Electromagnetic fields, virus and bacteria

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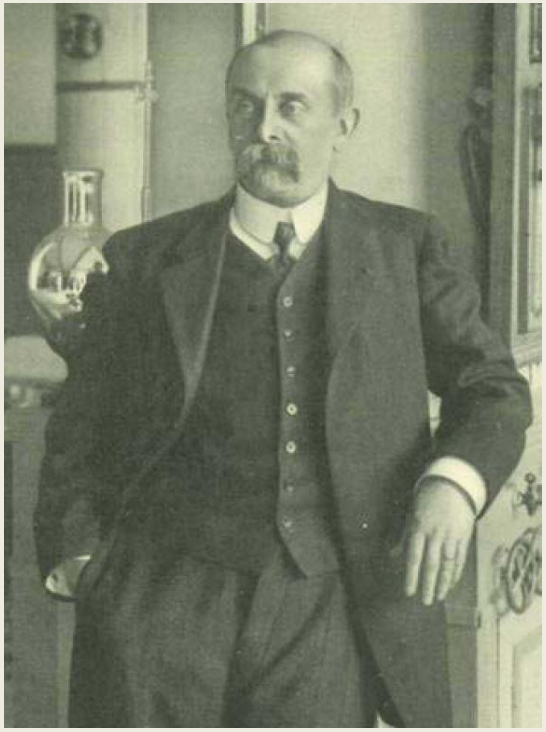
Early studies on the interaction between electromagnetic fields (EMF) with bacteria and viruses

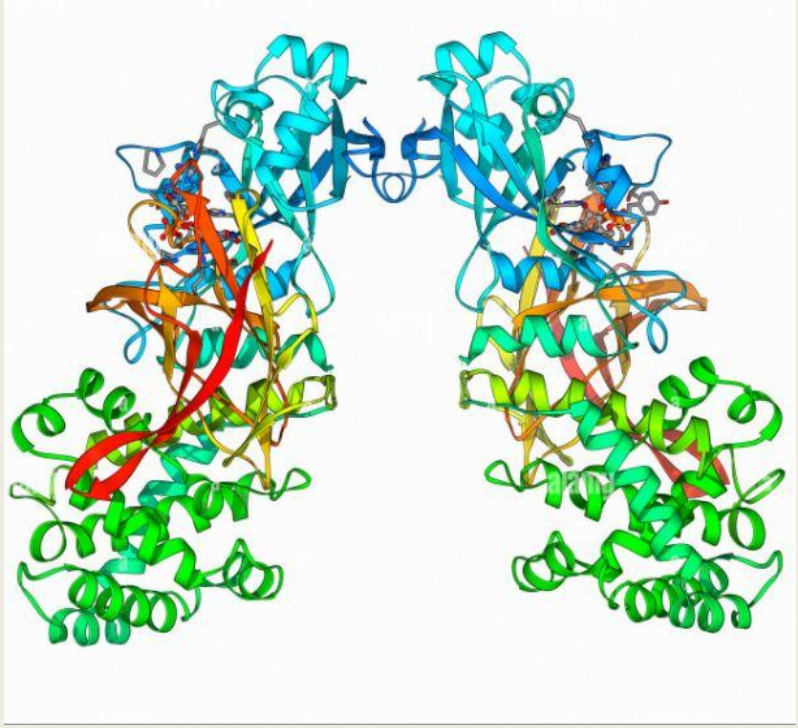
In 1893 Jacques Arséne d'Arsonval (1851-1940), using the coil invented by Nikola Tesla (1856-1943), generating high voltages of high frequency and low current. D'Arsonval together with M. Charrin (1857-1907) discovered the bactericidal effect of high frequency currents: to kill Bacillum Pyocyaneous it was sufficient to expose it for 30 minutes to currents of frequency v = 200 kHz (λ = 1,500 m).



