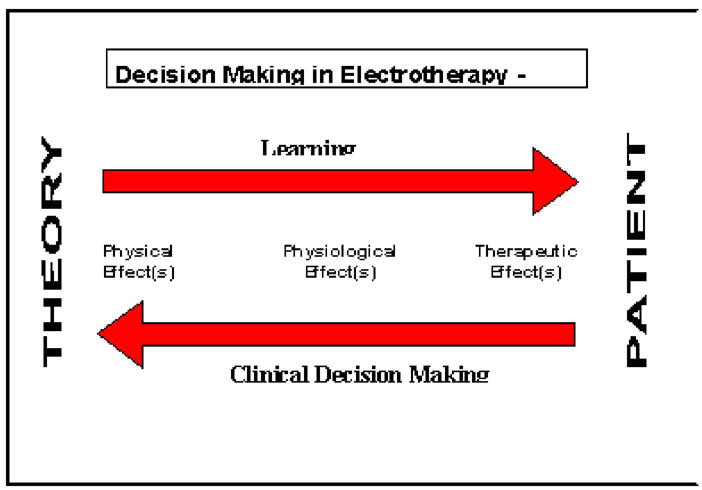
The Changing Nature of Electrotherapy

(Author Unknown)

Much as electrotherapy has been a component of physiotherapy practice since the early days, its delivery has changed remarkably and continues to do so. The most popular modalities used these days are in many respects quite dissimilar to those of 60 or more years ago.

Modern electrotherapy practice needs to be evidence based and used appropriately. Used at the right place, at the right time for the right reason, it has phenomenal capacity to do good. Used unwisely, it will either do no good at all, or worse still, make matters worse. The skill of electrotherapy is to make the appropriate clinical decision as to which modality to use and when.

A simple, but effective clinical decision making model (represented in the diagram right) can be utilised. All electrotherapy modalities (with the exception of biofeedback) involve the introduction of some physical energy into the system. This energy brings about one or more physiological changes, which are used for therapeutic benefit. Clinically, it is probably more useful to work the model in reverse - determine first the nature of the problem to be addressed. Then establish the physiological changes that need to take place in order to achieve these effects. Lastly, the modality which is most able to bring about the changes in the tissue(s) concerned should be a relatively straightforward decision.



The Body Bioelectric

The electrical activity of the body has been used for a long time for both diagnostic and monitoring purposes in medicine, largely in connection with the 'excitable' tissues. Examples include ECG, EMG, EEG. More recent developments have begun to look at the tissues which were not regarded as excitable, but in which, endogenous electrical activity has been demonstrated. The endogenous electrical activity of the body arises from a variety of sources, some of which are well documented whilst others remain more obscure in their origins & control mechanisms (Offner 1984, Leonesio and Chen 1987). The relationship between endogenous electrical activity (not exclusively potentials), injury & healing have been researched in several areas of clinical practice.

These investigations appear to follow three main themes:

- that the endogenous electrical activity of the body can be used as an indicator of a particular pathological process without necessarily attributing a cause/effect relationship. (Edelberg 1971, 1977 Marino et al. 1989, Woodrough et al. 1975).

- that the endogenous electrical activity of the body acts as an initiator, control mechanism or modulator of the post embryonic growth & healing processes. (Becker et al. 1962, Becker 1967, 1974, Borgens 1982, Foulds and Barker 1983, Hinkle et al. 1981, Illingworth and Barker 1980, Patel and Poo 1982).

- that by enhancing the endogenous electrical activity of the damaged tissues, the growth and/or healing processes can be stimulated or enhanced. (Brighton et al. 1981, Brown et al. 1988, Carley and Wainapel 1985, Kincaid 1989, Kloth and Feedar 1988, Reed 1988, Rowley et al. 1974, Wheeler et al. 1969).

The subject of endogenous bioelectricity is somewhat larger than can be detailed here, though what follows may provide a useful overview.

