TAMALPAIS UNION HIGH SCHOOL DISTRICT
Larkspur, California

Course of Study
Biomedical Sciences 1-2

1. ***Introduction/Course Description:***
Title of Course: *Biomedical Sciences 1-2*

Schools where the course will be taught: *Tamalpais High School*

Length of Course: One year

Subject Area and Discipline: Science and Technology, Biomedical Sciences

Grade Levels: 11th & 12th grades

Is this course being submitted for possible UC honors designation? No

Is this course an integrated course? No

Course Overview:
Biomedical Sciences 1-2 is a yearlong upper division life science course which builds upon the foundations established in Integrated Science 1-4. Content is taken from the biological sub-discipline molecular biology. The level of difficulty reflects typical coursework in molecular biology based college courses. The intended audience of Biomedical Science are students interested in molecular biology, and those interested in pursuing post-secondary education in the areas of pre-med, pre-vet, virology, microbiology, molecular biology, biomedical science, biomedical engineering, and other molecular biology related degree programs. Individual molecular biology topics include:

- biomolecular structure, function, and chemistry
- biochemistry of prokaryotes, eukaryotes and viruses and related functions via molecular pathways
- prokaryotic and eukaryotic genetics to include protein synthesis and gene expression in both cell types
- molecular pathways of the human immune system
- genetic engineering
- DNA amplification
- quantitative analysis of enzymes, marker proteins, and DNA

Prerequisites (required or recommended):
A. Prerequisite courses: Integrated Science 1/2 and 3/4
B. Prerequisite or concurrent course: Chemistry
C. Priority registration will go to students in the 12th grade

Course Content:

Fall Semester

Career Exploration student project outside of class time covering (throughout the semester)

Description:

Overarching project and application for exploration and clarification of relative careers and job expectations in the Biomedical Sciences. The motivation behind the project is to allow students to see how biomedical technology has transformed the key physical and social components of the world. It also allows the students to identify and discern between sub-disciplines of biomedical sciences. Students will determine that many of the technical procedures overlap, but the specific information analysis may be different based on job application.

Summary:

The project is formatted as a report compiled from research, an interview and a final summative oral presentation. Students will reflect on their research and information obtained from an interview and present it to their peers.

Associated Next Generation Science Standard Performance Expectations:

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Related Disciplinary Core Idea:

- **PS1.A: Structure and Properties of Matter**
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

Related Engineering Practices:

Obtaining, Evaluating, and Communicating Information-

- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
- *I.e. Students will articulate the importance of the chemical properties of designed materials in medical health and how they tie in to biomedical Careers.*

Cross Cutting Concepts:

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Related Disciplinary Core Idea:

- **LS1.A: Structure and Function**
  - Systems of specialized cells within organisms help them perform the essential functions of life.
  - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

Related Engineering Practices:

Constructing Explanations and Designing Solutions

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- *I.e. Students will articulate the importance interwoven relationship between DNA and gene expression and how this translated into problem solving in a real world career.*

Cross Cutting Concepts:

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Related Disciplinary Core Idea:

- **4.D: Biodiversity and Humans**
  - Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Related Engineering Practices:
Constructing Explanations and Designing Solutions-

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
- *I.e. Students will articulate the importance and relevance of biodiversity and its significance in Biotechnology research.*

Cross Cutting Concepts:
Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity

Related Disciplinary Core Idea:

- **ESS3.C: Human Impacts on Earth Systems**
  - The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Cross Cutting Concepts:
Influence of Engineering, Technology, and Science on Society and the Natural World

- Modern civilization depends on major technological systems.
- New technologies can have deep impacts on society and the environment, including some that were not anticipated.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Related Disciplinary Core Idea:

- **ETS1.B: Developing Possible Solutions**
  - When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts

Related Engineering Practices:
Constructing Explanations and Designing Solutions-

- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
- *I.e. Students will articulate the importance and relevance of engineered*

Biotechnology and its significance in Research.