The inoculated animal was not affected in any way by the high frequency currents that passed through it; the germs, on the other hand, underwent a selective attenuation effect.

Early studies on the interaction between electromagnetic fields (EMF) with bacteria and viruses

D'Arsonval carried out numerous experiments on the attenuation of the action of diphtheria toxin and the venom of cobra and viper. To eliminate the doubt that heat was responsible for the observed effects, d'Arsonval cooled and controlled the temperature of the culture medium to make sure it did not increase significantly.

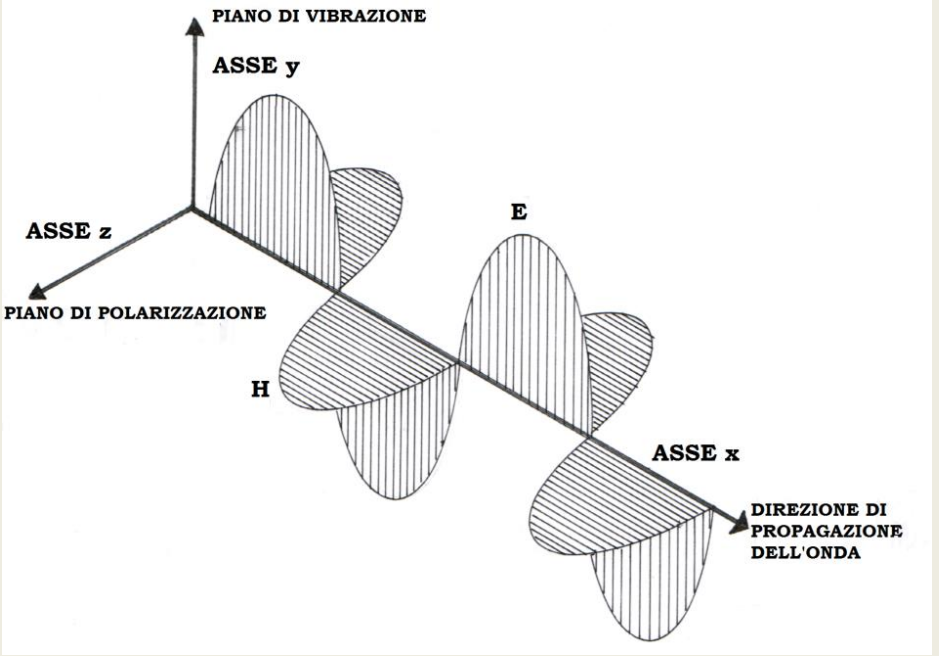


These first experiences convinced Arsonval that the effects of high frequency currents were not only related to the heat produced in biological systems and that there were specific effects, which today we would define as non-thermal, of the fields.

EMF in tumor treatment

TTF is the acronym for TTFields (Tumor Treating Fields). With this name or Alternating Electric Field Therapy, in the scientific literature is indicated the therapeutic technique of the use of EMF in tumor therapy.

In 2011, the FDA (Food and Drug Administration) recognized the validity of these studies and authorized human trials.

