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Bioengineering and Healthcare: Approaches for Understanding the Relation between Epigenetics, Environmental Factors and Life-Style

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There are some concepts that deal with health and relation between the environment and human life-style: 1. environmental determinants of health (medical and health geography), 2. Political ecology of health, and 3. Social studies of biomedicine. For medical and health geography, environmental epigenetics shows the need to treat place and space as more than a setting, and bodies as more than receptors [1].

Populations are impacted by environmental physical or chemical factors e.g., toxins, stress, temperature, radiation, etc. with varying degrees, and potential to cause changes in gene expression [2]. Many ecological external mechanisms and their effects on human bodies are known through epigenetics. Dworkin [3] demonstrated that in addition to classical gene mutations, there is a mechanism, called "epigenetics," refers to a change in the gene expression.

There is constant interaction between the external and internal environments that is required for normal development and health maintenance as well as for influencing disease load and resistance (Figure 1). For example, exposure to pharmaceutical and toxic chemicals, diet, stress, exercise, and other environmental factors are capable of eliciting positive or negative epigenetic modifications with lasting effects on development, metabolism and health. These can impact the human body so profoundly as to permanently alter the epigenetic profile of an individual [4].

Figure 1 Illustrates some of beneficial factors for health and behaviour, others might be harmful and interfere with the body. Some of the beneficial influences listed are exercise, microbiome (beneficial intestinal bacteria), and alternative medicine whereas harmful influences include exposure to toxic chemicals and drugs. The environment thus complements and shapes human health [4].

Natural environment is an attractive source of new therapeutic products found in huge diversity of plants, animals, marine organisms and microorganisms [5]. The intestinal microflora is a key component of human metabolism and immunity. This can be helpful in healthcare, especially for the management of digestive diseases and food-borne illnesses [6].

Through gene technology and molecular biology it became possible to express the biological active copies of such powerful molecules from food and commensal bacteria. Genetically engineered probiotics can be used to treat some diseases such as Crohn's disease and ulcerative colitis, as well as other disorders resulting from an overactive immune system [7]. Also, microbial metabolites are among the most important of the cancer chemotherapeutic agents. Many compounds with anticancer properties have been isolated from natural sources. More than 60% of the current compounds with antineoplastic activity were originally isolated as natural products or are their derivatives. Among the approved products deserving special attention are actinomycin D, anthracyclines, bleomycin, mitomycin C, anthracenones, calicheamicin, taxol and epothilones [7].

Nutraceuticals are derived from various natural sources such as medicinal plants, marine organisms, vegetables and fruits. Currently, nutraceuticals (natural therapeutic products) play an increasingly important role in the treatment of various chronic diseases such as colon cancer, diabetes and Alzheimer's disease. Nutraceuticals have shown the potential to reduce the risk of colon cancer and slow its progression. These dietary substances target different molecular aspects of colon cancer development [8]. So, nutraceuticals have the ability to control the DNA damaging factors in cancer cells and regulate DNA transcription in tumors. Meanwhile, natural food contains high diverse of natural products such as flavonoids, steroids, sulphur-containing compounds, alkaloids, phenolic acids, vitamins, minerals and other antioxidants. These nutraceutical compounds may increase the protection from various factors such as high

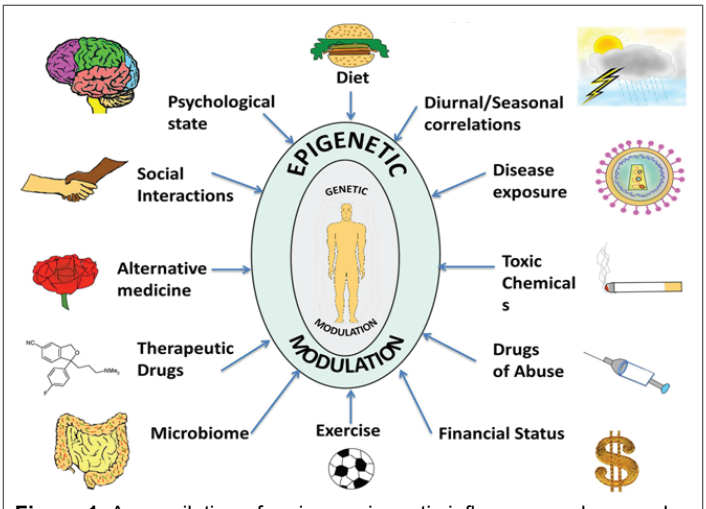

Figure 1: A compilation of various epigenetic influences on humans by different sources of the found in environment [4].

alcohol consumption and other drugs. Kuppusamy et al. [8] mentioned that nutraceuticals is beneficial in the control of colon cancer generation. They possess numerous therapeutic benefits such as anti obesity effects, cardiovascular effects, antidiabetic effects, immune enhancement, natural antioxidant activity, and anti-inflammatory effects [9].

