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NOTE

Daubert v. Merrell Dow: Is This Just What the EMF Doctor Ordered?

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In Daubert v. Merrell Dow Pharmaceuticals, Inc., *the Supreme Court announced a new standard for the admissibility of expert testimony at trial. This decision could have a significant effect on litigation where both sides will hotly contest whether exposure to a particular agent actually caused the plaintiffs injury. Such is the case with exposure to low frequency Electromagnetic Fields (EMF). Scientists do not agree whether exposure to EMF causes injury to humans, but plaintiffs are claiming they were injured by EMF and are seeking compensation. In this article, the nature, sources, and studies of EMF health effects are described and the possible effects of the Daubert decision on this controversy are explored.*

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I. Introduction

One needs only to read the newspaper or watch the evening news to know that society is becoming increasingly aware of the potential hazards from exposure to seemingly innocuous items such as electric blankets, cellular telephones, blow dryers, or those electric distribution wires running along the sidewalk in front of one's house.[1] Are exposures to these things really dangerous? Are the illnesses observed simply the statistically expected "normal" rates among the population or can it be that exposures to these modern everyday conveniences increase the chance for serious illnesses?[2]

Although answers to these questions are not currently available, people who believe they were injured by these phenomena are seeking compensation in the courts.[3] The courts, in accordance with legal principles, must decide if the plaintiffs' injuries or illnesses were caused by exposure to these environmental hazards, regardless of whether there is conclusive *scientific* proof of causation.[4] This is the center of

1. One newspaper article listed the results of its readers' poll showing that electromagnetic fields (EMF) should be the country's foremost environmental health priority. *Memo to Al Gore*, U.S.A. WEEKEND, Feb. 19-21, 1993, at 15. *See also* Joan Beck, *Scare Science May Be Hazardous to Your Health*, CHI. TRIB., Mar. 25, 1993, at 29; *Electromagnetic Fields*, CONSUMER REP., May 1994, at 354.

2. *See Natural Radiation Focused by Power Lines: New Evidence*, ELECTRONICS WORLD + WIRELESS WORLD, Nov. 1992, at 912.

3. One author has indicated that over 100 EMF lawsuits have been filed since 1985. ELLEN SUGARMAN, WARNING: THE ELECTRICITY AROUND YOU MAY BE HAZARDOUS TO YOUR HEALTH 174 (1992). A newspaper article recently published a survey by the Texas Public Utilities Commission which revealed that in 1992 alone 201 challenges to utility projects were based on EMF concerns. Bill Richards, *Elusive Threat - Electric Utilities Brace for Cancer Lawsuits Though Risk is Unclear*, WALL ST. J., Feb. 5, 1993, at A1.

4. For example in Christophersen v. Allied Signal Corp., 939 F.2d 1106 (5th Cir. 1991), the court had to decide whether nickel and cadmium were the cause of plaintiff's colon cancer despite the lack of conclusive scientific proof of causation. Likewise, the court in Renaud v. Martin Marietta Corp., 749 F. Supp. 1545 (D. Colo. 1990), had to decide if there was sufficient legal causation between rocket fuel and the cancer complained of by the plaintiffs without knowledge of scientific proof of causation.

most "toxic tort" litigation.[5] Legal causation in these cases can be onerous for plaintiffs to prove and often requires expert testimony detailing scientific evidence because exposure to the offending substance may have been short-term, in small amounts, and the effects may not manifest themselves for many years after the exposure.[6]

In *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,[7] the Supreme Court announced the standard for admissibility of scientific evidence at trial. This article will discuss the decision and examine how it might affect plaintiffs' cases seeking compensation for injuries allegedly caused by exposure to electromagnetic fields (EMF) generated from electric power lines and household appliances.[8] Specifically, the article will focus on the effects of extremely low frequency (ELF), 60 hertz EMF, which most thought were not connected with potential health problems. Part II is a discussion of what EMF are, their sources, and a review of the research dealing with

5. "Toxic tort" cases generally refer to those cases in which plaintiffs seek compensation for injuries or illnesses allegedly caused by exposure to harmful materials. *See* MICHAEL DORE, THE LAW OF TOXIC TORTS § 2.02 (1992).

6. Ayers v. Jackson Township, 525 A.2d 287, 301 (N.J. 1987). For an excellent discussion of this dilemma and a pre-*Daubert* analysis on the question of admissibility of expert testimony, see Alex R. DeSevo, Note, Rubanick v. Witco Chemical Corp *and* Landrigan v. Celotex Corp.: *The Admissibility of Expert Testimony in Toxic Tort Litigation*, 10 PACE ENVTL. L. REV. 423 (1992). *See also* Susan R. Poulter, *Science and Toxic Torts: Is There a Rational Solution to the Problem of Causation?*, 7 HIGH TECH. L.J. 189 (1992).

7. 113 S. Ct. 2786 (1993).

8. Electromagnetic energy exists over a broad frequency range: from visible light which occupies a small portion of the spectrum to other frequencies which are used for radio, television, and microwave transmissions. ELECTRIC POWER RESEARCH INSTITUTE, SOURCEBOOK FOR UTILITY COMMUNICATIONS ON EMF 2-2 (June 1992) [hereinafter EPRI, SOURCEBOOK]. Since the product of frequency and wavelength of electromagnetic energy equals the speed of light, nearly 300,000,000 meters/second, the wavelength of 60 Hz power frequency is very long - 5000 kilometers. *Id.* Scientists have known for years that "ionizing" EMF radiation such as X-rays and high frequency non-ionizing radiation such as microwaves are harmful because they have enough energy to strip electrons from atoms or to heat biological tissue by vibrating its molecules. EMF In Your Environment: Magnetic Field Measurements Of Everyday Electrical Devices, EPA, Report No. 402-R-92-008, at 7, 8 (1992) [hereinafter EPA, EMF In Your Environment]. *See also* Bette Hileman, *Health Effects of Electromagnetic Fields Remain Unresolved*, CHEMICAL & ENGINEERING NEWS, Nov. 8, 1993, at 18.

EMF-related health effects. Part III gives a historical overview of previous case law regarding the admissibility at trial of scientific evidence. Part IV is a discussion of the *Daubert* decision. Part V is an analysis of how this new ruling may affect the outcome of current and future litigation involving EMF. Part VI is the conclusion.

II. Electromagnetic Fields and Their Possible Health Effects

A. The Nature and Sources of EMF

EMF contains two components that vary independently: electric fields, measured in kilovolts per meter (kV/m), and magnetic fields, also known as magnetic flux density, measured in gauss (G) or milligauss (mG).[9] Electric field strength is dependant on voltage, whereas magnetic field strength is dependant on current.[10] Electric fields start and stop on charges, and thus most persons will be shielded by the charges present in clothing.[11] Because shielding from electric fields can also come from walls, roofs, or trees, a typical house will shield about ninety percent of the exterior electric fields.[12] In addition, the human body reduces the electric component significantly; "the internal electric field induced

9. EPA, EMF In Your Environment, *supra* note 8, at 9. *See also* M. GRANGER MORGAN, DEP'T OF ENGINEERING AND PUBLIC POLICY, CARNEGIE MELLON UNIV., MEASURING POWER-FREQUENCY FIELDS 14 (1992). The international unit for magnetic field strength is the tesla (T). One tesla equals 10,000 gauss. Electricity flows in wires much like the way water flows in pipes; current flows along "hot" wires (any wire that carries voltage) just as water flows through pressurized pipes. BLACK & DECKER, BASIC WIRING & ELECTRICAL REPAIR 6 (Cy DeCosse ed., 1990) [hereinafter BASIC WIRING]. Just as water leaves a system through an unpressurized drain system, similarly, electric current flows back to its source through "neutral" wires that contain zero voltage. *Id.* However, unlike water, electric current will not flow unless it has a complete, continuous circuit to its return source. *Id.* at 16. In a house, this return path is provided by white neutral wires that return current to the service panel, and then through a neutral wire to a power pole transformer. *Id.*

10. Hileman, *supra* note 8, at 18.

11. MORGAN, *supra* note 9, at 14.

12. *Id.*

by an external electric field is about one millionth to one-hundred millionth of the applied field."[13]

Magnetic fields, however, pass through most materials nearly unchanged in low-frequency ranges.[14] Shielding people from magnetic fields is difficult and can require thick plates of specially alloyed metal that are prohibitively expensive with existing materials and design methods.[15]

When two magnetic fields are exactly in phase, alternating in strength and direction, they will add together, forming a stronger field.[16] When the two fields are exactly out of phase, contradicting in strength and direction, the fields will tend to cancel.[17] Because the supply and return currents move in opposite directions, they tend to produce equal but opposite magnetic fields that may cancel each other.[18] Thus, where wires are closely spaced and the currents are fairly well balanced (no ground loops), the magnetic field will generally be small.[19] "For this reason, twisted-pair wiring and coaxial cables produce little or no external magnetic fields."[20] This is also why most household wiring, e.g., lamp cords carrying equal amounts of current to and from an appliance, does not create large magnetic fields.[21] If, however, the current goes around a loop, such as in a motor or electric appliance, the magnetic field is not canceled because of the absence of this closely spaced wire.[22] In addition, many older homes have "knob and tube" wiring in which the hot and neu-

13. Hileman, *supra* note 8, at 18.

14. *Id.*

15. John Douglas, *Managing Magnetic Fields*, EPRI J., July-Aug. 1993, at 13 [hereinafter Douglas, *Managing Magnetic Fields*].

16. *Id.* at 20. This principle also applies to electric fields. *Id.*

17. *Id.*

18. Electric and Magnetic Fields: An EPA Perspective on Research Needs and Priorities for Improving Health Risk Assessment, EPA Report No. 900/9-91/016F, at V-2 (1992) [hereinafter EPA, Electric and Magnetic Fields].

19. *Id.*

20. *Id.*

21. HANOVER ENVIRONMENTAL METER CO., HOW TO REDUCE YOUR EXPOSURE TO ELF MAGNETIC FIELDS 3 (1991).

22. *Id.*

tral wires are separated by many inches, making significant contributions to the average magnetic field in these homes.[23]

While attention is generally focused on EMF associated with high voltage transmission lines that transport large amounts of electricity from the generator to distribution substations, these fields actually exist everywhere that electric energy is used, including electric distribution lines (the lines that deliver electricity from substations to the ultimate consumer), electric appliances, and home neutral-to-ground connections.[24] However, EMF are not solely produced by man-made sources. Electric and magnetic fields are created by charges found throughout nature and all things electrical.[25] While the highest time-varying fields we are exposed to come from man-made sources, the static natural magnetic field from the earth averages about 0.5 gauss or 500 milligauss (mG), and varies slowly with time, most notably during thunderstorms and solar activity.[26] Although homes near transmission lines have some of the highest median indoor fields, often the transmission lines account for only a fraction of the indoor field levels.[27] However, because transmission lines generally produce higher field levels in homes than do distribution lines, many alternative line configurations that operate with reduced magnetic field levels are being examined.[28]

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23. *Id.*

24. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 9.

25. MORGAN, *supra* note 9, at 1.

26. Hileman, *supra* note 8, at 18. This static field has a maximum vertical component (at the magnetic poles) of 670 mG, with a maximum horizontal component (at the magnetic equator) of 330 mG. ELECTRIC POWER RESEARCH INSTITUTE, EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS AND CANCER: A LITERATURE REVIEW 1-1 (December 1989) [hereinafter EPRI, EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS].

27. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 9.

