

# AIR IONS AND HEALTH

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In places where mountains are situated to the south, the south winds that blow are parching and unhealthy; where the mountains are situated in the north, their northern winds occasion disorders and sickness...The winds which must pass over mountains to reach cities do not only dry, but also disturb the air which we breathe and the bodies of men, so as to engender diseases.

Hippocrates, Regimen II, Chapters 37-38

The reactions between water, land and air during the long slow physical evolution of our planet have greatly affected the course of biological evolution. To a very considerable extent, this interplay is responsible for the emergence of man - a singular product of evolution - and man, in an extremely brief span of time, through his genius for blindly manipulating natural resources, has attained the unique capacity to alter his total environment. While we have begun to express serious concern for the grim consequences of our role as spoilers in disturbing ecological balances in general, our interest is most avidly focused upon those facets of man-engendered pollution which pose the most immediate and direct danger to us.

We live in an ocean of air and each of us is inexorably required to breathe in at least ten thousand litres of air every twenty four hours just to maintain life in our bodies. Since we are utterly dependent upon the physical and chemical properties of this air, it isn't surprising that we are now deeply immersed in exploring all atmospheric parameters. Characteristically, most of our efforts are devoted to the detection and control of those toxic particulates and gases contributed to the ambient air by industry and by the multitude of anthropocentric activities which require the combustion of fuel. Their threat to life is pressing and it is obvious that measures for their abatement must be developed in the immediate future. Other, more subtle atmospheric changes are in progress which, because they are less conspicuous, tend to be put aside for future consideration. Among these one would have to list those phenomena involving small air ions.

Very shortly after the existence of atmospheric electricity was demonstrated by Franklin [1] and by d'Ailbard [2] in the mid 1700's, several natural philosophers ascribed to it a variety of biological effects. For example, Father Giambattista Beccaria [3] in 1775 reported that "it appears manifest that nature makes extensive use of the atmospheric electricity for promoting vegetation" In this he was supported by Abbe Nollet [4] and Abbe Bertholon [5]. Abbe Bertholon [6] in addition concluded that the course of various diseases of man was influenced by atmospheric electricity. I 1899, Elster and Geitel [7] and J J Thompson [8] independently proved that atmospheric electricity depends upon the existence of gaseous ions in the air. It then became possible to develop generators for producing air ions and equipment for determining their numbers in the air. Using these technical aids, a vast amount of experimentation was undertaken to define the physical and biological properties of air ions.

There are ions in the air around us all the time, but changes in their concentration or in the ratio of positively to negatively charged molecules can have marked biological effects on plants and animals. Indeed, ion depletion and charge imbalance may play a significant role in a wide range of human ailments including respiratory infection in office workers and the malaise caused by weather conditions such as the khamsin winds of the near East. Further, artificially generated air ions may prove valuable as a therapeutic modality in the treatment of burns, reparatory disorders, stomach ulcers and nervous disorders.

Air ion formation begins when enough energy acts on a gaseous molecule to eject an electron. Most of this energy comes from radioactive substances in Earth's crust and some from the shearing forces of water droplets in waterfalls (Lenard effect) or the friction which develops when great volumes of air move rapidly over a land mass (for example, the foehn, sharav and Santa Anna winds) or from cosmic rays. The displaced electron attaches itself to an adjacent molecule which becomes a negative ion, the original molecule then becoming a positive ion. Molecular collisions transfer the charge, so that positive charges come to reside on molecules with the lowest ionisation potential, while electrons are attracted to the species of greatest stability. Next, small numbers of molecules of water vapour, hydrogen and oxygen cluster about the ions to form small air ions. In normal pollutant free air over land, there are 1500 to 4000 ions/cm<sup>3</sup>. But negative ions are more mobile and Earth's surface has a negative charge, so negative ions are repelled from the Earth's surface. Thus the normal ratio of positive to negative ions is 1.2 to 1.