Cross Cutting Concepts:
Influence of Science, Engineering, and Technology on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Microbiology to include biomolecular structure and function, sterile/aseptic lab protocols, bacterial differentiation, growth and metabolism, and quantitative analysis (10 weeks)

Description:

- This unit involves the understanding of the construction and interactions of macromolecules along with the structure and function of Bacteria and how we study it. The first part of the content covered is related to the structure of important macromolecules in the body and their role in body. The content then moves into the in-depth differences between prokaryotic and eukaryotic cells. A major part of the student's application of the material is the use of high power oil immersion microscopes to look at different bacterial cells. The preparation of these cells allows the use of Heat fixing a sample to a slide. The students must use their critical thinking skills to determine how the Gram Stain method clarifies the resulting samples and what the significance is of the differing results.

Part I: Heat fixing and Simple Staining Lab/Part II: Gram Stain Lab:

- The first part of this assignment allows the students to properly heat fix and simple stain a bacterial sample. The secondary assignment allows students to determine the difference between Gram positive and Gram Negative stained bacteria.

Associated Next Generation Science Standard Performance Expectations:

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Related Disciplinary Core Idea:

- **LS1.C: Organization for Matter and Energy Flow in Organisms**
  - The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
  - As energy and matter flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

Related Engineering Practices:
Constructing Explanations and designing solutions-

- Construct and revise an explanation based on valid and reliable evidence

obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

- *I.e. Students will take the provided information about the chemistry of macromolecules and will determine how a stain can anneal to a sample based on the understanding of the chemical structure of the stains and their interactions with lipopolysaccharides in the cell as well as the cellular tissue fiber being stained.*

Cross Cutting Concepts:

- **Energy and Matter**
  Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Related Disciplinary Core Idea:

- **PS1.A: Structure and Properties of Matter**
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

Related Engineering Practices:

Planning and carrying out investigations-

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
- *I.e. Students will use different bacterial strains combined with different stains to determine which stain is the best fit for the elucidation of each sample. This builds upon their use of a provided description of the chemistry of macromolecules and will determine how a stain can anneal to a sample based on the understanding of the chemical structure of the stains and their interactions with lipopolysaccharides in the cell as well as the cellular tissue fiber being stained.*

Cross Cutting Concepts:

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects

of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Related Disciplinary Core Idea:

- **PS1.B: Chemical Reactions**
  - Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

Related Engineering Practices:
Constructing Explanations and Designing Solutions-

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- *I.e. Students will model this by the results obtained by the "Heat fixing" experiment. They will answer questions related to why different stains bond to different bacterial strains and how the charges and properties interact.*

Cross Cutting Concepts:
Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Related Disciplinary Core Idea:

- **PS1.A: Structure and Properties of Matter**
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- **PS2.B: Types of Interactions**
  - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Related Engineering Practices:
Obtaining, Evaluating, and Communicating Information-

- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
- *I.e. Students will demonstrate this practice in the macromolecule building*

activity as they manipulate physical puzzle pieces into whole structures in order to better understand the properties that interact with forces in our world.

Cross Cutting Concepts:
Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Related Disciplinary Core Idea:

- **ESS3.C: Human Impacts on Earth Systems**
  - Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

Related Engineering Practice:
Constructing Explanations and Designing Solutions

- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
- *i.e. Students will demonstrate this practice in their "Career Exploration" assignment as they navigate the different issues in Biomedical Science that are addressed in the varying career paths.*

Cross Cutting Concept:
Influence of Science, Engineering, and Technology on Society and the Natural World

- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Related Disciplinary Core Idea:

- **ETS1.C: Optimizing the Design Solution**
  - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed

Related Engineering Practice:

- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations
- *I.e. Students will demonstrate this as they maneuver through their understanding of the relationships between macromolecules in cells and the chemistry of materials that are utilized for research.*

Immune System (3 weeks)

Description:

○ This unit is related to the human immune system's structure and function and how its processes are connected to the real world. The immune system is a human's first line of defense from pathogens that can be encountered in the environment or through other vectors. It is important for students to understand the benefits and detriments that exist in the human relationship with bacteria. Students must be able to assess what happens when there is too much bacteria in a food source and why there are precautions that need to be taken by the food industry. Bacteria is a large part of the natural world and is inevitable to avoid. In order to test how much bacteria is in a sample, a properly diluted titer (bacterial content) must be analyzed.

