

# ENVIRONMENT AND HUMAN HEALTH

C. S. Paulose, Arise Krishnakumar and Anu Joseph

### Abstract

Neuroscience is the study of the nervous system, including the brain, spinal cord and peripheral nerves. Neurons are the basic cells of the brain and nervous system which exert its functional role through various neurotransmitters and receptor systems. The activity of a neuron depends on the balance between the number of excitatory and inhibitory processes affecting it, both processes occurring individually and simultaneously. The functional balance of different neurotransmitters such as Acetylcholine (ACh), Dopamine (DA), Serotonin (5HT), Nor epinephrine (NE), Epinephrine (EP), Glutamate and GABA (gamma amino butyric acid) regulates the growth, division and function of a normal cell. Any change in the micro-environment that may be caused by the cell environment causes imbalance in the neurotransmitter and junction.



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**Key Words:** Neurotransmitters, neurological disorders, environment, pollution.

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Neuroscience is the study of the nervous system, including the brain, spinal cord and the peripheral nerves. Neurons are the basic cells of the brain and nervous system. Neurons communicate to each other by releasing neurotransmitters. Neurotransmitters are the chemicals which account for the transmission of signals from one neuron to the next across synapses. It transmits information within the brain and from the brain to all the parts of the body.

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### Introduction

Neuroscience is the study of the nervous system, including the brain, spinal cord and the peripheral nerves. Neurons are the basic cells of the brain and nervous system. Neurons communicate to each other by releasing neurotransmitters. Neurotransmitters are the chemicals which account for the transmission of signals from one neuron to the next across synapses. It transmits information within the brain and from the brain to all the parts of the body.

Neurotransmitters exert their effect by binding to specific receptors on the neuronal postsynaptic membrane. The activity of a neuron depends on the balance between the number of excitatory and inhibitory processes affecting it, both processes occurring individually or simultaneously (Paulose *et al.*, 1999). The functional balance of different neurotransmitters such as Acetylcholine (ACh), Dopamine (DA), Serotonin (5-HT), Norepinephrine (NE), Epinephrine (EPI), Glutamate and Gamma amino butyric acid (GABA) regulates the growth, division and other vital functions of a normal cell / organism (Sudha, 1998).

### Microenvironment Of The Cell

The micro-environment of the cell plays an important role in its efficient functioning. The micro-environment is in turn controlled by the changes occurring in the macro-environment that surrounds the individual. Pollution is a significant cause of imbalance caused in the macro-environment. Any change in the cell environment causes imbalance in cell homeostasis and function. Interaction with polluted environments can have an adverse impact on the health of humans. In recent years, there has been a progressive increase in pollution that is characterized by high concentrations of atmospheric hydrocarbons, oxides of nitrogen (NO<sub>x</sub>), ozone (O<sub>3</sub>), and respirable particulate matter (PM<sub>10</sub>), resulting primarily from increased use of liquid petroleum and gas in the transport, manufacturing industries and domestic settings (Hassan *et al.*, 1998). Tiny particles travel beyond the lungs and bloodstream to penetrate deep inside cells. The pollutants accumulate within cell component of the cell and damage its critical function. Damage to the cellular component is known to lead to an assortment of diseases. Harmful chemical exposures may negatively impact normal bodily functions and may lead to birth defects, growth and developmental damages, neurological defects and reproductive problems. The central nervous system (CNS) is the primary target for many serious air pollutants causing environmental hazards.

### Pollution and Brain Health

The intensities of local levels of environmental pollution, combined with air pollution inside the home, provide the background for other more direct chemical attacks on human biological systems. Epidemiologic studies have reported that there is a clear association between episodes of air pollution and impaired lung function, cough, and respiratory diseases (Leon *et al.*, 2003). Suspected neurotoxic air pollutants, other heavy metals, pesticides and organic solvents also cause neurobehavioral dysfunction. Exposure to complex mixtures of pollutants produces inflammation in the brain. Persistent inflammation leads to the deterioration of brain tissues which have a significant role in the neuropathology of the brains of the highly exposed individuals. They may also cause immature brain development, poorer memory, reduced visual recognition, less developed movement skills and lower IQ scores. Experimental studies proved