Certain properties of small air ions are pertinent to this discussion. They readily unite with condensation nuclei and with most classes of air pollutants to form large or Langevin ions. In both cases the biological activity of the small air ions is lost. This is true also of the combination that occurs between small air ions of opposite charge. Further, ions like charge (unipolar ions) repel one another and tend to flow to enclosing surfaces where their ionic nature dissipates. Since they are small and carry a charge, they are deflected by electrical fields. All of these characteristics make it difficult to maintain high concentrations of small air ions and means that air ion densities are significantly altered by the indoor living and air pollution characteristic of urban life.

While the nature of air ions was under investigation by the physicists, vigorous attempts were being made by the life scientists to determine their biological effects. Although the amount of work accomplished by the biologists is a tribute to their industry, it must be admitted that many of the results reported in the literature is not convincing. Several factors in the area of experimental design served to cloak the whole field in an aura of ambiguity. Often experiments were performed with corona discharges as ion sources, neglecting the ozone and oxides of nitrogen sometimes produced along with the ions. Ion densities, temperature and relative humidity were not monitored. Experimental subjects were not grounded; their external surfaces developed high electrostatic charges and in consequence, repelled ions. As a rule, the air was not purified and combination of ions with air pollutants led to widely fluctuating ion densities. Clinicians assessing the value of air ions as a therapeutic modality frequently

committed all or some of the errors listed above and in addition, neglected to utilise the double blind cross over technique for ion administration. In

view of these omissions, it is not surprising that convincing proof of the role played by air ions as physiological mediators or as therapeutic agents has been slow to emerge.

In addition to these elements of uncertainty in experimental procedures, the evaluation of air ions as biologically active agents has been hampered by the widely cultivated belief that the idea is theoretically absurd. There seems to be something about the term "ion" that provokes incredulity - consider the state of Svante Arrhenius, who first applied it in 1884 to describe atoms and molecules in aqueous solution bearing a positive or negative charge which enabled them to migrate in an electrical field. His doctoral committee thought this idea so bizarre that they accepted his work with the greatest reluctance and granted his degree with the lowest possible grade. The major obstacle to acceptance of this magnificent concept was the requirement that fundamental differences in the properties of charged molecules (ions) and uncharged molecules be acknowledged. In the case of air ions there is no disagreement about the disparate physical nature of air ions and non ionised gaseous molecules, but there is considerable reluctance to grant that this diversity is of biological significance.

At any rate, the essence of the argument against biologically active air ions is this: The maximal ion density one can attain in a closed atmosphere is approximately  $1 \times 10^6$  ions/cm<sup>3</sup>, of air. Air contains  $2.7 \times 10^{19}$  non ionised molecules/cm<sup>3</sup>, so that the ratio of small ions to non ionised molecules is 1:27 trillion. For the reasons already mentioned above, ions have a very brief life span and under the conditions ordinarily prevailing, attainable ion densities usually are considerable less than  $1 \times 10^6$  ions/cm<sup>3</sup>, making the final dilution in non ionised air greater by one or two orders of magnitude. From this unquestioned fact, the dubious conclusion has been drawn that the very sparseness of air ions places them beyond the range of biological effectiveness. The merit of this inference is more specious than real, since many biological systems respond to extremely minute chemical and physical stimuli. Two examples suffice to bear out this contention: first, the human eye can detect a flash of light when a single active quantum reaches the retina [9]; and second, the male silkworm reacts to as few as 2600 molecules of the female's sex attractant pheromone in air containing a concentration of  $<200$  molecules/cm<sup>3</sup>[10]. One further factor, that of commercial exploitation, has retarded development in the field of air ionisation. During the mid-1950's air ion generators were sold directly to the public through high-powered advertising campaigns extolling their efficacy in treating a wide range of diseases. The Federal Drug Administration brought these activities to a halt and since then has prohibited the sale of ion generators for any medical application. This unfortunate episode has led scientists and laymen alike to conclude that the whole subject is permeated with mis-representation or even outright fraud.

