Appendix Five
Summary Table of Studies on Chicken Embryo Development

APPENDIX FIVE SUMMARY TABLE OF STUDIES ON CHICKEN EMBRYO DEVELOPMENT

		DESCRIPTION OF STUDY POPULATION			DESCRIPTION OF EXPOSURE SYSTEM			
Study (ref)	Hypothesis (Objectives)	Gender/Age	Strain	Number	Fields/Freq.	Intensity	Polarization	List Study Groups & No.
Study 1 Martin, *Bioelectromag* 9:393-96 1988	There is a critical period of development sensitive to EMFs	Fresh fertile eggs, used within 5 days of laying	White leghorn H & N Line Redmond, Washington	600	Magnetic 100 Hz Pulsed	1 μt	Horizontal	Control – exposed Exposed for 1) 48 hrs – 100c/100E 2) 1st 24 hrs – 100/c/100 exp 3) 2nd 24 hrs-100c/100 exp
Study 2 Berman et al., *Bioelectromag* 10:169-87 1990	To determine the effect of EMFs on development	Fresh fertile eggs, used within 5 days of laying	White Leghorn and Arbor In one lab	1,200 in 6 labs	Magnetic 100 Hz Pulsed	1 μt	Horizontal	6 laboratories sham & exposed 100 & 100 eggs per experiment 10 sham/10 exp. per run for 10 runs/exp.
Study 3 Martin, *Bioelectromag* 13:223-230 1992	To determine if metering EMF parameters alters the effect of EMFs on chick development	Fresh fertile eggs, used within 5 days of laying	White leghorn	800/ 200 per form	Magnetic 60 Hz	3 μt	Horizontal	Pulse type – C – exp #7 eggs/run unipolar – 200 – 10 Split – 200 – 10 Bipolar – 200 – 10 & 72 hrs no pulse
Study 4 Moses & Martin, *Biochem Int* 28(4):659-664 1992	To determine the effect of EMFs on enzyme activity in the chick embryo	As above	As above	380	Magnetic 60 Hz split pulse	4 μt	Horizontal	Control normal Exposed normal Control abnormal Exposed abnormal Enzymes tested were 5 "NT; ACHE and ALP

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Study 5 Moses & Martin, *Biochem & Mol Biol Int* 29(4):757-762 1993	To determine the effect of EMF on 5 'NT activity inc per mount on transient	Fresh fertile eggs, used within 5 days of laying	White leghorn	260	Magnetic 60 Hz	4 μt	Horizontal	1) Exposed 3 days & 3 field-free day = 200 eggs 2) Exposed 3 days & 15 field-free days = 60 eggs. Day 6 – whole embryo Day 18 – brains of embryo
Study 6 Martin & Moses, *Biochem Mol Biol Int.* 36(1):87-94 1995	Superimposed noise with same parameters mitigates the effect of EMFs on enzyme activity	Fresh fertile eggs used within 5 days of laying	White leghorn	600	Magnetic 60 Hz	4 μt	Horizontal	Control – 200 Field – 200 Field & Noise – 200
Study 7 Litovitz et al., *Bioelectromag* 18:431-438 1994	Living cells are affected only by EMFs that are spatially coherent	Fresh fertile eggs, used within 24 hrs of laying	White leghorn H & N line Redmond, Washington	1,107	Magnetic 100 Hz pulsed	1 μt	Horizontal	Run 1) Sham – 255 EMF – 152 EMF & Noise – 110 Run 2) Sham – 206 EMF – 203 EMF & Noise – 181

