BM5063 Systems Medicine

Project statements

1. **Vitiligo**: Vitiligo is a skin disorder characterized by the loss of pigment, leading to irregular, white patches on the skin. It occurs when melanocytes, the cells responsible for skin color, are destroyed. The condition is thought to be autoimmune, where the body's immune system attacks its own pigment-producing cells. While vitiligo does not pose significant health risks, its impact on a person's appearance can be profound. Social stigma and misconceptions about the condition often lead to psychological distress.

   Reference: *Vitiligo: An Autoimmune Skin Disease and its Immunomodulatory Therapeutic Intervention by Chang et al. (link)*

   Problem statement: Formulate and analyze a mathematical model incorporating the spatial description of the loss of pigment during vitiligo.

   Team: BM22BTECH11001 and BM22BTECH11012

2. **Effect of salt on blood pressure and its role in hypertension**: Excessive salt intake can raise blood pressure by increasing the amount of sodium in the bloodstream. Sodium attracts water, increasing the volume of blood, which in turn raises blood pressure. This effect is particularly significant in individuals with salt sensitivity, where even moderate salt consumption leads to higher blood pressure. Over time, this chronic elevation can contribute to hypertension, a major risk factor for cardiovascular diseases, kidney damage, and stroke. The kidneys struggle to excrete excess sodium, leading to fluid retention and further increasing blood pressure.

   Reference: *Mechanisms of blood pressure salt sensitivity: new insights from mathematical modeling by Clemmer et al. (link)*

   Problem statement: Formulate and analyze an ODE-based mathematical model to understand the role of salt intake in hypertension. For this, you should analyze scenarios of normal physiology as well as the case of hypertension.

   Team: BM22BTECH11013 and BM24MTECH11009

3. **Circadian rhythm**: The circadian rhythm is the body's internal 24-hour clock that regulates various physiological processes, including sleep-wake cycles, hormone release, and body temperature. It helps synchronize the body's internal clock with the external environment, ensuring proper sleep patterns and overall health.

   Reference: *Mechanism of the circadian clock in physiology by Richards and Gumz (link)*

   Problem statement: Formulate and analyze a model of circadian rhythms. You can easily find several models of circadian rhythms in humans. You can also consider one such research paper/model and reproduce its results.

   Team: BM22BTECH11016 and BM22BTECH11020

4. **Physical exercise**: During physical exercise, the body responds with a coordinated increase in heart rate and blood pressure to meet the higher oxygen and nutrient demands of the muscles. As exercise begins, some parts of the nervous system are activated, releasing specific neurotransmitters. These hormones stimulate beta-1 adrenergic receptors in the heart, increasing heart rate and contractility, which raises cardiac output. Simultaneously, vasoconstriction occurs in non-essential areas, such as the digestive system, while vasodilation occurs in active muscles, which helps increase blood flow. As a result, both heart rate and blood pressure increase in parallel, but the extent depends on exercise intensity.

   Problem statement: Formulate and analyze a model to study the interactions between heart rate and blood pressure in response to physical exercise using coupled ODEs.

   Team: BM22BTECH11015 and BM22BTECH11003

5. **Diabetes management:** In class we have modeled the progression of diabetes. We can also extend the model to study the effect of different management strategies for diabetes. Specifically, how can key physiological processes — such as glucose metabolism, insulin sensitivity, hormonal regulation, and circadian synchronization — be integrated into a set of differential equations to predict the effects of interventions like timed fasting, activity synchronization, etc. on the progression of type II diabetes?

   Team: BM24RESCH11008 and PH24RESCH11009

6. **Pulmonary fibrosis**: Pulmonary fibrosis is a progressive lung disease characterized by the scarring and thickening of lung tissue, which impairs gas exchange and leads to difficulty breathing. As discussed in class, scarring occurs when the tissue becomes damaged, triggering an abnormal healing process where fibroblasts produce excessive collagen, forming thick, stiff tissue.

Reference: *Multi-scale Models of Lung Fibrosis by Leonard-Duke et al. (link)*

Problem statement: Formulate and analyze a mathematical model incorporating the spatial description of pulmonary fibrosis and its impact on lung physiology.

Team: BM24MTECH11002 and BM24MTECH11005

7. **Angiogenesis in cancer**

   Team: BM22BTECH11002

8. **Pattern formation in tissues**

   Team: BM22BTECH11017