It is evident then that progress in the field of research devoted to the detection of air ion effects on living forms has been retarded by the very real difficulties attending the performance of meaningful experiments, by an unhappy example of commercial exploitation and by categorical rejection of the whole idea as a matter of principle on the part of many component scientists. The technical obstacles are the major reason that we now are faced with enormous accumulation of data of very uneven quality. The matter of rejection is not so vital, although it is disconcerting at times to find

that some of our peers classify the subject with the occult arts.

## THE BIOLOGICAL EFFECTS OF AIR IONS

The experimental observations taken as a whole serve to establish the fact that air ions are physiologically active and can produce functional alterations varying from barely discernible to substantial. Further, air ions, are capable of evoking a wide range of response in bacteria, protoza, higher plants, insects, animals and man. Sometimes both positive and negative ions induce essentially the same biological reaction, in other cases they elicit the opposite effects. A few selected examples will be presented to illustrate the range of biological effects of small air ions and the reader is referred to more detailed reviews of the experimental evidence [11, 12, 13].

A brief review of the effects of air ions on micro-organisms reveals that both negative and positive ions (1) inhibit the growth of bacteria and fungi on solid media, (2) exert a lethal effect on vegetative forms of bacteria suspended in small droplets of water, and (3), reduce the viable amount of bacterial aerosols [12].

With mammalian cells in tissue culture, Worden found that Girardi's human heart cells exposed for fourteen days to unipolar ionised atmospheres and then transplanted into non-ionised atmospheres for an additional fourteen days showed adversely affected growth characteristics and rate of proliferation with positively ionised air; growth was normal with negatively ionised air. Using fibro blasts he obtained statistically significant evidence that negative ions increase and positive ions decrease the rate of proliferation. Furthermore, when the fibro blasts were removed to a non-ionised atmosphere, the cells previously exposed to negative ions continued to divide at an increased rate, while the cells treated with positive ions recovered slowly and eventually attained the normal rate of growth [14].

Over the past nineteen years, the Air Ion Laboratory of the University of California has conducted experiments to detect ion-induced physiological changes in plants and small animals. The subjects were maintained in a controlled micro-environment supplied with pollutant-free air, the sole variable being concentration of air ions in the ambient atmosphere. Soft  $\beta$  (beta) emission from tritium absorbed on zirconium served to ionise the air without evolving toxic by-products; selection of positive or negative ions was accomplished by applying a corresponding charge to the generator electrode.

Plants appear to benefit from increases in both positive and negative ionisation, and we have shown that such ionisation markedly increases the rate of growth of higher plants such as barley, oats and lettuce. With seedlings grown in chemically defined media, we found that unipolar (one charge only) ionised atmospheres containing approximately 10,000 positive or negative charged ions/cm<sup>3</sup> increased the rate of growth by as much as 50% (as measured by integral elongation or weight) without altering the protein, sugar, or chlorophyll content of the plant. In marked contrast to growth stimulation elicited by air ions, their removal from the atmosphere resulted in a lower rate of growth, reduced turgor (pressure in plant cells) and the development of soft, fleshy leaves. Chlorophyll production was not affected[15]. Several clues to the biochemical mechanism were

uncovered. Positive and negative ions expedite both the uptake of iron and its utilisation of the production of ion-containing enzymes. The ions stimulate the metabolism of the high-energy compound adenosine triphosphate (ATP) in the chloroplast's and augment both nucleic acid metabolism and oxygen uptake. All of these phenomena are consistent with the observed ion-induced increase in growth rate.

Similar results were obtained when silkworm eggs and emergent larvae were exposed to ions of either charge. Hatching began earlier, larval growth accelerated and there was increased synthesis of three enzymes (catalase, peroxidase and cytochrome C Oxidase). Spinning began earlier and cocoons were heavier [16].

