69 Dr Moulder argued for the need to clearly distinguish between the evidence for adverse health effects from exposure to radiofrequency radiation as opposed to extremely low frequencies (ELF). The applicability of ELF research to radiofrequency exposure was referred to by EMF South World Pty Ltd:

> … observed bioeffects induced by mobile phone microwave radiation[85] are remarkably similar to bioeffects induced by power-line frequency EMF.[86] This means that two decades of epidemiological data on power-line frequency EMF can be used in the debate on potential health effects of

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80 Repacholi, 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 814.

81 Stewart Report, p 76. A similar comment was made in relation to ELF. See Royal Society of Canada Report, p 42, which states: 'The potential additive or synergistic responses between various environmental hazards need to be considered in assessing the risks of ELF exposure'.

82 An enzyme, ornithine decarboxylase. See para 2.82.

83 Royal Society of Canada Report, pp 47, 98.

84 CSIRO, Submission 95, p 11.

85 That is, radiofrequency radiation, as used in this report – see Chapter 1.

86 Electromagnetic field.

> mobile phone radiation, on which there is virtually no epidemiological data.[87]

2.70 Dr Moulder advised that it was not appropriate to extrapolate the results of exposure to frequencies from different areas of the electromagnetic spectrum:

> … the biophysics of the interaction is completely different. I do not want to be absolutist … But, in general, if you want to understand the biological effects of radiofrequency radiation, you use radiofrequency radiation.[88]

2.71 Dr Moulder later added:

> In general … most of the effects of radiofrequency radiation that we know of are not strongly dependent on frequency … But the bigger the jump you make, the less certain you can be … if we finally concluded that radiofrequency radiation was safe enough for all practical purposes, that does not tell us whether powerline frequency is safe. … But, if you demonstrated that the frequencies used for FM and television were hazardous, then you would certainly worry about cell phone frequency. It would not prove it, but the closer together in frequency your information is, the more likely it is to be relevant.[89]

2.72 The Committee notes, however, the views expressed by Professor Philip Jennings, who stated:

> Our society's experience with ionising radiation should persuade us to take great care … The original standard set for ionising radiation protection … has proven to be quite inappropriate and as further research has been performed and evaluated the public limit has been reduced by nearly a factor of a thousand. This could also happen with EMR. We are still in the infancy of EMR research and we should learn from the mistakes we made with ionising radiation and introduce a principle of prudent avoidance or ALARA'.[90]

2.73 Professor Litovitz argued that:

> The cell's characteristic response to a mobile phone is the same as that to a power line. This was beautiful for us, because it meant that all the data out there on powerline problems could be translated to the data on cell phone or mobile phone problems. That is to say, you could put them together to try to understand what is going on.[91]

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87 EMF South World Pty Ltd, Submission 129, p 2.

88 *Proof Committee Hansard*, Canberra, 2 March 2001, p 318 [Moulder].

89 *Proof Committee Hansard*, Canberra, 2 March 2001, pp 323-324 [Moulder].

90 Professor Philip Jennings, Submission 122, p 1.

91 *Official Committee Hansard*, Melbourne, 22 September 2000, p.148 [Litovitz].

2.74 Many of the studies cited during this inquiry relate to extremely low frequency (primarily 50/60Hz) exposure, which report observed effects on the reproductive system, blood changes, ECG[92], heart rate, blood pressure and body temperature, melatonin and cancer.[93] Studies have also been conducted into the health implications of exposure to radars, which operate at radiofrequencies ranging from 300 MHz to 15 GHz.

2.75 Submissions and evidence to this inquiry have referred to biological and health effects associated with powerlines, radio and television towers and video display units (see below); however, this inquiry is concerned with electromagnetic radiation associated with telecommunications technologies.

2.76 Dr Neil Cherry reported in his submission that:

> Ten epidemiological studies have found significant miscarriage from EMR exposure across the spectrum from ELF, SW, to RF/MW. The Scandinavian physiotherapist studies, Kallén et al. (1982) and Larsen et al. (1991) also found significant prematurity, congenital malformation, still birth and cot death. Ouellet-Hellstrom and Stewart (1993) confirm the causal relationship with a highly significant dose-response relationship.[94]

2.77 Dr Cherry said it was also important to note that if an effect is seen with low frequency signals, such as an ELF 50 Hz or 60 Hz signal, or the Schumann Resonance ELF signals, then it is more likely and likely to be worse for modulated or pulsed RF/MW:

> This is because an ELF signal has a very long wavelength and generally passes easily right through the body. Unless there is a resonant oscillator, such as for the Schumann Resonances, it induces quite small fields in the body. On the other hand the RF/MW signals have wavelengths closer to the dimensions of bodies and body parts, they are more strongly absorbed in human bodies through the aerial effect.[95]

2.78 The Committee notes that the World Health Organization draws a distinction between radio and TV broadcasting and telecommunications facilities. While for the most part the Committee has confined its comments to telecommunications technologies, in acknowledgment of concerns raised in relation to electromagnetic radiation generally, the Committee has digressed into other frequency ranges and technological applications in its review.

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92 Electrocardiogram.

93 WHO Fact Sheet No 201, *Electromagnetic Fields and Public Health: Extremely Low Frequency (ELF) Electromagnetic Fields*, August 1998, pp 3-4, included in The World Health Organization, Submission 56, Volume 4, p 777-778.

94 Dr Neil Cherry, Submission 146, p 13.

95 Dr Neil Cherry, Submission 146, p 14.

Observed biological and health effects of radiofrequency radiation

Movement of substances across cell membranes

2.79 Studies have examined the effect of radiofrequency radiation on the movement of substances across cell membranes. The role of calcium in the functioning of brain and other cells has prompted research into calcium movement in brain tissue. While some studies have shown that low levels of RF exposure cause an increase in calcium efflux from brain tissue, according to the Stewart Report results are contradictory, and evidence of an amplitude modulated response at extremely low frequencies does not appear to be relevant to mobile phone technology, 'where the amplitude modulation within the critical frequency band is very small'.[96] The Stewart Report further concluded that '[i]f such effects occur as a result of exposure to mobile phones, their implications for cell function are unclear and no obvious health risk has been suggested. Nevertheless, as a precautionary measure, amplitude modulation around 16 Hz should be avoided, if possible, in future developments in signal coding'.[97]

Exciting neurons

2.80 The Stewart Report found evidence that exposure to high intensity radiofrequency fields, sufficient to result in a temperature rise in tissue, can reduce the excitability of neurons. However, exposure at non-thermal levels does not appear to have an effect.[98]

2.81 It also reported that various studies have examined the potential of radiofrequency radiation to affect gene expression and produced inconsistent results. While the well publicised study showing an increase in the lifecycle of nematodes may be suggestive of a non-thermal effect, the report said that there was little evidence to support the proposition that mobile phone radiation causes a stress response in mammalian cells.

ODC activation

2.82 The enzyme ornithine decarboxylase (ODC) plays a role in the synthesis of polyamines which can trigger DNA synthesis, cell growth and cell differentiation. Activation of ODC has been related to the late, 'promotional' phase of cancer production, which is usually (but not always) correlated with an increase in the rate of cell division in the affected tissue. Again, the results of studies examining the effects of radiofrequency radiation on ODC activity have been mixed. Positive findings do not indicate an obvious pattern of dose-response or reveal a mechanism to explain the changes. The Stewart Report noted that although all carcinogenic factors stimulate

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96 Stewart Report, pp 50-51.

97 Stewart Report, pp 50-51. The Royal Society of Canada Report states: 'ELF-modulated RF radiation may effect [calcium] efflux from brain tissue' (p 36).

98 Stewart Report, p 52.

ODC, not all stimuli that increase ODC activity promote cancer, and said it was unlikely that the small increases observed from exposure to pulse-modulated radiofrequency fields could, on their own, have a tumour-promoting effect.[99]

2.83 The Royal Society of Canada Report states that:

> … the lack of major [cell] proliferative response in the tissue of cell line following ELF exposure does not necessarily mean that ELF is incapable of serving as a tumour promoter, particularly if alterations in ODC activity are involved …. It is possible that this small change in ODC activity brought about by ELF is unrelated to human cancer risk.[100]

2.84 The Report suggests that further research is warranted.

Heat-shock protein response

2.85 Dr Peter French indicated that the heat-shock protein response which is activated by external stressors such as chemicals, heavy metals, drugs and radiofrequency radiation has been shown in a separate study to be causally linked to cancer formation. Other research submitted by Dr French suggested a link between RF exposure, cell changes and gene transduction.

Melatonin production

2.86 Submissions referred to studies that had shown that extremely low frequency (ELF) electromagnetic fields reduce melatonin production by the pineal gland, and the magnetic fields prevent melatonin from inhibiting the development of breast cancer.[101] Circulating levels of this hormone have a strong circadian rhythm with melatonin levels peaking in humans at night. Melatonin affects the mammalian reproductive system as well as other physiological and biochemical functions.[102] While it may be hypothesised that similar effects may result from exposure to radiofrequency radiation, the Royal Society of Canada Report said that additional research is required to test the effects of RF radiation on pineal function, circulating melatonin levels, and the utilization of melatonin by target cells and tissues.[103]

2.87 Dr Cherry cited a study from Switzerland on the Schwarzenberg tower:

> … They were sampling melatonin before and after the tower was permanently turned off and they found a significant rise in melatonin after the tower was turned off. They found a dose response increase in sleep

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99 Stewart Report, p 64.

100 Royal Society of Canada Report, pp 41-42. The Royal Society of Canada Report provides a detailed summary of ODC-related research at pp 36-42.

101 Mr Stan Stanfield, Submission 36, p 1. See also The EMR Safety Network International, Submission 111, Attachment 3.

102 Royal Society of Canada Report, p 42.

103 Royal Society of Canada Report, pp 42-43.

> disturbance. When the tower was turned off experimentally, the sleep quality improved and melatonin rose in animals.[104]

2.88 The Stewart Report commented that part of the brain and the gland involved in melatonin production are further from the surface of the head in humans than in animals and concluded that:

> … even if there were an effect on melatonin production in animals resulting from a direct interaction of fields within the brain, it would be much less likely to occur in people.[105]

2.89 In his submission, however, Dr Cherry claims that EMR reduces melatonin and enhances free radical activity in humans and that this is genotoxic, damaging the DNA and chromosomes, enhancing oncogene expression and transforming cells to neoplastic cells and causing cancer in exposed populations.

> We have natural EMR-based communication systems in our brains, hearts, cell and bodies. External natural and artificial EMR resonantly interacts with these communication systems altering hormone balances and damaging organs and cells. The brain and the heart are especially sensitive because they mediate and regulate primary biological functions that are vital to life, thinking and heart beat, using EMR signals, the EEG and ECG. When EMR interferes with the EEG this is communicated to the body by neurotransmitters and neurohormones, including the serotonin/melatonin system. EMR reduces melatonin. Melatonin is vital for the health of the Immune System, the Brain, The Heart and every cell, because it is the most potent naturally produced antioxidant. It is a potent free radical scavenger that plays a vital protective role to protect the DNA in every cell. Reduced melatonin causes cancer, miscarriage, heart disease, neurological diseases, viral and bacterial diseases, etc….[106]

2.90 In his submission, Dr Cherry says:

> Cancer is a chronic disease problem from accumulated genetic cell damage. Latencies for children and soft tissue cancers are as short as a few years, for most cancers they take 10 to 40 years to develop. Cancer rates rise rapidly with age over 65 years because of the life-time of accumulated cell damage and the drastic reduction in melatonin that occurs after puberty.[107]

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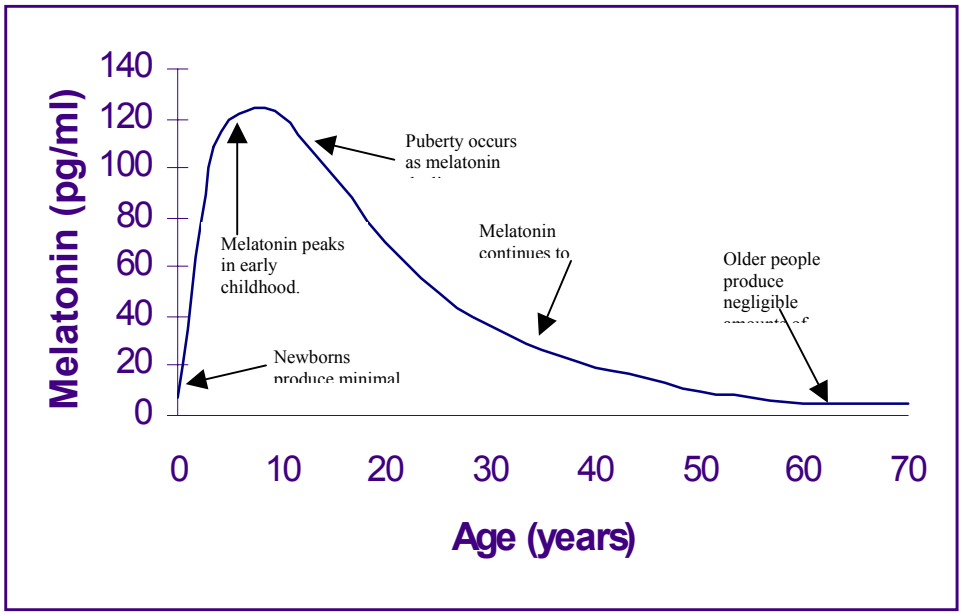
104 *Proof Committee Hansard*, Canberra, 2 March 2001, p 330 [Cherry].

105 Stewart Report, p 61.

106 Dr Neil Cherry, Submission 146, p 1.

107 Dr Neil Cherry, Submission 146, p 2.

Figure 1: Melatonin Production varies with age, Reiter & Robinson (1995)[108]



> This shows how vulnerable very young children are because they have very low melatonin levels and undeveloped immune systems. It also shows how reduced melatonin makes older people more vulnerable and much more prone to disease and cancer.[109]

2.91 Dr Cherry cited a large epidemiological study of female breast cancer over 24 states in the US which identified several organic solvents, including organochlorines, that significantly increased the incidence of breast cancer and which showed that radiofrequency fields were as dangerous as toxic chemicals and ionising radiation.[110]

108 Reproduced from Dr Neil Cherry, Submission 146, p 2.

109 Dr Neil Cherry, Submission 146, p 2.

110 Cantor *et al*, 1995.

Table 1: Breast cancer from occupational exposures, Cantor et al. (1995) [111]

Substance	Odds Ratio	95%Confidence Interval
Carbon Tetrachloride	1.13	1.1-1.2
Methylene chloride	1.15	1.1-1.2
Styrene	1.18	1.1-1.3
Metals and Oxides	1.13	1.0-1.3
Ionizing Radiation	1.14	0.9-1.4
Radiofrequency fields	1.15	1.1-1.2

2.92 Dr Cherry says this evidence is backed by more than 10 other studies showing that EMR across the spectrum increases breast cancer incidence and 15 studies showing reduced melatonin, including four with dose-response relationships:

> … These are sufficient to classify a causal relationship between EMR and breast cancer, with melatonin reduction [a]s the biological mechanism.[112]

2.93 Dr Cherry also cited studies which found that melatonin reduction can be a cause of miscarriage and that microwaves significantly increased the incidence of miscarriage in a dose-response manner in the first trimester and that very young babies are sensitive to variations in the natural EMR at extremely low levels:

> One of the most important single studies involved cot death (Sudden Infant Death Syndrome) in Ontario, Canada. O'Connor and Persinger (1997) were investigating the GMA melatonin hypothesis by seeing if a melatonin-related syndrome (SIDS) varied with GMA. They found that SIDS incidence significantly increased when GMA >30 nT and GMA <20 nT, - a homeostatic result. This confirms that GMA causes illness and death in vulnerable people, babies, and involves melatonin homeostasis.[113]

Blood brain barrier

2.94 A number of studies have examined the potential of radiofrequency radiation to affect the permeability of the blood-brain barrier.[114] While most studies have had negative results, one study did find an increased blood-brain permeability to albumin in RF irradiated rats. While it has been suggested that blood-brain barrier breakdown

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111 Reproduced from Dr Neil Cherry, Submission 146, p 3.