Some natural compounds are secreted internally by microbes in large intestine cause colon cancer by blocking the activity of DNA repair [10]. Other genes may work in concert to affect regulation of cell-cycle and DNA-repair processes, and mutations in one or more of those genes may alter susceptibility to other genetic, lifestyle, hormonal or environmental challenges [11]. However, there are some natural compounds for example; curcumin, resveratrol or quercetin can bind to many target molecules implicated in human disease [12,13]. Some of these targets such as acetylcholinesterase or monoamine oxidases A and B, are unique to animals and have no homologues in plants that produce these natural agents [14]. Phenolic glucoside arbutin, which is used to treat urinary tract infections itself, is ineffective until it is hydrolysed and oxidized to hydroquinone in the human body [14]. Further examples are the sennosides, which are converted into laxative anthrones by bacteria in the gut. Similarly, conjugated phytoestrogens have to be hydrolysed in the stomach or the gut to exert their oestrogen-like effects [14]. Strictly speaking, these plant molecules are not drugs, but proto-drugs [14].

Also, natural products can be used as potential therapeutic agent against Alzheimer's disease (AD). Alzheimer's disease is characterized by the death of nerve cells in the cerebral cortex and is the most common subtype of dementia that affected 25 million people worldwide in 2000 and is expected to increase to 114 million by 2050 [15]. Recently, natural products for example anti-AD properties have attracted much attention. But very few natural products have been investigated for their biological activities. Some of these natural products have a strong potential to develop biologically active compounds with new chemical structures [15].

The modern instrumentation of biochemistry and biology especially the various omics techniques allowed researchers to detail the exact nature of the biological effects of natural compounds on the human body, and to uncover possible synergies, which holds much promise for the development of new therapies against many devastating diseases, including dementia and cancer [16].

The exposure of people to nanomaterials and engineered nanoparticles are rapidly increased, and their impacts on the public health are still unknown. The modifications of epigenetic properties are interested topic for understanding the molecular mechanisms of gene and environment interaction.

The main goal of this review is to demonstrate the important relation between bioengineering (including biotechnology, genetics, biochemistry, ecology, etc.) and medical sciences for improving the human life-style quality and our environmental health. The development of the bioengineering design for modelling, measuring, manipulating and manufacture of microbial systems for health biotechnology is one of the truly required challenge for emerging healthcare and environment issues. Bioengineering provide the bioinstrumentation used in the diagnosis and disease treatment according to the new data of the medical staffs. Bioengineers can provide devices and biomaterials for medical applications and uses.

Moreover, several daily activities are supposed to change our life-style e.g., nutrition, behaviour, stresses, physical activities, working routine and habits, smoking, drugs and alcohol consumption. Increasing evidences showed these environmental factors may influence epigenetic mechanisms, e.g., DNA methylation [17].

Because of many environmental events happened during the last 30 years increases in the global population and limitations of the natural resources, healthcare is becoming increasingly dependent on the development of technologies to avoid global warming caused by heavy industrialization, deforestation, and depletion of biotic and abiotic resources. In order to reduce public health problems and to protect the wildlife and human population on our planet, healthcare clusters provide the opportunities to develop novel conceptions to integrate the principle research cooperation between specialists of the different fields of engineering sciences and natural as well as life science engineers together with medical specialists. This requires a very close cooperation between the bioengineering and healthcare specialists because bioengineers are mainly responsible for investigating the qualities of life-style parameters from different points e.g., the nutrition, climatic changes, demography, environmental health and quality (air, soil, water), marketing, etc. while the healthcare workers are responsible for medication managements e.g., treatment, prevention and vaccination, controlling the infectious diseases, distribution of epidemic diseases, methods of disease transmission, quality of patient safety, the hygiene practices, etc.