Much of the work we have done with animals has been on air ion effects in the respiratory tract and we found that air ions influence survival in respiratory diseases. High concentrations of positive ions substantially increased the death rate of mice infected with measured doses of a fungus (*Coccidioides immitis*), a bacterium (*Klebsiella pneumoniae*) or a strain of

influenza virus, all administered intranasally. Ion depleted air (comparable to ion concentrations found in urban environments) also increased the death rate in mouse influenza while a high concentration of negative ions decreased the death rate [17]. In other experiments where the influenza virus was introduced as a fine aerosol, thus by-passing the protective mechanisms of the upper respiratory tract, changing ion concentrations had no influence on the death rate. This and other observations suggest that the site of action of air ions is the mucosa of the upper respiratory tract [18].

#### An Ecological View of Health MECHANISM OF AIR ION ACTION

With regard to the mechanism underlying the response of animals to air ions, we have worked for several years on the changes in blood levels of serotonin (5-hydroxy tryptamine or 5-Ht), a powerful neurohormone capable of producing profound neurovascular, endocrine and metabolic effects throughout the body. In the hypothalamus 5-Ht participates in various processes such as sleep, the transmission of nerve impulses and in our evaluation, of mood. We found a readily reproducible and significant change in blood 5-Ht levels in mice exposed to air ion densities of  $4-5 \times 10^5$  positive or negative ions/cm<sup>3</sup>. Positive ions raised blood levels of 5-Ht, while negative ions had the opposite effect. Additionally, we found that the brain content of free 5-Ht was responsive to the concentration of ions in the air. Because the chief metabolic route for removing Serotonin (5-Ht) depends upon the enzyme monoamine oxidase, we hypothesised that small negative ions stimulate, while small positive ions block the action of monoamine oxidase, thus producing respectively a drop or rise in the concentration of free 5-Ht in certain tissues and eliciting a corresponding physiological response [19].

This general mechanism of air ion action has been confirmed by other investigators. Grant Gilbert at Pacific Lutheran University demonstrated that continuous treatment with negative ions produced statistically significant reductions in emotionality and brain Serotonin levels in rats [20]. Jean-Michel Olivereau of the Psychophysiology Laboratory at the University of Paris conducted extensive experiments on the endocrine

systems and the nervous mechanisms of rats treated for various periods of time with air ions [21, 22]. Employing elegant biochemical and histochemical techniques, he surveyed air ion action on the hypothalamus, the hypophysis, the adrenals, the thyroid, brain metabolism, behaviour, eating, spontaneous activity, psychomotor performance and adaptation to stress. He concluded that air ion-induced alterations in blood levels of 5-Ht account for very significant physiological changes in the endocrine glands and central nervous systems, these, in turn, substantially alter basic physiological processes. A significant facet to Olivereau's research is his observation that negative ions exert a measurable anxiety lessening effect on mice and rats exposed to stressful situations, a phenomenon noted by several other workers [23]. This response parallels that which follows administration to animals or man of the drug reserpine. Both reserpine and negative ions reduce the amount of Serotonin in the mid-brain and this apparently accounts for the tranquillising action.

Direct and indirect evidence supporting the theory that 5-Ht is an important mediator of air ion action on animals and humans is found in the reports of several investigators [24-25] and is reviewed elsewhere [26,27]. However, there is no reason to suppose that 5-Ht is the sole agent responsible for air-ion induced alteration of physiological function.

Such tentative biochemical probings are really no more than the first step in elucidating the arcane mechanisms when air ions make contact with the tissues of the test organism. Our ignorance extends from the interface between the atmosphere and the cell wall to include the cellular organelles, their component enzyme systems and almost all the tissues and organs of living forms. When we turn to the matter of air ion dosage necessary to elicit biological responses, the situation is somewhat better. Dosage constitutes a very practical element, for if extremely high ion densities are demanded, there is little likelihood of air ions playing a significant role in nature and the whole topic becomes academic, or at best, is limited to therapeutic applications. If on the other hand, biological effects are associated with such displacements of ion densities or charge ratios as are known to occur in Earth's atmosphere, or even with relatively small shifts in ion concentration that can be affected by ion depletion or artificial ionisation in ordinary living and working quarters, the subject acquires great interest and importance.