112 Dr Neil Cherry, Submission 146, p 3.

113 Dr Neil Cherry, Submission 146, p 13.

114 Barrier made up of small blood vessel and nerve tissue which limits the passage of certain substances between the blood and the brain.

following microwave radiation exposure may be due to thermal effects, some researchers have suggested that the disturbance may occur under 'power window' conditions where there may be a range of power intensities at which the barrier remains intact.[115]

2.95 The Stewart Report concluded that '[t]he available evidence for an effect of RF exposure on the blood-brain barrier is inconsistent and contradictory. Recent, well-conducted studies have not reported any effects'.[116] In contrast, the Royal Society of Canada Report stated that effects on the blood-brain barrier permeability, calcium efflux and ODC activity 'occur at exposures not thought to elicit thermal effects, [and] it is likely that these effects, even if they also occur at higher exposure levels, are non-thermal biological effects'.[117]

DNA

2.96 A number of studies also have examined the potential of radiofrequency fields to cause damage to DNA, and some have found no effects at non-thermal levels of exposure. While radiofrequency fields do not have sufficient energy to break chemical bonds or directly cause DNA strand breaks, several studies have shown an increase in breakages at non-thermal levels of exposure and chromosomal aberrations. Whilst these studies have not been replicated, they are 'confirmed' by the fact that they were similar and carried out in laboratories independent of each other.

2.97 According to Dr Cherry:

> The first identified study that showed that pulsed RF radiation cause significant chromosome aberrations was Heller and Teixeira-Pinto (1959). Garlic roots were exposed to 27 MHz pulsed at 80 to 180 Hz. for 5 mins. They were examined 24 hrs later. They concluded that this RF signal mimicked the chromosomal aberration produced by ionizing radiation and c-mitotic substances. No increased temperature was observed. …[118]
>
> Garaj-Vrhovac et al. (1990) noted the differences and similarities between the mutagenicity of microwaves and VCM (vinyl chloride monomer). They studied a group of workers who were exposed to 10 to 50 $\mu W/cm^2$ of radar produced microwaves. Some were also exposed to about 5 ppm of VCM, a known carcinogen. Exposure to each of these substances (microwaves and VCM) produced highly significant ($p<0.01$ to $p<0.001$) increases in Chromatid breaks, Chromosome breaks, acentric and dicentric breaks in human lymphocytes from blood taken from exposed workers. The results were consistent across two assays, a micronucleus test and chromosome aberration assay. Chromosome aberrations and micronuclei are

115 EC Report, p 54.

116 Stewart Report, p 60.

117 Royal Society of Canada Report, p 47.

118 Dr Neil Cherry, Submission 146, p 18.

> significantly higher than the controls, ($p<0.05$, $p<0.001$, $p<0.0001$), for each of the exposure intensity.[119]

2.98 Dr Cherry also drew the Committee's attention to studies done of staff in the US Embassy in Moscow that was chronically exposed to radar over a decade and found increased chromosome damage:

> … I have found more than 30 studies showing chromosome damage in people exposed to radiofrequency microwave radiation. This is far more than we have for benzine, which is a carcinogen.[120]

2.99 The results of genotoxic[121] studies were said by the Stewart Report to have been generally negative. Dr Cherry says the studies he cited in his submission show very strong evidence of genotoxic effects from RF/MW exposures and notes that when chromosomes are damaged, one of the primary protective measures is for the immune system natural killer cells to eliminate the damaged cells.

2.100 The Committee notes that the general public ICNIRP guideline for microwaves above 2 GHz is 1 mW/cm^2, and for workers is 5 mW/cm^2. Dr Cherry pointed out that the Garaj-Vrhovac *et al* (1991) study of Chinese hamster cells in an isothermal exposure system showed that even at exposures 100 times below the public exposure guideline a 60 minute exposure kills 28 per cent of the cells and 30 minutes kills 8 per cent of the cells.

2.101 Garaj-Vrhovac (1999) also found that 12 workers occupationally exposed to microwaves had significantly increased chromosome damage as well as disturbances in the distribution of cells over the first, second and third mitotic divisions.

2.102 Dr Stan Barnett in commenting on the CSIRO's unsuccessful proposals for NHMRC funding which was to look at cell response to radiation at specific periods in the cell division cycle, said:

> … One of the biggest failings of all cellular studies is that, largely, they either use highly transformed cell lines which are very sensitive to almost anything, or they use cell lines which are general laboratory, fairly robust cells like lymphocytes. Nobody bothers to try to synchronise the cells. It is well known in radiation biology that cells respond to radiation at specific periods in the cell division cycle. Our proposal was to use a fairly complex system which would allow us to use what we know as a radiation sensitive cell line and to synchronise it so that we only exposed it in G1, where we know – because of 30 years of background work – this particular cell is highly sensitive to radiation. It is deficient in DNA repair enzymes, and we know that, if you are going to produce any kind of impairment of DNA repair which would be manifest as single strand breaks as per the Henry Lai

119 Dr Neil Cherry, Submission 146, pp 18-19.

120 *Proof Committee Hansard*, Canberra, 2 March 2001, p 331 [Cherry].

121 Substances toxic to DNA.

> study, this would be an opportunity to use the most sensitive available end point that we know of to test that scenario.[122]

2.103 It is also the case that studies have shown an increase in the number of cells with micronuclei, the formation of which are considered to reflect DNA damage, after exposure to RF radiation. In spite of this, the Stewart Report concluded that implications for human health are unclear as normal tissue can also exhibit a high and variable incidence of micronuclei, making results difficult to interpret.[123]

2.104 Overall, while there have been numerous studies showing a range of biological effects, and while further research is required to satisfy the need to replicate positive results and to establish their implications for human health, the Committee Chair is persuaded that there is cause for concern.

Health effects discussed

2.105 Sleep disturbance, chronic fatigue, immune system impairment and learning difficulties have also been observed in radiofrequency exposed residential populations, and it has been argued that these effects are consistent with observed biological effects including calcium ion alteration and melatonin reduction. Various symptoms such as headaches, dizziness, feelings of discomfort, burning skin, which appear to be highly correlated with 'warm sensations' on and behind the ear against which the mobile phone is held, are described by Hocking (1998) and later observed in a survey of over 10,000 mobile phone users in Norway and Sweden.[124] There have also been newspaper reports of more epileptic seizures in a school since mobile phone use has increased.[125]

Cancer

2.106 Although the development and promotion of cancer ranks in the general public's mind as a real health risk associated with mobile phone and other telecommunications technologies, and indeed with other artificial sources of electromagnetic emissions, the scientific evidence for this association is said by many to be less definitive.

2.107 One area of contention is whether radiofrequency radiation initiates cancer or whether it may be implicated in the promotion of cancer.[126] While there is general

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122 *Official Committee Hansard*, Sydney, 16 November 2000, pp 225-226 [Barnett].

123 Stewart Report, p 73. See also the Royal Society of Canada Report, which concludes: 'The great majority of [laboratory] studies have failed to demonstrate genotoxic effects due to exposure to radiofrequency fields. … Overall, a number of different assays [technique for analysing something] for studying genotoxicity have failed to produce consistent positive findings regarding RF fields' (p 76).

124 The EMR Safety Network International, Submission No 111, Attachment 2.

125 The EMR Safety Network, Submission 111, Submission Vol 8, p 1718.

126 See Stewart Report, p 77, that concluded that RF exposure is unlikely to be a tumour initiator and that evidence of its effect on tumour progression is equivocal.

agreement that the energy in non-ionising radiation emitted by mobile telephones is unlikely to break chemical bonds, thereby inducing alterations in the genome,[127] Dr Cherry informed the Committee that in his view there is now sufficient evidence to show that EMR interacts and interferes with communication systems in our brains, hearts, cell and bodies through neurotransmitters and neurohormones, including the serotonin/melatonin system.

2.108 According to Dr Cherry, both through reducing melatonin and through enhancing free radical activity, EMR is genotoxic, damaging the DNA and chromosomes, enhancing oncogene expression and transforming cells to neoplastic cells and causing cancer in exposed populations.

2.109 The 1994 CSIRO report says:

> For any biological effect to become significant the body's homeostatic mechanism has to be overcome. Homeostatis uses cellular communications via molecules and ions to control the three basic functions of cells: proliferation, differentiation, and activation. Cancer promotion involves the disruption of cell-to-cell communication.[128]

2.110 There is more agreement and significant evidence to support non-ionising radiation as a cancer promoter.

2.111 Dr John Holt stated that cancer cells were three times as conductive of RF as non-cancer cells, and that non-ionising radiation rendered tumours more sensitive to ionising radiation.[129]

2.112 In its report of 1994, CSIRO said:

> However, because a promoting agent requires high doses, must continue for long periods of time, and is reversible, it has been argued that the risks from a promoting agent are less than the risks from an initiating agent.[130]

2.113 Most epidemiological studies[131] that have been published focussed on RF exposure not directly related to cellular phones, and provide primarily indirect evidence from occupational or amateur radio operator radiofrequency exposure, with exposures being 'more varied in dose, type of signal, and anatomical localisation than exposures from cellular telephones'. These studies had variable findings.[132]

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127 DNA.

128 CSIRO Report, p 85.

129 *Official Committee Hansard*, Canberra, 8 September 2000, pp 81-83 [Holt].

130 CSIRO Report, pp 85-86.

131 Human populations health studies.

132 Kenneth J Rothman, 'Epidemiological evidence on health risks of cellular telephones', *Lancet*, 2000, 356, pp 1837-1840 (Rothman, 2000).

2.114 Professor Mark Elwood, epidemiologist, concluded:

> … overall … I do not see any consistency in relationships between cancer and radiofrequencies. There are quite a lot of studies, so there are some positive results which require further assessment. The studies are limited by lack of information on exposure, lack of control for other factors and, in some studies, biases in the data. … Very often it is the weaker studies, with much smaller numbers and much weaker study designs, that tend to show unusual results, which therefore need testing. So, overall, my conclusion is that there is no consistent evidence relating radiofrequency exposures and cancer in humans, in terms of current research.[133]

2.115 The information provided by these studies is considered, by most reviews, to be of limited value because of inherent selection biases and because they incorporate exposure conditions dissimilar to those experienced from cellular phone use.

2.116 The Stewart Report notes that studies of brain cancer have provided 'inconsistent results'.[134] The Report also refers to studies of other types of cancer, concluding 'data on other types of cancer are more sparse and although some have suggested increased risks from RF exposure, their limitations are such that these findings should not be a cause for concern'.[135] Several studies published since the Stewart Report support this conclusion.[136]

2.117 The recent occupational study of Motorola employees is considered to have dealt with some of the shortcomings of earlier studies.[137] This extensive study of 195,775 Motorola employees between 1976 and 1996 found that for the nine per cent of employees that had experienced moderate to high levels of RF exposure, there was no increase in brain or lymphatic/haematopoietic[138] cancer mortality than either the general population or employees that had been exposed to lower levels of RF radiation.[139]

2.118 Professor Elwood, in his submission to the Committee, commented that the comparisons of employee mortality with general population mortality in this study were of limited value, but that the analyses of mortality between employees with different levels of exposure were more powerful.[140] His analyses revealed no

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133 *Official Committee Hansard*, Melbourne, 22 September 2000, p 143 [Elwood].

134 Stewart Report, p 96.

135 Stewart Report, p 96.

136 See Dr John Moulder, Submission 60A.

137 Although limitations to this study were noted by the authors.

138 Blood-related.

139 RW Morgan, MA Kelsh, K Zhao, KA Exuzides, S Herunger, W Negrete, 'Radiofrequency exposure and mortality from cancer of the brain and lymphatic/hematopoietic systems', *Epidemiology*, 11, pp 118-127, 2000 cited in Rothman, 2000.

140 Professor Mark Elwood, Submission 11, Submission Vol 1, p 47.

increased risk for cancers of the brain, all lymphatic and haemopoetic cancers, leukaemia, non-Hodgkin's lymphoma and Hodgkin's disease (although given the small numbers involved, a slight increase or decrease could not be discounted), nor for any general increased mortality risk.

2.119 Professor Elwood noted that an important finding of this study was the lack of association between degree of exposure and the incidence of the cancers studied, and that it also indicated no difference in overall specific risks between the men and women studied.[141] However, he advised:

> … even a study of this size cannot confidently exclude a modest increased risk of specific cancers which occur in relatively small numbers, although it can confidently exclude increases in total mortality or from major causes such as all cancers.[142]

2.120 In evidence to this Committee, Dr Peter French, Principal Scientific Officer, Centre for Immunology, St Vincent's Hospital, Sydney, advised that there was no 'definitive evidence' for a link between mobile phone radiation and cancer. However, he added that while there apparently was insufficient evidence on the surface, buried within the unsubstantiated assertions, fears, anecdotes and myriad of facts there were clues that point to a link between cancer and mobile phone emissions.[143]

2.121 Professor Elwood, on the other hand, concluded that based on an overall assessment of the research to date, there was 'no consistent evidence relating radiofrequency exposures and cancer in humans'.

> … the better studies … are the ones that show no association. Very often it is the weaker studies, with much smaller numbers and much weaker study designs, that tend to show unusual results which therefore need testing. So, overall, my conclusion is that there is no consistent evidence relating radiofrequency exposures and cancer in humans, in terms of current research.[144]

2.122 Radiation oncologist, Dr John Moulder, in his submission to the Committee, concluded that:

> … the epidemiological evidence for a causal association between cancer and exposure to radio-frequency radiation is weak to non-existent.[145]

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141 Professor Mark Elwood, Submission 11, Submission Vol 1, pp 47-48.

142 Professor Mark Elwood, Submission 11, Submission Vol 1, p 49.

143 *Official Committee Hansard*, Sydney, 16 November 2000, p 262 [French].

144 *Official Committee Hansard*, Melbourne, 22 September 2000, p 143 [Elwood].

145 Dr John Moulder, Submission 60, p 23.

> … animal carcinogenesis studies conducted to date provide no replicated evidence that exposure of animals to radio-frequency radiation at non-thermal intensities causes or promotes cancer.[146]
>
> …[o]verall, exposure of cells to radio-frequency radiation with an intensity that does not significantly raise cell temperature does not produce any consistent evidence for genotoxic or epigenetic activity.[147]

2.123 The interpretation of the scientific literature by some expert bodies, including the ICNIRP in the preparation of its exposure safety guidelines, has been criticised.[148] Dr Cherry stated:

> They decide that there is no evidence of genotoxicity but they do not cite any studies that have been published that do show that RF microwave damages chromosomes – and that is the classic test of genotoxicity… Secondly, when I looked at two of their studies on cancer, they said that two recent studies do not show any significant effects. I have those studies and they do show significant effects.[149]

2.124 Dr Barnett advised that the CSIRO had submitted two projects to the NHMRC, both of which were shortlisted but unsuccessful, related to the potential effects of radiofrequency radiation on DNA and cancer production:

> One was an animal system, where we were looking at repeating, I believe, a very important research finding which has been largely ignored, which was finally published in 1992 by Chou and others. That work was actually undertaken at the Brooks Air Force Base in San Antonio. That study looked at simply exposing rats to 2450 megahertz of radiation throughout their lives.
>
> When the data was analysed for tumour development in the exposed versus controlled animals, it turned out that, depending on how you chose to analyse the data, you got either a negative or a positive result. The study had been largely referred to as providing a negative result. It was only negative if you separated out each type of cancer and then looked at the difference in numbers for each type of cancer. Clearly, because they only used a couple of hundred animals, when it was broken down into all the different types of cancer, the numbers that were being compared were extremely small, so the statistical power would be pretty poor. When they compared the incidence of primary malignancies between the two groups there was a fourfold increase in the exposed group.[150]

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146 Dr John Moulder, Submission 60, p 28.

147 Dr John Moulder, Submission 60, p 32.

148 The EMR Safety Network International, Submission 111, Attachment 2. See also, Mr Don Maisch, Submission 20, Executive Summary.

149 *Proof Committee Hansard*, Canberra, 2 March 2001, p 339 [Cherry].

150 *Official Committee Hansard*, Sydney, 16 November 2000, p 225 [Barnett].

2.125 Some witnesses to this inquiry referred to anecdotal evidence of people claiming, 'with hindsight and when prompted', to suffer from a range of cancer types resulting from chronic exposure to electromagnetic radiation.[151] While it has been claimed that the involvement of electromagnetic emissions in the proliferation of cancer cells and possibly even as the cause of cancer is 'beyond doubt',[152] this view has not been supported by recent reviews on recently published papers.