Beef Titer Lab:

○ The students will learn how to measure the titer in a sample of Beef Broth Titer. This applies the practices of using a micropipette, serial dilutions, and spreading a bacterial sample on a plate. If after the Gram stain multiple species are present, the students must relate these results to their understanding of safety of food sources in the real world.

Associated Next Generation Science Standard Performance Expectations:

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Related Disciplinary Core Idea:

- **LS1.A: Structure and Function**
  - Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.

Related Engineering Practices:

Developing and Using Models-

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
- *I.e. Students will use a petri dish to model the relationship between our environmental conditions, natural food sources and the microscopic bacteria that live on them and determine which range and microflora population is healthy.*

Related Cross Cutting Concept:
Systems and System Models-

- (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scale

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Related Disciplinary Core Ideas:

- **LS1.A: Structure and Function**:
  - Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

Related Engineering Practices:
Planning and Carrying Out Investigations -

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly
- *I.e. Students will be provided with different environmental conditions for different harmful bacterium that affect food products and determine the potential effects.*

Related Cross Cutting Concepts:
Stability and Change-

- Feedback (negative or positive) can stabilize or destabilize a system.

Cancer (3 weeks)
Description:

- The cancer unit will emphasize how a tumor or an area of unregulated cellular growth becomes "cancer." Students must connect the significance of the malfunction in regulated stimulatory and inhibitory pathways in the body to the behavior of cancer. Students must understand the complex relationships between genetics and their inherited or environmental factors that could lead to cancer. The students must understand that cancer is an umbrella term for unregulated malicious cell behavior and how it attacks normal bodily processes. They must connect their real world understanding with the actual physical occurrences in the body.

Cancer Portfolio

○ Students will take on the task of researching and creating an Informational Portfolio about cancer. This assignment asks students to determine the most significant cancers in the human population, their genetic influence, and realistic treatments that are currently under study.

Associated Next Generation Science Standard Performance Expectations:

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Related Disciplinary Core Idea:

- **LS1.A: Structure and Function**
  - Systems of specialized cells within organisms help them perform the essential functions of life.
  - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

Related Engineering Practices:

Constructing Explanations and Designing Solutions

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- *I.e. Students will determine how connected gene expression is with the occurrence of cancer in particular individuals.*

Cross Cutting Concepts:

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Related Disciplinary Core Ideas:

- **LS1.A: Structure and Function**:
  - Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living

system.

Related Engineering Practices:
Planning and Carrying Out Investigations -

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly
- *I.e. Students will explore how cancer affects the feedback mechanisms in the body that maintain homeostasis.*

Related Cross Cutting Concepts:
Stability and Change-

- Feedback (negative or positive) can stabilize or destabilize a system.

HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Related Disciplinary Core Ideas:

- **LS3.B: Variation of Traits**
  - In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited

Related Engineering Practices:
Engaging in Argument from Evidence-

- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.
- *i.e. Students will acquire knowledge and evidence about cancer research in the production of their portfolio.*

Related Cross Cutting Concepts:
Cause and Effect -

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Related Disciplinary Core Ideas:

- **LS4.C: Adaptation**
  - Natural selection leads to adaptation, that is, to a population

dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

Related Engineering Practices:
Constructing Explanations and Designing Solutions-

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- *I.e. Students will create a self-guided exploration of how particular bodily processes work and manifest different cancer types that are addressed by research in the medical world.*

Related Cross Cutting Concepts:
Cause and Effect -

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Scientific Knowledge Assumes an Order and Consistency in Natural Systems-

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

Student Presentations (2 weeks cumulative)

Spring Semester

1. **Job Shadow/Internship Project - student project outside of class time assigned during week 1 and due in parts during the last 3 weeks of the semester**
   (Aligned Performance expectations similar to Career Research Project)

Associated Next Generation Science Standard Performance Expectations:

HS-PS4-2. Evaluate questions about the advantages of using digital transmission and storage of information.