An outstanding example of dependence of physiological response upon dosage has been reported by Bachman and his co-workers [24]. In studying the influence of air ions on the spontaneous activity of rats they noticed a curious zonal response with activity levels falling, rising and peaking then falling again as negative ion concentrations were increased.

Several studies, however, have demonstrated marked biological effects with lower dosage approximating natural conditions ( $1.5 \times 10^3$  to  $4 \times 10^3$  small ions/cm<sup>3</sup>). In the experiments of Knoll and his collaborators on the effects of ions on simple visual reaction time in humans, ion concentrations of only  $2 \times 10^3$  ion cm<sup>3</sup> produced a remarkable decrease in reaction time [28]. Delaneau and his colleagues found that relatively small ion dosages, for example,  $5 \times 10^3$  to  $15 \times 10^3$  ions/cm<sup>3</sup> of air effectively influenced the development of gastric ulcers in starving rats [29]. Silverman and Kornblueh were able to detect changes in alpha frequencies of the EEG in humans exposed to only  $1.8 \times 10^3$  positive or negative ions/cm<sup>3</sup> for thirty minutes [30]. Also, a sudden increase in negative ions or a precipitate

drop in positive ions within the atmospheric range of  $1 \times 10^3$  to  $2 \times 10^3$  ions  $\text{cm}^3$  was reported to increase moulting in aphids [31].

In our studies mentioned above on the effect of air ions on the course of mouse influenza produced by intranasal challenge, we found that ion dosage influenced the cumulative mortality rate. Unipolar low densities of positive or negative ions (comparable to indoor and urban environments) increased the rate of death, mid-range concentrations of ions of either charge had no effect, while a reduction in mortality rates occurred when the animals were exposed to high concentrations of negative or to low concentrations of mixed ions with mixed ions with negative ions predominating [17].

## NATURAL ION ENVIRONMENTS

We have already presented evidence that air ion concentrations comparable to those found in nature can modify physiological processes in a variety of living forms under laboratory conditions. Now it seems appropriate to ask, Do air ion-linked phenomena occur in humans outside the laboratory? This question can be answered affirmatively with some assurance in light of recent investigations of large scale weather-related changes in air ion concentrations and charge ratios coupled with concurrent clinical studies.

To begin with, a great deal of work has been done in France, Italy, Germany and the USSR on the ionic environment of spas, particularly those situated near waterfalls. The consensus seems to be that the air in many such locales for whatever reason, contains a high concentration of small air ions with a ratio of negative to positive ions being considerably greater than normal - The Lenard effect. Bio climatologists are inclined to attribute to this fact some of the *vis mediatrix* of these resorts. This is an attractive hypothesis, but one that is difficult to prove, since many curative modalities are brought to bear on patients simultaneously.

Turning to the adverse effects associated with certain ion environments, there have been long traditions in the folklore of nearly every country that link certain changes in weather with changes in health and behaviour. One such tradition has to do with the winds of ill repute, for example, the Foehn (Southern Europe), Sirocco (Italy), Santa Ana (United States), Khasmin (Near East), and Mistral (France). Wherever they prevail, their victims attribute to them the ability to induce respiratory distress of various sorts, nervousness, headache and a multitude of other ills. So malign is their influence that when they blow, judges deal leniently with crimes of passion, surgeons postpone elective surgery and teachers expect more than the usual fractiousness from their students.