2.126 The results of a case-control study conducted at five United States academic medical centres between 1994 and 1998 using a structured questionnaire, were published by Muscat *et al* in 2000.[153] There were 469 men and women aged between 18 and 80 years with primary brain cancer, with 422 controls. Details obtained from interviews included the number of years of use, minutes/hours of use per month, year of first use, phone manufacturer, reported average monthly bill, demographics, smoking history, alcohol consumption, exposure to power frequency fields, occupation and medical history. No assessment was made of participants' diet.

2.127 The researchers concluded that the study 'shows no effect with short-term exposure to cellular telephones that operate on (primarily) analog signals' and recommended that further research is undertaken to account for longer induction periods, particularly for slow-growing tumours, and the differences between analog and digital mobile phones.[154]

2.128 There was no association observed between the duration of cellular phone use and incidence of brain tumours. In the cases examined, cerebral tumours occurred more frequently on the side of the head to which the phone had been held, however, for patients with temporal lobe cancer, the tumours occurred more frequently on the side opposite to that against which the phone was customarily held. This contrasts with a Swedish study that found an association between the side of the head a brain tumour occurred and the side of phone use, although this study also did not find an overall association between cell phone use and the risk of brain cancer.[155]

2.129 The Committee received a confidential submission from a person suffering from a growth inside their skull. The growth was adjacent to the mobile telephone antenna position. This person was a heavy user of both analogue and digital mobile phones and believes that the excessive microwave radiation resulting from extremely heavy mobile phone use, most probably caused the malformation.[156]

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151 The EMR Safety Network International, Submission 111, Submission Vol 8, p 1719.

152 The EMR Safety Network International, Submission 111, p 3.

153 Joshua E. Muscat, 'Handheld cellular telephone use and risk of brain cancer', *JAMA*, 20 December 2000, pp 3001-3007 (Muscat *et al,* 2000).

154 Muscat *et al,* 2000.

155 Hardell *et al*, 1999, cited in National Cancer Institute Press Release, 'No association found between cellular phone use and risk of brain tumours', 21 December 2000.

156 Confidential submission.

2.130 Dr Bruce Hocking undertook a survey of 40 people to categorize the types of symptoms exhibited by users of mobile phones. The symptoms mainly affected the head and, for a few, the waist. These symptoms included dull pain, an unpleasant warmth or heating, as well as ache, throb, sharp pain and pressure. All respondents could distinguish the sensations from ordinary headache. Most respondents felt the sensation less than five minutes after commencing the mobile phone call, but for others the sensation built up as the day progressed. For some, the sensation lasted less than an hour after ceasing calls, for others it lasted till bed-time, and five respondents felt it the next day.[157] In addition, Dr Hocking co-authored a paper[158] on a detailed study of a person who had enduring effects on the side of his head where he used his GSM mobile phone. He experienced persistent unpleasant feelings lasting for more than a year and underwent extensive investigations by neurologists to find out if he had brain tumours or some other odd sort of neurological condition that could have been causing these problems, and nothing had been found. Dr Hocking informed the Committee:

> This is the first time that I am aware of that there has been a clear demonstration of a health effect in humans attributable to a mobile phone. I agree it is only one case, and before you get too excited you would like to see more. Nonetheless, I think it is a significant warning when you see it in context with the previous 40 cases that I was reporting that were getting similar sorts of symptoms that there is considerable likelihood that mobile phones, at the low levels of radiofrequency which they are operate on, are causing disturbances of neural function.
>
> It is also considerable evidence of an athermal effect. Given that mobile phones operate at low intensity – we are told by government, WHO and industry that mobile phones operate well within safety standards – that to produce this sort of effect we are having effects outside at low levels. [159]

2.131 Since 1994, researchers at the National Cancer Institute (NCI) in the United States have been conducting an adult brain tumour study which includes investigating a range of possible risk factors including: workplace exposures to chemical agents and electromagnetic fields; dietary factors; family history of tumours; genetic factors; home use of selected appliances; reproductive history and hormonal exposures; viruses; and medical and dental exposure to ionising radiation. Cell phones, as another potential risk factor, were included in the research program in response to public concern about possible links between cellular phones and brain cancer.

2.132 Results from NCI research into cell phones and brain cancer were published early in 2001. The case-control study of the relationship between cellular/mobile

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157 Hocking B, *Preliminary report: Symptoms associated with mobile phone use*, Occupational Medicine, Volume 48, No. 6, 1998, pp 357-360.

158 Hocking B, and Westerman R, *Neurological abnormalities associated with mobile phone use*, Occupational Medicine, Volume 50, No. 5, 2000, pp 366-368.

159 *Official Committee Hansard*, Melbourne, 22 September 2000, p 113 [Hocking].

phone use and brain tumours was conducted in three hospitals in the United States between 1994 and 1998. The study identified 782 patients in these hospitals who had glioma, meningioma or acoustic neuroma; from the same hospitals, 799 patients with non-malignant conditions, were used as the control group.

2.133 The study found no evidence that the risks of glioma, meningioma, acoustic neuroma, or all types of tumours together, was higher among people who used mobile phones for an hour or more a day or regularly for five or more years. The researchers concluded that the results did not support the hypothesis that the use of mobile phones causes brain tumours, but stated that the results were 'not sufficient to evaluate the risks among long term, heavy users and for potentially long induction periods'.[160]

2.134 The Committee acknowledges the difficulty of testing long term exposure and notes that the results of this study should be interpreted cautiously for the following reasons:

- widespread use of mobile phones is only a recent phenomenon, with few people in the United States having used mobile phones prior to the 1990s. Only a small number of study participants had used a mobile phone for over five years. Consequently, the study would not have been able to detect the risk of brain tumours after a long latency period;
- there was a reliance on interviews and the ability of participants to accurately recall mobile phone use rather than by objective measurements of exposure;
- the study was designed to assess the risk of all types of glioma, and the sample was too small to detect increased risk for glioma subtypes; and
- factors other than duration of use influenced the level of exposure of brain and nervous system tissue in the head to radiofrequency radiation, including distance from the base station, local topography and vegetation, whether the phone is used indoors or outdoors, the design of the phone, and the position of the phone and the antenna in relation to the head.[161]

2.135 In recognition of these limitations, the NCI advised that 'it would be premature to conclude that use of hand-held cellular telephones does not cause tumors of the brain and nervous system'.[162] Noting that analog phones were predominantly in use during the study period, contrary to recent years when phones have been increasingly based on digital technology, the NCI nevertheless offers the view that

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160 Peter D Inskip *et al*, 'Cellular-telephone use and brain tumours', *The New England Journal of Medicine*, 344 (2), 11 January 2001, pp 79-86.

161 National Cancer Institute, *Questions and Answers for the National Cancer Institute Study of Brain Tumors and Use of Cellular Telephones*, Press Release, 31 December 2000. See also, Dimitrios Trichopoulos and Hans-Olov Adami, 'Cellular telephones and brain tumours (Editorial)', *The New England Journal of Medicine*, 344(2), 11 January 2001, pp 133-134.

162 National Cancer Institute, *Questions and Answers for the National Cancer Institute Study of Brain Tumors and Use of Cellular Telephones*, Press Release, 31 December 2000.

'there is no evidence at this time that cancer risk would differ for the two types of phones'.[163]

2.136 The results of a unique Danish study into the relationship between mobile phones and cancer were also published at the beginning of February 2001 in the *Journal of the National Cancer Institute*.[164]

2.137 A research team, headed by Dr Christoffer Johansen, conducted a retrospective cohort study[165] of cancer incidence in 420,095 Danish users of mobile phones between 1982 and 1995, using telephone subscription lists from two Danish mobile phone operating companies and the Danish Cancer Registry. The team observed no significant difference between expected and observed incidence of cancers of the brain, nervous system or salivary gland, or of leukaemia. Risks for these cancers did not vary by duration of cellular telephone use, time since first subscription, age at first subscription, or type of cellular phone used (analog or digital). The study concluded that the results did not support the hypothesis that there is an association between the use of mobile phones and tumours of the brain, salivary gland, leukaemia or other cancers.[166]

2.138 Dr Johansen is reported as stating that '[i]f it is assumed that tumour promotion occurs close to the site of exposure, this finding provides additional evidence against a link between cellphone use and brain cancer'. However, Dr Johansen indicated that the study results did not rule out a relationship between mobile phones and other health risks such as ringing noises in the head, migraine, headaches, other symptoms of the conditions associated with the central nervous system, Parkinson's and Alzheimer's diseases, various types of dementia, and skin diseases.[167]

2.139 Responding to the report, Australia's Dr Bruce Armstrong, who is undertaking an epidemiological case-control study on the relationship between exposure to radiofrequency radiation and brain and other tumours in adults (see

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163 National Cancer Institute, *No Association Found Between Cellular Phone Use and Risk of Brain Tumors*, Press Release, 31 December 2000. Not in relation to this study, but in evidence to the Committee, Professor Mackenzie said: '… pulsed radiation should not be considered to be equivalent to continuous radiation of the same frequency and power level. It is important to distinguish between radiation which is made up of short, high-intensity pulses and radiation which is made up of a lower level of continuous radiation. That is the important thing that we need to flag at this time, that there is an actual difference between response to continuous radiation and that to a train of pulses of the same average power …. Analog, of course, is a heavily modulated continuous signal, but it is not very similar to the digital. The digital is much more intense over short time periods. The pulses are more intense and more widely spaced than in the analog system. So there could be a difference in the biological response to the two signals' (*Official Committee Hansard*, Sydney, 16 November 2000, p 272 [Mackenzie]).

164 Johansen *et al*, 2001, Cellular Telephones and Cancer – a Nationwide Cohort Study in Denmark', *Journal of the National Cancer Institute*, 93 (3), February 7, 2001, pp 203-207.

165 A cohort study refers to a study which follows what happens to a group of people over a period of time.

166 Johansen *et al*, 2001, pp 203-207.

167 *Danish cellphone study shows no cancer link*, Reuters news report, Story No. 5178, 7 February 2001.

Australian research below), stated that while it was a 'reassuring study', it did not 'give an ultimate assurance of a lack of a hazard'. A shortcoming of the study was that only a small percentage of the mobile phone service subscribers had used their phones for more than seven years and this 'raised questions on what links there were between cancer and long term mobile phone users'.[168]

2.140 The Committee Chair considers that there is sufficient doubt as to the association between radiofrequency and cancer to warrant further research before the public can be confident that any risks are adequately safeguarded against through current exposure standards. A discussion of the efficacy of current standards is discussed in Chapter 4.

Other effects

2.141 Although a dominant concern, cancer is only one of the health effects that has been attributed to radiofrequency exposure. Electromagnetic emissions have also been implicated in many debilitating and/or serious health conditions, often immune system related, including allergies, repeated flu-like episodes and auto-immune diseases.[169] There is also some evidence of genetic predisposition and age-related factors that may influence sensitivity to potential effects of RF radiation.[170]

2.142 While there have been reports of effects on the cardiovascular system from exposure to electromagnetic radiation, the Stewart Report concluded that 'on the basis of published evidence, [there is] no basis for concern about effects of mobile phone use on the heart and circulation'. People subject to chronic electromagnetic energy exposure have also reported suffering heart attacks and high blood pressure.[171] The Stewart Group said, however, that while normal use of a mobile phone against the head is unlikely to have a direct effect on the human heart, influences on cardiovascular centres in the brainstem and on the carotid body, a body of tissue involved in the regulation of the heartbeat, were more conceivable, and further experimental work on human volunteers was warranted. Observed effects were said to be attributable to thermal effects from acute exposures to radiofrequency radiation.[172]

2.143 Despite concerns about the possible effects of mobile phone use on cognitive functions such as memory, attention and concentration, relatively few laboratory studies have addressed this issue in people and, of those that have, all have investigated effects from acute rather than chronic exposure. While exposure to radiofrequency radiation at levels which cause increases in core temperature of 1ºC

168 *New cancer and mobile phone findings cautiously welcomed*, AAP news report, Story No. 6757, 7 February 2001.

169 The EMR Safety Network International, Submission 111, p 2.

170 CSIRO, Submission 95, p 4.

171 The EMR Safety Network International, Submission 111, p 3.

172 Stewart Report, pp 85-86.

lead to changes in performance of primates in well-learned tasks or other simple behaviour, on which the current standards are based, the Stewart Report said that results at non-thermal levels are inconsistent and recommended further research.[173] Most studies which investigated exposure to low levels of RF radiation focussed on physiological measures of brain function, such as the electroencephalogram (EEG), rather than indices of cognitive performance *per se*. The Stewart Report noted that the functional significance of different components of the normal, waking EEG is poorly understood, making it difficult to interpret results showing an influence of radiofrequency signals on the EEG.

2.144 This was said to be less of a concern with respect to EEG patterns associated with sleep as these are 'well characterised and routinely used as indices of the different sleep stages that a typically healthy individual will move between during the night'. There have been observations of a range of sleep-related disorders, including altered sleep patterns, circadian rhythm and reaction times, from naturally occurring electromagnetic radiation and short-wave radio exposure.[174] However, these effects have been observed at lower frequencies than what are used for mobile phone transmissions. In addition, the Stewart Report said that results of work on the neurotransmitter system, which is involved in regulation of emotion, memory and sleep, appear to show temperature-related effects. To determine the extent to which the results of those studies can be extrapolated across the electromagnetic spectrum requires that these studies should be repeated using radiofrequencies. The Stewart Report concluded that further research should be conducted in both areas.[175]

Alzheimer's Disease

2.145 Reference was made to a study that linked exposure to electromagnetic fields with an increase in incidence in Alzheimer's Disease (AD), which, it is hypothesised, is due to a chain reaction of cellular effects starting with interference to cellular calcium ion homeostasis.[176] In its report, the Royal Society of Canada acknowledged this and another related hypothesis, but noted that studies aimed at testing these claims had used exposure to extremely low frequency fields (powerlines) rather than radiofrequency radiation. In addition, methodological shortcomings limited the interpretation of the results. The report concluded that 'there are no convincing, reproducible data to suggest a relationship between AD and [microwave] exposure'.[177]

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173 Stewart Report, p 60.

174 The EMR Safety Network International, Submission 111, Attachment 2. Cf. Dr David Black, referring to one study that investigated sleep disturbances, stated: '… the investigators for the … study were prepared to commit themselves no further than to say that there seemed to be an association between the presence of the transmitter and sleep disturbances but emphasised that no urgent intervention was indicated' (Submission 93, p 28).

175 Stewart Report, pp 53, 55.

176 The EMR Safety Network International, Submission 111, Attachment 2.

177 Royal Society of Canada Report, p 98.

The Immune System

2.146 While it has been suggested that the evidence indicates that an increase in diseases connected with the immune system may be the long term effect of radiofrequency radiation from mobile phone use,[178] other reviews have been more cautious and point to the ambiguous nature of outcomes in this area of research. The European Commission Report noted that there is a level of adaptability and redundancy built in to the immune system via self-regulation.[179] Thermal effects that have elicited responses in the immune system have been found to be transitory, with levels returning to normal with the cessation of radiofrequency exposure. The Stewart Report concluded that, given the inconsistent results from studies using low level radiofrequency radiation exposure, it was difficult to attribute any effects to exposure.[180]

The eyes

2.147 The Stewart Report also referred to various studies that had investigated the effects of high intensity pulsed RF fields on the eye. Noting that these exposure levels were well above the specific absorption that could occur from the use of current mobile phones, it warned that possible adverse health effects in the eye may be associated with high peak-power pulsed radiofrequency fields.[181]

Reproductive problems

2.148 Some drugs and environmental hazards are known to have damaging effects on a developing embryo at exposure levels which are of little or no risk to the adult animal. According to the Stewart Report, despite extensive research into the potential effects of radiofrequency fields on fertility and development, studies have failed to show any convincing evidence of effects.[182] The Stewart Report referred to a 1993 study that showed an increased risk of miscarriage in physiotherapists who reported exposure during the first six months before or three months after pregnancy and a higher risk in those with more frequent exposure and concluded that there was a 'relatively low response rate to the questionnaire that was used to collect information' and that '[n]o corresponding association was found with use of short-wave diathermy'.[183]

2.149 The Royal Society of Canada Report also referred to the low overall response rate and 'lack of validity in interview-based exposure assessment', limiting the

178 *Official Committee Hansard*, Sydney, 16 November 2000, p 193 [Fist].

