Rescue of Moribund Chicken Embryos by Extremely Low-Frequency Electric Fields

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Background: Modern living is awash with low-frequency electromagnetic radiation raising concern over health effects, birth defects, and infant cancers especially leukemias. Medical/scientific opinion is ambivalent, especially regarding possible mechanisms of action despite our bodies' many electric currents.

Aims: Are some cancers induced by morphogenetic changes rather than direct mutation? We wished to see if morphogenetic effects of weak, extremely low-frequency electric (ELF) fields in embryonated hen's eggs could induce cancers, knowing that such treatment is usually deleterious. We report a pilot study intended to reveal a promising cell source in which to search for cancer cells by established methods and then to check for DNA damage.

Methods: Stored (5°C for 1–36 days) fresh, fertile hens' eggs were incubated (38°C, total five or six days) in presence or absence of a weak ELF oscillating electric field (1–40 V/cm, 1–50 Hz and two to six days). Separated embryos were assessed for development stage.

Results: Storage of untreated eggs (> 12 days, 5°C) allows a steady loss of normal embryo formation at 38°C (few viable by 25 days, half-life ~18 days). Surprisingly, incubation in a weak ELF field during the period of declining viability significantly (*P*: 0.03–0.0001) improved viability and condition of the embryos (new half-life ~21 days), rather than the expected converse. Thus for a few days, the field could keep viable some embryos that would otherwise not have survived.

Conclusions: The rescued embryos and their untreated controls seem the most promising place to seek any carcinogenic effects of ELF fields. The nature of the presumed critical component keeping them viable during 5°C storage is at least of equal interest.

Key words: electric fields, chick embryos, embryonic morphogenesis, cellular potentials, cancer induction

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INTRODUCTION

After decades of debate, aversion to living near high-voltage power lines remains high among the general public, possibly (and not surprisingly) because of anecdotal and some epidemiological evidence of associated birth defects or childhood cancers. Many large trials and reviews[1] have invariably given negative or inconclusive results, again not surprisingly given the near impossibility of comparing dosages actually received. Similarly, modern living gives almost universal exposure to low-frequency electric fields via cell phones, Wi-Fi hubs, electric blankets, and multiple appliances, although we know our hearts, brains, and almost all the rest of us depend on tiny internal electric currents all the time. Another concern expressed is the apparent lack of identified mechanisms for harmful action, especially cancer induction.

However, it has long been known that individual living cells carry small-surface electrical charges and that such potentials and associated electrical currents may drive certain steps in early ontogeny.[2,3] Fertilized ova exhibit surface clusters of ion channels and pumps, heritable organelles conferring electric poles and secure orientation systems on each daughter cell. Extremely small electric currents can modify differentiation and recently the concept of a bioelectric code may explain why specific voltage values induced specific embryonic structures in alien loci, e.g., eye formation in gut areas.[4] Electric fields induce changes in charge distribution in nearby conductors and fluctuating electric fields induce fluctuating charge distributions, i.e., electric currents. *In vivo* biochemical processes are modified in very weak electrostatic fields oscillating at extremely low frequencies (ELF).[5,6] Meanwhile, the exact relation between applied AC electric fields and endogenous (chemical) DC fields remains to be understood.

Several reports describe usually adverse changes in chick embryos induced by ELF fields.[7] We wished to adapt this system, familiar to us from virus studies, to search for cancer induction by ELF fields. The following results describe a pilot study to identify the most promising target for this work, using AC electrostatic gradients (plates) rather than electromagnetic fields (coils).

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Table 1. Rescue of Stored (12 days, 5°C) Chick Embryos by a Weak (4 V/cm), Extremely Low-Frequency (12.5 Hz) Electric Field After 6 Days' Incubation at 38°C. Same Experiment as Figure 1 and #14 of Table 2

Embryo Development (Stage)	Zero Field	Field
Normal (29)	0	2
Normal (28)	0	3
Normal (27)	2	2
Normal (26)	2	4
Normal (25)	1	1
Abnormal (24)	2	0
No embryo	5	0
Total wet wt. embryos, g	0.94	2.55
Mean wet wt. embryos, mg	188	213
Recorded normal viability	5/12	12/12, $P = .0001$

MATERIALS AND METHODS

Source of Eggs

Batches of 100 fertile, un-incubated hens' eggs (White Leghorn: Bimbimbi Poultry Farm, Mernda, Victoria, Australia) from a single day's production were received within two days of laying and at once stored at 5°C. Viability (normal embryos at 38°C) was 100% from this reliable supplier if incubated within eight days of receipt. Without special consideration, University Ethics Guidelines disallowed treated eggs from hatching and all eggs were euthanized by 11 days' incubation.