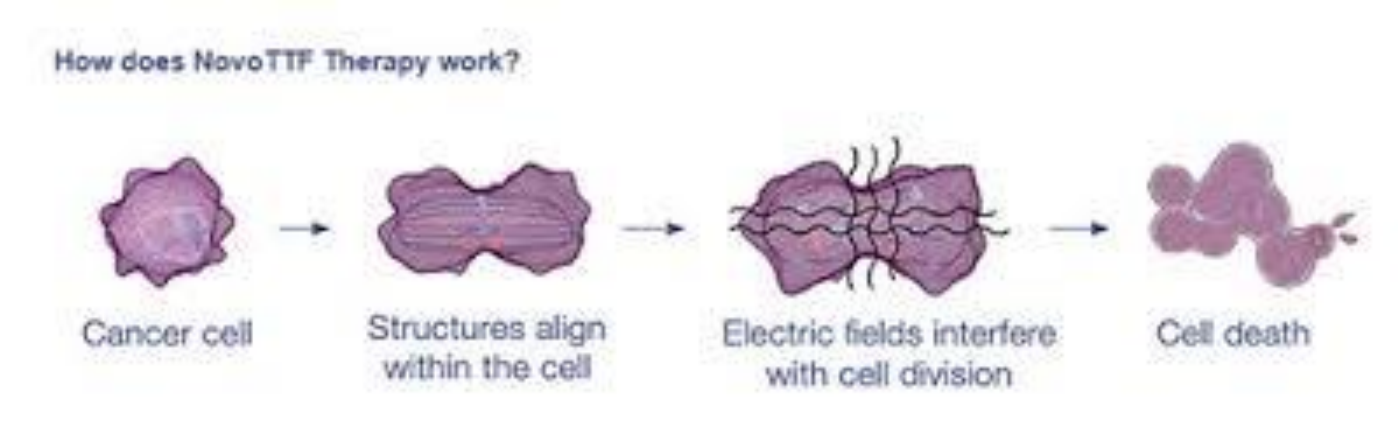


EMF in tumor treatment

For now, it is known that the action on cancer cells occurs in two ways:

1. **arrest of proliferation;**
2. **destruction during the cell division process.**

The action seems selective on microtubules and in particular on the electric dipole associated with tubulin.



EMF in tumor treatment

Glioblastoma (GB) and glioblastoma multiforme (GBM) is a very aggressive brain tumor that has not seen significant improvements in treatment in the past 10 years.

Every year 12500 new cases of GB are diagnosed in the U.S.. The median survival of patients with this type of tumor is 15 months.

In the U.S., 270 clinics use the TTF-100A OPTUNE, an EMF generating device (*200 kHz, intensity 2,25 V/cm*)

The research of Fadel Mohamed Ali Aga, a biophysicist from the Department of Biophysics, of the Faculty of Sciences of the University of Cairo

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INHIBITION OF EHRLICH TUMOR GROWTH IN MICE BY ELECTRIC INTERFERENCE THERAPY (IN VIVO STUDIES)

An Extremely Low Frequency EMF - EMF-ELF - specifically 0.5 and 5 Hz, can inhibit the growth of tumors in mice. There is a problem! The Z impedance of the fabric is given by:

$$Z = \frac{1}{2\pi f C}$$

Where C is the tissue capacitance and f the frequency of the applied signal. From the formula we see that $Z \rightarrow \infty$ for $f \rightarrow 0$. By applying tensions at these frequencies to the skin, its impedance prevents the signal from reaching deep tissue.

Research with Cancer cells - the electromagnetic interference technique

To solve this problem Fadel M. Ali and his team thought of applying two high frequency voltages orthogonal to each other but with slightly different frequencies, f1 and f2; in this way, due to the interference effect (beats), the frequency obtained is the difference between the two frequencies (f1 - f2). The high frequency allows to reach the target tumor cells inside the mouse.

Considering the surface of the electrodes, a CEM with a frequency

(f1 - f2 = 1 MHz) of intensity of 10 kV/m is applied to the skin surface.