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Study (ref)	Hypothesis (Objectives)	Gender/Age	Strain	Number	Fields/Freq.	Intensity	Polarization	List Study Groups & No.
Study 8 Farrell et al., *Bioelectromag* 18:43-438 1997	To determine if genetic composition of flocks can alter response to EMFs	As above	As above	2,841	Magnetic 100 Hz Pulse or 60 Hz Sinusoidal	Pulse 1 μt Sine 4 μt	Horizontal	Pulse 4 groups or campaigns Total of 2,296 eggs Sinusoidal 1 group or campaign Total of 545 eggs
Study 9 Farrell et al., *Bioelectromag* 19:53-56 1998	A superimposed noise field inhibits 60 Hz - 4 μt attention on ODC activity	As above	As above	60	Magnetic 60 Hz	4 μt	Horizontal	Control – 20 60 Hz – 20 60 Hz & Noise – 20 At each data point 5–7 embryos tested
Study 10 Leal et al., *J of Bioelectricity* 7(2):141-153 1989	To determine if weak changes in the earth's geo-magnetic field alters response of balance systems to EMFs	Fresh fertile eggs, used within 3 days of laying	White leghorn	520-650	Magnetic 100 Hz pulsed	1.4 – 1.0 μt	Horizontal	Control – 13 groups/20-20 Exposed –13 groups/20-25 eggs/group
Study 11 Chacon et al., *J of Bioelectricity* 9(1):61-66 1990	To compare effect of 30 Hz MFs to earlier studies using 100 Hz	Fresh fertile eggs, used within 2 l/2 days of laying	White leghorn	350	Magnetic 30 Hz	1 μt	Horizontal	Control – 175 Exposed – 175

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Study (ref)	Hypothesis (Objectives)	Gender/Age	Strain	Number	Fields/Freq.	Intensity	Polarization	List Study Groups & No.
Study 12 Ubeda et al., *Bioelectromag* 15:385-398 1994	To assess the permanence of the effects induced by early MF exposure	As above	As above	597	Magnetic 100 Hz Pulse A 85 μs time Pulse B 2.1 μs	1 μt	Horizontal	Control – 276 Exp. I Shem – 75 PMF-A – Exp – 72 Exp II PMF-B Shem 92 Exp – 82
Study 13 Koch & Koch, *J of Bioelectricity* 19(1&2):65-80 1991	To test whether development is altered by PEMFs	Fresh fertile eggs	Arbor acre Preterm cross White leghorn Cornel	394 274 38	Magnetic 100 Hz	1 μt	Horizontal	3 Groups all 1 μt 1) Pulse –5 experiments 1,020 eggs 2) Biopolar square-1 exp 100 eggs 3) Sinusoidal-1 Exp 100 eggs
Study 14 Singh et al., *J Anat Soc India* 39:41-47 1991	To determine effect of EMFs at varying intensity & frequency on chick embryogenesa	Fresh fertile eggs	White Leghorn	67	Magnetic 100 to 1,000 Hz	0.5 to 40 μt	Not given	Control – 2 eggs/exp. Exp. 0.5 μt/100 Hz-10 0.5 μt/1000 Hz – 9 19 μt/100 Hz – 8 40 μt/1000 Hz – 9 40 μt/1000 Hz – 9

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Study 15 Espinar et al., *Bioelectromag* 18:36-44 1997	To test effect of static (20 MT) field on development of chick cerebellum	Fresh fertile eggs	White Leghorn	144 total 3 Exps with 48 eggs per exp.	Magnetic static	20 MT	Not clear Possible Horizontal?	Eggs exposed from day 1 (L Exp) or day 6 (S exp) and removed on day 13 or 17 Control – shem day 13 or 17 C-48 eggs S Exp – day 13 (24 eggs)17-24 L Exp – day 13 (24) 17 (24)
Study 16 Blackman et al., *Bioelectromag* 9:129-140 1988	To study the interaction of EM fields with the developing CNS	Fertile eggs, used within 7 days of laying	Not given	Exp1 = 144 Exp2 = 160 Exp3 = 128	EM 50 or 60 Hz	Av 10 vems/m 73 ntrms 0.073 µt	Not given?	Exp 1 72 eggs/50 Hz 72 eggs/60 Hz Exp 2 80 eggs/50 Hz 80 eggs/60 Hz Exp 3 64 eggs/50 Hz 64 eggs/60 Hz
Study 17 Yip et al., *J Magn Res Imaging* 4:742-748 1994	To determine if exposure to ML fields affect early development of the chick embryo	Eggs, used within 2 days of laying	White leghorn	Total 846	Magnetic radio Fl 64 MH2	Magnetic 1.5 T R.F 64 MH2	Circular	2 groups Morphology at 53 Hz C – 268 Exp – 274 Morphology at 6 days C – 150 Exp – 154