179 EC Report, p 36.

180 Stewart Report, p 77.

181 Stewart Report, p 63. The Royal Society of Canada Report concluded: 'At the present time, no definitive conclusions can be reached regarding RF field exposure and effects in the eye. … The unique properties of the eye make this an area which should be treated with caution and concern (p 102)'.

182 Stewart Report, p 80.

183 Stewart Report, p 97.

interpretation of the results.[184] It stated that the Kallén study, while a good design and having a high participation rate, 'the numbers exposed to microwave equipment were too small to provide reliable risk estimates'.[185] The Report also referred to the Larsen *et al* 1991 study cited by Dr Cherry, and noted that '[t]here was no significant association of spontaneous abortion with exposure to short-wave radiation … nor was there any association with the other outcomes studied, except for gender ratio … in the high-exposed group'. The Stewart Report said that other studies of pregnancy in physiotherapists did not support the relationship between miscarriage or other adverse outcomes.[186]

2.150 Dr Cherry disagrees, citing ten epidemiological studies that have found significant miscarriage from EMR exposure across the spectrum from ELF, SW to RF/MW:

> The Scandinavian physiotherapist studies, Kallén et al (1982) and Larsen et al. (1991) also found significant prematurity, congenital malformation, still birth and cot death. Ouellet-Hellstrom and Stewart (1993) confirm the causal relationship with a highly significant dose-response relationship.[187]

2.151 Dr Cherry also argued that research linking cot death to reduction in melatonin related to ELF signals:

> One of the most important single studies involved cot death (Sudden Infant Death Syndrome) in Ontario, Canada. O'Connor and Persinger (1997) were investigating the GMA melatonin hypothesis by seeing if a melatonin-related syndrome (SIDS) varied with GMA. They found that SIDS incidence significantly increased when GMA >30 nT and GMA, <20 nT, – a homeostatic result. This confirms that GMA causes illness and death in vulnerable people, babies, and involves melatonin homeostasis.
>
> This shows that very young babies are sensitive to variations in the natural EMR and extremely low exposure levels. Thus we would expect the fetus to also be vulnerable.[188]

2.152 A study by Magras and Xenos (1997) responded to health concerns among residents living in the vicinity of an RF transmission tower in Greece. They placed groups of mice at various locations in relation to the tower and monitored the fertility

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184 Royal Society of Canada Report, p 89.

185 Royal Society of Canada Report, p 88.

186 The Stewart Report, p 97. The Royal Society of Canada Report also noted that a follow-up study (Guberan 1994) 'did not observe a difference in gender ratio between exposed and non-exposed pregnancies, nor was the result affected by intensity or duration of exposure (p 89)'. See also Dr David Black, Submission 93, p 26, who stated: '[t]aken as a whole, this body of research does not identify any clear association between antenatal EMF exposure and either congenital malformations or spontaneous abortions'.

187 Dr Neil Cherry, Submission 146, p 13.

188 Dr Neil Cherry, Submission 146, p 13.

of the mice over several generations. The 'low' exposure group (0.168μW/cm^2) became infertile after 5 generations and the 'high' exposure group (1.053μW/cm^2) became infertile after only 3 generations. According to the Stewart Report however, this study is not conclusive because it did not include a matched control group nor take into account other environmental factors to which the mice were exposed.[189]

2.153 Dr Cherry disagrees with this interpretation too saying the study confirmed the evidence that chronic low level exposure to RF radiation leads to reproductive problems.

Electro-sensitivity

2.154 Several submissions also referred to the issue of hypersensitivity of some people to prolonged exposure to electricity and electromagnetic fields.[190] The EMR Safety Network International advised, in its submission, that an increasing number of people, through a process of elimination, are attributing health effects to EME exposure and 'find they can no longer tolerate such exposure in the home or workplace'.[191] It was claimed that symptoms including fatigue and concentration difficulties suffered by electro-sensitive people have been dismissed as 'extreme intolerance to stress or imaginary illness', despite evidence that electromagnetic fields can affect body cells and cause disease:[192]

> Electro hypersensitive individuals must also be acknowledged and respected. These people are not merely a few electrophobic individuals seeking attention and special protection. They are visible examples of the injury that any individual may ultimately sustain due to EMR exposure at levels well below the now accepted standards based on the ICNIRP recommendations. At present, electro hypersensitivity is believed to be affecting only a minority group. In my view, this is a gross underestimation of the real situation. It can take time for the individual to develop intolerance to EMR. The unique physiological and genetic make-up of any individual determines the degree of EMR tolerance that they will have and which body system may become affected.[193]

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189 The Stewart Report, p 80. The Committee notes that Dr Cherry was critical of the approach taken by ICNIRP in its health assessment upon which its exposure guidelines are based, which he claimed 'wrongly dismiss[es] the strong association between RF/MW exposure and miscarriage and congenital adverse effects' presented in epidemiological studies. See The EMR Safety Network International, Submission No 111, Attachment 2.

190 National Council of Women of Australia, Submission 32, p 2. See also Mr Don Maisch, Submission 20, p 31; Dr Graeme Stringer, Submission 64, p 3; EMRAA, Submission 80, Submission Vol 7, p 1441. See also *Official Committee Hansard*, Canberra, 7 November 2000, pp 191-192 [Johansson].

191 The EMR Safety Network, Submission 111, p 1.

192 The EMR Safety Network, Submission 111, p 1; EMRAA, Submission 80, Submission Vol 7, p 1441.

193 *Official Committee Hansard*, Sydney, 16 November 1999, p 257 [EMR Safety Network International].

Children

2.155 The greater sensitivity of children to the effects of electromagnetic radiation was raised in several submissions.[194] It has been argued that children are likely to be more susceptible to any adverse health effects because of high cell turnover/division,[195] children have thinner skulls,[196] their immune system and brain wave activity is less robust than adults,[197] and because they will have experienced a longer period of exposure over their lifetime. Parent concerns about this issue are leading some to remove their children from schools that are located near mobile phone towers or base stations.[198]

2.156 The Consumers' Telecommunications Network expressed its concern at the vulnerability of children to potential adverse health effects of mobile phone technologies:

> Our understanding of the publicly available research suggests that we still do not know exactly what the health effects might be. We believe that such effects are likely to be cumulative over time and with usage, that children are likely to be more vulnerable than adults, and that we may not understand the effects fully for some years.[199]

2.157 The incidence of childhood cancer was alluded to in the Stewart Report when it referred to two studies that had been conducted in Australia, which looked at the incidence of leukaemia in children residing in three municipalities surrounding television masts. While the earlier study by Hocking *et al* had found a 60 per cent increase in leukaemia in children living close to the TV towers, the later study by McKenzie *et al* found that this excess occurred in only one of the three municipalities close to the mast.[200] The Royal Society of Canada Report was critical of the ecological design of the 1996 Hocking *et al* study, which it considered weakened the

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194 Mr Joe Friend, Submission 17, p 1; Mr Greg Eggert, Submission 14, p 1; Mr Leigh Tanner, Submission 18, p 1; Mr Noah Yamore, Submission 24, p 1; Ms Sandy Carr, Submission 26, p 2; National Council of Women of Australia, Submission 32, p 1; Professor Barry Boetcher AM, Submission 41, p 2; Mr Gary Schroder, Submission 50, p 1; Sunshine Coast Environment Council Inc, Submission 55, p 2; EMRAA, Submission 80, p 15, Gwenda and Tom Spencer, Submission 82, p 1; Betty and Trevor Shelley, Submission 87, p 1; The EMR Safety Network International, Submission 111, p 2; One-Tel Tower Committee, Submission 132, pp 1-2; Ms Nikki Carabetta, Submission 135, p 1; Mrs Ms Allen, Submission 136; Ms Diane Beaumont, Submission 138, p 7; Mr Alan K Tunnah, Submission 139, p 2; Sunshine Heights Kindergarten, Submission 140, pp 1-2; Mrs Leanne Noakes, Submission 144, p 1.

195 See for example, EMRAA, Submission 80, Submission Vol 7, p 1440.

196 *Official Committee Hansard*, Sydney, 16 November 2000, p 217 [Consumers' Telecommunications Network]; *Official Committee Hansard*, Melbourne, 22 September 2000, p 173 [Dalton].

197 Hyland, GJ, *Potential Adverse Health Impacts of Mobile Telephony*. Memorandum, February 2000 (attached to Submission 111, The EMR Safety Network International, p 1768).

198 Mrs PR Richards, Submission 49, p 2; One-Tel Tower Committee, Submission No 132, p 2.

199 Consumers' Telecommunications Network, Submission 101, Submission Vol 8, p 1635.

200 Stewart Report, p 98.

strength of the results. It also noted that the McKenzie study did not support Hocking's conclusion.[201] In response to criticisms of his study, Dr Hocking stated:

> We have subsequently responded to McKenzie and Morrell, and that is the letter that I have tabled in front of Senator Allison for you, and we point out several things which are incorrect about McKenzie and Morrell's criticisms. I am now standing in front of the poster and pointing out that in the three municipalities surrounding the tower – North Sydney, Lane Cove and Willoughby – there are more cases of leukemia in Lane Cove than in the other two areas. The substance of their criticism is that if the radiofrequency was distributed evenly across all those areas you would have expected proportionately the same number of cases in each one of those municipalities.
>
> …
>
> … We obviously adjust our data to allow for per thousand population of something like that. Nonetheless, there is this increased rate or numbers of cases in Lane Cove whichever way you look at it. …
>
> There are two things to say. First of all, the original hypothesis was that the group of municipalities surrounding the towers could have a different rate of leukemia compared to the group of municipalities out there. To then take the data and to subdivide it after we had done a test of homogeneity to show there was evenness within statistical bounds between these areas and then to say, 'We are going to treat these areas differently, one from the other, and because there is a bigger number here, therefore this does not hold up,' is incorrect. We have the problem that it is basically moving the goalposts after the kick is taken. The original hypothesis was to treat all of these areas as one unit compared with all those areas out there as one unit. They are then wanting to subdivide the data and say, 'A pocket here is different from a pocket there and yet we would have expected them to be the same. Therefore, there is something wrong with the study.' You cannot do that with such a fragile study. It is a very crudely designed study for reasons I will explain to you.
>
> We were basically constrained by the geographic boundaries of local government areas in Sydney. Therefore, we had to go along the boundaries of Willoughby and Lane Cove and so forth simply to gather in the data. It does not necessarily mean that there is an effect occurring where those borderlines are. If there is an effect it could be that the effect only goes out for two kilometres from the towers and not to the four kilometres where these boundaries roughly lie. In such a case you are then diluting your data. In other words, by having to incorporate cases with the data close to the towers, along with population where there is no effect occurring, you basically wash out or dilute your effect.

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201 Royal Society of Canada Report, p 87.

…..

> Morrell and McKenzie were factually incorrect. There was additional high power broadcasting in the sense that the transmission times of these television stations increased from 18 hours a day to 24 hours a day in 1975 or 1976 – I have forgotten what it was. Our study commenced in 1972 and went through until 1990. Effectively, you have three or four years where there were only 18 hours a day going up to 24 hours a day. That is a negligible difference in the exposure. …[202]

2.158 The Royal Society of Canada Report concluded that 'none of the few investigations of risk of childhood cancer conducted so far can be regarded as providing useful information concerning the effect of radio-frequency fields on risk of childhood cancer'.[203]

2.159 While the Stewart Report concluded that exposures below ICNIRP guidelines do not cause adverse health effects to the general public, in line with its recommended precautionary approach to the use of mobile phone technologies, it recommended that children be discouraged from using mobile phones for non-essential calls. The Stewart Report recommended that the mobile phone industry should refrain from promoting the use of mobile phones by children.[204] The Independent Expert Group on Mobile Phones (IEGMP)[205] referred to evidence that specific energy absorption rate (SAR) is larger in children than in adults because children's tissue contains more ions and therefore has a higher conductivity.[206] ARPANSA, however, disputed this conclusion in its response to the IEGMP recommendation about mobile phones and children, stating:

> There is no scientific evidence to support the idea that any adverse health effects would occur to any individual exposed to levels below the Australian limit. It is true that children are likely to be exposed for a much longer time than adults but in the absence of any knowledge of an injury mechanism, there is no reason to believe that children will be inherently more vulnerable than any other age groups. However, just as concerned persons may choose to restrict personal use of mobile phones, concerned parents may also choose to limit the use of mobile phones by their children.[207]

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202 *Official Committee Hansard*, Melbourne, 22 September 2000, pp 118-120 [Hocking].

203 Royal Society of Canada Report, p 88.

204 Stewart Report, p 8.

205 Authors of the Stewart Report.

206 Stewart Report, p 38.

207 ARPANSA, Submission 128, Submission Vol 9, p 2046.

2.160 The Committee also notes the views of Dr David Black, medical practitioner, in commenting on the Stewart Report's recommendations vis a vis children:

> The importance given to the perceived differences in RF absorption between children and adults seems to me to be a generically derived concern searching for a mechanism. The debates about skull thickness have been had and dismissed in the literature several years ago. The ideas about different absorption based on conductivity seems to be based on only unquantified unpublished data. In simply considering … the underlying biophysics of this idea … any difference would be small and not important compared to other factors …[208]

2.161 Dr Black further stated:

> … it may be that children do have slightly more ionic fluid in their brain and, therefore, have slightly more conductive tissues. But if that is so, then there would be an increase in screening as well as the conductivity. Therefore, that might even out – it might not. But the difference is only a factor of maybe 20 or 30 per cent, and the actual safety margin and the standard is much higher than that. Furthermore, the testing systems that are currently used for cell phone handsets actually use fluid of much higher conductivity than is in the adult brain, which would be in fact higher than you would find in a child's brain. So I do not think any of those points raised in the Stewart report are actually valid, so I cannot agree with them.[209]

2.162 The Committee notes, however, Dr Cherry's evidence when referring to his early involvement on the siting of a base station in a school that at that time he '[did] not know of any studies showing adverse effects from radiofrequency/microwave radiation or cell phone radiation, but I do know about resonant absorption and I do know about the way the brain works, because we have studied that. So I would be concerned about the sensitivity of children's brains …'.[210]

2.163 The National Cancer Institute has noted that few children used cell phones prior to 1994. While certain agents, for example ionising radiation and particular chemicals, which are known to cause brain and nervous system cancer in rats, have greatest effect when administered early in life when the nervous system is developing, this has not yet been established with respect to mobile phones.

2.164 Of concern to some witnesses were marketing campaigns designed to sell mobile phones to children.[211] It was suggested that mobile phones should be labelled with additional warnings to advise that children and young adults have a greater risk

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208 Dr David Black, Submission 93, p 30.

209 *Official Committee Hansard*, Canberra, 8 September 2000, pp 60-61 [Black].

210 *Proof Committee Hansard*, Canberra, 2 March 2001, p 334 [Cherry].

211 *Official Committee Hansard*, Sydney, 16 November 2000, p 216 [Consumers' Telecommunications Network]. See also, EMRAA, Submission 80, Submission Vol 7, pp 1456, 1462-1463.

of EME absorption, and protective devices or hands-free kits should be included with any mobile phones sold to, or intended for use by, children under the age of 18 years.[212]

2.165 There was support from a number of submitters and witnesses for the Stewart Report's recommendation with respect to children and mobile phones.[213] The Committee considers that a precautionary approach is desirable, and supports the Stewart Report's recommendation that the effects of RF radiation on children should be treated as a priority research area given the increasing use of mobile phones by young children and teenagers.

2.166 Others considered more susceptible or at greater risk to any adverse effects from electromagnetic radiation are pregnant women, the immuno-depressed, workers occupationally exposed to EMR and the elderly. One submission suggested that a national register should be established to record the health status of workers occupationally exposed to electromagnetic radiation.[214]

Mobile phone towers and base stations

2.167 A considerable number of submissions expressed concern about the proliferation of mobile phone towers, particularly in sensitive locations, and their impact on health.[215] One of the concerns about exposure to radiation from towers, in contrast to mobile phones, is the continuous exposure from towers compared with the

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212 Consumers' Telecommunications Network (CTN), Submission 101, p 2.