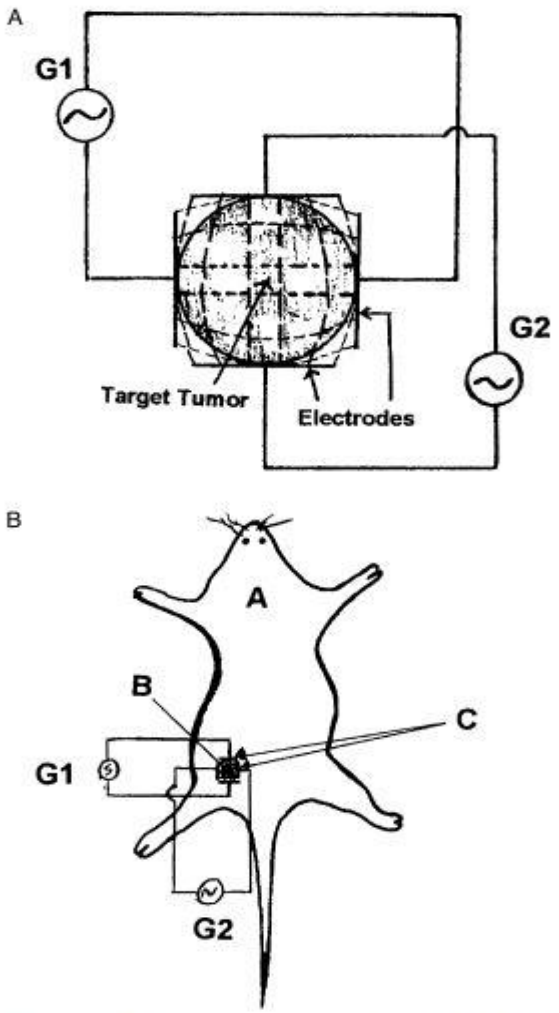


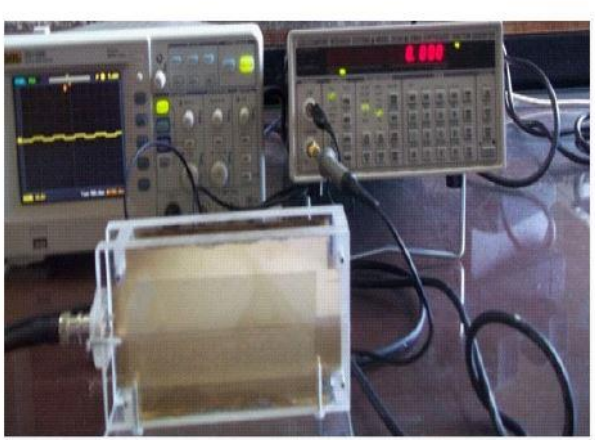
Figure 1. (**A**) The method for interferential frequency application in biological tissue. (**B**) Set-up for extremely low frequency electric field (ELF-EF) treatment of a local tumor implanted into a mouse; (A) mouse, (B) Tumor tissue, (C) Electrodes, G1 and G2 are the two generators of the beat oscillation.

Research with Cancer cells

With this experimental technique it was observed that the mice treated with the voltages of 5 Hz showed a significant reduction in the tumor mass compared to the untreated controls. No difference with 0.5 Hz. In 2014 the study was repeated with the same positive results. In a conference held in Milan in 2018, Fadel M. Ali reaffirms the validity of the electromagnetic interference technique.

Research on *Staphylococcus aureus* Bacteria (2013-2014)

Fadel M. Ali and his team used square waves varying in frequency from 1 to 10 Hz. The carrier was a sinusoidal waveform with a frequency of 30 MHz. The cuvettes, the small container (parallelepiped) made of glass or plastic, in the various cultures were located, were placed between two electrodes placed on the external surface of the vessel. The exposure of the staphylococcus aureus culture with a square wave with a frequency of 0.8 Hz determines the inhibition of the reproduction of the bacterium.



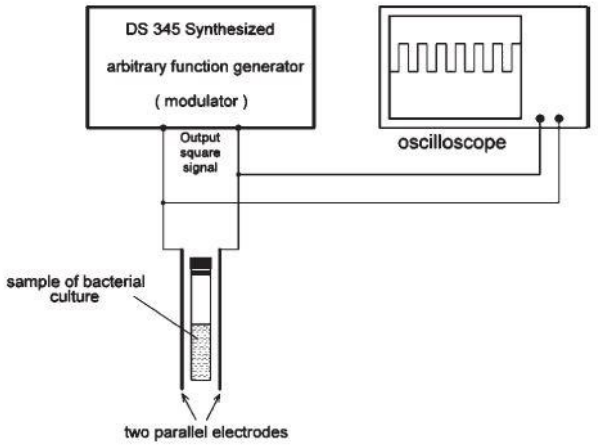


Fig: 1. Synthesized function generator for the exposure facility of the bacterial culture

Research on *Salmonella Typhi* Bacteria (2012-2014)

Fadel M. Ali and his team in 2012 try to treat *Salmonella Typhi* bacterium in mice infected with this bacterium with a magnetic field of 0.5 T, 0.8 Hz.