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Study (ref)	Hypothesis (Objectives)	Gender/Age	Strain	Number	Fields/Freq.	Intensity	Polarization	List Study Groups & No.
Study 18 Yip et al., *J Mag Res Imaging* 4:799-804 1994	To assess effect of ML exposure on cell proliferation and magnetion of chick LMC neurons	Eggs, used within 2 days of laying	White Leghorn	58	Mag & R.F	1.5 T Static Magnetic of 0.65/em	Circular	Motor neuron development C-32 MR exp 26 # of irradiated embryos not given
Study 19 Coulton & Bakker, *Phys Med Biol* 36(3):369-381 1991	To study the claimed stimulatory effect of EMFs on bone growth	Fertile eggs, used within 2 days of laying	Ross I	240	15 Hz	2.1 mT series 1 & 2 21 µt series 3	Possibly vertical?	Series I C-49 – Test – 56 Series 2 C – 28 T – 30 Series 3 C-39 T – 38
Study 20 Youbicier-Simo et al., *Bioelectromag* 18:514-523 1997	To assess effect of EMFs rm. VDTs on young chickens	Not given	Blanche JA	240	15 to 80 Hz	From 2 T 660 NT	Horizontal and/or vertical	Exp 1 – TV Control 30 Exp – 30 Exp 2 Computer C – 30 Exp 34 Exp 3 – Computer Control – 60 Exp 60

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Study (ref)	Hypothesis (Objectives)	Gender/Age	Strain	Number	Fields/Freq.	Intensity	Polarization	List Study Groups & No.
Study 21 Piera et al., *Acta Anat* 245:302-306 1992	To assess effect of continuous exposure to EMFs on development of chick embryos	Fertile Fresh	White Leghorn	144	Assumed 50 Hz? Not given in paper	0,181, or 361 S2/CM^2	Not given	Control 48 Exp – 1,813 Exp – 36,132
Study 22 Pakouva et al., *Toxicology* letters 88:313-316 1996	To assess effect of MFs plus chemical teratogen on chick development	Not given	White Leghorn	3 Exps 1-210 2-205 3-120	50 Hz	10 mT	Horizontal	Exp 1 C-96 Exp 114 2 Teritogen – 95/MFATER110 3 Teritogen – 60/MFATER 60
Study 23 Pakouva et al., *Rev on Environ Health* 10(3-4):225-233 1994	To assess the effect of 50 Hz MFs on chick embryonic development	Not given	White leghorn	324 in 10 Exps	50 Hz	10 mT or 6 µt	Horizontal or vertical	10 mT – Horizontal Control – 73 6 Exper – 94 10 mT – Vertical Control – 13 2 Exper – 42 6 µt Horiz c – 21 Exp – 20 6 µt vert c – 31 Exp – 30

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Study (ref)	Hypothesis (Objectives)	Gender/Age	Strain	Number	Fields/Freq.	Intensity	Polarization	List Study Groups & No.
Study 24 Pakova et al., *Rev on Environ Health* 10(3-4)235-241 1994	To study interaction of 50 Hz fields with x-rays Direct or indirect interaction	Not given	White leghorn	282 and 196	50 Hz	10 Mt	Horizontal	Indirect exposure Control – 83 x-ray – 100 MF & x-ray – 99 Direct Control – 45 x-ray – 96 x-ray & MF – 55
Study 25 Veicsteinas et al., *Bioelectromag* 17:411-424 1996	Alteration of extracellular matrix components play role in abnormal development	Eggs used within 5 days of laying	White leghorn hisex	420	50 Hz	200 μt	Horizontal	2 Protocols A – 100 eggs 50 C 50 Exposed B – 320 Eggs 80 C 80 Exp x 2

OUTCOME & DISEASE MODEL								
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 1 Recorded every 15 seconds maintained between 37.6 – 38.0ºC	48 hrs	% of normal embryos	Embryos removed and under microscope assessed for H&H stage of development viability & percentage normal	% normal 1. Sham – 93 Exp – 76 2. Sham – 94 Exp 76 3. Sham – 86 Exp 89		Protocol & apparatus as used in henhouse project	Only 48-hr embryos were assessed	Pulsed EMFs cause a significant increase in the number of abnormal embryos when applied during the 1st 24 hrs of incubation, the critical period