213 *Official Committee Hansard*, Melbourne, 22 September 2000, pp 114, 128 [Hocking]; *Official Committee Hansard*, Melbourne, 22 September 2000, p 173 [Dalton]. Cf *Proof Committee Hansard*, Canberra, 2 March 2001, p 327 [Moulder] who expressed confusion about the basis for the Stewart Report's recommendation on mobile phone usage by children.

214 Dapto Residents Against Tower Health Risks, Submission 92, p 3.

215 Mr John C Bedford, Submission 3, p 1; Warrimoo Citizens Association, Submission 4, pp 1-3; Chris & Marie Kougellis, Submission 16, pp 2-3; Ms Sarah Wallace, Submission 31, pp 1-2; National Council of Women of Australia (NCWA), Submission 32, p 1; Ms Lyn Ward and Mr Mark Lamb, Submission 33, pp 1-2; Ms Helen Joyce, Submission 35, p 1; Ms Sylvia Douglas, Submission 38, p 1; Ms Stephanie Evans, Submission 39, p 1; Professor Barry Boettcher AM, Submission 41, p 2; City of Melville, Submission 42, p 1; Mr JW Purchase, Submission 46, p 1; Mr E and Mrs A Vassallo, Submission 48, p 1; Mrs PR Richards, Submission 49, p 2; Mr Gary Schroder, Submission 50, p 1; Town of Kwinana, Submission 53, p 1; Sunshine Coast Environment Council Inc, Submission 55, pp 1-2; Mr Nick McKillop, Submission 63, Attachment 5; Ms Helen McKillop, Submission 67, p 1; Mr CS Newton, Submission 70, pp 2-3; Castlemaine Optus Antennas Relocation Group (COARG), Submission 72, pp 1-2; Mr Harold Hird MLA, Submission 74, p 1; Ms Sonia Venditti, Submission 76, pp 1-2; Gwenda and Tom Spencer, Submission 82, p 1; Mr Paul Hunt, Submission 84, p 1; Mr Roger M Lilley, Submission 85, p 2; Maleny Residents' Action Group, Submission 86, p 1; Betty and Trevor Shelley, Submission 87, p 1; The Maple Street Cooperative Society Ltd, Submission 90, p 1; Ms Ruth Parnell, Submission 94, p 1; Mr & Mrs Davies, Submission 97, p 1; Ms Sandra Jordan, Submission 104, p 1; Mr Richard Giles, Submission 112, p 3; Centre for International Research on Communication and Information Technologies (CIRCIT), Submission 114, pp 1-3; Ms Heather Anne Meyer, Submission 123, p 1; Dr J Phua, Submission 126, p 1; Sutherland Shire Council, Submission 130, p 1; Ms Diane Beaumont, Submission 138, p 7; Sunshine Height Kindergarten, Submission 140, p 1; Sunshine Action Group, Submission 141, p 1; Mrs B Humphries, Submission 145, p 2.

more spasmodic nature of mobile phone calls,[216] and the involuntary nature of the exposure.[217]

2.168 There have also been differing claims about the relative risks associated with exposure to mobile phone emissions and radiation from mobile phone base stations or television towers. For example, Mr Neil Boucher, consulting engineer, said in his submission that:

> … it is worth noting that the exposure from a base station placed 100 meters away is minuscule compared to the exposure one would get from making a few calls a day with a handheld mobile phone.[218]

2.169 One submission stated:

> Real or perceived, people are afraid of these installations and don't want to live near something that pumps out electromagnetic radiation 24 hours a day. Just what the world needs: more pollution, both visual and environmental in the case of this technology. And all to operate mobile phones which now appear to be hazardous to our health![219]

2.170 Concern was also expressed about the community being used as 'guinea pigs to prove or disprove the effects of long term exposure to EMR'.[220] The radiation from mobile phone towers was seen to be 'an invisible time bomb', where 'if the radiation was visible such as smoke … the issue would have been clearly addressed sooner'.[221]

2.171 Although some evidence to the Committee and conclusions from recent expert reviews indicate that radiation from mobile phone towers is considered to be potentially less harmful than mobile phone emissions, it was suggested by physicist Dr GJ Hyland, that this may not be the case. In referring to studies which examined the effects of electromagnetic radiation exposure on DNA, Dr Hyland stated:

> Although the power density of the radiation used in these experiments is typically that associated with mobile phone handsets, and thus much higher than that found in the publicly accessible areas [in] the vicinity of a Base-station, the *information content* of the radiation emitted by the latter is the **same**; accordingly, these results are *not* irrelevant to the consideration of potential adverse health effects associated with chronic exposure to Base-

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216 The Vaucluse Progress Association, Submission 5, p 2. See also, Ms Sarah Wallace, Submission 31, pp 1-2; Telecommunications Officers Association Branch of the CEPU, Submission 66, p 3; Betty and Trevor Shelley, Submission 87, p 1; The Maple Street Cooperative Society Ltd, Submission 90, p 1.

217 Ms Sonia Venditti, Submission 76, p 2; Maleny Residents' Action Group, Submission 86, p 1; Mr Roger M Lilley, Submission 85, p 2; Mr Stewart Fist, Submission 30, pp 2-3.

218 Mr Neil J Boucher, Submission 118a, Submission Vol 11, p 2377.

219 Chris & Marie Kougellis, Submission 16, p 3.

220 Betty and Trevor Shelley, Submission 87, p 1. See also Sunshine Action Group, Submission 141, p 2; EMF South World Pty Ltd, Submission 129, p 2.

221 Sunshine Action Group, Submission 141, p 4.

> station radiation. Indeed, there are instances where the response of the living system is either sharper … or actually *increases* … as the irradiating power density **decreases** – possibly due to a corresponding decrease in thermal influences, which at higher intensities tend to mask (and eventually obliterate) any (contra-thermal) non-thermal effects. [222]

2.172 Nevertheless, ARPANSA noted that:

> … ARPANSA has conducted extensive survey measurements of environmental radiofrequency levels produced by mobile telephone base stations and also by other broadcast sources of radiofrequency radiation. The ARPANSA data clearly show that mobile phone base stations contribute only a small fraction of total environmental RF levels arising chiefly from other sources such as AM radio masts and television towers. In addition, total environmental exposure levels are low in comparison to public exposure limits specified [in] relevant Standards.[223]

2.173 Mr Wayne Cornelius, ARPANSA, stated:

> … For the most part, people in the general environment are not exposed to the levels that are being debated about as low level; but there is the issue of the mobile phone, where the device is quite close to the head and the levels are very much higher than from, say, a base station transmitter or a radio tower, unless you are very close to a radio tower.[224]

2.174 The Stewart Report concluded that there is no general health risk to people living near mobile phone base stations, but said anxiety about the uncertainty felt by those people could affect their well-being. ARPANSA suggested that appropriate research should be undertaken to examine the health implications of the public's anxiety about potential health risks associated with mobile phone base stations.[225]

Benefits of mobile phones

2.175 It was suggested to the Committee that although there are concerns about the potentially higher risk to children from excessive mobile phone use, it may also promote safety by enabling children to keep in contact with their parents. However, the Committee notes that there have also been cases of people being mugged for their mobile phone.[226]

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222 GJ Hyland, *Potential Adverse Health Impacts of Mobile Telephony Memorandum*, February 2000, (included in The EMR Safety Network International, Submission 111, Attachment 3).

223 Australian Radiation Protection & Nuclear Safety Agency (ARPANSA), Submission 128, Attachment K, p 3.

224 *Proof Committee Hansard*, Canberra, 2 March 2001, p 347 [Cornelius].

225 ARPANSA, Submission 128, Submission Vol 9, p 2046.

226 *Official Committee Hansard*, Sydney, 16 November 2000, p 216 [Consumers' Telecommunications Network].

2.176 The extent to which the benefits of mobile phone technology should take precedence over the health of the community was also raised. The Dapto Residents Against Tower Health Risks stated:

> The authorities seem to have adopted the view point that the advantages of telecommunications equipment and facilities are far greater than the disadvantages like possible adverse health effects from the emitted electromagnetic radiation (EMR).[227]

2.177 The Consumers' Telecommunications Network (CTN), noted that its members value the benefits of mobile phone technology and 'would not support restrictions in their availability'.[228] People with hearing aids have also expressed a desire for greater access to mobile telecommunications.[229] The CTN did not support EMRAA's call for the prohibition of mobile phone use in certain public places.[230]

Electromagnetic Interference (EMI)

2.178 Evidence was put to the Committee that electromagnetic interference (EMI) from digital, but not analog, mobile phones can affect the operation of implantable cardiac pacemakers and defibrillators. The effect is not present when the mobile phone is turned off.[231] Electromagnetic interference with cochlear implants was also referred to in one submission,[232] and with hearing aids.[233]

2.179 The Stewart Report acknowledged the potential hazards that may arise from indiscriminate use of mobile phones in areas, including hospitals, where RF radiation may interfere with sensitive electronic equipment.[234] The Independent Expert Group on Mobile Phones (Stewart Group) supported steps to warn people about the dangers of using mobile phones at these sites and recommended that hospitals place visible warning signs at entrances to buildings advising that mobile phones should be turned off.[235]

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227 Dapto Residents Against Tower Health Risks, Submission 92, p 2.

228 Consumers' Telecommunications Network (CTN), Submission 101, p 1. See also AMTA, Submission 19, pp 17-18.

229 CTN, Submission 101, p 1.

230 CTN, Submission 101, p 1.

231 US Food and Drug Administration – Centre for Devices and Radiological Health. *Cellular Phone Interference*, 1 November 1995. Attachment C, Answers to questions on notice, AMTA, 31 January 2001. See also Rothman (2000), which refers to two studies that examined interference to pacemakers from mobile phones, one of which determined that the frequency of interference was dependent on the type of pacemaker and type and position of the phone (Hayes *et al*, 1997), while the other found no pacemaker interference from mobile phones used in Europe (Occhetta *et a*l, 1999).

232 Ms Gillian Summerbell, Submission 62, p 1.

233 Deafness Council of NSW Inc, Submission 149, p 1.

234 Stewart Report, p 121.

235 Stewart Report, p 121.

2.180 To minimise the potential for EMI, the Australian Therapeutic Goods Administration has advised that mobile phones should not be kept in pockets above the site of implants, and that users use the ear furthest away from the implant when operating the phone, and avoid direct contact between the antenna and the user's skin.[236]

2.181 The Committee Chair is of the view that greater efforts should be taken by industry to solve these interference problems.

2.182 Given the problems of interference associated with electromagnetic radiation for planes, cardiac pacemakers, hearing aids and other medical devices, it has been suggested that a human being may not be immune from similar interference.[237] The Committee notes that an analogy has been drawn between electromagnetic interference with mechanical devices and biological effects. However, Dr John Moulder, oncologist, argued:

> Some of our modern electronic equipment, particularly in the hospital environment … is incredibly sensitive to picking up electromagnetic interference, in part because that is how it was designed. You can certainly interfere with delicate radio equipment at RF levels that are hundreds to thousands of times below where anyone has seen any biological effects. The other advantage is that, although we cannot always prevent electromagnetic compatibility problems, they are fairly well understood from the electrical engineering side, and the sorts of things which cause compatibility problems would not be expected to have much relevance to biology … On the other hand, I would accept that as a totally human reaction. If it interferes with my radio, maybe it can interfere with me. But in terms of the biology and physics it is not an obvious connection at all.[238]

2.183 Scientific uncertainty and continuing fears about the possible adverse health effects from exposure to radiofrequency radiation are important in the policy making process, particularly in relation to the inclusion of a precautionary approach for current standards. These issues are discussed in Chapter 4.

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236 Cellular Mobile Phones and Cardiac Pacemakers. Attachment B, Answers to questions on notice, AMTA, 31 January 2001. See also CEMEPHI, Submission 127, Submission Vol 9, pp 1950-1951.

237 The EMR Safety Network, Submission No 111, Attachment 3. See also, for example, *Official Committee Hansard*, Sydney, 7 November 2000, p 194, where Professor Olle Johansson from the Karolinska Institutet, Sweden, stated in relation to 'human electromagnetic compatibility': 'Your mobile telephone should not alter the figures at the bank, change the equipment at the hospital or whatever, and it should not affect electronics in an aircraft. Therefore, they are in different ways shielded from each other. … If you have a computer screen, a light tube or a mobile telephone, to what extent should we allow it to affect molecular and cellular events in our body?'

238 *Proof Committee Hansard*, Canberra, 2 March 2001, p 318 [Moulder]. The Committee notes that the view that electromagnetic interference cannot be compared to adverse health effects from radiofrequency, was not supported by Dr Cherry, who stated: 'My judgment is that that is completely wrong. The early studies show that oscillating signals interfere with the brain very significantly and can change EEG and can change calcium ions, and these change reaction times. That is a classical physics approach of resonant absorption. If a system can oscillate and an oscillating signal comes in, it can resonantly be absorbed (*Proof Committee Hansard*, Canberra, 2 March 2001, p 332 [Cherry]).

Electromagnetic radiation from non-telecommunication technologies

2.184 In addition to concerns about mobile phone technology, submissions and witnesses also referred to evidence about possible health effects from other artificial sources of electromagnetic radiation, including visual display units, TV towers and powerlines. Some of these concerns are outlined below.

2.185 Associate Professor Olle Johansson, Experimental Dermatology Unit, Karolinska Institutet, Sweden, in his submission to the Committee, referred to evidence of similarities between the cutaneous alterations and damage from UV, X-rays and radioactivity and the symptoms of people claiming to suffer from electrosensitivity or screen dermatitis.[239]

2.186 The issue of the placement of high voltage/tension electricity lines away from populated areas was also addressed in submissions.[240] Dr Repacholi from the WHO, also expressed concern about the potential health effects from extremely low frequency power lines. He stated:

> Some studies suggest increases in leukemia and brain tumours by working with power frequency fields. But the most worrying to me is the residential studies where children living near powerlines seem to have a higher incidence of leukemia. That is what we are concentrating our research on now.[241]

2.187 A recent report from the chairman of the UK's National Radiological Protection Board's Advisory Group on Non-ionising Radiation, epidemiologist Sir Richard Doll, concluded:

> Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK. In the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the epidemiological evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children. Unless, however, further research indicates that the finding is due to chance or some currently unrecognised artefact, the

239 Professor Olle Johansson, Submission 103, p 1.

240 See for example, Power to the People Action Group, Submission 109, p 1; National Council of Women of Australia (NCWA), Submission 32, p 2; Mr John Allen, Submission 65, p 1; Mr Tony & Mrs Lorraine Reeves, Submission 105, p 1; Power to the People Action Group, Submission 109, p 1; Mr Darryl Davies, Submission 116, p 1; Coomera Valley Progress Association, Submission 117, p 1.

241 *Official Committee Hansard*, Canberra, 31 August 2000, p 18 [Repacholi].

> possibility remains that intense and prolonged exposures to magnetic fields can increase the risk of leukaemia in children.[242]

2.188 Comparatively little evidence was received by the Committee in relation to possible health effects from TV towers. It was claimed that the emissions from television towers far exceed the emissions from mobile phone towers, and concerns were raised at the placement of TV towers close to schools and residential areas.[243]

2.189 The Committee Chair considers that further research is required to study the incidence of cancer around TV towers and notes the recent publicity given to the incidence of tumours and leukaemia around the Vatican's radio towers. On these installations, Dr Cherry said in evidence to the Committee:

> The radio towers are much more powerful than the base stations so, as the Hocking study shows, the effects occur much further out. I believe that the community concern that the base stations are closer to their homes because there are many more of them is a valid concern.[244]

2.190 The Committee notes that, while this inquiry has focussed on the standards for exposure to telecommunications technologies, there is considerable community concern about other artificial sources of electromagnetic radiation.

Recommendation 2.1

The Committee Chair recommends that, particularly in the light of recent reports on the links between powerlines, radio towers and leukaemia, additional research into extremely low frequencies and TV/radio tower exposure should be encouraged.

Recommendation 2.2

The Committee Chair recommends that precautionary measures for the placement of powerlines be up-graded to include wide buffer zones, and undergrounding and shielding cables where practicable.