The growth of the bacterium in culture and in mice is inhibited.

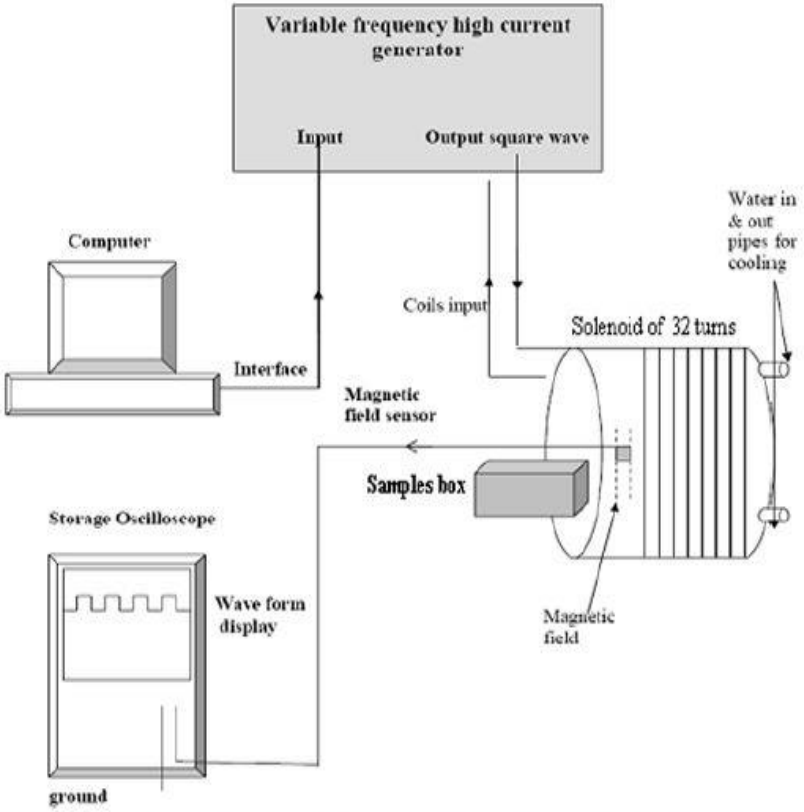


Figure 1: Sketch Diagram of the magnetic field exposure system.

Research on *Salmonella Typhi* Bacteria (2012-2014)