28. *Id.* While direct current is unidirectional, an alternating current periodically changes its direction. RUFUS P. TURNER & STAN GIBILISCO, PRINCIPLES AND PRACTICE OF IMPEDANCE 1 (2d ed. 1987). "An alternating current starts at zero, increases to its maximum positive value, decreases through zero to its maximum negative value, and returns to zero[;]" this process is called a cycle and is shown by a sine wave. *Id.* at 1-2. Frequency is the number of complete cycles per second, often expressed in hertz (Hz). *Id.* at 3. The electric power generated in North America uses alternating current modulated at a frequency of 60 cycles per second, or 60 Hz, while most European countries use 50 Hz

A three-phase system is commonly used for generation, transmission, and distribution of power.[29] This system is basically the same as three single-phase systems with the three voltages and currents of equal amplitude of the single-phase systems out of phase with each other by one-third of a cycle (120 degrees).[30] If the loads in the three phases of the three-phase system are equal and the voltages in the phases are balanced, the currents in the phases will also be balanced, and their sum will be zero at every instant.[31] In practice, however, the transmission systems will rarely be balanced, and this can promote the creation of greater EMF.[32]

By changing the traditional configuration to one that is triangular (often referred to as the delta configuration),[33] aligning the conductors in the vertical plane, compacting the configuration (making field cancellation more likely), or converting the line from a three-phase, double-unit configuration to a six-phase, single-unit configuration, it is believed that magnetic fields experienced on the ground can be significantly reduced.[34] In addition, stringing of additional wire loops around the transmission lines to passively (through currents induced from the transmission lines' EMF) or actively (through currents actively imposed) reduce the fields is

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electric power. C. STEPHEN REDHEAD & CHRISTOPHER H. DODGE, CONGRESSIONAL RESEARCH SERVICE - THE LIBRARY OF CONGRESS, HEALTH EFFECTS OF POWER-LINE ELECTROMAGNETIC FIELDS (EMFs) CRS-1 (Feb. 8, 1993) [hereinafter REDHEAD & DODGE]. A wavelength is the distance traveled during one oscillatory cycle. INDIRA NAIR ET AL., DEP'T OF ENGINEERING AND PUBLIC POLICY, CARNEGIE MELLON UNIV., BIOLOGICAL EFFECTS POWER FREQUENCY ELECTRIC AND MAGNETIC FIELDS 6 n.1 (1990) [hereinafter NAIR] (report prepared for Congress of the United States Office of Technology Assessment).

29. H. H. SKILLING, ALTERNATING CURRENTS, ENCYCLOPEDIA OF PHYSICS 37-38 (Sybil P. Parker, ed., 2d ed. 1993). A phase is one current passing through a conductor. Generators may produce more than one current or phase of electricity at a time. These phases pass through different conductors in a transmission or distribution system. Phase difference is the measure of the portion of a cycle by which one sinusoidally alternating current leads or lags another. *Id.*

30. *Id.* at 38.

31. *Id.*

32. EPA, Electric and Magnetic Fields, *supra* note 18, at V-3.

33. Richard Kennon & Kathy McFarland, *Reduce Magnetic Fields in Transmission Lines by Design*, ELECTRIC LIGHT & POWER, Feb. 1994, at 9.

34. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 8.

another option.[35] However, not everyone believes this is a viable option.[36]

Overhead distribution line magnetic fields are often caused by unbalanced currents along the three line phases.[37] The sum of the currents flowing through conductors toward a load is optimally zero because the magnetic fields produced by one conductor are often canceled by those from the other conductors.[38] In efforts to balance the load across the phases, utility companies try to connect equal numbers of houses to each phase of a residential distribution network.[39] However, if substantial amounts of current return to a distribution transformer through the ground and not through the neutral line conductor, the magnetic field produced will not be canceled, and may become a large EMF source in nearby homes.[40]

While transmission line magnetic fields can be reduced by configuration changes, this method has relatively little effect on magnetic fields from distribution lines.[41] Underground distribution lines usually produce low magnetic fields near homes because the close proximity of conductors may promote canceling of the magnetic field. However, they may have levels comparable to overhead transmission lines[42] because the distribution lines are often close to the surface of the ground and/or close to buildings, and the fields may not be able to decrease with distance as fields from overhead lines often do.[43] It should be noted, nevertheless, that burying transmission lines may be the best way to reduce exposure to magnetic fields, although electric utilities and ratepayers may be unhappy with the cost of this measure.[44]

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35. *Id.*
36. Kennon & McFarland, *supra* note 33, at 10.
37. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 8.
38. *Id.*
39. NAIR, *supra* note 28, at 5.
40. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 8.
41. *Id.* at 9.
42. EPA, EMF In Your Environment, *supra* note 8, at 8.
43. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 9-11.
44. COMMONWEALTH ASSOCIATES, INC., COST EFFECTIVENESS ANALYSIS: MITIGATION OF ELECTROMAGNETIC FIELDS iii (1992). A report prepared for Rhode

Other significant contributors to EMF exposure in many households are fields produced by ground currents in home water pipes, cable television, or telephone wiring. Ground wires connect the electrical system to the soil, discharging excess power into the earth.[45] They are a safety feature designed to provide an additional return path for electrical currents to the service panel and ultimately to the transmission system or to the ground rather than through a person.[46] The earth has a unique ability to absorb current electrons, so that in the event of a short circuit or overload, excess electricity will find its way along the grounding wire to the earth, where it is harmlessly discharged.[47]

Each modern outlet has three wires. The black or red wire is the "hot" wire. The white or gray wire is the "neutral" wire that provides the current return path needed to complete the circuit.[48] The bare copper or green wire is the ground wire that is connected from the service panel to the outlet box (if it is metal) or to the outlet grounding screw.[49] Household grounding is usually completed by wiring the service grounding panel to a metal cold water pipe and/or a buried metal grounding rod.[50]

While neutral-to-ground connections are critical protection against shock and fire from fault currents, multiple grounding connections and current-carrying metal water pipes offer many avenues for neutral return current flow back to the electric distribution system instead of through secondary neutral wires, thereby creating significant magnetic fields.[51]

Island EMF investigatory subcommittee noted that burying the lines would reduce magnetic fields from a 345,000 volt transmission line to 1.7 mG directly above the lines and 0.12 mG 25 feet away - at a construction cost increase of 372% compared with overhead construction and life-cycle cost increase of 266%.

45. BASIC WIRING, *supra* note 9, at 12.

46. *Id.* at 16.

47. *Id.*

48. *Id.* at 14.

49. BASIC WIRING, *supra* note 9, at 14.

50. *Id.*

51. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 9.

"Ground currents are often produced because the neutral (or grounded) distribution line wires are physically connected to the earth in several places."[52] While some current flows back to the utility through the "neutral return" path, in many cases substantial amounts of it flow through the ground itself or through metal pipes used for water, sewer, or gas, as well as other conductors such as the outer sheath of cable television wires that are also grounded to the house inlet water pipe.[53] While the voltages involved are very low, these ground return currents can produce significant magnetic fields.[54]

Return current flows through the ground wire to the water pipes and other ground connections because, like water, it seeks the path of least resistance.[55] At times, current flow will split up and go into neighboring houses' return wires because there is less resistance to flow through several parallel conductors than through one return wire.[56] Therefore, an adjacent home may have a significant ground current through its main return line, even if it is a light user of electricity.[57] Moreover, interconnected water pipes can also provide paths for significant neutral current flows between neighboring residences, creating additional magnetic fields.[58] These "stray" ground currents create significant magnetic fields because whereas magnetic fields created by a pair of closely spaced wires (e.g., house wiring) tend to cancel each other because of the equal and opposite current flow, those in these extraneous conductors are not canceled.[59]

Reduction of ground current fields in homes is especially challenging to electric utilities because mitigation efforts will most likely include changes on the customer's residence and will possibly require modification of the National Electric

52. NAIR, *supra* note 28, at 15.
53. MORGAN, *supra* note 9, at 15.
54. *Id.*
55. HANOVER ENVIRONMENTAL METER CO., *supra* note 21, at 32-33.
56. EPRI, SOURCEBOOK, *supra* note 8, at 33.
57. *Id.*
58. *Id.*
59. John Douglas, *EMF in American Homes*, EPRI J. Apr.-May 1993, at 22 [hereinafter Douglas, *EMF in American Homes*].

Code (NEC).[60] Homeowners may reduce these ground currents and prevent the intrusion of ground currents from nearby homes through the interconnected water pipes by eliminating improper regrounding within a residence or by inserting connections made of polyvinyl chloride (PVC), which does not conduct electricity, in their own residential water lines to isolate their homes.[61]

B. Measurement Of EMF

Imre Gyuk, program manager for electromagnetic research at the Department of Energy has stated that about one-third of EMF exposure comes from distribution lines, one-third from household appliances, and the remaining one-third from grounding wires.[62] Average fields in the home are generally less than two mG, but can be much higher, especially under transmission lines.[63]

Since kitchens are often the location of many electric appliances such as microwave ovens, toasters, can openers, and electric ranges, they typically have slightly greater median magnetic fields than in other residential rooms.[64] Although appliances connected to a source of electricity have an electric field around them even when the appliance is turned off, they must be operating to generate a magnetic field.[65] The most intense magnetic fields found in the home are near appliances.[66] However, they are not generally large contributors to time-averaged magnetic field exposure because these fields fall off more quickly with distance than fields from power lines and ground currents, and people usually spend only brief amounts of time very close to them.[67]

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60. *Id.* at 11. The NEC contains the rules and regulations for the proper installation of electrical wiring and devices to govern safety. *Id.*

61. *Id.*

62. Hileman, *supra* note 8, at 18.

63. *Id.*

64. *Id.* at 9.

65. EPA, EMF In Your Environment, *supra* note 8, at 3-5.

66. NAIR, *supra* note 28, at 8-15.

67. *Id.*

Estimating subject exposure has been one of the most difficult aspects of EMF-related research.[68] Early studies did not use direct field exposure measurements but used substitutes, such as wire codes, which were based on qualitative observations of power lines near homes.[69] A variety of meters have been developed to measure EMF, including wristwatch-like dosimeters to measure EMF exposure over time,[70] hand-held portable meters to record instantaneous levels,[71] and microprocessor-driven stand-alone recorders designed to generate EMF profiles in a room.[72] Tables 1 through 8 list an EPA compilation of magnetic field measurements from a wide variety of sources in the home, office, and from electric transmission lines.

In each of the following tables:

x	The magnetic field measurement at this distance from the operating appliance could not be distinguished from background measurements taken before the appliance had been turned on.
*	Data taken by the Electric Power Research Institute[73]
**	Data taken by the Illinois Institute of Technology Research Institute[74]
***	Data taken by the EPA[75]

68. *Id.* at 19-20.

69. *See* Douglas, *EMF In American Homes*, *supra* note 59, at 19.

70. ELECTRIC POWER RESEARCH INSTITUTE, TECHNICAL BRIEF NO. RP799-16, AMEX DOSIMETER (1988).

71. David E. Miesse, *What You Should Know about EMF*, OUTSIDE PLANT, Jan. 1992, at 13.

72. Douglas, *EMF In American Homes*, *supra* note 59, at 19.

73. EPA, EMF In Your Environment, *supra* note 8, at 28 (citing ELECTRIC POWER RESEARCH INSTITUTE, INTERIM REPORT NO. TR-100194, SURVEY OF RESIDENTIAL MAGNETIC FIELD SOURCES (1992)).

74. EPA, EMF In Your Environment, *supra* note 8, at 29 (citing ILLINOIS INSTITUTE OF TECHNOLOGY RESEARCH INSTITUTE, REPORT NO. E06549-3, HOUSEHOLD APPLIANCE MAGNETIC FIELD SURVEY (1984)).

75. EPA, EMF In Your Environment, *supra* note 8, at 29.

Table 1—Magnetic Fields From Bathroom Sources (mG)[76]

Distance from Source	6″	1′	2′	4′
	HAIR DRYERS**			
Range	1-700	x-70	x-10	x-1
Median	300	1	x	x
	ELECTRIC SHAVERS**			
Range	4-600	x-100	x-10	x-1
Median	100	20	x	x

Table 2—Magnetic Fields from Kitchen Sources (mG)[77]

Distance from Source	6″	1′	2′	4′
	BLENDERS**			
Range	30-100	5-20	x-3	x
Median	70	10	2	x
	CAN OPENERS**			
Range	500-1500	40-300	3-30	x-4
Median	600	150	20	2
	COFFEE MAKERS**			
Range	4-10	x-1	x	x
Median	7	x	x	x
	CROCK POTS**			
Range	3-9	x-1	x	x
Median	6	1	x	x
	DISHWASHERS**			
Range	10-100	6-30	2-7	x-1
Median	20	10	4	x
	FOOD PROCESSORS***			
Range	20-130	5-20	x-3	x
Median	30	6	2	x
	GARBAGE DISPOSALS**			
Range	60-100	8-20	1-3	x
Median	80	10	2	x
	MICROWAVE OVENS			
Range	**100-300	* 1-200	* 1-30	* x-20
Median	** 200	* 40	* 10	* 2
	MIXERS**			
Range	30-600	5-100	x-10	x
Median	100	10	1	x
	ELECTRIC OVENS**			
Range	4-20	1-5	x-1	x
Median	9	4	x	x
	ELECTRIC RANGES			
Range	** 20-200	* x-30	* x-9	* x-6
Median	** 30	* 8	* 2	* x
	REFRIGERATORS			
Range	** x-40	* x-20	* x-10	* x-10
Median	** 2	* 2	* 1	* x
	TOASTERS**			
Range	5-20	x-7	x	x
Median	10	3	x	x

76. *Id.* at 13.
77. *Id.* at 14-5.