Since the turn of the century, several scientists and physicians have hypothesised that the immediate cause of such malaise is the upset in electrical balance of the atmosphere that precedes or accompanies the winds. This relationship between air ions and disease, tenuous at first, is finding support in the meteorological observations of investigators such as Robinson and Dirnfield who studied the Sharav, a weather complex afflicting the Near East and characterised by persistent wind, a rapid rise in temperature and a fall in relative humidity. Robinson and Dirnfield measured solar radiation, temperature and relative humidity, wind velocity and direction and the electrical state of the atmosphere before, during and after the Sharav. They found that 12 - 36 hours before the characteristic

changes in wind, temperature and humidity, the total number of ions increased (from 1500 ions/cm<sup>3</sup> to 2600 ions/cm<sup>3</sup>) and the ratio of positive to negative ions jumped from the normal 1.2 to 1.33. This early shift in ion density and ratio coincided with the onset of nervous and physical symptoms in weather sensitive people and was considered the only meteorological change that could be responsible for the discomfort associated with the Sharav [32].

This conclusion is supported by the extensive studies of Professor Felix Sulman and his colleagues in Jerusalem. They designate as the "Serotonin Hyper function Syndrome" the cluster of signs and symptoms that afflict a considerable segment of the population a day or two before the onset of a hot dry wind characteristic of the Sharav. Individuals in this category suffer from insomnia, irritability, tension, migraine, amblyopia, oedema, palpitations, precordial pain, respiratory distress, hot flashes, tremor, chills, diarrhoea, polyuria, vertigo etc. These patients display an increased output of Serotonin in the urine and they experienced relief when treated with negative ions or with Serotonin blocking drugs [33,34]. There exists then, a scientific basis for accepting the tradition that the winds of ill repute can produce malaise in humans, that air ion imbalance is the direct meteorological incitant and that the proximate cause of the irritation syndrome is the positive air-ion-induced hyper secretion of Serotonin. Supporting laboratory evidence for the adverse effect in humans of air ion imbalances comes from a well controlled double blind experiment by Winsor and Beckett in which volunteer subjects developed a dry throat, husky voice, headache, itch or obstructed nose and a reduction in maximum breathing capacity when exposed to nasal inhalation of positive ions in concentration of  $3.2 \times 10^4$  ions/cm<sup>3</sup> [35].

#### AIR IONS AND THE HUMAN URBAN ENVIRONMENT

In modern urban life, man often faces ion conditions far different from natural ion balances, with a significant depletion of small air ions and a markedly increased ratio of positive to negative ions commonly encountered. A fourteen day study in 1971 by B. Maczynski and others showed that in an office containing four people the small air ion concentration dropped as the day went on, falling on the average to only 34 positive ions and 20 negative ions/cm<sup>3</sup> [36]. Central heating and air conditioning, smoking, the usual household activities of dusting and cooking all combine to lower levels of small ions in indoor environments. Further, the static electricity generated by the widespread use of synthetic fibres in clothing and room furnishing as well as stray electric fields add a different dimension to the indoor climate which is not conducive to the preservation of small air ions [37].

The effects of air pollution on air ions in the ambient atmosphere are also marked. As stated earlier, the small physiologically active air ions readily combine with gaseous and particulate pollutants to form large (Langevin) ions that are considered physiologically inert. A test in a light industrial area of San Francisco by J C Beckett in 1959 showed a small ion count of less than 80 ions/cm<sup>3</sup> as compared to levels of 1500-4000 small ions/cm<sup>3</sup> found in fresh unpolluted air [38]. The fundamental reaction is disarmingly simple: man-> atmospheric pollutants; atmospheric pollutants + small air ions -> air ion depletion.

That this progression has attained significant magnitude is evidenced by

the fact that small air ion levels far at sea - normally very constant - are becoming appreciably lower with time, as air pollutants drift out from land. Thus while very few of our activities add small air ions to the air, much of what we do cumulates in ion loss. The question then amounts to this: Will the smogs, hazes and invisible pollutants we generate with a lavish hand so reduce the small ion content of the atmosphere that plants, animals and man must suffer the harmful consequences?