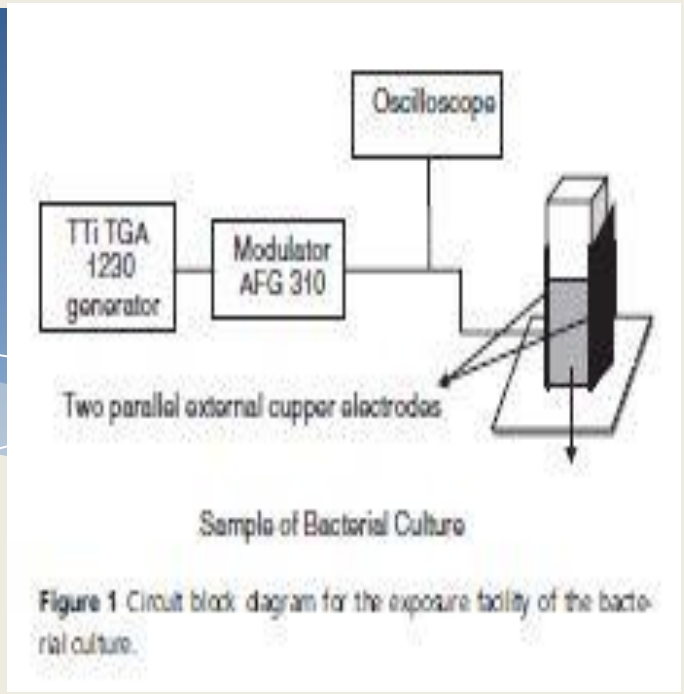


Figure 1 Circuit block diagram for the exposure facility of the bacterial culture.

Subsequently Fadel M. Ali and his group (2014) experimented with the treatment of the salmonella bacterium with a sinusoidal signal. Carrier 10 MHz, 10 Vpp; modulating 0.8 Hz, 2V; field intensity 200 V/m, 75 min of exposure. The results are superior to the use of the magnetic field. No tests were performed with infected mice

Research on virus*: the Rift Valley Fever* (2014)

In the research Fadel M. Ali and his team used:

- a culture of the RVFV strain;
- a culture of *Vero cells*.

The *in vitro* experiments are carried out on cultures of "immortal" cells, which contain the virus, usually attenuated, which are used to carry out laboratory experiments. Fadel M. Ali and his group used the RVFV *pan tropic Menya Strain* (Menya/Sheep / 258). In the language of biologists it translates as Seed strain of RVFV variety Menya Pantropic. *The attenuated RVFV MP-12 strain* is usually found in texts about experiments with viral strains.

Research on virus*: the Rift Valley Fever* - RVF

Fadel M. Ali and his group experimented with the modulated sine wave with square waves varying in frequency from 1 to 10 Hz, modulation depth (modulating amplitude) V = ± 1 V. The carrier was a waveform sinusoidal whose value Vpp = 10 V and frequency 10 MHz. The cuvettes, the small container (parallelepiped) in glass or plastic, in which the various cultures were located, were placed between two electrodes placed on the external surface of the container.

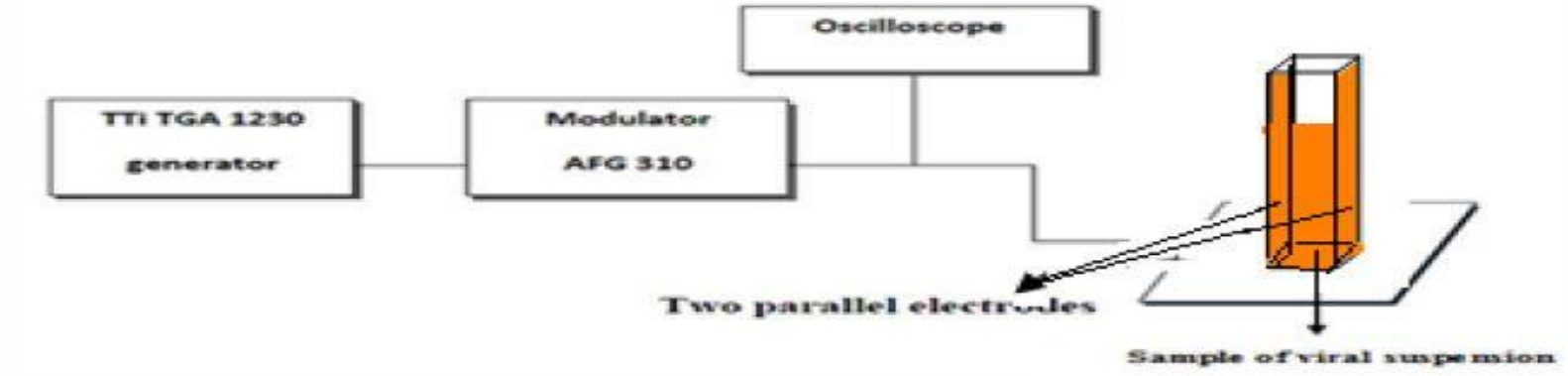
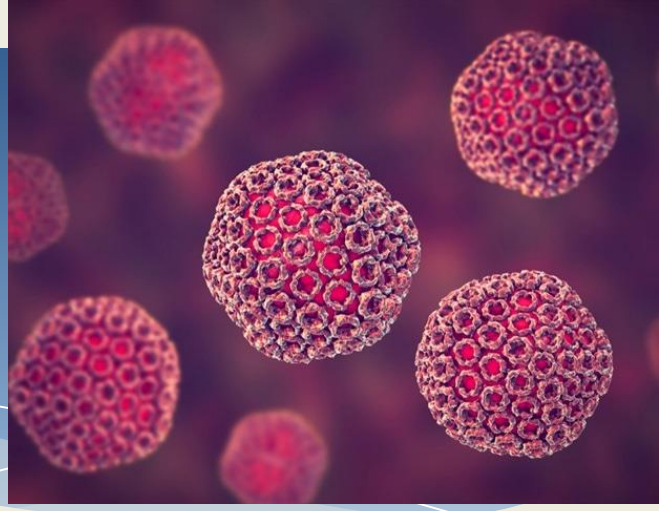