Measures to minimise potential health risks

2.191 There are a number of ways in which potential health effects may be minimised, particularly given community concerns about the placement of mobile

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242 National Radiological Protection Board, *ELF Electromagnetic Fields and the Risk of Cancer. Report of an Advisory Group on Non-ionising Radiation*, Vol 12, No 1, March 2001.

243 Mrs Leanne Noakes, Submission 144, p 2.

244 *Proof Committee Hansard*, Canberra, 2 March 2001, pp 337-338 [Cherry].

phone towers and base stations near schools, hospitals, shopping centres, churches and people's homes:[245]

- adopting a precautionary approach in the setting of emission/exposure safety standards;
- ensuring that the mobile phone tower/base station emission beams of greatest intensity are sited away from sensitive areas like schools and hospitals;
- encouraging limits to the use of mobile phones, particularly by children;
- using devices which shield or otherwise minimise the level of emissions from mobile phones; and
- labelling mobile phones to inform consumers about emission levels, with the additional objective of allowing market forces to encourage companies to develop phones that can be efficiently used with the lowest levels of emissions possible.

2.192 The Committee also received evidence which suggested that the superimposition of random frequencies eliminated observed biological effects associated with pulsed radiofrequency radiation from digital mobile phone transmissions.[246] However, while the Committee was advised that several laboratories had successfully tested this hypothesis,[247] the Stewart Report stated that the experimental evidence had yet to be independently replicated.[248] According to Dr Swicord, the Food and Drug Administration in the United States also was unable to replicate this result.[249]

2.193 The incorporation of a precautionary approach for acceptable emission levels could be adopted as part of the new standard. This is probably of most importance with respect to occupational use of mobile phones or other telecommunications technologies, where a personal approach to limiting use may not be practical. The requirement to attach meaningful labels to phones, in manuals and at point of sale, could also be incorporated into industry codes of practice. These issues are discussed in Chapter 4.

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245 See for example, Mr Greg Hutchison, Submission 108, pp 2-3. See also *Official Committee Hansard*, Canberra, 31 August 2000, p 6 [Repacholi]: 'Individuals can be encouraged to take their own precautions if they have concerns about children. There was a lot of press following the Stewart inquiry about children being more sensitive. If people feel that this is the case – and there is no evidence for that, but it is a possibility – then hands-free kits or limiting times of calls are good ways to reduce exposures'.

246 See for example, *Official Committee Hansard*, Melbourne, 22 September 2000, pp 148-151 [Litovitz].

247 See for example, Simon Fielding, OBE, Submission 119, p 2; EMF South World Pty Ltd, Submission 129, Submission Vol 10, p 2077; EMF Southworld Pty Ltd, Submission 129a, pp 1-2; *Official Committee Hansard*, Melbourne, 22 September 2000, p 153 [Litovitz].

248 Stewart Report, p 44.

249 The Committee notes that Dr Litovitz was involved in this replication attempt. *Proof Committee Hansard*, Canberra, 2 March 2001, p 367. The Committee also notes EMF Southworld's explanation for this failure (Submission 129a, p 2).

Limiting phone use

2.194 Individual phone users could limit the time spent on a mobile phone, an approach particularly recommended for children. The Committee supports the Stewart Report's statement that:

> If there are currently unrecognised adverse health effects from the use of mobile phones, children may be more vulnerable because of their developing nervous system, the greater absorption of energy in the tissues of the head …, and a longer lifetime of exposure… we believe that the widespread use of mobile phones by children for non-essential calls should be discouraged. We also recommend that the mobile phone industry should refrain from promoting the use of mobile phones by children.[250]

2.195 The Committee recognises that many people are blase about their health, particularly the young, as evidenced by the continued rate of smoking uptake in teenagers despite labelled warnings and strong evidence of a causal link between cancer and smoking. However, the Committee considers that government has a responsibility to the community to provide clear, objective and detailed information about the potential risks, to enable individuals to make an informed choice about the extent to which they are prepared to expose themselves to electromagnetic radiation.

Recommendation 2.3

The Committee recommends that based on a growing body of research that provides evidence of biological effects, the Commonwealth Government considers developing material to advise parents and children of the potential risks associated with mobile phone use.

Shielding devices and hands-free kits

2.196 Other options for preventing or minimising the level of mobile phone emissions to which the body is exposed are shielding devices and hands-free kits.[251]

2.197 While a consumer association's magazine in the UK claimed that hands-free kits were found to act like an aerial and delivered three times as much radiation towards the brain,[252] tests conducted for *Choice* magazine in Australia found that

250 Stewart Report, p 121. See also Mr Stewart Fist, Submission 30, p 2.

251 The Committee was advised of EMF bioprotection technology, which is not a shielding device, but claimed to eliminate non-thermal biological effects, based on work carried out by Professor Litovitz at the Catholic University of America. *Official Committee Hansard*, 8 September, p 67 [EMF South World Pty Ltd].

252 Referred to in Ms Ruth Parnell, Submission 94, p 2; EMRAA, Submission 80, pp 29-30.

'radiation was greatly reduced'.[253] The Electrical Compliance Testing Association (ECTA), which undertook the tests criticised the inadequate instructions on how to use the hand held set. They recommended holding the phone along the bottom of the device and away from the body.[254]

2.198 Concerns about potential health risks from mobile phones has led to the development of various shielding devices. These devices claim to shield users from RF radiation. The Committee was advised, given the manner in which mobile phones operate, that it is possible that the level of exposure may actually be greater when a shielding device is used. Under normal circumstances, a mobile phone 'powers down' the closer it is to a tower. Shielding devices may make it difficult for the phone to 'contact' the base station or tower and result in the mobile phone 'powering up' and raising emission levels,[255] or directing emissions to other parts of the body.[256] ECTA expressed concern that many of the shielding devices currently on the market were unregulated.[257]

2.199 Another device that has been mentioned recently is the attachment of a so-called 'ferrite choke' to a hands-free set, to further reduce radiation without affecting sound quality or battery power. However, it has been claimed that the choke would only bounce the radiation off onto another part of the body.[258]

2.200 The Committee Chair was disturbed at the lack of industry and government attention to developing or promoting lower-emission mobile phone technology or consumer advice about minimising exposure. The Committee found that the effectiveness of shielding devices and hands-free kits was at best unclear, that no standards or other regulations existed for these devices and that whatever guarantees there were of mobile phone compliance with current standards, these became null and void with the use of such devices.

Recommendation 2.4

The Committee recommends that shielding and hands-free devices are tested, labelled for their effectiveness and regulated by standards.

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253 *Official Committee Hansard*, Melbourne, 22 September 2000, p 159 [ECTA]. See also, AMTA, Submission 19, p 23, which add that regardless of whether a hand-held or hands-free kit is used, all mobile phones are required to meet safety standards.

254 *Official Committee Hansard*, Melbourne, 22 September 2000, p160 [ECTA].

255 *Official Committee Hansard*, Melbourne, 22 September 2000, p 159 [ECTA].

256 ECTA, Submission 98, p 2.

257 ECTA, Submission 98, p 2. See also Mr Don Maisch, Submission 20(c), p 1; EMRAA, Submission 80, p 2; *Proof Committee Hansard*, Canberra, 2 March 2001, p 408 [Doull].

258 'Scientists Believe A Ferrite Choke Clipped to the Wire of A Hands-Free Set Could Dramatically Lower Radiation', *Financial Times*, 12 February 2001.

2.201 The Committee notes that no advice was available from AMTA or ARPANSA on the implications of moving to the new generation (3G) spectrum mobile phones.

Siting of mobile phone towers

2.202 While recent reviews have agreed that the potential health risks associated with mobile phone towers are considerably lower than those that may be related to mobile phones, there are steps that should be taken to minimise any risks. A number of submissions received during this inquiry highlighted community concerns about the placement of base stations and mobile phone towers, particularly those near schools, hospitals, shopping centres, churches and people's homes. Community groups and individuals were also concerned about the inadequate consultative process when decisions were being made to install new towers.

2.203 An approach that could be adopted in relation to the siting of mobile phone towers and base stations is to prohibit the placement of these structures at particular distances from sensitive sites such as schools, a practice that has been adopted in some countries.[259] The manner in which the emissions are beamed results in a concentration of the RF intensity at around 100 metres from the tower or base station so a buffer zone of 150 metres may be appropriate. The Stewart Report in discussing the moves in some communities to oppose the siting of transmission towers on school grounds, for instance, recommended:

> … a better approach would be to require that the beam of greatest RF intensity … from a macrocell base station sited within the grounds of a school should not be permitted to fall on any part of the school grounds or buildings without agreement from the school and parents … when consent is sought from a school and parents about this question, they should be provided with adequate information to make an informed decision, including an explanation of the way in which the intensity of radiation falls off with distance from the antenna. This may be particularly relevant for schools with large grounds. If, for an existing base station, agreement could not be obtained, its antennas might need to be readjusted.[260]

2.204 The network operator should provide similar advice where a base station is located near school grounds, nursing homes, child care facilities, hospitals and so on, and if necessary, placement should ensure that vulnerable groups are not chronically exposed where the beam is of greatest intensity.

2.205 An Australian Communications Industry Forum (ACIF) code of practice is expected to address these issues (see Chapter 4).

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259 Stewart Report, p 117.

260 Stewart Report, p 118.

Recommendation 2.5

The Committee Chair recommends that the Government review the Telecommunications (Low-impact Facilities) Determination 1997, and as a precautionary measure, amend it to enable community groups to have greater input into the siting of antenna towers and require their installation to go through normal local government planning processes.

Complaints mechanism

2.206 The Committee notes that currently there is no mechanism by which health effects attributed by users to their mobile phones are collected.[261] In 1995, Dr Bruce Hocking, occupational health consultant, after reviewing the recommendations of the 1994 CSIRO *Report on the Status of Research on Biological Effects and the Safety of Electromagnetic Radiation: Telecommunications Frequencies*, additionally recommended, *inter alia*, the establishment of a 'register of health effects to systematically investigate and record reports of adverse health effects from mobile phone use'.[262]

2.207 The Committee also notes that Dr Hocking has periodically published reports of symptoms claimed to be associated with mobile phone use. The value of a database of anecdotal reports was criticised by Dr Black, a New Zealand medical practitioner:

> I think you can only have a formal reporting system when you have a clear sort of threshold point or diagnosis. It would be very difficult to get data from, for example, GPs. It would be a bit meaningless because you would have the number of cases but you would not know the population that was over. There will be too many variables for consistency of reporting. … I do not think it would be possible to have any system of mandatory reporting because I do not know what the data would mean. But it is certainly an area which is deserving of continued monitoring and scrutiny.[263]

2.208 The Mobile Manufacturers Forum indicated that a database of symptoms claimed to be associated with emissions from mobile phones or other telecommunications structures would serve only to prompt scientific research into possible health effects:

> All the anecdotal reports do in those reporting mechanisms is tell you one of two things: either you should do human studies or you should do epidemiological studies. What we are doing now is going to the next step. We are supporting human studies and epidemiological studies to address the

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261 See for example, EMRAA, Submission 80, p 38; *Official Committee Hansard*, Sydney, 16 November 2000, p 215 [Consumers' Telecommunications Network].

262 ACA, Submission 100, p. 11.

263 *Official Committee Hansard*, Canberra, 8 September 2000, p 62 [Black].

> issues in a scientific way. There is no added value in looking at the issue of anecdotal reports.[264]

2.209 Dr Swicord, appearing on behalf of the Mobile Manufacturers Forum advised that studies into electro-hypersensitive people were already under-way, and one study had already been completed and had been unable to demonstrate an association between symptoms including headaches and exposure to radiofrequency radiation emitted by mobile phones.[265]

2.210 The Committee Chair notes, however, that there is a difference between electro-hypersensitivy (EHS) and health effects. EHS covers a broader range of problems, including neurological and the Committee did not receive sufficient evidence on EHS to form a view about collecting data in this field.

2.211 The Australian Communications Authority (ACA) was questioned about its efforts in recording complaints about health effects resulting from mobile phone use. Mr Ian McAlister, Manager, Radiocommunications Standards Team, ACA, stated:

> … I should admit it [the complaints system] is rather embryonic at the moment. We have had some 20 to 25 legit complaints that we have recorded, more or less. What we have started to do now is to ask the same questions of people ringing up with complaints. We started this at the request of Dr Hocking when he was starting to do some work into headaches and mobile phone use. He said, 'If you get any calls, please take them down'. We started doing that, but now it is a much more methodical arrangement. But it is not anything like a database or something like that…
>
> … I do know, for example, that people complain they will go to the carriers; they will go to suppliers where they bought the phones; they will go to the TIO; they will come to the ACA; they will go to the department and the Department of Health as well. I think if you pulled them all together, you might get a basis for some research.[266]

2.212 He later continued:

> The ACA gets complaints on a whole range of things. With headaches, we have not worked out a set policy on this; but if someone rings me directly I tell them they should talk to their medical practitioner first.
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> … As I mentioned, it is at a very early stage, where we decided to collect information and to start to record information coming from people ringing us directly. We were not setting up a database or setting up some sort of basis for epidemiological study or anything.

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264 *Proof Committee Hansard*, Canberra, 2 March 2001, p 373 [Swicord].

265 *Proof Committee Hansard*, Canberra, 2 March 2001, p 372 [Swicord].

266 *Official Committee Hansard*, Sydney, 16 November 2000, p 309 [McAlister].

> … All I did was at Dr Hocking's suggestion, that he would like to know of people who had complaints about headaches and if we asked them if they would be willing for us to pass their contact details on to someone doing research in this area we would be happy to do so. That is the basis of our complaint handling on adverse health effects.[267]

2.213 Dr Robert Horton, Deputy Chairman, ACA, added:

> What we will be doing is a sort of community education campaign, if you like, over the coming six months. We will be putting together fact sheets and so on which explain whatever the circumstance is, the process you should follow, and what is in place – who is responsible for what – whether it is about towers or whether it is about purchasing equipment in the marketplace. There are plenty of questions and answers, which we will set out and go public with. We have also found that there is an education campaign with even local councils who do not understand the new act and their position in this area.
>
> … I cannot tell you what they [the fact sheets] will say at the moment or if they will say anything about headaches, but we may provide information of where people should go if they do have problems.[268]

2.214 The Committee recognises that research is being undertaken to investigate a range of symptoms attributed to mobile phone use but industry codes of practice should be developed which ensure that mobile phone users who complain are provided with advice with regard to minimising exposure and referred to a Government agency such as ARPANSA or the Health Department and records of consumer complaints reported annually.

2.215 The Committee is of the view that the development of a database of reports of adverse health effects from mobile phones and other sources of radiofrequency radiation would assist consumers and provide researchers and Government agencies with valuable data in formulating future research hypotheses.

Recommendation 2.6

The Committee recommends the development of an industry code of practice for handling consumer health complaints.

Recommendation 2.7

The Committee recommends the establishment of a centralised complaints mechanism in ARPANSA or the Department of Health for people to report adverse health effects associated with mobile phone use and other

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267 *Official Committee Hansard*, Sydney, 16 November 2000, pp 310-311 [McAlister].

268 *Official Committee Hansard*, Sydney, 16 November 2000, pp 309-310 [Horton].

radiofrequency technology, and for the data from this register to be considered by the NHMRC in determining research funding priorities.

The difficulties of drawing conclusions

2.216 There were essentially three positions put in relation to the scientific evidence on the health effects of radiofrequency radiation. There were those who argued that there is insufficient evidence on adverse health effects associated with RF radiation, those who said the evidence is insufficient to rule out any health risks, and those who argue that evidence shows a causal relationship between health effects and exposure to low-power microwave emissions.

2.217 It is important to acknowledge the complexity of the subject matter and to also recognise that parties offering interpretation of the scientific literature are not always completely at arms-length from industry.