Tissue batteries are found in bone, skin and muscle and nerve, and probably other musculoskeletal tissue. These tissues seem to produce a potential difference between various parts of the tissue, and this potential is different in the injured and non injured situations. Bone exhibits piezoelectric potentials, streaming potentials and steady potentials (Fukada 1984, Pollack et al. 1984, Friedenberg et al. 1973, Borgens 1984, Chakkalakal et al. 1988). In the skin, there are a wealth of bioelectric phenomena, but particularly in this context, Skin Potential Levels, Responses to psychological stimulation and changes associated with injury and pathology (Barker et al. 1982, Edelberg 1968, Foulds and Barker 1983, Christie and Venables 1971, Millington and Wilkinson 1983, Vanable 1989). Similar potentials have been shown in muscle (Betz et al. 1984, 1986) and collagenous based tissues (Anderson and Eriksson 1968, Athenstaedt 1970).

Growing and Developing Tissues exhibit numerous very interesting bioelectric activities. Amphibian limb regeneration studies (Borgens 1982, Becker 1961, Sisken 1983), mammalian partial limb regeneration (Neufeld 1989, Becker 1972) and rabbit ear regeneration (Chang and Snellen 1982, Goss 1981) have been reasonably well investigated. Fingertip amputation and regeneration in children provided the focus for an interesting study (Illingworth and Barker 1980). In addition, there has been considerable work into electric effects in embryology and morphogenesis (Robinson 1989, Jaffe 1981,1986, Jaffe and Nuccitelli 1977, Nuccitelli and Erickson 1983)

Injured Tissues are reported to be electrically active, and this activity appears to be more than just an epiphenomenon. The exact origin of the injury potential remains debatable (Nordenstrom 1983, Thakor and Webster 1978, Becker 1967, 1974). Tissues which have demonstrable electrical changes on injury include Skin (Barker et al. 1982, Foulds and Barker 1983, Jaffe and Vanable 1984, Vanable 1989), Bone (Friedenberg et al. 1973, Lokietek et al. 1974, Chakkalakal et al. 1988, Borgens 1984), Muscle (Lokietek et al.

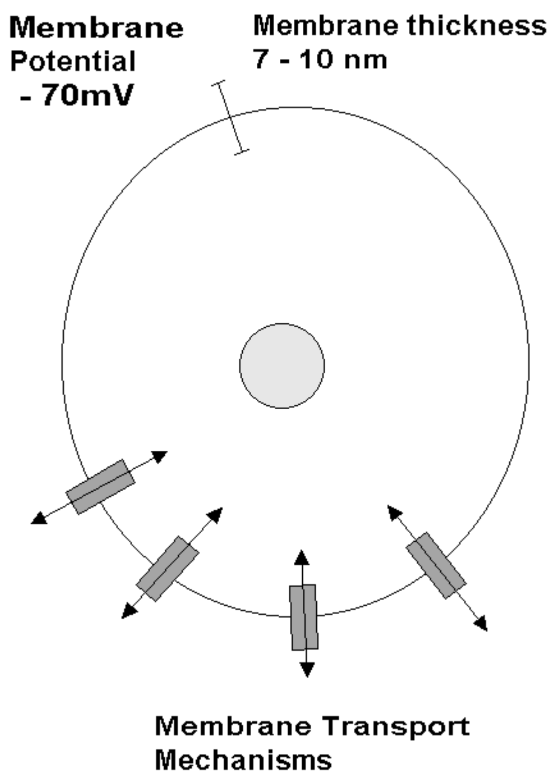
1974, Betz et al. 1984), Nerve (Shibib et al. 1988a,b, Borgens and McCaig 1989), Blood vessels (Sawyer et al. 1953) and several others. Ulcers and other skin wounds appear to have electrical links (Carley and Wainapel 1985, Rowley 1985, Griffin et al. 1991, Kloth and Feedar 1988, Reed 1988).