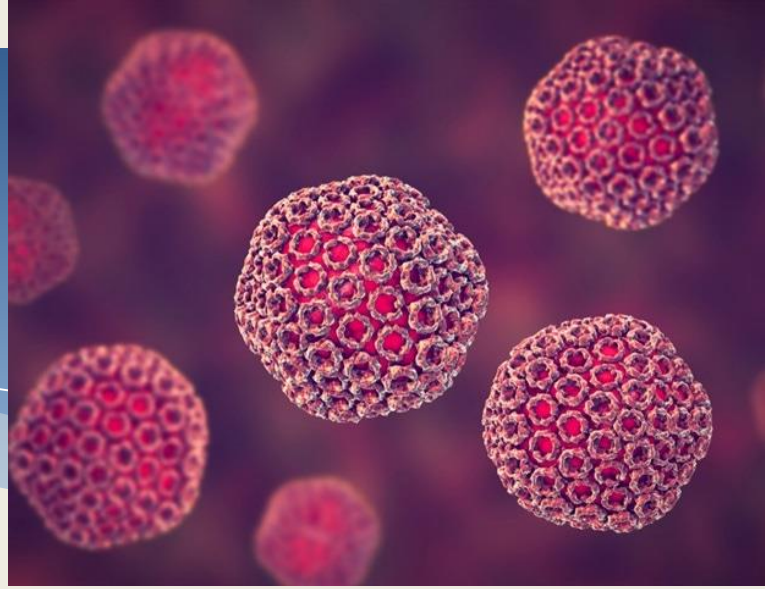
Figure (1): Circuit block diagram of the exposure facility of the viral sample.

Research on virus*: the Rift Valley Fever* - RVF



The suspension of RVFV (viral samples) and Vero cells were exposed to modulation frequencies in the range from 1 to 10 Hz, for a duration of 30 m and for each frequency. Each test was repeated three times and after exposure, dead and living cells were counted with a microscope. This procedure was used to find the "resonant" frequency. Comparison with untreated samples indicated that there were no significant differences between the two groups. The applied electric field was 1 V/cm.

Research on virus: *the Rift Valley Fever* - RVF



Vero Cells infected with RVFV showed a significant increase in the growth rate when the square wave frequency was 4.4 Hz; otherwise there was growth inhibition for the frequency of 5.2 Hz. Fadel M. Ali states that 4.4 and 5.2 Hz are respectively the resonant frequency for stimulation and growth inhibition of cells infected with the virus. Obviously the difference is compared to the control culture.