2.218 The Committee Chair notes that Dr Michael Repacholi has in the past been employed by the power and telecommunications industry both as a consultant and as their scientific expert in court. He now holds influential positions as Coordinator, Occupational and Environmental Health at the World Health Organization and Chairman of the International Radiation Protection Association's International Non-ionizing Radiation Committee which later became ICNIRP. This committee interacts with the WHO, the International Labour Office, the International Commission on Radiological Units, the International Electrotechnical Commission and the Commission of European Communities. Dr Repacholi was instrumental in developing the TE/7 Committee standard setting procedures in Australia, advocates the adoption of the ICNIRP based standard and was seconded from the Royal Adelaide Hospital to the Australian Radiation Laboratory – now ARPANSA – for two years to complete EMF research projects. Dr Repacholi was also a member of the Independent Expert Group on Mobile Phones (The Stewart Report). The involvement of Dr Ken Joyner, employee of Motorola, and member of the Australian RF EME Expert Committee which provides advice to NHMRC on research grants is also discussed in Chapter 3.

2.219 It is difficult for people, especially those without a working knowledge in this field, to confidently understand all the implications of the research methodologies and interpretation of results, particularly when abstracts of studies are extensively relied upon.[269]

2.220 While it has been argued that 'the jury is still out' with respect to the effects of exposure to electromagnetic radiation, in particular, mobile phones, and that current research provides no evidence of long term adverse health effects from relatively short exposures to radiofrequency/microwave radiation, it is also the case that few studies

269 CSIRO, Submission 95, p 7.

have examined directly the effects of mobile phone emissions and that, necessarily, no long term studies have been done on humans to show that cancer, with its long latency period, is neither promoted or initiated by radiofrequency radiation.

2.221 Given the evidence put before it, the Committee considers that it would be unwise to be complacent about the potential adverse health effects of mobile phone use, particularly effects that may manifest themselves after long term exposure.

2.222 The failure to provide sufficient evidence to allow the technology to be considered safe, is in contrast to the continued appearance of studies that have found biological effects if not health effects.

2.223 The Stewart Report concluded that whilst a number of scientific studies suffered from methodological or analytical shortcomings, the public cannot be reassured that there is no risk. The Committee Chair found, however, that there was by no means agreement about these criticisms and notes that it is possible for vested interests to undermine the integrity of studies in this way, leaving the general public uncertain about the findings.

2.224 Nevertheless, the Committee agrees with the need for rigorous and well-designed studies in this as in all fields of science.

2.225 There are many historical examples of scientific results that are found to conflict with other results and with established understanding but which eventually replace earlier theories. In fact there were a variety of reasons for discounting research that found links between mobile phone emissions and biological or health effects.[270]

2.226 The Committee Chair considers that the effects of electromagnetic radiation deserve attention and that a concerted and targeted approach to research in this area is needed,[271] and, in the light of the inconsistency of many of the results of these studies, a cautious approach should be adopted to policy-making in this area (see Chapter 4 for a discussion of precautionary approaches as they relate to the setting of standards for mobile phone emissions).

2.227 The Committee notes that a conference was held in Coogee, Sydney, Australia on 22-23 March 2001, entitled: *The Radio Frequency Spectrum: Managing Community Issues*, which provided a forum for all views in this debate to be represented and discussed. The Committee considers that such forums are valuable opportunities for scientists and other interested parties to attempt to publicly discuss

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270 Ms Yvonne Jayawardena, Submission 81, p 3.

271 The Committee notes the views expressed by the CSIRO: 'Research has been sporadic. The results have been controversial and contradictory. It is not really surprising. Unless you have a properly structured and directed system of research, you will not overcome the initial problem of the undirected sporadic bits of research that are carried on, sometimes not particularly well … If you do not provide adequate or proper resources, you are being extremely optimistic in expecting a decent outcome' (*Official Committee Hansard*, Sydney, 16 November 2000, p 224).

the potential and actual health effects of exposure to radiofrequency radiation. The Committee sees merit in the Commonwealth Government sponsoring similar conferences, under the auspices of a body such as the National Academy of Science, to include respected Australian and international researchers in this field and for such forums to be open to the public. The Committee notes that in March 1999, the National Museum of Australia coordinated Australia's first consensus conference on gene technology in the food chain, which enabled lay people to put questions to an expert panel.[272]

Recommendation 2.8

The Committee recommends that the Commonwealth Government consider sponsoring conferences on the health effects of radiofrequency radiation along similar lines to that conducted on gene technology.

International research

World Health Organization International Electromagnetic Fields Project

2.228 In November 1996, an international seminar was held on the biological effects of low-level radiofrequency electromagnetic fields. The seminar, after surveying the literature and preparing status reports, concluded 'although hazards from exposure to high-level (thermal) RF fields were established, no known health hazards were associated with exposure to RF sources emitting fields too low to cause a significant temperature rise in tissue'. The seminar identified a number of research areas requiring further study or replication.[273] The WHO RF Electromagnetic Fields Research Coordination Committee outlined an agenda for future research into radiofrequency fields.[274] The WHO Committee said 'the only established health effects of RF fields relate to thermal effects (for frequencies between about 1 MHz and 300 GHz) or induced electrical currents and fields (for frequencies up to about 1 MHz), following exposures at relatively high levels' and that although 'some studies suggest biological effects from low-level RF exposure … there is a lack of well replicated findings'.[275] The WHO Committee recommended that:

a) exposure levels, frequencies, modulation and pulse characteristics should be as relevant as possible to human experience; and

b) there should be relevant biological end-points, that is, those that can be related to possible health risks.

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272 See www.austmus.gov.au/consensus/

273 Repacholi 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 806.

274 Repacholi 1998, included in The World Health Organization, Submission 56, Submission Vol 4, p 806.

275 NHMRC, Submission 69, p 43.

2.229 In terms of research priorities, the WHO Committee said greater emphasis was placed on the results of *in vivo* and epidemiological studies rather than *in vitro* studies, unless the latter provide mechanisms for extrapolation to humans or additional information that supports the results of *in vivo* studies.[276]

2.230 Research needs included in the WHO's research agenda were said to be identified on the basis of whether the evidence for a health risk was judged to be suggestive but insufficient to meet the criteria for assessing health risk. The overall goal was to promote studies that demonstrate a reproducible effect of EMF exposure that has the likelihood to occur in humans and has potential health consequences. This research agenda formed part of the Australian RF EME Expert Committee's considerations in making its research recommendations (see *Australian research* below).

2.231 The EMF Project provides a forum for a coordinated international response to various electromagnetic field issues. International scientific reviews have provided health status reports and identified gaps in knowledge where further research is required. Australia's EMF research program was largely based on the WHO's research needs identified at an international symposium on the biological effects of exposure to non-thermal radiofrequency fields in Munich in November 1996.

2.232 The EMF Project includes the monitoring of all relevant research results culminating in the publication of a report, anticipated to occur in 2005, that will provide information on health effects of exposure to static and time varying electric and magnetic fields in the frequency range of 0-300 GHz.

2.233 Organisations collaborating with the WHO on the EMF Project are:

- International Commission on Non-Ionizing Radiation Protection (ICNIRP) – develops international guidelines on exposure to non-ionising radiation;
- International Agency for Research on Cancer (IARC) – looks at carcinogenic effects of radiation;
- International Labour Office (ILO) – EMF exposure and occupational health;
- International Telecommunications Union (ITU) – development of telecommunications equipment; information on current and future communications systems;
- International Electrotechnical Commission (IEC) – standards;
- United Nations Environment Programme (UNEP) – environment and human health;
- North Atlantic Treaty Organization (NATO) – NIR effects on personnel; and

276 NHMRC, Submission 69, p 44.

- European Commission (EC)
    - Directorate General on Employment, Industrial Relations and Social Affairs (DG V)[277]
    - Directorate General on Science, Research and Development (DG XII)
    - Directorate General on Telecommunications, Market Information and Research Exploitation (DG XIII).

2.234 The 1997 WHO Research Agenda for the International EMF Project, being conducted under the auspices of the WHO, was re-examined in 1999. Of the seven areas that were deemed to require further research, two were considered to have not been addressed while several others were not fully addressed, according to Dr Swicord who made an assessment on WHO's behalf:

- In relation to bioassays to test for cancer initiation, promotion, co-promotion and progression, six studies were conducted in four laboratories including two EC studies, one in Germany and one in Finland.
- Two studies are being conducted to replicate the Repacholi mouse study, one in Australia (see the Vernon-Roberts study below) and the other, supported by the EC, in Italy.
- In relation to studies to test the reproducibility of reported changes in hormone levels, effects on the eye, inner ear and cochlea, memory loss, neurodegenerative diseases and neurophysiological effects, a French study is examining behavioural elements of this area. In addition, an Australian study (see the Stough study below) is addressing components of the neurophysiological area.
- In response to WHO's call for epidemiological studies to be undertaken which focus on head and neck cancers and any disorders associated with the eye or inner ear, a large scale IARC mobile telephone study is covering nine countries in Europe, Israel and four additional countries, for which funding is not yet in place. One of the additional countries is Australia, which has recently announced funding for the extension to the Armstrong pilot study (see below). A large occupational study in the UK is also in the pilot study phase.
- In relation to studies to provide a better assessment of any health risks from exposure to radar technology, including ultra-wide band radars, Dr Swicord advised that this issue was not currently being addressed. However, the NHMRC noted that the US military had undertaken considerable work in this

277 Supports communications among European scientific researchers through COST 244 *Biomedical effects of electromagnetic fields* initiative, originally proposed by the Faculty of Bioelectrical Engineering, University of Zagreb, Croatia, and adopted in October 1992. COST, European Cooperation in the field of Scientific and Technical Research, was set up in 1971 and is a framework for R&D co-operation in Europe, involving 25 countries and the European Commission. COST Actions exist in over 15 research domains the largest of which is COST Telecommunications. See radio.fer.hr/mainpage.htm.

area which was in the process of being published, and that additional work was being undertaken in Russia, China, and the UK.

- While it was indicated that studies testing people reporting specific symptoms such as headaches, sleep disorders or auditory effects, and who attribute them to RF exposure, were required, the NHMRC advised that some areas on cognitive disorders and behaviour are proposed and that a number of other human studies in this area have been proposed or are under-way in Germany, Italy and the UK.
- In relation to suggested research at the cellular level that may be directly relevant to possible *in vivo* effects, this was considered to have been addressed to a large extent already, with the possible exception of replication studies of DNA aberration results and ODC results. The NHMRC noted that some work on ODC and DNA aberrations is being undertaken in France, Italy and Finland.[278]

2.235 In late 1999, the Research Coordination Committee of the WHO International EMF Project reassessed its research agenda and identified one area that was not being well addressed; there is still a need for well controlled studies to test people with specific symptoms such as headaches, sleep disorders or auditory effects, which they attribute to RF exposure.

European Commission

2.236 Internationally, the European Commission has also responded to WHO's (revised) research agenda, announcing, in early 2000, four projects in addition to the IARC study (see below):

- *Combined effects of EMFs with environmental carcinogens: molecular changes and genetic susceptibility*: This study, to be conducted by Jukka Juudlainen at the University of Kuopio in Finland, is examining the possible effects of RF/MW exposure and known mutagenic agents; whether RF/MW similar to those emitted by mobile phones enhance tumour development in a carefully selected animal model; whether RF/MW exposure is a possible enhancer of DNA damage *in vivo*; and examining *in vitro*, what the effects are of RF/MW fields, alone or in combination with environmental chemicals, on selected cellular processes related to carcinogenesis and non-genotoxic carcinogenesis.
- *Risk evaluation of potential environmental hazards from low-energy EMF exposure using sensitive in vitro methods*: Franz Adlkofer, Foundation for Behaviour and Environment in Munich, Germany, is carrying out *in vitro* investigations of molecular and functional responses of living cells to EMFs covering genotoxic effects, and effects on differentiation and function of embryonic stem cells and tumour cells, gene expression and targeting, the immune system, and cell transformation and apoptosis.

278 NHMRC, Submission 69, pp 22-23.

- *In vivo research on possible health effects related to mobile telephones and base stations: carcinogenicity studies in rodents:* This study, coordinated by Clemens Dasenbrock at the Fraunhofer Institute in Germany, is undertaking two-year bioassays in Wistar rats and B6C3F1 mice with 900 MHz GSM and 1800 MHz PCS radiation, a replication of the DMBA-initiated breast cancer bioassay in female Sprague-Dawley rats with 900 MHz GSM radiation, and a replication of the lymphoma bioassay in *Pim-1* transgenic mice with 900 MHz GSM radiation.
- *Development of advice to the EC on the risk to health of the general public from the use of security and similar devices employing pulsed EMFs*: Coordinated by Jürgen Bernhardt, German Federal Radiation Protection Office, Oberschleissheim, Germany, this study will produce an advisory document for the European Commission and member states addressing the issue of possible adverse public health effects from exposure to pulsed electromagnetic fields associated with electronic security and similar devices.[279]

IARC INTERPHONE study

2.237 Following recommendations from several expert reviews and the completion of a detailed feasibility study in 1998 and 1999, which determined that a multi-national study into a range of cancers would be feasible and informative, the International Agency for Research on Cancer (IARC) established, and will coordinate, a multi-centre study of brain tumours, salivary gland tumours, acoustic neurinomas and other head and neck tumours, and leukaemia and lymphomas in Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden and the UK. The results are expected in 2003 or 2004. This study is partially funded by the EC Fifth Framework programme.[280]

UK Link Collaborative Research Programme

2.238 On 8 December 2000, in response to the Stewart Report's recommendations, the UK Government announced a £7 million collaborative Mobile Telecommunications and Health Research Programme.[281] Applications have been called for and will close at the end of March 2001, with a further call for research applications later in the year. Research contracts would be awarded on the basis of the most creative approach, those likely to be effective and predictable, and those demonstrating value for money. The areas of research for which bids are being particularly sought reflect the recommendations from the Stewart Report: effects on brain function; consequences of exposure to pulsed signals; improvements in dosimetry; sub-cellular and cellular changes induced by radiofrequency radiation and their possible impact on health; psychological and sociological studies related to the use of mobile phones; and epidemiological and human volunteer studies including the

279 CEMEPHI, Submission 127, Submission Vol 9, pp 1923-1924.

280 See MMF, Submission 75, p 8. See also europa.eu.int/comm/research/fp5.html and www.iarc.fr/pageroot/UNITS/RCA4.html.

281 See www.doh.gov.uk/newsdesk/archive/december/4-naa-08122000.html.

study of children and individuals who may be more susceptible to radiofrequency radiation.

Cooperative Research and Development Agreement (CRADA) on Health Effects of RF Emissions from Wireless Phones (Mobile Units for Commercial Mobile Radio Services)

2.239 As part of a collaborative research program between the US Food and Drug Administration (FDA) and the Cellular Telecommunications Industry Association (CTIA), the US FDA's Center for Devices and Radiological Health (CDRH) will make recommendations on the studies that are required, and the CTIA will contract directly with third parties to undertake this research, the results of which are to be published in peer-reviewed journals or other appropriate forums. Interim reports and ongoing working data of these researchers will be kept confidential under the terms of the Agreement. The research undertaken by the third parties will be conducted under agreement independent of the CRADA, and CTIA will make the decision on which research proposals should be funded. The Agreement will focus on two topics: mechanistic studies related to genotoxicity (or carcinogenesis) and research on additional epidemiological studies, and is due to conclude in December 2002.

2.240 The Committee understands that the Working Group for the genotoxicity study was formed in August 2000, and that a request for genotoxicity proposals was issued in September to be responded to by December. The Working Group for the epidemiology study appears to be still being organised, and it will be some months before research proposals are sought. The Committee was advised that no genotoxicity research grants appear to have been awarded as yet.[282]

Australian research

Radiofrequency electromagnetic emissions research program (RF EME program)

2.241 The background to and components of Australia's electromagnetic emissions research program will be detailed later in this report. Briefly, the Committee on Electromagnetic Energy Public Health Issues (CEMEPHI), currently convened by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), has responsibility for the overall implementation of the Australian Radiofrequency Electromagnetic Energy Program, and was responsible for developing the research strategy. The National Health and Medical Research Council (NHMRC) is responsible for the management of the research component of the program through its Strategic Research and Development Committee (SRDC), which established a Radiofrequency (RF) Electromagnetic Energy (EME) Expert Committee to oversee the research.[283]

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282 *Committee correspondence,* Dr John Moulder, 17 February 2001.