that pollution damaged the shape of mitochondria, causing them to stop producing the cellular fuel and start producing other chemicals, leading to more inflammation and cell damage. Damage to mitochondria, can increase over time as cells divide, leading to a breakdown of cell function and early onset of various diseases including neurodegenerative diseases like Parkinson's disease, Alzheimer's disease, strokes and other neurological impairments. According to a study presented at the American Thoracic Society International Conference, people with diabetes, heart failure, chronic obstructive pulmonary disease and inflammatory diseases such as rheumatoid arthritis are at increased risk of death when they are exposed to particulate air pollution or soot, for one or more years. Pollution is thus a potentially modifiable risk factor for neurological disorders.

### Oxygen Deprivation and Brain Function

Brain cells are extremely sensitive to oxygen deprivation. Hypoxia is one of the most common and serious stresses challenging homeostasis. It arises due to the reduction in partial pressure of oxygen, inadequate oxygen transport, or the inability of the tissues to use the available oxygen. Industrialization and increase in the number of vehicles have resulted in unchecked release of harmful chemicals through smoke and vehicular exhaust. Exposure to carbon monoxide, a main component of vehicular exhaust, causes the formation of carboxyhemoglobin causing impaired delivery of oxygen, which can interfere with cellular respiration and cause tissue hypoxia. Calabresi *et al.*, (1995) reported that there exist a relationships between oxygenation, energy balance and cell volume regulation during hypoxia/ischemia. In neuronal cells, responses to a decrease in oxygen availability or hypoxia include both facilitation and inhibition of neurotransmitter release (Gibson & Peterson, 1981; Gibson *et al.*, 1991). During experimental conditions, hypoxic rats show a change in pre- and postsynaptic myocardial adrenergic function which is associated with both decrease in externalized  $\beta_1$ -adrenoceptor and an increase in inhibitory G-protein subunit (Karine, *et al.*, 1998). Chronic responses depend on the modulation of hypoxia-inducible transcription factors, which determine the expression of numerous genes encoding enzymes, transporters and growth factors (Lopez-Barneo *et al.*, 2004).

### Free radicals and Cell Damage

For years researchers have known that free radicals can cause cell degeneration, especially in the brain. Studies in animals have suggested that diesel exhaust particles induced lung injury may be a result of increased production of active oxygen radicals (Sagai *et al.*, 1993; Sagai *et al.*, 1996). It targets proteins, fats and even DNA. It is believed that age, abnormal stress, genetic defects in the body's defense system damage internal checks and balances to reinforce the free radical reign causing cell damage. Researchers discovered that the neurotransmitter

glutamate plays a role in the neurodegenerative pathway. Accumulation of glutamate and related amino acids in the brain trigger oxidative stress and neurotoxicity. Scientists have implicated the unstable molecules as a cause of neurodegenerative disorders such as Lou Gehrig's disease (amyotrophic lateral sclerosis), Parkinson's disease and Huntington's disease. Scientists have discovered the activation of the survival gene, bcl-2, can protect nerve cells from the cell death signals induced by free radicals. One form of amyotrophic lateral sclerosis may result from defects in the gene responsible for producing the neuro-protector, superoxide dismutase (SOD). Studies performed in yeast show that the activation of the bcl-2 gene stops free radical induced death in cells lacking a functional SOD gene (Brain briefing, 1996).

#### Rotenone and Parkinson's Disease

Scientists have pointed to rotenone, one of the toxic agrochemicals pervading the world and linked it to Parkinson's disease (PD) (Todd *et al.*, 2003). Rotenone causes trembling and loss of muscle control and formation of distinctive microscopic lumps- Lewy bodies, in the brain which is a sure sign of the disease. Rotenone is a naturally occurring pesticide used by organic farmers both to kill insects and as a means of killing fish in water management programmes. The etiology of PD is not completely understood, but it is believed to involve an interaction between genetic and environmental factors. Epidemiological studies indicate that exposure to pesticides, rural living, farming and drinking well water are associated with an increased risk of developing PD. Rare cases of PD are caused by mutations in nuclear genes, and there is increasing evidence for susceptibility genes that alter disease risk (Sherer *et al.*, 2002). PD is caused by a progressive degeneration and loss of dopamine producing neurons which leads to tremor, rigidity and hypokinesias.