Cells which are electrically responsive include FIBROBLASTS (Vanable 1989, Weiss et al. 1990, Erickson and Nuccitelli 1984, Dunn 1988), EPIDERMAL CELLS (Brown et al. 1988, Brown et al. 1989, Luther and Peng 1983, Robinson 1985, Vanable 1989), MACROPHAGES (Vanable 1989), NEUTROPHILS AND ERYTHROCYTES (Becker and Murray 1967), BONE AND ARTICULAR CARTILAGE (Brighton et al. 1981, Rubinacci and De Loecker 1988, Norton et al. 1977, Okihana et al. 1985), TENDON (Stanish et al. 1985), LIGAMENT (Akai et al. 1988, Frank et al. 1983).

Psychological and Emotional factors include a wide range of electrodermal activity (Edelberg 1968, Edelberg 1971, 1977, Christie 1981), links with hypnosis and sleep (Becker 1974, Leonesio and Chen 1987), electroanalgesia (Becker 1990), some voluntary control may be possible using biofeedback (Nishimura and Nagumo 1985, Volow et al. 1979), and finally, possible links with psychiatric disorders (Venables 1978, Williamson et al. 1985).

The Bioelectric Cell

Every living cell has a membrane potential (of about -70mV), with the inside of the cell being negative relative to its external surface. The cell membrane potential is strongly linked to the cell membrane transport mechanisms in that much of the material that passes across the membrane is ionic (charged particles), thus if the movement of charged particles changes, then it will influence the membrane potential. Conversely, if the membrane potential changes, it will influence the movement of ions.



Relative to the size of the cell, the membrane potential is massive. The membrane is, on average 7-10 nm thick (a nanometre is a thousandth of a millionth of a metre). The equivalent voltage is somewhere in the order of 10 million volts per metre (which is reasonably impressive!).

Approaches to Electrotherapy

Given the natural energy systems of the living cell, there are two approaches to the application of electrotherapy modalities. Firstly, one can deliver sufficient energy to overcome the energy of the membrane and thereby force it to change behaviour. Secondly, one can deliver much smaller energy levels, and instead of forcing the membrane to change behaviour, it can be 'tickled'. Low energy membrane tickling produces membrane excitement, and membrane excitement in turn produces cellular excitement. Excited cells do the same job as bored cells, but they do so at a rather harder and faster rate. It is the excited cells which do the work rather than the modality itself.

In addition to considering the endogenous potentials, there are several exciting aspects of this work which are of more direct relevance to physiotherapists and others working in the rehabilitation filed. Most obviously is the possible relationship between the endogenous bioelectric activity and the energy inputs (in a variety of forms) by means of electrotherapy treatments.

There has been a general trend over the last few years, for the energy levels applied in electrotherapy to be reduced. Ultrasound treatment doses are significantly lower (in terms of US intensity & pulse ratios) than previously thought to be effective. Pulsed Shortwave employs power levels which are several orders of magnitude lower than those applied during continuous shortwave therapy. Laser therapy is another such example of the clinical application of low energy levels to damaged, irritated or traumatised tissues.

The over-riding principle of these interventions, is that the application of a low power/energy modality can enhance the natural ability of the body to stimulate, direct and control the healing & reparative processes. Instead of 'hitting the cells' with high energy levels, and thereby forcing them to respond, the low energy applications are aiming to tickle the cells, to stimulate them into some higher activity level and thus use the natural resources of the body to do the work.

This philosophy can be applied to many areas of therapy, not exclusively to electrotherapy - though it does marry well with the subject. Several areas are currently being investigated in this respect, including the possibility of using the endogenous bioelectric activity as a feedback mechanism to enable the patient to take (natural) control of their healing, measurement of the physiological effects of a variety of electrotherapy modalities (including Pulsed Shortwave, Interferential), and an initial investigation which considers the relationship between endogenous bioelectrc activity and manual/manipulative therapies.

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