Table 3—Magnetic Fields from Living/Family Room Sources (mG)[78]

Distance from Source	6″	1′	2′	4′
		CEILING FANS*		
Range		x-50	x-6	x-1
Median		3	x	x
		WINDOW AIR CONDITIONERS*		
Range		x-20	x-6	x-4
Median		3	1	x
		TUNERS/TAPE PLAYERS***		
Range	x-3	x-1	x	x
Median	1	x	x	x
		COLOR TVs*		
Range		x-20	x-8	x-4
Median		7	2	x
		BLACK AND WHITE TVs*		
Range		1-10	x-2	x-1
Median		3	x	x

Table 4—Magnetic Fields from Laundry/Utility Room Sources (mG)[79]

Distance from Source	6″	1′	2′	4′
		ELECTRIC CLOTHES DRYERS**		
Range	2-10	x-3	x	x
Median	3	2	x	x
		WASHING MACHINES**		
Range	4-100	1-30	x-6	x
Median	20	7	1	x
		IRONS**		
Range	6-20	1-3	x	x
Median	8	1	x	x
		PORTABLE HEATERS**		
Range	5-150	1-40	x-8	x-1
Median	100	20	4	x
		VACUUM CLEANERS**		
Range	100-700	20-200	4-50	x-10
Median	300	60	10	1

78. *Id.* at 16.
79. EPA, EMF In Your Environment, *supra* note 8, at 17.

Table 5—Magnetic Fields from Bedroom Sources (mG)[80]

Distance from Source	6″	1′	2′	4′
	DIGITAL CLOCKS*			
Range		x-8	x-2	x-1
Median		1	x	x
	ANALOG (CONVENTIONAL CLOCK-FACE) CLOCKS*			
Range	1-30	x-5	x-3	
Median	15	2	x	
	BABY MONITORS***			
Range	4-15	X-2	x	x
Median	6	1	x	x

Table 6—Magnetic Fields from Office Sources (mG)[81]

Distance from Source	6″	1′	2′	4′
	AIR CLEANERS***			
Range	110-250	20-50	3-8	x-2
Median	180	35	5	1
	COPY MACHINES***			
Range	4-200	2-40	1-13	x-4
Median	90	20	7	1
	FAX MACHINES***			
Range	4-9	X-2	x	x
Median	6	X	X	x
	FLUORESCENT LIGHTS			
Range	** 20-100	* X-30	* x-8	* x-4
Median	** 40	* 6	* 2	* x
	ELECTRIC PENCIL SHARPENERS***			
Range	20-300	8-90	5-30	x-30
Median	200	70	20	2
	VIDEO DISPLAY TERMINALS***			
Range	7-20	2-6	1-3	x
Median	14	5	2	x

Table 7—Magnetic Fields From Workshop Sources (mG)[82]

Distance from Source	6″	1′	2′	4′
	BATTERY CHARGERS***			
Range	3-50	2-4	x	x
Median	30	3	x	x
	DRILLS**			
Range	100-200	20-40	3-6	x
Median	150	30	4	x

80. *Id.* at 18.
81. *Id.* at 20.
82. *Id.* at 21.

	POWER SAWS**			
Range	50-1000	9-300	1-40	x-4
Median	200	40	5	x
	ELECTRIC SCREWDRIVERS (while charging)***			
Range	X	x	x	x
Median	x	x	x	x

Table 8—Magnetic Fields from Electric Power Transmission Lines (mG)[83]

Types of Transmission Lines	Maximum on Right-of-Way	Distance From Lines			
		50′	100′	200′	300′
	115 KILOVOLTS (kV)				
Average usage	30	7	2	0.4	0.2
Peak usage	63	14	4	0.9	0.4
	230 KILOVOLTS (kV)				
Average usage	58	20	7	1.8	0.8
Peak usage	118	40	15	3.6	1.6
	500 KILOVOLTS (kV)				
Average usage	87	29	13	3.2	1.4
Peak usage	183	62	27	6.7	3.0

C. Possible EMF Health Effects

Several factors may be related to any EMF health effects: duration of exposure; frequency of the EMF; field strength; and whether the fields change characteristics rapidly.[84] Research to date is inconclusive as to what, if any, is the dominant factor in any EMF-caused health effects.[85]

The body generates its own electric currents independently of the influence of external 60 Hz EMF. For example, extremely small currents flow across individual cell membranes because of temperature changes within the body and the random opening and closing of ion channels.[86] These currents and significantly larger currents produced by the physiological activity of nerves, muscles, heart, and brain, can generate current densities of up to ten milliamperes per

83. EPA, EMF In Your Environment, *supra* note 8, at 24.
84. *Id.* at 3.
85. EPA, Electric and Magnetic Fields, *supra* note 18, at 11-1.
86. REDHEAD & DODGE, *supra* note 28, at CRS-3.

square meter and create a background electrical noise inside the body.[87]

In addition, the human body contains free electric charges that move because of electric and magnetic fields generated by nearby power lines and appliances.[88] The processes that cause these weak electric body currents are called electric and magnetic induction.[89] These currents may alter the binding of molecules to receptors on the surface of the cell membrane, disrupt membrane signaling events, and trigger abnormal biochemical reactions, e.g., changes in mineral uptake or protein synthesis.[90] However, current densities induced by exposure to 60 Hz EMFs are, in almost all cases, substantially less than those produced by nerve and muscle activity, and this observation has left some commentators skeptical of the purported link between cancer and EMF exposure.[91]

Cancer clusters have caused much of the public EMF concern. For instance, a cancer cluster among the people living near an electric substation on Meadow Street in Guilford, Connecticut, first prompted widespread concern over fields from substations and transmission lines.[92] However, Raymond R. Neutra, acting branch chief for environmental health and investigations at the California Department of Health Services in Emeryville, commented that cancer "clusters are a lot more common than people would intuitively

87. *Id.*

88. NAIR, *supra* note 28, at 16.

89. *Id.*

90. REDHEAD & DODGE, *supra* note 28, at CRS-3.

91. *Id.* at CRS-3 to CRS-4.

92. Hileman, *supra* note 8, at 16. Cancer clusters are relatively small geographic areas with high cancer rates among those living or working there. *Id.* Many clusters purportedly associated with EMF have received widespread media attention including one where four New York Giants football players were diagnosed with cancer between 1980 and 1986; the Giants play in the Meadowlands Sports Complex in East Rutherford, New Jersey, where exposure to radiofrequency fields created by fifteen AM radio broadcast antennas within eight miles is about as high as it is anywhere in the United States. *Id.* But cancer clusters in the general population are often a false signal of problems because most arise by chance alone rather than from exposure to a common source as in an occupational cancer cluster. *Id.*

think."[93] He also suggested cancer clusters in the workplace are easier to trace to a carcinogen than cancer clusters in residential areas, noting that many workplace carcinogens have already been identified through cancer clusters.[94]

Besides cancer, EMF exposure may cause other health effects, including spontaneous abortions, birth defects, nervous system disorders, and possibly chronic depression.[95] Concerns about EMF exposure from transmission lines have long been expressed during new line siting hearings, and have helped stimulate some of the research on possible health effects from exposure.[96] Many organizations around the world are conducting laboratory studies seeking biological mechanisms that could explain if and how EMF affect organisms.[97] The Electric Power Research Institute (EPRI) believes that the EMF electric field component can be virtually eliminated as a probable health effects cause.[98] Nevertheless, EPRI and many others conduct ongoing studies to address the possible health effects of magnetic fields.[99]

The issue of whether EMF causes detrimental health effects is being hotly contested both in the laboratory and in the media.[100] Some commentators argue that EMF exposure in-

93. *Id.* Only one carcinogen in the residential environment has been identified in this manner. This was arionite mineral, with high concentrations of asbestos, discovered in a small European town. *Id.*

94. *Id.* at 16. The National Fraternal Order of Police has collected information from officers who believe use of radar devices has caused their cancer: out of 55 cases of testicular cancer among police officers, 53 routinely placed the radar gun in their laps to shield the devices from radar detectors. *Id.* at 21. While no solid evidence that these devices directly caused these cancers is yet known, Connecticut has banned the use of hand-held radar guns, and several police departments across the country have shifted to radar units with exterior antennas. *Id.* at 20.

95. MORGAN, *supra* note 9, at 17.

96. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 8.

97. *See generally* EPRI, EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS, *supra* note 26.

98. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 7. The Electric Power Research Institute is located in Palo Alto, California and is a major research laboratory mostly funded by the electric power industry. EPRI, SOURCEBOOK, *supra* note 8, at back cover.

99. *Id.*

100. *See* Richards, *supra* note 3, at A1. Carlos Alvarez, a Florida attorney who has defended utilities in EMF cases crystallized a large reason for the pub-

deed causes a variety of health effects.[101] Others argue that EMF are not dangerous, that lab studies which show biological effects from EMF are flawed in some way, and that there is some other explanation for the results,[102] or that the risk is minimal.[103] Other commentators maintain that data accumulated to date is inconclusive.[104] They point out that even if there was a statistical link between high EMF exposure and illness, demonstrating a cause and effect pattern would be difficult because there are many "confounding" factors that cloud the analysis, i.e., human exposure to chemicals or traffic fumes in highly populated areas.[105] Others have suggested that in addition to the fact that EMF causes detrimental health effects, there have been cover-ups by electric utilities, or even a conspiracy between the government and the utilities to hide it.[106]

The available literature analyzing this debate prior to 1986 indicated that the results were inconclusive.[107] Today, however, there appears to be a strong enough argument that EMF is potentially carcinogenic to warrant further research.[108] An unofficial paper prepared for the Congressional Office of Technology Assessment has concluded "unequivocally that under certain circumstances, the membranes of the cells can be sensitive to even fairly weak externally imposed

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lic's reaction to preliminary studies showing increased health risks, such as childhood leukemia, from EMF exposure. He suggests that the public "tends to be frightened by [talk of] cancer and radiation and children.... [When] [y]ou tie those emotional words together, ... it will scare the daylights out of you." *Id.*

101. *See generally* SUGARMAN, *supra* note 3.

102. Richards, *supra* note 3, at A1. Dr. Robert Adair, a Yale physicist, has stated that the reaction to EMF research is "electrophobia" and that the fields are far too weak to cause damage. *Id.*

103. Joel Lang, *'Power-Line Coverup': High Voltage Charges, Weak Case*, HARTFORD COURANT, Sept. 9, 1993, at E3.

104. *See* NAIR, *supra* note 28, at 67.

105. Thomas E. Riley & Steven L. Vollins, *Electromagnetic Field Property Damage Claims: Why Class Actions Are Not Appropriate*, INSIDE LITIGATION, Jan. 1994, at 24.

106. *See generally* PAUL BRODEUR, THE GREAT POWER-LINE COVER-UP 210-99 (1993); SUGARMAN, *supra* note 3.

107. Status Report Of The Research In Electromagnetic Fields, EPA, at 1 (June 24, 1991).

108. *Id.*

low frequency electromagnetic fields."[109] In finding evidence of some biological effects related to laboratory exposure to magnetic fields, the paper cautioned that although there may be a health risk from EMF exposure, a significant health risk has yet to be established.[110] While the United States government has taken the position that the current findings with respect to EMF and possible health effects are inconclusive, not all countries are as patient. In Sweden, for instance, a brain tumor supposedly caused by EMF exposure has been classified as an industrial illness.[111]

Research continues using several different methodologies, including statistical epidemiological analysis methods, cellular level studies, and human and animal studies.[112] Epidemiological studies do not show specific cause and effect, but can show statistical associations between exposure to a hazard and illness in a human population[113] that closely approach hard proof.[114] Cellular level studies search for exposure effects on human or animal cells or tissues, while whole animal studies examine effects in body function, chemistry, disease, or behavior for entire organisms.[115] Many studies have been very specific, including examinations of EMF effects on childhood cancers,[116] adult cancers,[117] fetal exposures,[118] and occupational exposures.[119]

These studies attempt to determine the risk of disease when exposed to a potential hazard compared to the popula-

109. NAIR, *supra* note 28, at 2.

110. *Id.* at 3.