		OUTCOME & DISEASE MODEL						
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 2 Recorded every 15 sec with Chessel recorder limits 37.6-38.0ºC	48 hrs	% Normal embryos & H & H stage & fertility	Embryos removed and microscopically examined for H & H stage; abnormalities; viability	1. Sham – 70 Exp 64, P - .08 2. Sham – 76 Exp 78, P - 0.617 3. Sham – 73 Exp 69, P - .402 4. Sham – 43 Exp 76, P- .001 5. Sham – 86 Exp 84, P - .606 6. Sham – 88 Exp 77, P - .03	Lab 2 used arbor acre; rest used white leghorn	Protocol and apparatus similar in all laboratories		In 5 of 6 labs the % of abnormal embryos was higher in exposed than in controls. The only significant interaction was between site and exposure condition on number of normal embryos
Study 3 Limits as above 37.6-38.0ºC	48-hr exposure and 72 hrs, no field	% of abnormal & number dead embryos	Embryos removed staged by H & H method and classified as normal, abnormal, or dead	Exposed & 48 hrs Abnormal Sham 14, Exp 15 Dead Sham 2, Exp 5 + 72 hr no field Abnormal Sham 6, Exp 5 Dead Sham 6, Exp 7		As above	Longer field free incubation is needed	Exposure & the zut 60 Hz field has no effect of % of abnormal embryos. With extended no field, % of abns drops and % of dead embryos rises

OUTCOME & DISEASE MODEL

Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 4 Limits as Above 37.6-38.0ºC	78-88 hrs	Mean specific activity of 5'NT, Ache & Alp	Activity was determined spectrophotome-trically from hemogenete of whole embryos	Normal embryos C Exp SNT 10 5 Helte 29 28 Alp 58 57 Specific activity Abnormal Embryos C Exp SNT 38 12 Helte 196 57 Alp 111 67		Used same exposure apparatus and protocol as in the above 3 experiments	Small number of abnormal embryos N=19	In normal embryos exposed to the field, only the activity of 5'NT was reduced. In abnormal embryos, the activity of all the enzymes 5'NT, Helte & Alp were reduced
Study 5 Limits 37.6-38.0ºC checked with Chessel recorder	Exposed 3 days then either 3 or 15 days, no	Enzyme activity of 5'NT, Ache & Alp	Total protein content with enzyme activity determined spectrophotome-trically	3 day exp & 3 day –No field Normal embryos ONLY 5'NT reduced by 4,070 Ache & Alp Cerebellum of 18 day embryos 5'NT C – 24 (10) Exp (1) – 12 (12) (2) - 14		As above	Small number of abnormal embryos only values for normal Only 9 abnormal embryos in first 200 eggs	Activity of 5'NT was reduced by 40 to 50% in 6 day embryos and in cerebellum values in cortex were unaffected Values for cortex are in parentheses. Numbers are specific activity (nmol/min/mg protein)

		OUTCOME & DISEASE MODEL						
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 6 Limits 37.6-38.0°C Recorded every 15 sec with Chessell multi-point	Exposed for 3 days & harvested or incubated field free for extra 3 days	Specific activity of 5'NT	Enzyme activity determined with Sigma Reagrat kit. Centrifugation analyzer was used to quantify 5'NT activity	Mean specific act <u>3 day expos</u> C Fin F Mean 12 11 7 SEM 13 139 107 Mean specific act <u>3 day & 3 day</u> C Fin F Mean 18 17 11 SEM 136 121 139		Used same protocol and apparatus as in previous 5 experiments	Only incubated for 3 days post exposure	Superimposi-tion of a noise field of similar parameters mitigates the effect of EMFs on activity of 5'NT. Activity levels remained reduced even after 3 days of field-free incubation

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Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 7 Temp con-trolled within 0.4°C as in protect henhouse	48 hrs	% abnormal embryos	Embryos removed at 48 hrs and live embryos examined Per henhouse protocol	Percent abnormal Run 1 Sham 6.3% Pulse 19.1 Pt Noise 7.3 Run 2 Sham 2.9% Pulse 10.8 Pt Noise 3.3		Used same protocol and apparatus as Henhouse 10 replicates per run	Used only 48 hours as benchmark	At improved noise ach to EMF strength, the abnormal mate was the same as control. Sham and pulse is significant $p<0.05$ & exp vs. exp & noise is also significant $p<0.05$
Study 8 Tem was monitored daily as above	48 hrs	% abnormal embryos	Embryos examined as above, also lethality was determined	Percent Abn Campaign C– E – P 1 14 29 <.01 2 1.4 14.3 0.37 3 6.0 17.6 .0001 4 1.4 10.3 .0001 5 2.3 7.1 .04		As above	Results were over 5 year span	Exp to EMFs numbers of abnormal embryos in all campaigns, increase number of abns in exposed variations appear to be related to genetics due to flock change