283 National Health and Medical Research Council (NHMRC), Submission 69, Submission Vol 6, pp 1076.

2.242 The RF EME Expert Committee developed research priorities based on the CEMEPHI research strategy.[284] The research agenda also took into consideration the proposals of the European Commission's 1996 report on 'Possible health effects related to the use of radiotelephones – Proposals for a research program by a European Commission Expert Group'. The WHO's 1996 and subsequent revised RF research agendas are also referred to in determining research priorities.[285]

2.243 The main priorities of the research strategy identified by the CEMEPHI were:

- dosimetry and exposure systems;
- field measurements of RFR sources and personal exposure;
- numerical modelling and verification of SAR[286] distributions in the body;
- *in vivo* and *in vitro* studies of biological effects;
- mechanisms for interaction between radiofrequency radiation and cellular processes;
- animal and human laboratory studies on non-cancer disorders of the brain and neck, including neurobehavioural and immune system effects, affect on blood brain permeability, sleep disorders etc;
- epidemiological studies on acute and chronic exposure to radiofrequency radiation, particularly of groups with higher exposure than the general population;
- brain cancer; and
- further testing of hypothesised association between residence near TV towers and childhood leukaemia.[287]

2.244 The NHMRC advised the Committee that, although the EME program is intended to be Australian-based and to examine RF EME issues of particular relevance to the Australian environment, it is also intended that the program complement overseas research activities.[288] Four research projects were funded from the first round and they are outlined briefly below.

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284 National Health and Medical Research Council (NHMRC), Submission 69, Submission Vol 6, pp 1070-1072.

285 CEMEPHI, Submission 127, p 6.

286 Specific Absorption Rate.

287 CEMEPHI, Submission 127, pp 51-53.

288 NHMRC, Submission 69, Submission Vol 6, p 1073.

The Sykes pilot study on intrachromosomal recombination[289]

2.245 Dr Pamela Sykes, Flinders Medical Centre, Adelaide, was funded to conduct an *in vivo*[290] pilot study to test whether radiofrequency induced mutations in transgenic mice[291] with a view to identifying a biological mechanism that links RF and cancer. The study provided for exposure to radiofrequency radiation at a certain dose for three different time periods. If an increase in mutations were observed in the spleen cells of animals, then a lower dose would be investigated.

2.246 The study was conducted at Flinders University in South Australia. The results of the pilot study undertaken at specific absorption rates at which thermal effects might be expected, did not show more DNA breakage than was observed in mice not exposed to RF electromagnetic emissions (EME), although it did show changes which Dr Sykes said were worthy of further study. The results were evaluated by the NHMRC's RF EME Expert Committee, which decided not to recommend further funding for a full proposal by Dr Sykes, based on testing the same hypothesis with the same methodology.[292]

The Vernon-Roberts study on tumour incidence in transgenic mice

2.247 Professor Barrie Vernon-Roberts, Head of the Department of Pathology, Adelaide University and Director of the Institute of Medical and Veterinary Science, is undertaking a replication study of the 1997 Adelaide mouse study, to test whether exposure to GSM[293]-like radiofrequency fields affects lymphoma rates in *Eμ-pim-1* transgenic mice.[294] In addition to the methods followed in the earlier study, the Vernon-Roberts study will test a range of doses and use enhanced dosimetric techniques.

2.248 Large numbers of *Eμ-pim-1* transgenic mice, which are predisposed to lymphoma development, will be exposed to electromagnetic fields similar to those emitted by mobile telephones. There will be four dose exposure levels in addition to control groups. The incidence of cancer in exposed and non-exposed mice will be compared.

2.249 The Committee notes that the exposure of the mice is expected to be completed in June 2001, followed by analysis of pathology results and the report write-up, expected to be completed by June 2002.[295]

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289 Mutations

290 In a living body as opposed to *in vitro* – in glass.

291 Mice genetically engineered usually to be susceptible to a particular type of disease.

292 NHMRC, Submission 69, pp 7, 11. See also *Proof Committee Hansard*, 2 March 2001, pp 400-401 [NHMRC].

293 Global System for Mobile Communications – a standard for mobile telephony which uses pulsed signals.

294 A strain of genetically modified mice engineered to be susceptible to a particular type of cancer.

295 *Proof Committee Hansard*, Canberra, 2 March 2001, p 367 [Swicord].

2.250 The application originally included a proposal to undertake a similar study with another genetically-modified mouse variant (*p53* mice). However, the RF EME Committee considered that as definitive results from the *pim-1* study were two years away, and should the study show no increase in lymphoma risk, that this would substantially reduce the justification for funding the *p53* mouse study.[296] The funds have been used for the second round of NHMRC funding for EMR research (see below).

2.251 The World Health Organization, in its submission to this inquiry, recommended that the Vernon-Roberts team should be funded to complete a study using the *p53* mouse model, as results could 'add significantly to our understanding of the way RF fields interact with biological tissues' and 'allow a better understanding of the results of the *pim-1* mouse study'.[297] Dr Peter French, Principal Scientific Officer at the Centre for Immunology, St Vincent's Hospital, Sydney, in his submission to the Committee, noted:

> It is true that [the 1997 Adelaide mouse study] does not imply that there is an increased risk to humans of lymphoma induced by mobile phone exposure. It may indicate however that in individuals genetically predisposed to certain forms of cancer, the long term intermittent exposure to RF such as that used in mobile phone technology may be an important environmental stimulus in the induction of malignancy, by an as yet unknown mechanism.[298]

2.252 The authors of the original mouse study, in their conclusion, observed that while no humans were known to carry an activated *pim1* gene, there were cases of individuals expressing the *p53* gene, and that these individuals may 'comprise a subpopulation at special risk from agents that would pose an otherwise insignificant risk of cancer'.[299]

2.253 The Committee Chair recognises that funding decisions are made by the NHMRC, notes the reasons for the decision to re-allocate the funding originally set-aside for the *p53* study, but is persuaded that this study should be undertaken.

Recommendation 2.9

The Committee Chair recommends that a study into *p53* mice be listed as an area of research for which future research applications should be encouraged.

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296 *Official Committee Hansard*, Canberra, 8 September 2000, p 52 [NHMRC].

297 The World Health Organization, Submission 56, Submission Volume 4, p 773.

298 Dr Peter French, Submission 37, pp 2-3.

299 Michael H. Repacholi, Antony Basten, Val Gebski, Denise Noonan, John Finnie and Alan W. Harris, 'Lymphomas in Eμ-*Pim1* Transgenic Mice Exposed to Pulsed 900 Mhz Electromagnetic Fields', *Radiation Research*, 147, 1997, pp 631-640 at p 639.

The Stough study on neuropsychological impairment

2.254 Dr Con Stough, from Swinburne University, Victoria, was funded to conduct an 18 month human study to test whether exposure to EME emissions from mobile phones causes impairments in neuropsychological functioning (in contrast to previous studies of the use of mobile phones affecting driving performance that could just indicate divided attention). The study, using 120 participants taken from the general community, first established a baseline with respect to memory, attention and problem solving and then gave either an RF EME or 'sham' (placebo) for 60 minutes. The participants were reassessed on the same day after the 60 minutes of either EME or sham. After 7 days, a second baseline assessment was measured and was followed by a further assessment. At each assessment subjects completed various neuropsychological tests. These tests were designed to measure a wide range of psychological processes, including: visual-motor coordination and speed; visual scanning; incidental learning; sustained attention; language comprehension; rapid decision-making; psychomotor speed; short-term memory and attention; verbal encoding and recall; sequencing; capacity to learn; and short-term recall.

2.255 This study has been completed and the results are to be submitted for publication.

The Armstrong study on brain and other tumours

2.256 Professor Bruce Armstrong, Director of the Cancer Control Information Centre, NSW Cancer Council, has been funded to conduct a 16 month epidemiological case-control pilot study of brain and other tumours in adults and exposure to radiofrequency electromagnetic energy in the use of mobile phones. Professor Armstrong's research forms part of an International Agency for Research on Cancer (IARC) study that includes participation from the UK, France, Italy, Sweden, Denmark, Israel and Canada. The pilot study was accepted, and Dr Armstrong has received funding for the full study.[300]

2.257 The full study will examine adults aged 20-69 years, diagnosed for the first time with primary glioma[301] or meningioma[302] of the brain, acoustic neuroma[303], or cancer of the parotid gland[304] between 1999-2001. An equal sample size of age and sex matched controls has been randomly selected using electoral rolls. A 45 minute questionnaire based interview will be conducted that includes questions on mobile

300 *Proof Committee Hansard*, 2 March 2001, p 403 [NHMRC].

301 Gliomas are brain tumours of the glial cells, which make up the tissue that support nerve cells in the brain. Primary gliomas are those that arise in the brain rather than those that begin elsewhere in the body and spread to the brain.

302 Brain tumours that develop in the protective membrane, called the meninges, that surrounds the brain directly underneath the skull.

303 Tumours that develop in the cells that produce the substance that protects the acoustic nerve.

304 Largest salivary gland situated near each ear.

phone usage and pattern, type of phone (analog or digital), and use of antenna. Demographic and other variables will also be collected.

Latest research projects

2.258 A second round of funding was agreed to in February 2000 to address areas of research identified by the RF EME Expert Committee as being under-researched. In line with the revised research agenda developed by the World Health Organization (see above), the RF EME Expert Committee emphasised the areas of neuropsychological and neurophysiological abnormalities in its call for a second round of research expressions for interest, including:

- effects on the eye and vision;
- effects on the inner ear, cochlea and hearing;
- memory loss;
- headaches;
- sleep disorders;
- other neurological effects;
- neuroendocrine effects;
- immunological effects; and
- areas of possible biological effects.[305]

2.259 Two projects, out of five full research proposals submitted, were announced as part of the second round of funding.[306] The funding details of these projects are discussed in Chapter 3. The projects are briefly described below.

The Wood study on human physiological responses

2.260 Dr Andrew Wood, from the Swinburne University of Technology in Victoria, will conduct a three-year study which will expose human volunteers to radiation similar to that which would be experienced during a mobile phone call, to identify the immediate effects of mobile phone use on the ability of participants to respond to

305 NHMRC, Submission 69, Submission Vol 6, pp 1075-1076. The NHMRC also advised that research priorities identified in the report by the Royal Society of Canada may also be addressed in the latest round of EME funding proposals, including: laboratory-based studies of ocular effects and neurodegenerative changes, studies to identify the biophysical detection mechanism that detects RF radiation; as well as clinical studies to identify whether some people potentially are more sensitive to RF fields, and/or whether people vary in their response patterns to RF exposure of the brain activity (Submission 69, p 25).

306 Dr Michael Wooldridge, Minister for Health and Aged Care, 'NHMRC research to throw light on the human effects of mobile phone use', *Media Release*, 1 March 2001.

visual and auditory stimuli. The quality of participant sleep during the night following exposure will also be measured.[307]

The Mitchell study into effects on vision and hearing

2.261 Associate Professor Paul Mitchell, Westmead Hospital, University of Sydney, will conduct a two-year study based on the large scale Blue Mountain Eye Study[308] to examine the consequences of long-term mobile phone use on standard measures of vision, eye disease and hearing. The project will also test for subtle changes in sensory function.[309]

Future research

2.262 A number of areas of possible future research were highlighted in evidence to the Committee.[310] The Committee notes calls by submitters to this inquiry for more human and epidemiological research to be conducted on health risks associated with exposure to low levels of radiofrequency radiation,[311] and occupational exposure.[312]

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307 See also *Proof Committee Hansard*, Canberra, 2 March 2001, pp 397-398 [Clarkson].

308 This study examined a sight disorder called age-related macular degeneration (the macula is a part of the retina).

309 See also *Proof Committee Hansard*, Canberra, 2 March 2001, p 398 [Clarkson].

310 See for example, ACTU, Submission 89, pp 5-6; CSIRO, Submission 95, p 5; Mr Pranay Bhattacharya, Submission 107, pp 3-6; Ms Diane Beaumont, Submission 138, p 49, 53-54. The Committee also acknowledges the view expressed by Dr Cherry in evidence to the Committee when he stated: 'When I started in this area, I found that there was so much available that it did not need to have new studies to show effects because they were already published, but many of them were misinterpreting the radiation patterns because they did not know the engineering (*Proof Committee Hansard*, Canberra, 2 March 2001, p 333 [Cherry]). See also, *Proof Committee Hansard*, Canberra, 2 March 2001, p 343, where Dr Loy, ARPANSA, also indicated that further research in this field was required; *Proof Committee Hansard*, Canberra, 2 March 2001, p 407 [Doull].

311 See for example, Dr Bruce Hocking, Submission 21, p 1; *Official Committee Hansard*, Canberra, 8 September 2000, p 83 [Holt] and Melbourne, 22 September 2000, p 115 [Hocking]. See also Mr Simon Fielding, OBE, who stated that '[i]t is important to note, however, that to demonstrate any conclusive link between these biological effects and any long term health implications will take many years of epidemiological research' (Submission 119, Submission Vol 9, p 1832). The Committee notes the views expressed by Mr Neil Boucher who stated: 'Most of the "research" that has been carried out on the health effects of electromagnetism are top down studies. That is people are assembled, with largely medical and statistical qualifications (and usually with little or no knowledge of electromagnetism itself), to look for epidemiological evidence of some health effect. The fact that nothing conclusive has been found to date testifies both to the relative insignificance of any effect (if it exists) and to the futility of the methods employed …. A bottom up approach done by suitably qualified people that looked at the effect of low energy (radio frequency) electromagnetism on simple atoms, then simple molecules and then moving on to more complex organic molecules would reveal any mechanisms for interaction and suggest what (if any) types of damage could be caused by the exposure, accounting in particular for the levels that are necessary to be relevant compared to external background radiation and radiation developed with the organisms themselves as they go about their daily business.' (Submission 118, Submission Vol 11, pp 1826-1827. See also Mr Boucher's evidence where he advocates initially research at the physics level rather than the 'needle in a haystack approach of biology studies' (*Official Committee Hansard*, Canberra, 8 September 2000, p.79). See also *Official Committee Hansard*, Sydney, 16 November 2000, p 267, where Dr Peter French, cell biologist, stated: 'The issue is that it is very difficult to go looking for epidemiology for disease when you do not know exactly what the disease is … [What the] cell studies and the gene studies can tell us is what genes are affected. Those genes which are known have well-

The Committee Chair supports the view that human studies should be undertaken as quickly as possible to ensure that there are sufficient people to act as suitable controls.[313]

2.263 While the technology is relatively new and evidence of some health effects may have a long latency period, for example the incidence of cancer that may or may not be related to mobile phone and base station emissions, given the increasing number of people worldwide, particularly young people, using mobile phones, there is an urgent need to replicate studies, commence long-term epidemiological studies and establish a scientifically substantiated body of evidence to provide guidance to the public about the possible adverse health effects of electromagnetic radiation.

2.264 The Committee notes that while research into extremely low-level RF radiation is not as plentiful as research into other portions of the spectrum, there is sufficient evidence to justify conferences to discuss the current state of the science. The Committee has made recommendations relating to the funding of research in this area in the next chapter.

2.265 The Committee Chair also calls on the telecommunications industry to give priority in its technology development to research on reducing exposure to RF radiation.

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known connections to diseases and therefore that can provide the basis for an intelligent epidemiology study rather than a fishing trip…' and Professor David McKenzie who added: 'It is important to emphasise that a scientific approach is necessary. The mechanism has got to be identified before any substantial science can be done in this field. A viable mechanism has to be established by doing meticulous science, establishing that mechanism, working out what it could lead to and then looking for those effects in the population at large. A cell biology experiment is crucial here to identify and to prove the mechanism, identify possible links and then work on those links by looking at epidemiological evidence'. Cf Dr Holt who states in his submission: 'For any advance to be made in the problems facing your committee recourse must be had to the knowledge directly derived from living people and not artificial conditions from experimental work' (Submission 143, Submission Vol 11, p 2418). The Committee also notes the conclusion of the Royal Society of Canada Report (p 93): '…the epidemiological evidence [for non-thermal health effects] to date is inadequate for a comprehensive evaluation of risk, and does not support a hypothesis of an association between exposure to radiofrequency fields and risk of cancer, reproductive problems, or congenital anomalies. However, there is a need for additional, larger well-designed studies, to provide further information on these relationships'.

312 ACTU, Submission 89, p 4. See also *Proof Committee Hansard*, Canberra, 2 March 2001, p 407 [Doull].

313 See CEMEPHI, Submission 127, Submission Vol 9, p 1962.