111. G. Lindgren, *Cancer Has Become an Industrial Illness*, FALU SWEDEN, Sept. 19, 1992, at 1.

112. THOMAS SYKES & JEFFREY MILLER, WASH. STATE INST. FOR PUB. POLICY, POSSIBLE HEALTH EFFECTS OF ELECTRIC AND MAGNETIC FIELDS FROM ELECTRIC POWER LINES: A SUMMARY OF SCIENTIFIC STUDIES ii (March 1993).

113. *Id.*

114. Lang, *supra* note 103, at E3.

115. WASH. STATE INST. FOR PUB. POLICY, *supra* note 112, at ii.

116. Lennart Tomenius, *50-Hz Electromagnetic Environment And The Incidence Of Childhood Tumors In Stockholm County*, 7 BIOELETROMAGNETICS 191 (1986).

117. Nancy Wertheimer & Ed Leeper, *Adult Cancer Related To Electrical Wires Near The Home*, 109 AM. J. EPIDEMIOLOGY 345 (1982).

118. Nancy Wertheimer et al., *Possible Effects Of Electric Blankets And Heated Waterbeds On Fetal Development*, 7 BIOELECTROMAGNETICS 13 (1986).

tion average.[120] A risk ratio of 1.0 indicates the risk in the exposed population is equal to that of the unexposed population (control group) and 2.0 indicates that the risk in the exposed population is two times that in the unexposed population. Research has often taken the form of one researcher's attempt to replicate or correct the studies of a colleague in the field.

A study from the University of Colorado Health Sciences Center compared Denver children who died of leukemia between 1950 and 1973 to children who did not contract the disease.[121] The study found that a greater number of children who contracted leukemia lived in homes classified as having "high-field wire configurations" than those who did not.[122] This study was not based on actual EMF exposure measurements. Rather, EMF exposure was estimated on wire codes, that is, "the potential current flow suggested by different wiring configurations (nearness and size of wires, closeness to origin of currents, etc.)."[123] At first, the scientific community was highly skeptical of this research, prompting David A. Savitz of the Department of Epidemiology at the University of North Carolina, Chapel Hill, to repeat the study, correcting many factors criticized in the earlier study.[124] This latter study, examining all Denver childhood cancer cases between 1976 to 1983, found a relative lymphoma risk of 3.3 for children whose houses had high-field wire configurations, whereas the risk ratios for other child cancers ranged from 1.63 to 2.75 for similarly situated children.[125] However, this same study found that the relative cancer risk ranged only

119. K. Wiklund et al., *An Application Of The Swedish Cancer-Environment Registry: Leukemia Among Telephone Operators At The Telecommunications Administration In Sweden*, 10 INT'L J. EPIDEMIOLOGY 373 (1981).

120. EPRI, EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS, *supra* note 26, at 1-6.

121. Nancy Wertheimer & Ed Leeper, *Electrical Wiring Configurations and Childhood Cancer*, 109 AM. J. EPIDEMIOLOGY 273 (1970).

122. *Id.*

123. *Id.* at 275.

124. David A. Savitz et al., *Case-Control Study of Childhood Cancer And Exposure to 60-HZ Magnetic Fields*, 128 AM. J. EPIDEMIOLGY 21 (1988).

125. *Id.* at 34.

between 0.49 and 2.17 for most cancers when related to actual measured EMF exposures.[126]

The Savitz study noted that the correlations between cancers and EMF exposure were significant when EMF exposure was estimated using one wire code method.[127] However, there was "little indication that magnetic or electric field measurements under high power conditions are associated with increased cancer incidence."[128] The Savitz and Wertheimer studies illustrate a problem in the EMF research to date; inconsistencies such as these disparate findings, resulting from actual EMF exposure measurements compared with estimated exposures, raise questions as to the certainty of these studies' conclusions. In addition, other variables may cause the illnesses observed. An electric engineering professor, who worked on the Savitz study, noted that most homes in these studies were older and urban.[129] Therefore, the subjects may have been exposed to additional hazards such as traffic fumes, benzene, and lead paint.[130]

In cellular level experiments, a body of evidence points to the cell membrane as the primary site of interaction between EMF and the cell.[131] However, when a cellular level effect is observed, it is still difficult to extrapolate what implications EMF may have on an entire organism.[132] Some of these effects demonstrate a "windowing" tendency, that is, they occur only at certain frequency and intensity values, or at certain durations of exposure.[133] Some of these effects persist only

126. *Id.* at 30. The only exception to this finding was for soft tissue cancers under low power conditions. *Id.* The relative cancer risk in that case was 3.26, although it was based on a very small sample, and its actual value within a 95% confidence interval could have been anywhere from 0.88 to 12.07. *Id.*

127. *Id.* at 34.

128. David A. Savitz et al., *Case-Control Study of Childhood Cancer And Exposure to 60-HZ Magnetic Fields*, 128 AM. J. EPIDEMIOLGY 33-34 (1988).

129. Bill Torpey & Bill Ronkin, *Georgia Trial Tackles Whether High-Voltage Lines Spur Cancer*, ATLANTA CONT., Apr. 23, 1994, at B6. Similarly, another study following up the findings of Wertheimer's study found no correlation between high exposure wire-code configurations and childhood leukemia. *Id.*

130. *Id.*

131. NAIR, *supra* note 28, at 24.

132. *Id.* at 24-25.

133. *Id.* at 25, 28.

briefly after removal from the exposure.[134] Moreover, these effects may be influenced by how the field is positioned relative to the earth's natural magnetic field.[135] Because of these peculiarities, larger fields do not necessarily result in a larger effect and may, in fact, result in no effect at all.[136] It should be noted, however, that many of the studies observing these peculiarities have been conducted in single laboratories without replication in other laboratories.[137]

Some of these cellular studies are conducted with a chick's brain tissue observed *in vitro*.[138] Many agents such as ionizing radiation or chemicals can cause direct DNA damage leading to cancer.[139] Low frequency EMF, however, generally do not have enough energy to break bonds or otherwise disrupt the structure of DNA, so it appears unlikely that this EMF exposure could cause cells to mutate into a new cancer.[140] While scientists have known that strong non-ionizing EMF fields in the radio-frequency or microwave range can heat tissue leading to damage, most assumed that no biological effect would happen if the field could not heat tissue, or if the externally generated magnetic field potential was less than that which occurs naturally across cell membranes.[141] Since low-energy 60 Hz EMF do not heat up living tissue, or split chemical bonds within the body,[142] they were thought to be harmless.

Although scientists suspect that EMF probably interact with cells through more than one mechanism, all the mechanisms proposed to date are hypothetical.[143] A potential EMF-driven carcinogenic mechanism is that the fields accelerate

134. *Id.* at 25.
135. NAIR, *supra* note 28, at 28.
136. *Id.*
137. *Id.* at 25.
138. *Id.* at 26.
139. NAIR, *supra* note 28, at 29.
140. *Id.*
141. Hileman, *supra* note 8, at 18. The natural cell membrane gradient is much higher than the internal gradient induced by commonly encountered magnetic fields. *Id.* at 19.
142. REDHEAD & DODGE, *supra* note 28, at CRS-3.
143. Hileman, *supra* note 8, at 19.

cancer formation or cancer growth rather than initiating cancer.[144] Another possible mechanism is that decreased immune response may cause reduced disease resistance.[145] However, studies have shown no significant EMF effects on normal or specifically immunized cell immunologic functions, although one study did show an inhibition of mouse lymphocytes that specifically attack cancer cells.[146]

Whole animal systems studies have been conducted over many electric and magnetic field intensities with various exposure conditions and durations.[147] Many of these studies observed some effects such as hormone changes, subtle skeletal development effects, and possible brain and central nervous system effects in rats exposed to strong electrical fields.[148] A repeat of this study, however, was met with limited success.[149] In general, no immune or endocrine system changes have been induced by exposure over several months to electric fields of a rather high intensity.[150] This is in contradiction to the results that might be expected if the cellular studies mentioned above were extrapolated to whole animals.

In experiments with human subjects, most vital signs, physiological parameters, daily life activities, moods, reaction time, memory span, fatigue, and decision-making ability were not affected by the administered field strengths.[151] However, some variations in heartbeat interval in specific electro-encephalogram (EEG) activity tests were detected, but the variations were within normal ranges for these parameters and later studies of the observed heartbeat changes showed some EMF-related heartbeat and performance effects.[152]

EMF-induced cancer concerns have been generated by several epidemiological studies finding a casual link between

144. NAIR, *supra* note 28, at 31.
145. *Id.* at 30-31.
146. *Id.*
147. *Id.* at 35.
148. NAIR, *supra* note 28, at 39.
149. *Id.* at 47.
150. *Id.* at 39.
151. *Id.* at 50.
152. NAIR, *supra* note 28, at 50.

EMF exposure and cancer promotion.[153] Because this type of study may cause political decision makers to act based on public reaction to statistical reports of increased potential for disease that are disproportionate to the alleged risk, many epidemiological experts have employed an analysis based on several factors to separate causal from non-causal connections.[154] These factors include: 1) strength of association in exposed populations compared to that in non-exposed; 2) consistency in association between different test samples with different criteria, e.g., increased lung cancer incidence in smokers of all age groups and races; 3) specificity, i.e., single, not multiple effects from exposure to other factors; 4) the cause should precede effect in time; 5) a biologic gradient or dose-response relation with a definite mathematical relationship between the amount of the exposure and the incidence of the effect; 6) biologic plausibility for the potential mechanism, and coherence between the association and what is known about the disease; 7) experimental evidence, usually animal data that indicates the same association (although this may not always be true); 8) analogous modes of action and effects if there is an agent that is analogous to the agent under consideration, and its biologic effect is better known.[155]

In general, it appears that most epidemiological studies on the effects of EMF and human cancers have risk ratios that are concentrated in the range of 1.0 to 3.0.[156] Some occupational studies have yielded somewhat higher risk ratios, although, these studies have often been based on small population samples with uncertainty about exposure to EMF and to other agents.[157]

Since these epidemiological studies were conducted on human populations, they do not have the inaccuracies and potential for error in extrapolating from cell or whole animal

153. *Id.* at 57.

154. *Id.*

155. *Id.*

156. *See generally* EPRI, EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS, *supra* note 26 (containing a short discussion of many completed studies).

157. *Id.* at 1-7.

studies to human effects.[158] However, epidemiological studies completed to date are retrospective and can involve interferences and biases arising from a lack of control.[159] While future studies can be improved, all people continue to be exposed to EMF, and because this exposure is varied and difficult to control, questions in dose-response relationships will likely remain.[160] In addition, no one epidemiological study can demonstrate causation and several improved epidemiological studies will be needed before these effects can be determined with any certainty because current understanding does not yet yield any single coherent framework.[161]

In sum, research to date indicates that there may be a link between EMF exposure and a small increase in the population's cancer rate. No cause-and-effect relationship, however, has yet been established between EMF exposure and any health effects and no hazardous level of exposure has been determined.[162] Researchers are not sure whether extremely low frequency non-ionizing EMF can produce adverse health effects, but most believe there is a chance that low-level fields could pose a health problem and continuing research is needed.[163] One researcher noted,

> If it is learned, eventually, that magnetic fields do increase risk of childhood cancer, this would be of great concern as a public health issue. Nonetheless, childhood cancer is fortunately a very rare event, with about 1 in 10,000 children developing cancer per year. If the risk really were 1.5 to 2 fold greater among persons with elevated magnetic field levels, the risk would be 1.5 or 2 cancers in 10,000 children per year. Again, this would be very important, but minor relative to childhood injuries or risks from known cancer

158. *Id.* at 66.

159. *Id.*

160. *See generally* EPRI, EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS, *supra* note 26, at 66.

161. *Id.* at 66-67.

162. Douglas, *Managing Magnetic Fields*, *supra* note 15, at 7.

163. Hileman, *supra* note 8, at 16.

> hazards to adults such as cigarette smoking or asbestos exposure.[164]

However, even if the risk is small, those unfortunate enough to win this 1.5 or 2 chance out of 10,000 lottery will have a right to be compensated, and the admissibility of scientific evidence as an injured party attempts to prove that EMF is the source of injury could have a large effect on the outcome of this litigation.