OUTCOME & DISEASE MODEL

Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 9 Temp con-trolled within ± 0.4°C	From 8 to 26 hrs	ODC activity ODC activity at 16 & 26 hrs of incubation	Embryo proper was used if ODC activity protein analysis Kit (Biolab) expressed as Pmole ^{14} COL/30Min per mg protein	ODC activity has 2 peaks at 15 & 26 hours of incubation 60 Hz altered both, enhanced by 2X, decreased 2nd by 1/2 EMF & noise=control 1st peak – 2nd 15 hrs C 29 ± 4pm F 54 ± 6 pm F&N 29 ± 6pm 26 hours C 69 ± 2 pm F 40 ± 3 pm F&N 70 ± 3pm		As above	Extremely small number of embryos at various stages	Imposition of a noise field inhibits the effect of a 60 Hz 4 μt field, identical & control

OUTCOME & DISEASE MODEL

Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 10 38.0°C ± 0.2°C	48 hrs	% of abnormal embryos	Abnormality ratio determined % of Abn. Exp % of abn. Cent = AR AR of 1.9 taken as base value	13 experiments from 9-1984 to 11-1985 Exp AR H 1 1.4 326 2 3.5 344 3 3.2 298 4 3.0 323 5 0.6 387 6 1.2 381 7 1.0 374 8 2.2 363 9 0.7 376 10 0.8 391 11 0.3 392 12 1.7 404 13 0.6 374	In 6 of the 13 experiments, the percent of abnormal in control exceeded the number in exposed	Exposure system & protocol as used in henhouse project. Reproducible results as to teretogenic effects of previous studies	Used figures for 48 exposure to calculate effect at 8 intervals of 6 hrs	Weak pulse EMFs have only potential to be teratogenic, dependent on other factors such as changes in the earth's geomagnetic field. A significant relationship was found between frequency of abnormalities in control and mean H values.

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Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 11 38.0°C ± 0.2°C	48 hrs	% of abnormal & non-developed embryos	Embryos assessed for normal or abnormal morphology and non-developed and death	% C Exp Abn 19% 19% Non-developed 7% 16% 26% 35%	numbers in Table I do not add up	Protocol and apparatus the same as in previous study & Henhouse	Dead embryos did not appear to be counted	The field as used a significant increase in non-developed embryos (arrested development). Embryos with developmental defects can be further affected by EMFs
Study 12 38.0°C ± 0.2°C	48 hr exposure and 9 days incuba-tion field free	Dead and abnormal embryos combined	Examined for viability; morphology & staged as to H&H regimen	Abnormal embryos Control – 11.9% Exp. Sham – 8% #1 Exp – 16% Exp – Sham 12% #2 Exp – 29%		As above, same lab		Weak EMFs cause increased incidence of malformations. Waveform in the cage rise & fall time, is a Enertech reading to increase malformation

		OUTCOME & DISEASE MODEL						
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 13 37.5°C	48 to 72 hrs	% of fertile eggs H&H stage normal embryos	Embryos assessed for viability fertility, normal vs. abnormal	% of normal live egg Sham/Se exp/Se A/P 78/.03 .79/.04 A/A .92/.07 .91/.08 White leg .75/.06 .74/.06		Reproducible protocol set-up as used in henhouse examined different	Inability to reproduce results from labs using same fields, apparatus, protocol	No significant alterations were noted in any of the parameter tested. Strains did not react differently to EMF
Study 14 37°C, no limits given nor when checked	48 hr exposure & 17 days incuba-tion field free	Percent of exencephaly	Embryos removed at day 19 and examined for abnormality and/or lethality % given	Control = 0% and EX dead .5/100 Hz 10 0 .5/1000 Hz 11.1 10 19 μT/100 25 20 19 μT/100 11.1 10	Field not measured, stray fields were not measured and samples too small	Clear endpoint	Samples too small and no statistics given	40 μT had no sig effect. EMFs induced exencephaly with maximum effect at 19 μT/100 Hz, indicating a window effect

