Preface: McMaster Research Highlights

I. INTRODUCTION

In this issue, we highlight research conducted at McMaster University in four specific areas: water pollution, air pollution, migraine, and carpal tunnel syndrome. Biomedical engineers have multiple opportunities to enhance the knowledge in these areas by collaborating with other professional disciplines, including environmental studies, kinesiology, medicine, and electrophysiology. This theme is common to all six papers presented in this issue.

II. WATER POLLUTION

Clean and safe drinking water is essential for human health. In addition, human hygiene, sanitation, industrial activity, and livestock production all depend on the availability of uncontaminated water.[1] Unfortunately, pollution of drinking water continues to be a major cause of concern in many countries; it is responsible for a number of debilitating and potentially fatal diseases.[2] Over the years, many devices have been developed by engineers to improve the quality of drinking water.[3–5] The biomedical instrumentation in this field is reviewed by Hsu et al.[6]

III. AIR POLLUTION

Air pollution is linked to many pathologies such as stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma.[7] Major pollutants include ozone, particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide. Patel et al. review air pollution and its deleterious effects on the cardiovascular system,[8] while Kantipudi et al. present evidence that many respiratory illnesses are also linked to excessive levels of pollutants in the air.[9] Biomedical engineers have contributed to this field by designing sensitive instrumentation to detect critical air pollutants and by developing mathematical and physiological models of air pollution. Engineers working in the air pollution field can interact with other professionals in designing transportation infrastructure and urban housing projects to minimize air pollution and its harmful effects.

IV. TRANSCRANIAL MAGNETIC STIMULATION IN MIGRAINE

Migraine is a major headache disorder affecting 15%–20% of the global population, and it is the seventh most disabling disease.[10–13] Women are more vulnerable to migraine, and genetic and hormonal factors increase the probability of being affected by migraine. In addition, migraine has a profound economic impact in terms of lost days at work and productivity.[11] It is hypothesized that neuronal excitability plays a major role in the origin of migraine. The triptan class of drugs remain the most commonly prescribed therapy for migraine, but the triptans have serious side effects and are not curative.[12] Recently, transcranial magnetic stimulation (TMS) with a device designed by biomedical engineers has gained acceptance in treating migraine.[14] During TMS, the brain is subjected to a short electromagnetic pulse using a coil that induces electrical current within the brain tissue. Cessation of migraine headache is being achieved in a large percentage of patients without adverse side effects. In their review, Drs. McComas and Upton examine the pathogenesis of migraine and the efficacy of TMS in treating migraine. They also present their own experience and examine potential mechanisms for the action of TMS in migraine.[15]

V. VISUAL FIELDS IN MIGRAINE

Many migraine patients are aware of curious zigzag patterns in their visual fields that precede the headache. In a second paper, Drs. McComas and Upton have put forward the novel proposition that these visual illusions may tell us something important about

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the way that information is processed in the visual system.[16] The idea that the zigs and zags are the result of spontaneous discharges of the orientation-selective 'simple' and 'complex' neurons discovered by Hubel and Wiesel in the primary visual receiving area (V1) of the brain is not a new concept.[17] However, McComas and Upton argue that, if this is the case, then a distributed processing scheme for visual information cannot be correct, despite the latter being so widely accepted as to have become dogma.[17–19] On the basis of the zigzags, the range of receptive field orientations of the simple and complex cells is too limited for these neurons to be able to serve as image analyzers. Rather, the information used by 'higher' visual areas for object recognition must be coming in a relatively unmodified form from the only other available neurons in the primary receiving area—those that are mostly color sensitive and have concentric receptive fields. Furthermore, if distributed processing does not occur, at least in the way it has been envisioned, then the demands made on a 'binding' mechanism among the cortical visual areas is lessened. Either the migraine-related zigzags have nothing to do with orientation-selective neurons in the visual cortex, or the concept of distributed information processing is wrong. Further research is needed to resolve the dichotomy.

VI. CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome (CTS) arises out of compression of the median nerve and is a common nerve entrapment neuropathy. Its symptoms include pain, tingling, and numbness of the hand. The pain can radiate up the arm, and CTS patients experience reduced fine motor coordination in addition to hand weakness. It affects people who work in occupations that involve repetitive motions of the hand such as those who use computers for prolonged periods of time, video game players, and construction workers who handle vibrating equipment. Central mechanisms, including nociceptive facilitation and reduced endogenous pain inhibition, could contribute to CTS.[20] Viganis et al. examine the literature on CTS related to the workplace to quantify the influence of posture and loading factors that result in increased median nerve contact stress.[21]

VI. SUMMARY

This is a small sample of research conducted at the School of Biomedical Engineering at McMaster University, Ontario, Canada. Each paper in this issue arises out of research in the school of Biomedical Engineering and allied departments at McMaster University. These areas of research provide opportunities for biomedical engineering professionals to develop sensors, instrumentation, and software and to perform physiological and mathematical modelling in diverse fields, with a view toward improving human health and living conditions.

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