III. Historical Overview - The Legacy of *Frye v. United States*

In the past, scientific evidence had to be "generally accepted" in the scientific community to be admissible at trial, a standard expounded by the District of Columbia Court of Appeals in *Frye v. United States*.[165] In that case, the expert testimony at issue was the validity of a systolic blood pressure test (a lie detector test) that measured changes in physical conditions if the subject lied or had an emotional response.[166] Interestingly, a criminal defendant sought to admit this testimony.[167] The *Frye* court recited the criteria of when expert testimony is admissible, noting that its use is appropriate when the issue is of such a nature that inexperienced people will be unable to form a correct judgment on the subject matter by using their "common experience or common knowledge," and the subject matter requires a previous experience, habit, or training for an adequate understanding.[168] However, the court continued that an additional analysis by the trial court is necessary:

> [j]ust when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is

164. Letter from David A. Savitz, Dep't of Epidemiology, University of North Carolina, to "Persons concerned about reports of electromagnetic fields and childhood cancer" 1 (on file with the New York Power Lines Project Advisory Panel).

165. 293 F.2d 1013 (D.C. Cir. 1923).

166. *Id.* at 1013-14.

167. *Id.* at 1014.

168. *Id.*

> difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained *general acceptance* in the particular field in which it belongs.[169]

In 1975, the Federal Rules of Evidence (FRE) were adopted, and Rule 702, which governs the admission of expert testimony, states that "[i]f scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise."[170]

Rule 702 says nothing about general acceptance being a prerequisite to the admissibility of scientific evidence. There has been substantial disagreement among the Federal Circuit Courts about whether *Frye* still applied after the FRE took effect.[171]

For example, in *United States v. Williams*,[172] the Second Circuit chose not to follow the *Frye* standard, instead it relied on the "established considerations applicable to the admissi-

169. *Frye*, 293 F.2d at 1014. The court held that the systolic blood pressure lie detection method was not sufficiently recognized for it to be admissible in this case. *Id.*

170. FED. R. EVID. 702.

171. As of December 1992, three circuit courts have held that *Frye* did not survive the Federal Rules of Evidence: United States v. Jakobetz, 955 F.2d 786, 793 (2d Cir. 1992); DeLuca v. Merrell Dow Pharmaceuticals, Inc., 911 F.2d 941, 955 (3d Cir. 1990); United States v. Baller, 519 F.2d 463, 466 (4th Cir. 1975). Five circuits held that *Frye* remained in effect after the Federal Rules were adopted: Daubert v. Merrell Dow Pharmaceuticals, Inc. 951 F.2d 1128, 1129-30 (9th Cir. 1991); United States v. Two Bulls, 918 F.2d 56, 59-60 (8th Cir. 1990); United States v. Smith, 869 F.2d 348, 350 (7th Cir. 1989); United States v. Shorter, 809 F.2d 54, 59-60 (D.C. Cir. 1987); United States v. Metzger, 778 F.2d 1195, 1205 (6th Cir. 1985). *Cf.* Christophersen v. Allied Signal Corp., 939 F.2d 1106, 1110 (5th Cir. 1991) (standing for the proposition that the Federal Rules of Evidence, combined with *Frye*, provides a framework for trial judges whom are struggling with proferred expert testimony).

172. 583 F.2d 1194 (2d Cir. 1978), *cert. denied*, 439 U.S. 1117 (1979).

bility of evidence."[173] In *Williams*, the defendants were convicted of violating federal narcotics laws, and challenged the use of spectrographic voice-identification evidence by the prosecution from taped conversations to identify them.[174] The defense in *Williams* argued that this method of identification was not "generally accepted" as they listed ten experts that approved of its use and seventeen that did not.[175] The court noted that "[i]n testing for admissibility of a particular type of scientific evidence, whatever the scientific 'voting' pattern may be, the courts cannot in any event surrender to scientists the responsibility for determining the reliability of that evidence."[176] In its discussion, the Second Circuit indicated that *Frye's* restrictive standard had been difficult to apply and therefore held that scientific evidence will be admissible if its probativeness, materiality, and reliability outweigh the tendency to prejudice, mislead, or confuse the jury.[177] The court suggested several factors that could affect a court's reliability determination: 1) potential rate of error; 2) existence and maintenance of standards; 3) care and concern with which a scientific technique has been employed, and whether it appears to lend itself to abuse; 4) existence of an analogous relationship with other types of scientific techniques, and results that are routinely admitted into evidence; and 5) presence of "fail-safe" characteristics or the likelihood that potential inaccuracies will redound to the defendant's benefit rather than his detriment.[178] The court found virtually all these reliability indicia satisfied, holding that Rule 702 permitted the admission of this testimony, without evaluating whether the testimony was "generally accepted."[179]

Conversely, in *United States v. Smith*,[180] the Seventh Circuit upheld the *Frye* standard.[181] In *Smith*, the appellant

173. *Id.* at 1198.
174. *Id.* at 1195.
175. *Id.* at 1198.
176. *Williams*, 583 F.2d at 1198.
177. *Id.*
178. *Id.* at 1198-99.
179. *Id.* at 1200.
180. 869 F.2d 348 (7th Cir. 1989).
181. *Id.* at 350.

was convicted of thirty-one counts of bank, credit card, and wire fraud, and conspiracy to commit bank and wire fraud. The appellant also challenged the use of spectrographic voice-identification evidence, by the prosecution, from taped conversations used to identify her.[182] She argued that the use of spectrographic voice identification was not generally accepted by the relevant scientific community.[183]

The court held that spectrographic voice analysis expert testimony is admissible where the proponent of this testimony has established a proper foundation.[184] The court noted that "[b]ecause experts are given special latitude to testify based on hearsay and third-hand observations and to give opinions, . . . courts have cautioned that an expert must be qualified as an expert, provide testimony that will assist the jury, and rely only on evidence on which a reasonable expert in the field would rely."[185] The court noted that unanimity of opinion is not necessary among the scientific community to make the evidence reliable,[186] and found that the *Frye* reliability criteria were satisfied.[187]

An interesting feature of the *Smith* decision is that it clearly illustrates the difficulty the circuit courts were having in deciding the appropriate standard for admissibility of scientific evidence. Throughout the decision, while the court was taking pains to say it was applying the *Frye* standard, it referred several times to the *Williams* reliability factors, even though the *Williams* court had rejected the *Frye* standard.[188] It appears that the focus of the two courts was similar to the principles outlined in Rule 402, which states in part, "[a]ll relevant evidence is admissible, except as otherwise provided by the Constitution of the United States, by Act of Congress, by these rules or by other rules prescribed by the Supreme

182. *Id.* at 349.

183. *Id.* at 350. In this case, the voice identifications were particularly necessary, because the defendants were identical twin sisters, and this testimony was needed to identify which sister had committed which act. *Id.*

184. *Smith*, 869 F.2d at 350.

185. *Id.* at 351.

186. *Id.* at 352.

187. *Id.* at 353.

188. *Smith*, 869 F.2d at 352-53.

Court pursuant to statutory authority,"[189] provided the relevant evidence appears sufficiently reliable. Once this standard is satisfied, the jury must determine what weight to give to this testimony following cross-examination.[190] This author believes the two courts essentially relied on the same principles in approaching the admissibility decision, but simply labeled them differently.

IV. Daubert v. Merrell Dow Pharmaceuticals, Inc.

In *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (*Daubert I*),[191] Jason Daubert, born with a limb-reduction defect to his arm and hand after his mother ingested Bendectin during her pregnancy in late 1972, sued Merrell Dow Pharmaceuticals, Inc. (Merrell Dow) in a California state court under strict liability, breach of warranty, and negligence theories.[192] Bendectin was a prescription pharmaceutical product previously manufactured by Merrell Dow for the treatment of nausea and vomiting during pregnancy.[193]

Merrell Dow moved for summary judgment on the strict liability and breach of warranty issues, arguing that a pharmaceutical company cannot be held liable on these theories in a pharmaceutical products liability case.[194] Daubert argued that pharmaceutical companies can be held strictly liable for injuries caused by an ill-prepared drug or one with inadequate warning, noting that the defendants began receiving reports showing the possibility of a Bendectin-limb defects

189. FED. R. EVID. 402.

190. United States v. Williams, 583 F.2d 1194, 1199-1200 (2d Cir. 1978), *cert. denied*, 439 U.S. 1117 (1979).

191. Daubert v. Merrell Dow Pharmaceuticals, Inc., 711 F. Supp. 546 (S.D. Cal. 1989) [hereinafter *Daubert I*].

192. *Id.* at 547.

193. Daubert v. Merrell Dow Pharmaceuticals, Inc., 727 F. Supp. 570, 571 (S.D. Cal. 1989) [hereinafter *Daubert II*]. *See* Brief for Respondent at 2, Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2786 (1993) (No. 92-102) (this drug was introduced in 1956 and was available until 1983, when costs of litigation and insurance forced Merrell Dow to stop production: during that period, Bendectin was prescribed by doctors to about 30 million pregnant women).

194. *Daubert I*, 711 F. Supp. at 547.

link as early as 1962.[195] Merrell Dow contended that it conducted two studies on Bendectin's effects and found no such link.[196] Daubert claimed these tests were self-serving and plagued with unscientific procedures.[197] The court denied the summary judgment motion, holding that there were genuine issues of material fact[198] as to whether the drug was properly prepared and accompanied by appropriate warnings given this argument over the tests' reliability.[199]

Merrell Dow again moved for summary judgment, arguing that Daubert did not sustain the burden of showing a genuine issue of material fact with respect to whether the Bendectin did in fact cause the birth defect.[200] Daubert relied on *Oxendine v. Merrell Dow Pharmaceuticals, Inc.*,[201] which was more deferential to expert testimony than the majority of federal cases that had dealt with Bendectin product liability claims.[202] The court noted, "[t]here are two schools of thought governing expert testimony in these Bendectin cases, and one seems to be prevailing in the federal courts. Unfortunately for the plaintiffs, the prevailing school of thought warrants summary judgment in this case"[203] because without a firm understanding of how Bendectin may cause birth defects, this relationship could only be shown by epidemiological studies.[204]

The *Merrell Dow* court, in reaching their conclusion, looked to *Richardson v. Richardson-Merrell*,[205] where an expert, Dr. Alan Done, relied upon: 1) chemical structure activity analysis; 2) in vitro (test tube) studies; 3) in vivo (animal teratology) studies; and 4) reanalysis of epidemiology studies

195. *Id.*
196. *Id.* at 547-48.
197. *Id.* at 547.
198. *Id.* at 548. *See* FED. R. CIV. P. 56(c); *See also* Adickes v. S.H. Kress, 398 U.S. 144, 153 (1970); Anderson v. Liberty Lobby, Inc., 477 U.S. 242, 250 (1986); Celotex Corp. v. Catrett, 477 U.S. 317, 322 (1986).
199. *Daubert I*, 711 F. Supp. at 548.
200. *Daubert II*, 727 F. Supp. 570, 571 (S.D. Cal. 1989).
201. 506 A.2d 1100 (D.C. 1986).
202. *Daubert II*, 727 F. Supp. at 573.
203. *Id.* at 572.
204. *Id.*
205. 857 F.2d 823 (D.C. Cir. 1988), *cert. denied*, 493 U.S. 882 (1989).

to conclude that Bendectin causes birth defects.[206] The court in *Richardson*, however, held that Dr. Done's testimony lacked adequate scientific basis and that the chemical, in vitro, and in vivo studies were not capable of proving causation of birth defects in human beings faced with a large body of contradictory epidemiological evidence.[207] More importantly, the court also rejected the epidemiological studies reanalysis, concluding that there was no statistically significant correlation between Bendectin and limb reduction defects,[208] and "[o]nly by recalculating the data was Dr. Done able to obtain what he deems a statistically significant result. Moreover, the studies rejected by Dr. Done had been published in peer-reviewed scientific journals, while Dr. Done has neither published his recalculations nor offered them for review."[209]

In these cases, the underlying question is whether the already published epidemiological studies, which were calculated with a ninety-five percent confidence interval, can be recalculated using a confidence interval that is not as rigorous to show a greater link between the cause and effect of the study (here, the use of Bendectin and limb birth defects).[210]

Statistical analysis generally assumes a "null hypothesis," that is, it assumes a factor under study is not the cause of the result, and then queries whether the observable data departs from this hypothesis.[211] This is usually tested in the pharmaceutical field by observing the effects of one statistical group that has been exposed to the drug and comparing it to a control group that has not been exposed: if the "null hypothesis" is true (that the drug does not cause birth defects) there will be no observable differences between the two

206. *Id.* at 829-30.