#### Neurotransmitters and Hypertension

Irritating odours and cigarette smoke have been found to increase aggressive behavior and to decrease altruism leading to a degradation of social interaction. Mental stress, physical exertion, and stimuli promoted by outdoor air pollution, tobacco smoke and weather variables decreasing parasympathetic influences and increasing the sympathetic tone has been studied. This new situation leads to increases in blood pressure (Ibald *et al.*, 2001), heart rate, and lowers the ventricular fibrillation threshold (Ubiratan *et al.*, 2004). Increased level of noise pollution has extensively contributed to rise in hypertension and other stress related disorders. Hypertension results from general sympathetic stimulation involving serotonin in the central mechanism (Paulose & Dakshinamurthi, 1985; Dakshinamurthi *et al.*, 1990). This decrease in serotonergic activity causes alterations in the brainstem  $\alpha_1$  adrenoreceptor activity and hypothyroidism in the

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pyridoxine deficient rat model of hypertension (Viswanathan *et al.*, 1989, 1990; Dakshinamurthi *et al.*, 1985 & 1988). Stress leads to release of epinephrine, and norepinephrine which has significant role in the regulation of insulin production and diabetes (Eswar *et al.*, 2006). Air pollution was also notably associated with ischemic stroke mortality (Yun *et al.*, 2002).

#### **Air Pollution and Diabetes**

A highly significant correlation exists between the prevalence of diabetes and the release of toxicants into the air (Alan, 2002) and passive smoking in household has been implicated in the early onset of diabetes (Hathout *et al.*, 2006). Several studies have suggested that exposure to dioxins formed during the combustion of plastics incinerators may be related to the development of diabetes or altered insulin metabolism (Michalek, 1999). The synergistic impact of particulate matter in diabetes mellitus potentiates atherosclerosis (Sanjay *et al.*, 2005). Diabetes Mellitus is a metabolic disorder associated with insulin deficiency, which affects the carbohydrate metabolism and is also associated with various central and peripheral complications. Chronic hyperglycemia during diabetes mellitus is a major initiator of diabetic microvascular complications like retinopathy, neuropathy and nephropathy (Sheetz & King, 2002). The central nervous system (CNS) neurotransmitters play an important role in the regulation of glucose homeostasis. Dopamine (DA) is a major neurotransmitter of substantia nigra *pars compacta* (SNpc) neurons. Lesions in the substantia nigra not only resulted in reduced size and number of islet cell populations but also decreased the content of insulin and glucagon in the pancreas (Smith & Davis, 1985). During diabetes, an increased turnover of DA to NE has been reported in the pancreatic islets which could damage the stimulatory effect of DA (Morgan & Montagu, 1985). NE, a stress hormone at higher concentration not only inhibited the DA uptake but also its stimulatory effect on insulin secretion in the pancreatic islets (Eshwar *et al.*, 2006).

#### **Conclusion**

The magnitude of environmental problem in terms of public health has demanded new studies that can clarify the pathophysiological mechanisms responsible for the adverse respiratory, cardiovascular effects and neurological disorders attributed to pollution. Identifying toxins which damage health and controlling them through change in policy and consumer behavior will lead to implementing solutions that eventually will result in a lessening of harmful exposures. Health and government organizations should chart out programmes that will insure the health of masses. Legislations should be enforced to phase out chemicals that are persistent and bioaccumulative or those that can disrupt the neuro-endocrine system. Their continued use should be allowed only where

there is an inevitable societal need, where no safer alternatives exist, and when measures to minimize exposure are put in to practice. Today, nevertheless neuropharmacology and new imaging techniques such as CT, NMR, PET and ultrasonic scanning has transformed the management of neurological disorders but increased awareness of possible threats of environmental contamination, its prevention and effective management should help the common man to lead a healthy life.

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