Although the early results of ion depletion very likely will be unimpressive compared to the immediate and dramatic action of known toxic components of polluted air, this alone should furnish little solace. We have every reason to be aware from past experience that adverse effects may follow continued exposure to a small amount of a minor irritant (for example, organic solvents) or the long term deprivation of an essential metabolic requirement (for example, trace elements or vitamins). People travelling to work in polluted air, spending eight hours a day in offices or factories and living their leisure hours in urban dwellings inescapably breathe ion depleted air for substantial proportions of their lives. There is increasing evidence that this ion depletion leads to discomfort, enervation and lassitude and loss of physical and mental efficiency. This syndrome appears to develop quite apart from the direct toxic effects of the usual atmospheric pollutants.

Physicians and environmental engineers have long suspected that the inimical effects of "dead air" in crowded rooms are due to ion depletion. In 1939, three Japanese Scientists, S Kimura, M Ashiba and L Matushima showed that if temperature, humidity and carbon dioxide levels were all kept within ranges considered suitable for human comfort, but the ion level was reduced, individuals suffered from such as perspiration and depression. Further, these symptoms were promptly relieved when normal ion densities were restored by the use of ion generators [39]. Recently, a team of Soviet scientists tested the effects of varying ion conditions on humans employing an impressive battery of tests to measure cardiovascular functioning, reaction time and blood chemistry. They concluded that any enclosed compartments with "conditioned" air such as a space capsule, are likely to be depleted of ions and have a considerable excess of positive ions and that prolonged stays in such an ion environment is detrimental. The Soviet scientists recommended that ionisation in such environments be increased to a more normal 2000 ions/cm<sup>3</sup> and that the addition of negative ions be alternated with positive or bipolar ionisation [40]. The effect of various ion concentrations and charge ratios on human performance, reaction time, vigilance and psychomotor tasks is suggestive but inconclusive and has been reviewed elsewhere [41].

#### ARTIFICIAL ION GENERATION: CLINICAL APPLICATIONS

So much for the potential role of an air ion-depleted environment in man's future. There remains the more promising consideration of the environmental and medical applications of artificially generated air ions. At present, there exists several means of artificially producing air ions, including corona discharge and tritium generators. These ion generators make it possible to re-establish natural and optimal microclimatic conditions in living and working quarters. Eventually air ion standards for comfort and health may be established, just as we now have set limits for temperature, relative humidity, carbon dioxide levels, etc. It may also be possible to make available, highly beneficial ion-rich micro environments that could

serve various hygienic and therapeutic functions. However, the development and use of this technology must go hand in hand with efforts to reduce air pollution from industry, automobiles and tobacco smoke, which effectively interfere with attempts to create a balanced ionised atmosphere.

If the results of our experiments with respiratory disease in mice can be extrapolated to man, we might expect that the ion depleted air of our offices and factories would lower resistance to influenza and perhaps other infections. Conversely, inhaling a mixture of air with, say, 4000 ions/cm<sup>3</sup> and with negative ions predominating, should increase resistance. A recent study in a Swiss bank indicated that this is so. In the test, 309 volunteers worked for thirty weeks in an area where the air was treated to develop a high ratio of negative to positive ions, while 362 controls, worked in untreated air. During the test, the ratio of days lost because of respiratory illness in the two groups was an incredible 1 to 16 [42].

Finally, one can look at some medical applications of high ion concentrations. Kornbleuh and his colleagues have used negative ion therapy successfully for burn patients. Hospitalised patients were treated for 1 to 1.5 hours a day and out patients for twenty five to thirty minutes, to negative ion concentrations as high as 10,000 ions/cm<sup>3</sup>. Pain, restlessness and incidence of infection were reduced and healing promoted [43]. This application may be related to Serotonin hypothesis of air ion action. Burn patients present increased levels of Serotonin (5-hydroxytryptamine) in damaged tissues and in the blood and Serotonin is known to be associated with pain under some circumstances. We have shown in laboratory animals that inhalation of negative ions increases the conversion of Serotonin to 5-hydroxyindolacetic acid (a physiologically inactive metabolite) and this reaction may be involved in the relief of pain reported by burn patients treated with a high concentration of negative ions.