207. *Id.*

208. *Id.* at 831, *cited in Daubert II*, 727 F. Supp. at 573.

209. *Richardson*, 857 F.2d at 831.

210. Brief for Petitioner at 8, Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2786 (1993) (No. 92-102).

211. *Id.* In this case the "null hypothesis" would be that Bendectin does not cause birth defects. The statistical analysis would have to show this assumption to be false within a range of error for epidemiological studies to show that exposure to this drug did cause birth defects. *Id.*

groups.[212] Because natural and random events may skew the data, before scientists accept that the effect exists, they tend to require a significant correlation, usually a ninety-five percent confidence interval that the skew is not caused by randomness.[213] Daubert argued that with respect to birth defects that occur in only a small portion of the population, epidemiological studies at ninety-five percent confidence are unlikely to detect adverse reactions because of the limited population available to study, and that an eighty percent confidence interval should be appropriate in this case to allow the jury to determine if this cause and effect relationship exists.[214] Daubert further asserted that although the recalculations of the epidemiological studies may have lead to a "battle of the experts,"[215] this testimony should be admissible because the plaintiffs had provided sufficient evidence to support their claim.[216]

The district court in *Daubert II* held for Merrell Dow, stating that the evidence did not support a causal connection between the drug use and the plaintiff's birth defects.[217] The court found that the plaintiff failed to show significant epidemiological evidence that established a causal link between his birth defects and his mother's Bendectin use, despite the testimony of eight plaintiff's experts.[218] These experts could not produce any statistically significant epidemiological studies linking Bendectin and the birth defects.[219] The court noted that only by recalculating earlier studies could these experts show causation, and that these recalculated epidemi-

212. *Id.* (citing KENNETH ROTHMAN, MODERN EPIDEMIOLOGY 116-17 (Little Brown and Co. 1986)).

213. Petitioner's Brief at 9, Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2786 (1993) (No. 92-102). Here, for example, there is only a 5% chance that the null hypothesis is true and a 95% chance that the cause and effect relationship exists.

214. *Id.* at 10.

215. *Id.* at 42 (quoting Oxendine v. Merrell Dow Pharmaceuticals, Inc., 506 A.2d 1100, 1110 (D.C. 1986), *cert. denied*, 493 U.S. 1074 (1990)).

216. *Oxendine*, 506 A.2d at 1104.

217. *Daubert II*, 727 F. Supp. at 576.

218. *Id.*

219. *Id.* at 574.

ological studies were not subject to peer review.[220] Consequently, the court concluded that Daubert could only show that Bendectin could possibly have caused the injuries, and therefore, summary judgment was appropriate even when the data was viewed in the light most favorable to the plaintiff.[221] Daubert appealed to the Ninth Circuit Court of Appeals.

The Ninth Circuit reaffirmed *Daubert II*'s holding, stating that animal and chemical studies, and expert reanalysis of epidemiological studies provided an insufficient foundation to allow admissibility at trial of expert testimony that the drug caused the birth defects.[222] The court noted that it had continued to apply *Frye's* "general acceptance" standard because of the danger of undue prejudice or of confusing a jury with the "aura of special reliability" of expert testimony.[223] The court reasoned that expert testimony must be based on a methodology that does not diverge significantly from procedures accepted by recognized authorities in the field, and that if the testimony does diverge, it must be excluded because it fails to meet the "general acceptance" standard.[224] The court was unwilling to allow the plaintiff to rely on reanalysis of the epidemiological studies because they were not published or subject to peer review and therefore, did not meet the "general acceptance" standard.[225] It noted that this testimony was particularly troublesome because of the vast majority of peer reviewed studies with the contrary position, and that this testimony was generated solely for litigation.[226] Daubert sought and was granted certiorari by the Supreme Court.

The Supreme Court vacated the Ninth Circuit decision and remanded the matter for retrial and ordered the lower court to use the FRE standard for admissibility of scientific

220. *Id.* at 575.
221. *Daubert II*, 727 F. Supp. at 576.
222. Daubert v. Merrell Dow Pharmaceuticals, Inc., 951 F.2d 1128, 1131 (9th Cir. 1991) [hereinafter *Daubert III*].
223. *Id.* at 1129-30 (quoting United States v. Amaral, 488 F.2d 1148, 1152 (9th Cir. 1973)).
224. *Daubert III*, 951 F.2d at 1152.
225. *Id.*
226. *Id.* at 1131.

evidence.[227] In summary, the plaintiff's arguments were as follows: 1) *Frye* is no longer an available ground for excluding scientific testimony under the FRE because Rule 402 prevents federal judges from applying common law rules that were not incorporated into the FRE, and that *Frye* is not incorporated into the FRE; and 2) even if *Frye* survives, proper application of whether the expert's opinion is admissible at trial should not depend on whether it has been published in a peer-reviewed journal.[228]

Merrell Dow argued that the expert testimony was properly excluded because it did not have an adequate foundation required by FRE 702 and this testimony must be based on a foundation that is based on accepted standards in the expert's field.[229] In addition, this acceptance requires passage through peer review and scrutiny.[230] Applying this standard, Merrell Dow argued the reanalysis technique that the plaintiff advocated was not admissible at trial because this method contradicted current scientific standards under current methodologies and that their hypothesis must be tested by peer review.[231]

Justice Blackmun delivered the opinion of the Supreme Court, which unanimously rejected the *Frye* standard, holding that it had been superseded by the FRE.[232] The court based its decision on the FRE, noting that the Rules "occupy the field,"[233] but acknowledged that the common law continues to assist in interpretation of the FRE.[234] Justice Blackmun noted that Rule 702 directly speaks to this issue,[235] and stated that nothing in this rule, which specifically governs

227. Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2786, 2798 (1993) [hereinafter *Daubert IV*].

228. Brief for Petitioner at i, Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2786 (1993) (No. 92-102).

229. *Id.*

230. *Id.*

231. *Id.*

232. *Daubert IV*, 113 S. Ct. at 2793.

233. *Id.* at 2794 (citing United States v. Abel, 469 U.S. 45, 49 (1984)).

234. *Daubert IV*, 113 S. Ct. at 2794 (citing United States v. Abel, 469 U.S. 45, 51-52 (1984)).

235. *Daubert IV*, 113 S. Ct. at 2794.

the admissibility at trial of scientific evidence, gives any indication that "general acceptance" is a condition precedent to the admissibility of this evidence.[236] He further stated that this rigid standard is at odds with the liberal thrust of the FRE and their general approach of relaxing traditional barriers with respect to opinion testimony.[237]

Justices White, O'Connor, Scalia, Kennedy, Souter, and Thomas joined in the rest of Justice Blackmun's analysis.[238] The FRE places appropriate limits on the admissibility of scientific evidence at trial by making the trial judge determine if the evidence rests on a reliable foundation and is relevant to the case at hand.[239] The trial court must determine if expert testimony is related to scientific knowledge, where "scientific" implies a grounding in science's methods and procedures, and "knowledge" connotes a body of known facts or ideas inferred from such facts or accepted as true on such grounds.[240] Accordingly, such determination must be more than subjective belief or unsupported speculation.[241] This does not require that the testimony must be "known" to a certainty.[242] However, the process used to derive this inference must be based in the scientific method; FRE 702 requires that the testimony assist the fact-finder in understanding the evidence and its relevancy at trial by demanding a scientific connection to the inquiry as a condition precedent to admissibility.[243]

As with most evidence law, the goal is that the expert testimony be reliable and relevant to the case at hand.[244] The trial court must under Rule 104(a) decide whether the testimony reasoning or methodology is scientifically valid and can be applied to the facts at issue.[245] The trial courts are

236. *Id.*
237. *Id.*
238. *Id.* at 2791.
239. *Daubert IV*, 113 S. Ct. at 2795.
240. *Id.*
241. *Id.*
242. *Id.*
243. *Daubert IV*, 113 S. Ct. at 2795.
244. *Id.* at 2795-96.
245. *Id.* at 2796.

aided in this decision by a flexible standard including several factors: a) whether the theory or technique can be (or has been) tested; b) whether the theory or technique has been published after being subjected to peer review; c) known or potential error rate; d) existence of a standard controlling the operation; and e) whether the method is widely accepted in the relevant community.[246] The courts note that Rule 403 permits the exclusion of this evidence even if it is relevant and reliable "if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues or misleading the jury."[247] However, "vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence."[248]

V. Analysis: EMF Litigation And Daubert v. Merrell Dow

A. Current EMF Litigation

EMF related litigation will likely take on at least four different forms: 1) attempts to stop new construction or facility upgrades; 2) eminent domain and other property related actions; 3) worker's compensation claims for those who believe their illnesses were caused by EMF exposure in the workplace; and 4) personal injury claims.[249] Until recently,

246. *Id.* at 2796-97. One commentator noted that this decision requires a trial judge to use methods similar to those of the scientific community when scrutinizing scientific evidence. John A. Livingood, Jr., *Admissibility and Reliability Of Expert Scientific Testimony After* Daubert, DEFENSE COUNSEL J., Jan. 1994, at 19, 26. One post *Daubert* case noting that this fifth factor is very much like the "general acceptance test" stated, "the decision in *Daubert* kills *Frye* and then resurrects its ghost." Maiorana v. Nat'l Gypsum Co., 827 F. Supp. 1014, 1033 (S.D.N.Y. 1993).

247. *Daubert IV*, 113 S. Ct. at 2797 (citing FED. R. EVID. 403).

248. *Daubert IV*, 113 S. Ct. at 2798.

249. Roy W. Krieger & Michael E. Withey, *EMF And The Public Health*, NATURAL RESOURCE & ENVIRONMENT, Summer 1994, at 4-5. It will probably be difficult for those seeking compensation for personal injury under a theory of strict liability for ultrahazardous activity. *See, e.g.*, Walston v. Northeast Utilities, No. CV92-0327441, 1993 WL 451393 (Conn. Super. Ct. Oct. 18, 1993). In *Walston*, the plaintiff's allegation that the utility should be strictly liable was

most EMF cases that have gone to trial have been eminent domain cases; some plaintiffs have recovered because fear of EMF effects decreased property values.[250] In *San Diego Gas & Electric Co. v. Daley*,[251] the California Court of Appeals held that "the truth of whether electromagnetic projections caused a health hazard to humans . . . was immaterial. Rather, the question was whether the fear of the danger existed and would affect market value."[252] In addition, the New York Court of Appeals held that this fear need not even be reasonable, as even an unreasonable fear can adversely affect market value.[253] In *Houston Lighting & Power Co. v. Klein Independent School District*,[254] the Texas Court of Appeals upheld a jury verdict that followed contradictory expert testimony on the possibility of harmful EMF effects in an electric utility condemnation action, finding "the jury could have believed that the transmission lines posed a risk to the children

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dismissed because under Connecticut law, electric utilities may not be liable for damages without a finding of fault. *Id.* (citing Citerella v. United Illuminating Co., 266 A.2d. 382, 386 (1969)).

250. *See* San Diego Gas & Electric Co. v. Daley, 253 Cal. Rptr. 144, 152 (Cal. Ct. App. 1988); Florida Power & Light Co. v. Jennings, 518 So. 2d 895, 899 (Fla. 1987) (any factor, including fear, which impacts on market value may be considered to explain expert testimony); Criscuola v. Power Auth. of the State of New York, 621 N.E.2d 1195, 1197 (N.Y. 1993) (plaintiffs must establish some prevalent perception of a danger emanating from the objectionable condition). *See also* Richard A. Reed, *Fear and Lowering Property Values in New York: Proof of Consequential Damages From "Cancerphobia" in the Wake of* Criscuola v. Power Authority of the State of New York, N.Y. ST. B. J., Mar./Apr. 1994, at 30 (a good discussion of methods used to prove consequential damages).

251. 253 Cal. Rptr. 144 (Cal. Ct. App. 1988).