Incubation

Two or more random sets of 10–12 eggs each from one batch of 100 were pre-warmed (20 min, 38°C water bath) then transferred to a Styrofoam-insulated stainless steel box (60 × 45 × 25 cm) kept at 38 ± 0.2°C by water from an external thermostat bath via rubber tubing coiled within the

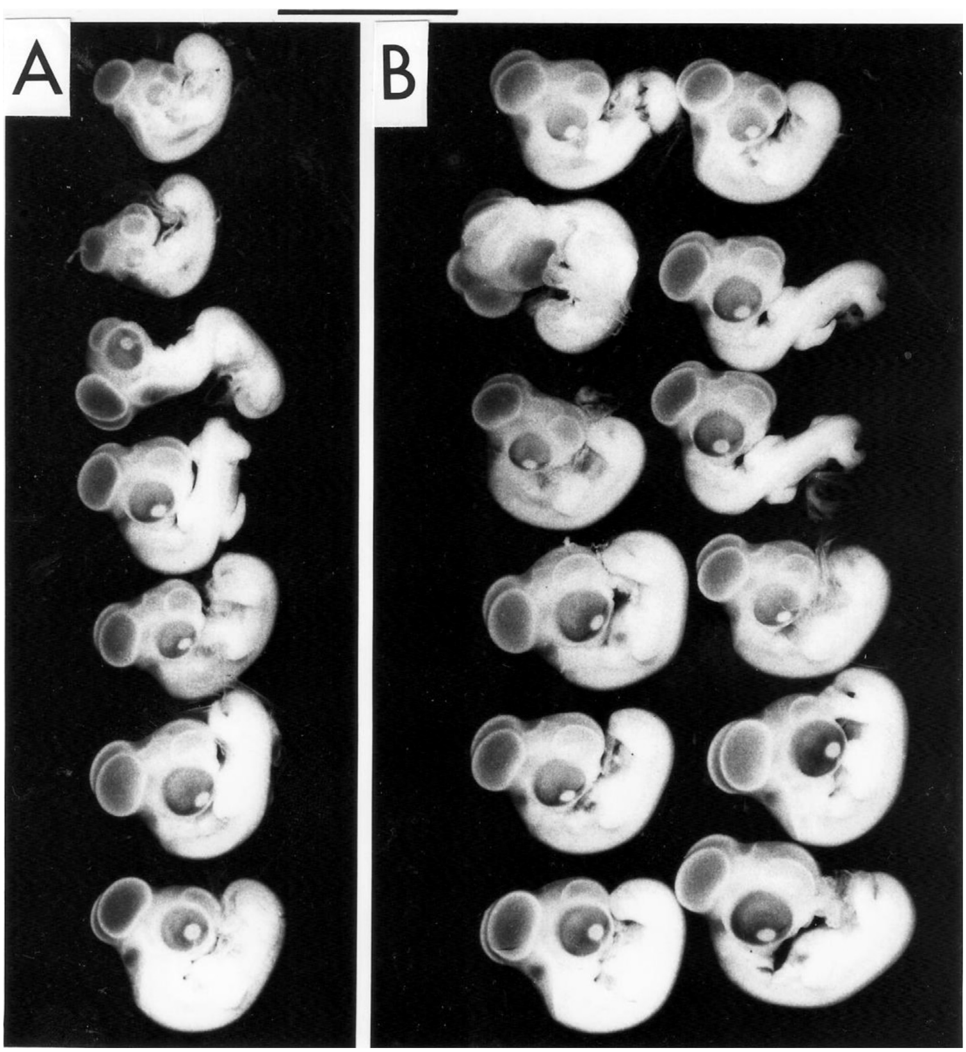

Figure 1. Yield of chick embryos from eggs stored for 12 days at 5°C then incubated for six days at 38°C: (A) without treatment, or (B) in a weak, extremely low-frequency electric field (12.5 Hz, 4 V/cm). This is the test shown in Table 1 and #14 of Table 2. Bar at top shows 1 cm.