		OUTCOME & DISEASE MODEL						
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 15 Continuous monitor 37.5°C, no limits given	S-Exp 7 or 11 days L-exp 13 or 17 days	Histology of cerebellum	Light on EM examination of sections of folium vic of chick cerebellum	*Day 13* C S1 L1 Live emb 22 22 21 MCS 0 21 21 *Day 17* C S2 L2 Live 22 23 20 MCS 0 15 20		Examined effect on different stages of development and effect of time of exposure	20 MT field not routinely found where development occurs	Exposure to static 20 mT field causes statistically significant aberrations with either short (s) or long (l) exposure and varying length of exposure (EXP) for entire incubation was most damaging

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Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 16 37°C, no limits given nor monitoring regimen	21 days Brains 20 min culture	Assay for radioactive calcium ion efflux	Or radioactive labeled calcium ions Egg positions reversed from results above	Egg Brain M S.E. Exp. Exp 50 Hz 50 – 1.005-.04 60 – 1.038 .029 60 Hz 50 - 1.385 .049 60 – 1.032 .032 50 Hz 50 - 0.986 .042 60 - 1.059 .047 60 Hz 50 – 1.385 .049 60 – 1.035 .039	Al eggs were exposed in same apparatus. No control embryos with no field	Results confirmed and reproduced in earlier studies from same lab	Difficult to reproduce exposure approaches to independ-ently check results	Frequency used to treat incubating eggs can alter subsequent response to EM fields. 60 Hz exposure to eggs gave brain tissue that reacted in insignificant manner to 50 Hz but not alter combinations ambient powerline frequency can alter response to EMFs

		OUTCOME & DISEASE MODEL						
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 17 37.0°C ± 1.0°C	6 hrs 1.5 T and 4 hrs 64 MHz	Malformations and dead embryos Expressed as percentage	Embryos removed and examined under dissecting scope at 53 hours and 6 days of incubation. Embryos were exposed during 4 periods in development – 0.6, 12-18	Morphology at 53 hrs Exposed Control Period percentages: 0-6 – 12.3 19.4 12-18 13.9 21.5 24-30 8.7 10.6 36-42 11.8 4.6 Total 11.7 14.2 Morph at 6 days % abn & dead Exposed Control Period percentages: 0-6 12.0 8.0 12-18 11.7 12.2 24-30 22.1 11.9 36-42 11.8 5.9 Total 10.5 10.7	Vibration assented with mr was not affecting controls	First 48 hrs divided into 4 sections	Longer incubation may have shown more abnormalities	Exposure to MR fields during first 48 hours of incubation resulted in no increase in abnormality at 53 hrs of incubation. At day 6 the incidence of dead & abnormal increased and was statistically synitiest $p < 0.05$ in exposed over controls.
Study 18 37.0°C ±1°C	6 hrs 1.5 T and 4 hrs RF pulse	Numbers and mean birthdates of LMC neurons	Several sections of chick neural tube and spinal cord were prepared. The H3 was used to different birthdates	Proliferation of LMC neurons is unaffected by exposure. Number of LMC neuron C – 32 – 11,187-1,077 MRI 26 – 11,106 – 851	Vibration of MRI was not allowed for	Used an endpoint and system that is well documented.	Exposure could have been earlier as critical period is 15 & 24 hrs.	Proliferation and of LMC neurons was unaffected by exposure to the fields of MRI

OUTCOME & DISEASE MODEL								
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 19 37.0°C ± .05°C 38.0°C ± .05°C Reading taken every 15 min	100 hr in 5 ms bursts	Embryo weight and bone length	Embryos removed and weighed; one length of tibia & femur measured microscopically	Pooled data Series Emb W Fem 1 T-1.15 3.02 .03 C-1.12 2.96 .02 2 T 1.25 3.15 .05 C 1.29 3.20 .04 3 T 1.19 2.90 -.04 C 1.19 2.87 .03 Ser Tibial Mean Temp 1 T 3.47 .04 37.41 .07 C 3.38 .04 37.30 .07 2 T 3.60 .07 37.29 .04 C 3.66 .06 37.32 .02 3 T 3.30 .05 37.15 .05 C 3.30 .04 37.14 .05	Test and control embryos in same incubator	Careful control of none exposure variables	Experiments covered several seasons and vibrations caused by MRI could have an effect	Exposure to a 2.1 nt er 2/μT had no effect upon embryo weight or upon length of tibia or femur