252. *Id.* at 152 (electric utility condemnation action for erection of a high voltage transmission line and landowner contested proposed compensation as inadequate). This fear reduced property values because of increased EMF exposure and was the main factor in defeating the erection of a commercial radio tower in Pescatello v. Planning and Zoning Comm'n of Waterford, 1994 WL 421475, (Conn. Super. Ct. Aug. 3, 1994). There, landowners submitted a letter from a real estate broker and an appraisal of property values if the tower was built. *Id.* No scientific evidence of EMF exposure dangers was offered, however the zoning application to erect the tower was defeated by the feared property value effects. *Id.*

253. *Criscuola*, 621 N.E.2d at 1196.

254. 739 S.W.2d 508 (Tex. Ct. App. 1987).

and that uncertainty over the magnitude of that risk should dictate caution."[255]

Other cases with respect to power line siting have had mixed results. In *Douglas County Board of Comm'r. v. Public Utils. Comm'n. of Colorado*,[256] the Colorado Supreme Court noted that, *inter alia*, they agreed with the Public Utilities Commission's finding that there was no concrete proof of adverse health effects from EMF.[257] However, a Pennsylvania administrative law judge ordered the energization of a new power line postponed until the state gives EMF standards for these right-of-ways.[258]

In addition to these actions, lawmakers are also becoming involved in the debate, and some are not waiting for conclusive scientific evidence to introduce EMF-related legislation. In Congress, for instance, a bill has been introduced to direct the Secretary of Energy to establish labeling requirements for products that emit extremely low frequency EMF.[259] A second bill was introduced to establish a national policy banning the location of new public schools and child care centers on real property where the EMF is greater than two mG per day.[260] Finally, additional EMF research funds were allocated in the Energy Policy Act.[261]

New major transmission lines in New York State must be designed so that the maximum electric field strength on the right-of-way, measured at one meter above ground, will

255. *Id.* at 518.

256. 829 P.2d 1303 (Colo. 1992).

257. *Id.* at 1306.

258. Jim Provance, *PUC Judge to PE: Hold the line*, BUCKS COUNTY COURIER TIMES, Aug. 20, 1992, at 1A.

259. H.R. 1665, 103d Cong., 1st Sess. (1993).

260. H.R. 1494, 103d Cong., 1st Sess. (1993).

261. Energy Policy Act of 1992, Pub. L. No. 102-486, § 2118, 106 Stat. 2776, 3075-80 (1992). Currently, about $20 million a year is being spent in the United States for EMF research; the new five-year program mandated by the 1992 National Energy Policy Act will increase the total by another $8 million to $10 million annually. The Department of Energy, the Electric Power Research Institute, and the National Institute of Environmental Health Sciences (NIEHS) are sponsoring most of the domestic EMF research; research is also being conducted in several countries, such as Canada, Sweden, United Kingdom, and Italy. Hileman, *supra* note 8, at 17.

not exceed seven kilovolts per meter (kV/m) at public roads, eleven kV/m at private roads, and 11.8 kV/m elsewhere.[262] Under normal day-to-day operating conditions, the electric field strength at the edges of the right-of-ways must be equal to or be less than 1.6 kV/m, measured one meter above ground.[263]

Although there is much concern about EMF, proof of causation in an allegedly EMF-induced personal injury claim is likely to be more difficult than proving real estate values are affected by EMF fears. A factfinder must be convinced that the plaintiff's injuries were indeed caused by the defendant-generated EMF, not that the plaintiff feared it was caused by the EMF or that it may have been caused by the EMF. In an allegedly EMF-induced personal injury action, property market value is eliminated from the analysis, and the focus is on the *legal* cause of the injury.

The stakes in this litigation are very high. As all are aware, a cancer-related verdict for a plaintiff could be significant and could open the floodgates for many other suits against electric utilities, appliance manufacturers, and many other entities. In addition to the compensation awards for personal injuries, the costs of remediation could be very large as well. Pennsylvania Power & Light Co. recently estimated EMF remediation costs for the overhead lines on its system at $600 million.[264] Given the cost on this 3,700 mile system, nationwide remediation costs could be astronomical.

A verdict for an alleged EMF-caused injury could even have a negative impact on efforts to clean up the environment. There are many who recommend that a hybrid (heat engine / battery-electric) electric vehicle be put on the road to solve the problems of reliance on petroleum, increases in air pollution, and the greenhouse effect.[265] This vehicle, which

262. NEW YORK STATE DEPARTMENT OF HEALTH, POWER LINES PROJECT, QUESTIONS AND ANSWERS 6 (1992).

263. *Id.*

264. Richards, *supra* note 3, at A8. As one of their employees, Bernard Bujnowski stated, "With all this scientific uncertainty about EMF, who's going to pay for that?" *Id.*

265. *Electric Cars on the Road*, EMF-EMI CONTROL, Jan.-Feb. 1994, at 4.

can be built with existing technologies, requires no major change in the infrastructure that provides energy for the vehicle, but it begs the question about the increased magnetic fields in the electric car.[266] EMF levels in these cars could exceed 100 mG.[267] The increased levels of EMF, if found to be dangerous to humans, could sound a death knell for one of our most promising solutions to the problem of auto emissions.[268] How society and the courts will balance between the potential cancerous effects of EMF and other dangerous effects of auto emissions remains to be seen.

The EMF controversy may also seem to be a proper issue for a class action suit where many property owners, for example, could seek compensation for property value losses when a power line is installed. However, the courts should resist class certification in such situations. As Riley and Vollins point out, "the only reason why the market value of the property near transmission lines may have depreciated is because of public fear - a fear which may prove to be completely unfounded."[269] In each case where property damage classes have been certified, the claimants' property value fell because of an acknowledged hazard, for example, asbestos exposure[270] or radiation exposure.[271] In addition, each person's damages will be very different because of differences in purchase price, time of purchase, and distance from the power lines.[272] Moreover, as noted above, these power lines are not the only EMF source people encounter. These concerns complicate the ability of an EMF plaintiff to show causation, which is required to successfully maintain an EMF personal injury suit, and thus, makes the testimony of experts in this area even more critical.

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266. *Id.*

267. *Id.*

268. *Id.*

269. Riley & Vollins, *supra* note 105, at 26.

270. *Id.* at 26 (citing *In re* School Asbestos Litigation, 789 F.2d 996, 999 (3d. Cir. 1986), *cert. denied*, 479 U.S. 852 (1986)).

271. *Id.* at 26 (citing *In re* Three Mile Island Litigation, 87 F.R.D. 433, 434 (M.D. Pa. 1980)).

272. Riley & Vollins, *supra* note 105, at 27.

Some EMF-related personal injury actions have been settled in the past. For example, in *Strom v. Boeing*,[273] Boeing paid a $500,000 out of court settlement to Robert Strom, who charged that he developed leukemia after twenty years of testing the effects of EMF pulse radiation on MX missile components.[274] In addition, some warn that: 1) a jury need not have conclusive evidence of causation to award a plaintiff damages; 2) the current climate could be ripe for such an award; and 3) utility actions to mitigate EMF could be taken as tacit admissions of guilt.[275] Some plaintiff's attorneys seeking to win the first EMF-related personal injury action are carefully choosing their clients, trying to find the one that could win the landmark suit: one firm states it employs three criteria before deciding to file an EMF claim: 1) a family history free from cancer; 2) level of exposure; and 3) considerations of utility efforts to mitigate EMF exposure.[276]

Given these developments, many are taking precautionary measures. With the multitude of allegedly EMF-induced personal injury actions currently pending and likely to be filed, many are becoming concerned that future verdicts finding EMF-related personal injury liability are on the horizon.[277] In a widely publicized action, a Florida man claims that his wife's fatal brain tumor was induced by her use of a cellular phone; news of this suit caused the stocks of several cellular phone companies to drop sharply.[278]

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273. Strom v. Boeing, 88-2-10752-1 (Wash. filed June 1988, settled out of court Sept. 21, 1990).

274. SUGARMAN, *supra* note 3, at 178.

275. *Utilities Warned: Juries May Not Wait for Conclusive Scientific Evidence in EMF Damage Cases*, ELECTRIC POWER ALERT, Oct. 28, 1992, at 1.

276. *Id.*

277. For example, an insurance trade publication article noted that insurers are being encouraged by some law firms to add exclusions for EMF hazards stemming from power lines to new policies. C. Dauer, *Insurers Warned to Lower Exposure to EMF Liabilities*, NATIONAL UNDERWRITER, Nov. 1993 at 31. Law firms are also preparing for this anticipated increase in EMF related litigation. In October, 1993, LeBoeuf, Lamb, Leiby & MacRae announced the hiring of three attorneys and one full time scientist "to defend tort actions involving electromagnetic fields." N.Y.L.J., Oct. 28, 1993, at 1.

278. John J. Keller, *Cellular Phone Safety Concerns Hammer Stocks*, WALL ST. J., Jan. 25, 1993, at B1.

The first EMF personal injury trial was conducted in the San Diego County Superior Court in 1993.[279] In that case, the plaintiffs claimed Mallory Zuidema was born with a rare form of kidney cancer because of *in vitro* EMF exposure from high voltage transmission and distribution lines near their home.[280] Preceding the *Daubert* decision, the court allowed the admission of expert testimony that EMF could have caused the defects over the defendant's objection that this data was inadmissible under the *Frye* test.[281] Although the plaintiffs could produce no studies linking EMF directly with this form of cancer,[282] some commentators at the trial believed that the defendants prevailed because their expert testimony was more qualified and objective than those of the plaintiffs, and that they simply won the "battle of the experts."[283] *Zuidema* is significant here because although the court found that the plaintiff's evidence was admissible, it appears that it was not conclusive enough for the jury to find the EMF-cancer link by a preponderance of the evidence. It remains to be seen if similar evidence will be admissible, given the *Daubert* standard, or whether the courts will demand some higher standard of reliability.

Having the "wrong" kind of cancer was not a stumbling block in *Jordan v. Georgia Power & Ogelthorpe Power*[284] which was decided on May 11, 1994. Nancy Jean Jordan sought compensation for an allegedly EMF-induced brain cancer. Several studies linked EMF with these forms of tumors, and consequently, many watched the proceedings

279. Zuidema v. San Diego Gas & Electric, No. 638-222 (Super. Ct. San Diego County 1993).

280. Noel Cohen, *Paucity of Scientific Data Derails EMF Case*, LEADER'S PRODUCT LIABILITY LAW AND STRATEGY, May 1993, at 3.

281. *Id.*

282. *Id.*

283. *Id.* The defense utilized illness experts who were familiar with the kidney cancer at issue whereas the plaintiffs used experts in the field of EMF. J. Stratton Shartel, *Causation Leads List of Issue Shaping Strategy in EMF Litigation*, INSIDE LITIG., Nov. 1993, *available in* WESTLAW, JLR Database. Some commentators note that "illness" experts are the most believable experts. *Id.*

284. No. 91-4103-SS 296 (Ga. Super. Ct. Douglas County).

closely.[285] This case also resulted in a defendant's verdict, but some jurors felt it was only a matter of time before an EMF plaintiff wins one of these actions.[286] One juror said, "they may have won this battle but the war is not over. None of us like the decision. But the law was the law; our hands were tied. I fully believe that EMFs cause cancer."[287] The jury forewoman stated "that scientific studies 'show there is something there, but we weren't convinced it caused this case . . . I honestly think someone will win one of these cases. The studies are consistent and getting more and more sophisticated.' "[288]

B. Does The *Daubert* Ruling Assist Plaintiffs Claiming Injuries Resulting From EMF Exposure?

Daubert IV has clarified the way federal courts are to examine scientific evidence to determine if it is admissible at trial. It appears that the key questions that a trial judge will have to answer when making these evidentiary rulings are: 1) are the data developed under scientific methods?; and 2) will the data help a factfinder determine the causation issue? The factors Justice Blackmun outlined should be useful in answering these questions: 1) whether the theory or technique can be (or has been) tested; 2) whether the theory or technique has been subjected to peer review; 3) the known or potential error rate; 4) existence of a standard controlling the operation; and 5) whether the method is widely accepted in the relevant community.[289]

Whether or not *Daubert* will have a substantial impact may depend on the state courts as well as individual judges. Plaintiffs' attorneys in EMF litigation stress that how judges approach their roles as evidentiary gatekeepers, either con-

285. James R. Pierobon, *EMF Litigation Three East Coast Lawsuits Go To Trial: Industry Braces For Shock Waves*, ELECTRICAL WORLD, Dec. 1993, at 96. *See also* Torpey & Ronkin, *supra* note 129, at B6.