Another instance of laboratory observations coinciding with clinical usage is to be found in our work at the university of California and that of Palti, De Nour, and Abrahamov at Hadassah Medical School in Jerusalem. Smith and Krueger noted that the inhalation of positively ionised air by small animals contracted the smooth muscle of the tracheo-bronchial tree and decreased the operational efficiency of the mucus escalator, effects that could be duplicated by the intravenous injection of 5-HT; negative ions had the opposite effect[44]. Palti and his colleagues found that exposure to positive ions increased the respiratory rate and degree of bronchospasm in infants with asthmatic (spastic) bronchitis while treatment with negative ions produced an opposite and therapeutic effect. The negative ion therapy terminated the spastic attack after a much shorter period than that required by the conventional mode of treatment and, in addition, no adverse side effects common to the drug therapy, were observed with the negative ionisation. Further, since the subjects in this experiment were infants under the age of one year, the possibility that the observed effects were due to physiological factors was minimised [45].

P C Boulatov, a Soviet investigator, has summarised his experiment work over the past thirty five years involving the treatment of over 3,000 bronchial asthma patients with high concentrations of negative ions. He has reported that after a short period of temporary exacerbation there followed substantial improvements in the general state of the patients, a normalisation of the blood picture, improved respiratory function and a reduction in the frequency and intensity of attacks of bronchial asthma

[46].

Kornbleuh, the pioneer American investigator of air ion phenomena and his co-workers obtained temporary relief of acute hay fever symptoms in patients treated with high concentrations of negative air ions. They speculated that the mode of action might be due to some physical and/or chemical effect on microscopic airborne contaminants such as dust, spores, bacteria and pollen or to a direct physiological action on the respiratory tract [47].

More recently, Dr A P Weaner reported on a closely related therapeutic modality: electro aerosols in which minute water droplets act as a vehicle for electric charges. This therapy used extensively in Germany and the USSR has reportedly been applied with success in the treatment of respiratory disorders and various manifestations of autonomic dysfunction such as migraine, nervous tension and depression [48]. Wehner also reviewed the work of K H Schulz who found that negatively charged aerosols seem to stimulate the parasympathetic nervous system and therefore can help to restore autonomic balance in cases of an overstimulated activation. From these observations, Schulz postulated that the effect of the ions would depend on the state of activation of the autonomic nervous system and further, that if the proper charge of ions is administered to a given ion "type" individual a normalisation of autonomic functioning would occur [49].

In line with this theory were the findings of Monaco and Acker, who performed a large number of tests on a group of Psychiatric patients and a group of non-patients. In the psychiatric patients, negative ionisation decreased systolic blood pressure, increased skin resistance and increased pulse finger volume, indicating increased parasympathetic nervous system activity. For the non patients, only a significant decrease in pulse finger volume occurred, indicating slight increase in sympathetic nervous system activity. Thus, it appears that the negative ions had a normalising influence, lowering activation of the psychiatric patients and increasing the activation of the non-patients [50].

Noting the relationship between air ions and neurohormones and following the reports that negative ions produce a sedative effect, R Ucha Udabe, R Kertesz and L Franceschetti at the Catholic University in Buenos Aires tried treating a large number of patients suffering from psychoneurosis and anxiety syndromes. Sessions varied from fifteen minutes to two hours and the number of treatments from ten to twenty. These authors were very impressed with the conspicuous disappearance of simatic complaints and claimed favourable results in 80% of their patients [51]. M Deleanu also claims success in the treatment of gastro duodenal ulcers in animals and man using relatively low dosages of air ions (5000 to 10,000 negative ions/cm<sup>3</sup> and 1000 to 2000 positive ions/cm<sup>3</sup>) [52].

This is only a brief review of some of the developing areas of clinical research, but based on the evidence surveyed in this paper, it appears that air ion investigations constitute a legitimate and promising branch of biological research. As more information is acquired about the mechanisms underlying the reactions between air ions and living systems, we should be able to evaluate more clearly than at present the importance of air ions in nature and assess their potential for clinical and non clinical applications.