		OUTCOME & DISEASE MODEL						
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Study 20 38.0°C ± 1°C	21 days entire incuba-tion period	Death as well as hormonal & antibody response	Eggs were candled to check viability & eggs opened after 21 days if not hatched blood assayed for CORT, Ig3, or melatonin	2X number of dead embryos following exposure (47-68%) Exp Day 38 Cort 1 C 6.0 ±.2 E 2.5 ±.1 2 C 8.6 ±.4 E 4.0 ±.1 Lg3 (titer log) Exp Day 38 1 C 4.0 ±.1 E 2.7 ± .3 2 C 5.0 ± .3 E 2.8 ± .2	Unable to ascribe effect to a particular field	Relates effects of VDT exposure to physiological anomalies	Continuous exposure to any field is unlikely especially during development	Continuous exposure to EMFs from VDTs or computers adversely affects embryos or young chickens
Study 21 Maintain 37.5°C, limits not given	5,10, or 15 days contin-uous exposure	H&H stage size weight of embryos	According to H&H classification measured using stereoscopic lens Salter Electroscale	Stage only 10 day exp to 1813 2/EM showed sig difference p .001 Size & weight only exp to 363e 2/cm at day 15 showed sig differences	Difficult to determine size & weight accurately (a range)	Non-exp variables were carefully controlled	Fields were unusually large. Graphs difficult to interpret	Different and growth are sensitive to EMFs but the intensity affecting each is different. Differentiation growth

OUTCOME & DISEASE MODEL								
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 22 Not given, 38°C in previous	Starting at 4 hrs incuba-tion 2 hrs exp 4 hours exp to day 9	Major malformations, Death	At day 9 embryos were assessed for morphological alteration or lethality	Cont Exp N 96 114 D&M 10 20 E 0.10 0.18 N 95 110 D&M 17 83 E .57 .23 N 182 189 D&M 144 109 E 8.0 5.9 Effects are pooled values	Eggs removed from incubator during exposure to MFs for 2 hrs at time	Reproducible results in 3 different studies	Spontaneous embryonic death was high	MFs at 50 Hz and 10 mT did not adversely alter chick development. Prior exposure to MFs as used in this study provides protection against chemical teratogens such as insulin or tetroycline.

OUTCOME & DISEASE MODEL

Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 23 38°C, no limits given	From 2 hr to 8 days, max exposure 70 hours	Major malformations & embryo toxicity	Embryos removed and # of abnormal & dead embryos counted E = D&M / N	10 MT Pooled data Sham N E Sig 54 0.11 NS Exposure 94 0.10 NS 10 MT Sham 13 .00 NS Exposed 42 .09 6 μT Sham 21 .19 NS Exp 20 .10 6 μT Sham 31 .19 Exp 30 .06 NS	Eggs removed from incubator for 2 hr intervals	Investigated interaction between different intensities and field vector	Field strength heavier than routinely encountered	Exposure to 10 MT or 6 μT fields with horizontal or vertical vector is not damaging to the developing embryo

		OUTCOME & DISEASE MODEL						
Temp	Duration	Endpoint(s)	Assessment Method	Effects Observed Results w/numbers	Flaws	Strengths	Limitations	Conclusions
Study 24 Not given, but 38.0°C in previous study	20 hrs for indirect & 12 hrs for direct exposure	Major malformation and embryo toxicity	Embryos removed on day 9 & embrotixicity determined	10 MT – Ind x-ray 0.64 MF& Xray 0.47-p.003 Control 0.08 19 NT direct x-ray 0.51 x-ray & MF 0.76 p=.02 Control 0.12	Eggs removed from incubator for 2 hour intervals	Showed positive interaction between MFs and other teratogens	Small samples	Exposure to MFs prior to x-rays, produce a reduction in teratogenicity. If MFs were applied after x-rays (direct interaction) teratogenicity was potentiated
Study 25 38.1°C ± 0.2°C	2 hrs exposure 22 hrs no exposure for either 48 hrs or entire incuba-tion period	Abnormals at day 2 (48 hrs) histololy and histochem	Embryos removed at 48 hrs & abnormalities and stage of development noted. Histological examination of embryos at days 7,12, and 18. Histochemistry on 7-day embryo was out.		Both exposed and sham eggs in same incubator	Morphology and histology collected as well as extended observation	High intensity of exposure and in protocal A very short exposure time.	Exposure to a high intensity EM field (200 μT) if a short repeated period does not adversely affect development of the chick embryo.