286. Bill Torpey, *I Got Cancer and Nobody Cares. They've Killed Me, Killed Me: Jury Decides Cancer Not Tied to Electric Lines*, ATLANTA CONST., May 12, 1994 at F1.

287. *Id.*

288. *Id.*

289. *Daubert IV*, 113 S. Ct. 2786, 2796-97 (1993).

servatively or liberally, will have an effect on *Daubert's* impact.[290] Defense attorneys minimize the negative effects of *Daubert*, stressing that technically it is a Federal case and State courts are free to follow the *Frye* standards.[291]

In some circuits, it is unlikely that *Daubert* will have any significant effect on the admissibility at trial of scientific evidence. For example, in *Williams*, the Second Circuit cited many of the same factors that Justice Blackmun did in its analysis in determining reliability of evidence: 1) the potential rate of error; 2) the existence and maintenance of standards; 3) the care and concern with which a scientific technique has been employed, and whether it appears to lend itself to abuse; 4) the existence of an analogous relationship with other types of scientific techniques and results that are routinely admitted into evidence; and 5) the presence of "fail-safe" characteristics or the likelihood that potential inaccuracies will redound to the defendant's benefit rather than his detriment.[292] It remains to be seen how the courts will apply these factors.

While each evidentiary ruling must be made independently, it should be noted that the *Williams* court focused on the method and reliability by which the data are collected, and not on its findings.[293] Consequently, trial courts will need to look closely at the methods by which researchers develop their hypotheses, and expert witnesses will have to be able to fully explain the details of methods of data collection and analysis. This will also require some technical study on the part of trial courts, and may require separate *in limine* hearings to determine whether scientific evidence can be admitted at trial, and whether the methodologies for the studies are based on the proper foundation.

Should trial judges find themselves unable to make an educated decision based on these arguments, a viable alternative might be for the trial court to appoint its own expert according to Rule 706 to explain the scientific techniques, and

290. Shartel, *supra* note 283.
291. *Id.*
292. United States v. Williams, 583 F.2d 1194, 1198-99 (2d. Cir. 1978).
293. *Id.* at 1198.

to allow the parties to question this third expert to further clarify difficult technical issues.[294] Unfortunately, this method of clarification not only lengthens the litigation, it also increases the costs significantly. The author would suspect that this would not be a popular option as it would slow the passage of lawsuits through the already overcrowded system. Furthermore, courts may be more likely to allow questionable testimony to be admissible at trial to speed the process and to allow the jury to determine whether the scientific evidence carries enough weight to prove the plaintiff's case by a preponderance of the evidence.

The benefit of not adding a court appointed expert under Rule 706 is that it speeds the process, puts the most faith in the adversary system, and asserts that a jury of lay people will be able to sort out complex issues, even when confronted by a "battle of the experts." As always, Rule 403 will be available to the trial judge in determining if the prejudicial value of scientific evidentiary testimony significantly outweighs its probative value.[295]

A corollary effect of the *Daubert* decision is that it may change the way expert witnesses are chosen. In the past, experts were often chosen based on their publications, participation in professional meetings, and scholarly positions at leading institutions.[296] Now, experts may also be chosen based on presentation style, apparent credibility, and possibly from lesser known organizations or with data that are less well known.[297]

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294. The court may appoint any expert witness agreed upon by the parties, and may appoint expert witnesses of its own selection . . . A witness so appointed shall advise the parties of the witness' findings, if any; the witness' deposition may be taken by any party; and the witness may be called to testify by the court or any party. The witness shall be subject to cross-examination by each party, including the party calling the witness.

FED. R. EVID. 706.

295. *Daubert IV*, 113 S. Ct. at 2798.

296. V. Hale Starr, *Aftermath of 'Daubert' Will See Experts Prepared to Explain Testimony More Clearly*, BNA TOXICS LAW REP., Summer-Fall 1993, at 38.

297. *Id.* at 39.

As the *Daubert* decision is applied to the EMF controversy, it appears that there will be several battlegrounds for adversaries to clash. The factors Justice Blackmun has articulated and the language of Rule 702 provide ample areas of debate for both sides. First, Rule 702 requires that the testimony assist the factfinder in understanding the evidence or determining a fact at issue.[298] Given the contradictory and uncertain results of EMF research to date, causation will be a difficult issue for a jury. However, to be admissible, the evidence need not be sufficient to carry the day, it need only "hav[e] any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence."[299] In most scenarios, plaintiffs, who seek introduction of EMF testimony showing a positive relationship between EMF exposure and cancer, will naturally argue this evidence will make it more likely that the exposure was the cause of the injury. On the other hand, defendants will argue that the data is not sufficiently probative to help in the decision at all. This writer believes that the language in Rule 702 will not exclude large amounts of expert testimony, given the liberal nature of the wording of Rule 401.

It is more likely than not that the exclusion of any scientific evidence will result from the use of Justice Blackmun's factors. Within the field of epidemiological study, there are several different types of experimental observations including case control studies, mortality studies, and retrospective follow-up studies, each of which uses a different method of conducting its evaluations.[300] Many studies conducted to date have been subject to criticism from the scientific community for a variety of reasons such as problems with control groups, insufficient allowance for confounding factors, insufficient sample size, EMF exposure estimations when actual measurements were not available, categorization of occupational studies, and extrapolation of animal or cellular stud-

298. FED. R. EVID. 702.

299. FED. R. EVID. 401.

300. *See generally* EPRI, EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS, *supra* note 26.

ies.[301] Given these uncertainties, arguments will certainly be waged over whether the studies are conducted according to techniques that can be tested, the potential or known error rate, and whether the method is widely accepted in the relevant scientific community. When the epidemiological studies suffer from any of these defects to a substantial degree, it is possible that a trial court will exclude the scientific evidence if the potential error rate is unacceptable or if the plaintiffs attempt to use a study that employs a novel approach to the problem, such as the plaintiffs did in *Daubert*.[302]

VI. Conclusion

In many cases, it appears that the growing quality of studies being conducted, along with growing sample sizes and the increased public awareness of the potential hazards, will tend to help EMF plaintiffs admit scientific evidence at trial using the *Daubert* standard. In *Zuidema*, the defense won largely because the jury believed the defense had better experts than the plaintiffs, and because that form of cancer had not been linked with EMF exposure.[303] Continuing study, growing methodology refinement, and peer review of EMF research will also make this data more readily admissible. However, this data should be used with caution. Although it

301. *Id.* at 1-12 to 1-13.

302. A question which is beyond the scope of this article is, "[i]f the scientific evidence of purported EMF exposure/cancer relationships is admissible, what degree of certainty in these studies will be sufficient to justify a finding for the plaintiff?" One federal district court in an asbestos litigation has proposed a listing of five factors that could be used in an EMF action:

1. What is the strength and consistency of the relationship? (The court stated that a relative risk of greater than 2.0 indicated it was more likely than not that exposure to the alleged carcinogen does indeed cause cancer.).
2. What is the dose response relationship?
3. What are the results of the experimental studies?
4. How plausible is the biological link?
5. How much coherence between the cause and effect? (This relates to compounding or alternative causes for the effect.).

Maiorana v. Nat'l Gypsum Co., 827 F. Supp. 1014, 1037-38 (S.D.N.Y. 1993). Given the current state of EMF/cancer studies, the results of this analysis would vary widely.

303. Cohen, *supra* note 280, at 3.

appears that most experts in this field believe that there may be a link between EMF exposure and human illness, they have not found conclusive evidence of this relationship, and those at either end of the spectrum will continue to be in the headlines.

While attention is generally focused on the electromagnetic fields associated with high voltage transmission lines, these fields actually exist *everywhere* that electric energy is used.[304] As a result, the issue goes to the very heart of how we depend on electricity for comfort, convenience, and safety.[305] If it is determined that electromagnetic fields must be reduced, it could require some fundamental changes in our society.[306] The courtroom is a place where truth can collide with perception and skillful argument. In the EMF arena, the stakes are usually high for the participants. However, with respect to issues such as this, that go to the heart of how we live, this writer believes that the courts should tread carefully as the stakes are not only high for those in the lawsuits, but they are very high for society as we know it. In a time when money is in short supply, the United States faces a four trillion dollar national debt and increased instability in the economic and social fabric of society, if the *courts* decide that EMF is harmful before science does, the costs to society could be drastic and may require fundamental changes. This would be particularly tragic if at some future date, science were to reach a consensus that extremely low frequency EMF exposure is not a hazard, but society had already suffered the cost of these fundamental lifestyle changes because we allowed the *courts* to decide a complex scientific issue.[307]

304. Letter from Stuart Russell, Planning Manager, Orange and Rockland Utilities Inc., to Norman Becker, Universal Home Inspection 1 (Aug. 14, 1991) (on file with author).

305. *Id.*

306. *Id.*

307. POST-SCRIPT: After this article went to print, on remand from the Supreme Court, the Ninth Circuit Court of Appeals unanimously dismissed Daubert's complaint under the Supreme Court's standard. Daubert v. Merrell Dow Pharmaceuticals, Inc., No. 90-55397, 1995 WL 1736 (9th Cir. Jan. 4, 1995). The court noted that

> [t]he opinions proffered by plaintiffs' experts do not, to understate the point, reflect the consensus within the scientific community. . . .

> In fact, apart from the small but determined group of scientists testifying on behalf of the Bendectin plaintiffs in this and many other cases, there doesn't appear to be a single scientist who has concluded that Bendectin causes limb reduction defects. *Id.* at *2.

The court went on to say that "something does not become 'scientific knowledge' just because it's uttered by a scientist; nor can an expert's self-serving assertion that his conclusions were 'derived by the scientific method' be deemed conclusive . . ." *Id.* at *3. A court must look at the basis an expert has for his testimony, rather than examine its content. *Id.* at *4.

The Ninth Circuit then went on to apply the Supreme Court's two part standard for analysis, that is, whether: 1) the testimony is "scientific knowledge . . . derived by the scientific method . . . [and 2)] relevant to the task at hand . . ." *Id.* at *3 (citing Daubert v. Merrell Dow Pharmaceuticals, Inc., 113 S. Ct. 2795, 2797 (1993).

The court held that a significant factor in determining whether to admit expert testimony is whether the experts have done research independent of the litigation or if they have "developed their opinions expressly for purposes of testifying." *Id.* at *5. Here, the plaintiffs' experts did not conduct research independent of the litigation, but merely recalculated data generated by others (who concluded that Bendictin did not cause birth defects) to state that Bendectin *may* cause these defects. *Id.* "Independent research carries its own indicia of reliability, as it is conducted . . in the usual course of business and must normally satisfy a variety of standards to attract funding and institutional support." *Id.* (emphasis added).

In addition, the court found that peer review and publication would also be important factors in the analysis and

> Bendectin litigation has been pending in the courts for over a decade, yet the only review the plaintiffs' experts' work has received has been by judges and juries, and the only place their theories and studies have been published is in the pages of the federal and state reporters. . . . It's as if there were a tacit understanding within the scientific community that what's going on here is not science at all, but litigation. *Id.* at *6.

Consequently, the court held that the plaintiffs' testimony failed the "scientific knowledge" part of the test. *Id.* at *6.

In addition, the Ninth Circuit also held that most of the plaintiffs' expert testimony also failed the second part of the Supreme Court's *Daubert* test, the relevancy requirement. *Id.* at *9. Most of these experts testified only that Bendectin was "capable of causing" birth defects. *Id.* California law requires that a plaintiff show that it is more likely than not that Bendectin caused her injury. *Id.* at *8 (citing Jones v. Ortho Pharmaceutical Corp., 163 Cal. App. 3d 396, 403 (Cal. Ct. App. 1985). This is shown by establishing that Bendectin more than doubled the risk of birth defects. *Id.* However, none of the plaintiffs' experts would testify that the relative risk for Bendectin mothers' was greater than 2.0, consequently the court held that while Bendectin *could possibly* have caused the plaintiff's birth defects, their proof did not rise to the level of proving this relationship by a preponderance of the evidence. *Id.* at *8, *9.