Due to the human activities, lot of nuclear radiation, biological, organic (e.g., trichloroethylene, dichloroacetic acid, trichloroacetic acid, benzene, phenolic compounds (such as bisphenol A), endocrine-disrupting chemicals and reproductive toxicants etc.) and inorganic toxicological items introduce to the life-style of humans such as heavy metals (for example, arsenic, nickel, chromium, lead, mercury and cadmium are widespread in the environment as contaminants capable of disrupting DNA methylation and histone acetylation and can cause a number of diseases including cancer, neurological disorders and autoimmune diseases), toxic gases (sulfur dioxide, nitrogen oxides, carbon mono and dioxides, dioxin, furanes from industrial activity, etc.) which litter become as ecotoxicological compounds in our biosphere and have been shown to lead to epigenetic changes in gene activity. All of these compounds are implicated in an increased risk for breast cancer [18]. Facing this dangerous fate, monitoring and evaluating of the ecotoxicological information are more than ever necessary for determining the level of pollution in various ecosystems.

The increasing release rate of ecotoxicological compounds into the environment, cause changes in gene expressions of the living organisms. These changes are not encoded in their DNA's nucleotide sequences and in this case the epigenetic changes can develop and modify the phenotypic properties of the living organisms. The occurrence rate of epigenetic changes is higher than mutations rate and no repair mechanisms comparable to those that protect the integrity of DNA have yet to be described. Epigenetic changes modify the way of genetic information in which it is expressed without directly changing the genetic code stored in DNA and this leads to health problems. Meanwhile, the epigenetic changes play an important role in the development of neurodevelopmental disorders, cardiovascular [19] disease, asthma [15] and cancer [20-22].

Evaluation of epigenetics in the field of ecotoxicological studies is a relatively new approach. This type of ecotoxicological pollutants may have carcinogenic or mutagenic effects on the genetic information and can introduce a new item to our background that is called ecotoxicogenomics [23]. They describe the integration between the genomics and environmental toxicant exposures. In the human context, the toxicogenomics is the study of expression of genes important in adaptive responses to toxic exposures and a reflection of the toxic processes per se [24].

One of the most important topics between the bioengineers and the medical researchers is how to repair the damage tissue or organ due to the trauma, disease or aging as well as the transplants. Translation of genomic and the ecotoxic study is a multidiscipline scientific research field and the integration of related fields like genetics, environmental health, social and behavioural sciences increase the interactions involved in disease etiology and progression, and have a transformative effect on translating principal discoveries into the practice of public health, healthcare and medicine.

Today the engineered nanoparticles offer technological advantages for a variety of industrial products and are effectively promising in biomedical applications [25].

Recent progress in the field of nanotechnology has led to increased exposure to nanoparticles by humans. The increasing incidence of a variety of cancers after the Second World War confronts scientists with the question of their origin [20].

Due to the air pollution, people are continuously exposed exogenously to varying amounts of chemicals that have been shown to have carcinogenic or mutagenic properties in experimental systems and this pollution is due to the heavily industrialization, transportation, etc. which produced ecotoxic air pollutants. Exposure can occur exogenously when these agents are present in food, air or water, and also endogenously when they are products of metabolism or pathophysiologic states such as inflammation [26].

It is recommended that epigenetic mechanisms, alongside genetic mechanisms, should eventually be considered in environmental toxicity safety assessments and in biomonitoring studies. This will assist in determining the mode of action of toxicants, no observed adverse effect level and identification of biomarkers of toxicity for early detection and risk assessment in toxicology but there are critical areas that remain to be explored before this can be achieved [27].

Today, more researches in the field of the effects of exposure to environmental pollutants on the epigenetically characterizations are needed to assess the potential phenotypic and epigenetic modifications level of different populations in various ecosystems. Also, further research is needed to determine whether these environmental epigenetic changes are transmitted through generations or not.

The cooperation between bioengineering science and medicine for monitoring the environmental pollution and by what aspects could improve the human and environmental health. So, the partnership between Biology, Engineering and Medicine will eventually enable the total design-based, predictive modification of environment important to us, including, the human healthcare.

Finally, the goal is to better understand, replace or fix a target system to ultimately improve the quality of healthcare and public health of the environment and human. For human health protection, it necessary to understand responses of living organisms to environmental factors such as chemical exposures, influence adaptation, susceptibility to toxicity and biodiversity and how genetic and epigenetic are important factors to discuss the relation between the human and the environment.

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