**Intro Week**

By the end of this week, you should be able to:

1. Compare the scales (sizes in order of magnitude) of various objects (entities), such as atoms, bacteria, humans, planets, stars, galaxies, and the Universe, expressed in scientific notation
2. Describe the procedure of Scientific method (hypothesis, prediction, test, observation, modify/confirm hypothesis) and distinguish science from non-science
3. Identify International System of Units (SI) units and convert units to and from SI units correctly
4. Estimate physical quantities by making reasonable assumptions and state the reasons for the assumptions

**MODULE 2: Is antibiotic resistance a big threat to the existence of humankind?**

**ABR 1: Introducing the Problem of Antibiotic Resistance**

By the end of this week, you should be able to:

1. Name different types of microbes and identify bacteria according to shape and cell structures
2. Identify and discuss how sensitive bacteria develop resistance
3. Describe the mechanisms of antibiotic resistance present in antibiotic resistant bacteria
4. Discuss the emergence of antibiotic resistance in bacterial populations
5. Interpret simple population growth models and associate them with conditions for bacterial growth.
6. Generate spreadsheets to plot the data and solve equations to calculate bacterial growth.

**ABR 2: How do bacteria multiply? How do they defend themselves?**

By the end of this week, you should be able to:

1. Describe basic principles of biology regulating DNA replication, RNA transcription and protein synthesis
2. Discuss that the unique DNA sequence that encodes all genetic information.
3. Discuss that the unique sequence of protein leads to its three dimensional shape that in turn is related to its function.
4. Define the mutation rate and estimate the number of mutations per replicative cycle.
5. Explain the processes leading to mutations in the encoded protein sequence and relate these to the development of antibiotic resistance

**ABR 3: How do drugs get into bacteria?**

1. Differentiate between active and passive transport of antibiotics across bacterial membrane
2. Model diffusion of antibiotics in bacteria by a random walk process and explain to a friend the probabilistic rules of a random walk process.
3. Calculate the parameters of a random walk model and evaluate competition between distance moved in a single step and time necessary for a single step.
4. Discuss if diffusion is an efficient mechanism of transport on different length scales and differentiate between free diffusion and biased diffusion.
5. Relate microscopic and macroscopic parameters of diffusion.

ABR4: Structure of biomolecules & Why are they targets for antibiotics?

Relate the effect of molecular interactions on the microscopic scale diffusion of antibiotic molecules in bacteria and evaluate the stability of drug-target interaction.

1. Calculate the average kinetic energy of molecules at room/body temperature and use the quantity \( RT \) \((k_B T)\) to evaluate whether free (unbiased, unrestricted) diffusion happens at a given temperature.
2. Using simple models calculate the internal energy of a molecule as the sum of all the bonded, non-bonded interactions and relate this to the stability of the structure using RT.
3. Discuss factors influencing interactions between molecules, e.g. drug-target interactions.
4. Compute the distance range at which molecular structures “feel” each other and compare and contrast bonded and non-bonded interactions.

ABR5: How antibiotics work - Atoms and molecules

Examine the three-dimensional structures of molecules relevant to the antibiotic resistance problem, distinguish their bond types and their interactions.

1. Relate the electronegativities of atoms to polarity of molecules
2. Identify the bonded and non-bonded interactions when presented with the molecular structure of an antibiotic or its targets.
3. Distinguish various non-bonding interactions (hydrogen bonding, dipole-dipole interactions, van der Waals interactions)
4. Calculate and compare the strengths of bonded and non-bonded interactions in molecular structures
5. By examining the three-dimensional structure of drug molecules, relate bond lengths with bond strengths.

ABR6: Drug and target interactions at atomic scale

Analyze at atomic scale structures of a given target site and a drug to determine if interactions would be stable, and argue if changes on the binding interface, e.g. due to point mutations, would alter the outcome on the organism scale.

1. Identify hydrogen bonds in the three-dimensional structure of biological molecules
2. Relate hydrophobicity and hydrophilicity to protein structures and drug-target interactions
3. Predict drug-target binding behavior based on shape, interactions and environment
4. Describe how mutations lead to evolutionary changes across microorganisms

ABR7: How evolution works

Evaluate whether antibiotic resistance is a big threat for the survival of our species based on an evolutionary biology perspective

1. Explain the evolutionary process of differential success of genetic variants (i.e. natural selection) that results in organisms becoming adapted to their environment
2. Describe the process of evolutionary diversification through the generation of new species
3. Explain and construct simple phylogenetic trees to show relatedness among species