Vero Cells infected with RVFV showed a significant increase in the growth rate when the square wave frequency was 4.4 Hz; otherwise there was growth inhibition for the frequency of 5.2 Hz.

The following table summarizes the results of the *in vivo* experiments with 48 mice divided into six groups:

GROUP	INFECTED WITH RVFV	EXPOSED 30 m/day *	Average life span in days **
A1	YES	NO	10
A2	NO	4,4 Hz	16
A3	NO	5,2 Hz	19
A4	YES	4,4 Hz	12
A5	YES	5,2 Hz	25
A6	NO	NO	35

* For 4 days;
** the calculation starts from the day on which groups A1, A4 and A5 were infected

In analyzing the results, it must be borne in mind that in an animal, unlike cell cultures, the applied field is strongly attenuated by the impedance associated with the tissues, especially the skin.

Study of the frequency response to cell cultures infected with bacteria and viruses with APEC-300

APEC-300 is an apparatus of advanced electronics fed by an ordinary battery and able to perform the analysis of two fundamental electrocutaneous (EC) parameters:

- cutaneous potential level;
- cutaneous impedance.

Furthermore, APEC-300 is an electronic device capable of stimulating biological and non-biological materials, with current and voltage waveforms.

In particular, in biological systems, in the field of electrophysiology, the cutaneous potential is the expression of the electrical activity of the cutaneous organ (epidermis + dermis + subcutaneous) and its measurement can be carried out directly with APEC-300, recording through the electrodes the signals of this activity according to the same modalities with which we proceed with the electrocardiogram (ECG) and the electroencephalogram (EEG). The skin impedance characterizes the electrical properties of the skin organ (resistance and capacity) and the measurement is performed with particular electrodes to which a voltage or electric current is applied.

Study of the frequency response to cell cultures infected with bacteria and viruses with APEC-300

In the potential configuration it is possible to measure

a) the potential difference (d.d.p.) between two areas of a body (solid or liquid);

b) between two areas of a body referred to mass (the zero of the potential, the earth);

c) the potential of an area of the body. In particular, APEC-300 is able to measure the bioelectrical signals detected not only on the skin but on the surface of a non-human biological system (plants, cell cultures, etc.).

In conclusion, APEC-300 has been designed, built and calibrated in order to perform the measurements of d.d.p. and impedance not only on areas of the human body but also on water and aqueous solutions, cell cultures, solid inorganic bodies.

The measurement frequency extends in the range from 0 to 30 Hz and the minimum detectable voltage value is 100 nV (1nV = 1 nanoVolt = 10^{-9} Volts, i.e. one billionth of a Volt). The duration time of the single recording can be adjusted up to a maximum of 300 s and is memorized.

Study of the frequency response to cell cultures infected with bacteria and viruses with APEC-300

The APEC 300 function generator can provide the following waveforms (it is displayed on the screen): **direct current**, **sinusoidal** (alternating wave form), **triangular** - peaked wave - (positive, negative, positive + negative), **square wave** - (positive, negative, positive + negative), **Chinese spike**. With the exclusion of direct voltage, for all other waveforms the frequency can be selected from 1 Hz to 100 Hz in steps of 1 Hz. The waveform can be applied in both voltage and current. Voltage and current can be varied up to a maximum value of 5 V and 10 μA respectively.

Study of the frequency response to cell cultures infected with bacteria and viruses with APEC-300

A research on cell cultures infected with bacteria and viruses carried out with APEC 300 would allow:

- to measure the electrical potential of infected crops to be treated and not (control);
- to detect the frequency spectrum in the range from 0 to 30 Hz of infected crops to be treated and not (control);
- to expose infected crops to electric fields of various shapes in the frequency range from 1 to 100 Hz and intensity from 1 to 5 V/cm;
- to measure the electrical potential of infected crops after exposure;
- to detect the frequency spectrum in the range from 0 to 32 Hz of infected crops after exposure.


Grazie per l'attenzione