Related Disciplinary Core Ideas:

- **PS4.A: Wave Properties**
  - Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses

Related Engineering Practices:
Asking Questions and Defining Problems-

- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design

- *I.e. Students will pair with a person in their chosen sub discipline of biotechnology and explore their career with an in person job shadow at a medical or research facility.*

Related Cross Cutting Concepts:
Influence of Engineering, Technology, and Science on Society and the Natural World -

- Modern civilization depends on major technological systems.
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

HS-ETS1-2

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Related Disciplinary Core Idea:

- **ETS1.C: Optimizing the Design Solution**
  - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed

Related Engineering Practice:

- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations
- *I.e. Students will use their job shadow experience to determine how large problems are solved by step by step processes in Biomedical Science.*

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Related Disciplinary Core Idea:

- **ETS1.B: Developing Possible Solutions**
  - When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts

Related Engineering Practices:
Constructing Explanations and Designing Solutions-

- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
- *I.e. Students will uncover the variety of ways Biomedical Science affects society and the potential implications of the research in the real world.*

Cross Cutting Concepts:
Influence of Science, Engineering, and Technology on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology

2. Viruses (5 weeks)

Description:

○ The virus unit utilizes a student's understanding of the differing viral structure and functions as related to a strain's mode of infection. The unit profiles different viral processes of genome replication. This is tied into how that method defines differences between Retroviruses and DNA based Viruses. The significance of the different host cells affected is acknowledged. The replication and life processes of the HIV virus are mainly profiled and dissected by students.

Quantitative Enzyme Linked Immunosorbent Assay [ELISA]

○ This lab allows students to determine if particles of a particular antibody are found in a sample and what the presence means when diagnosing a patient with a viral infection. The understanding of complex chemical reactions between viral antigens and antibodies that result in a particular immunoprecipitation will be navigated by student inquiry.

Associated Next Generation Science Standard Performance Expectations:

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Related Disciplinary Core Idea:

- **ETS1.A: Defining and Delimiting Engineering Problems**
  - Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Related Engineering Practices:
Asking Questions and Defining Problems

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions
- *I.e. Students will use an ELISA assay to determine the presence of viral antibodies in a sample and connect the results to diagnosing a patient.*

Cross Cutting Concepts:
Influence of Science, Engineering, and Technology on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology

HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Related Disciplinary Core Idea:

- **ETS1.B: Developing Possible Solutions**
  - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs

Related Engineering Practices:

Using Mathematics and Computational Thinking-

- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.
- *I.e. Students will use an ELISA assay to determine the presence of viral antibodies in a sample and connect the results to diagnosing a patient.*

Cross Cutting Concepts:

- **Systems and System Models**
  - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows— within and between systems at different scales

3. Structure, Chemistry, and Function of DNA (7 weeks)

Description:

In order for students to acquire a deeper understanding of the viral mode of infection they must have a solid background related to the structure of DNA and their relationship with restriction enzymes. The students must connect the significance of the "cutting" behavior of restriction enzymes and its ability to bond with a particular recognition sequence. The application of the disturbance of the forces and charges that hold DNA together ties in the biochemical aspect of the course. This unit also merges the student's knowledge of bacterial DNA structure, viral infection and differentiating different sized particles of DNA sequence. Overall the methods in this process model basic protocols in Genetic Engineering and Virology.

DNA Restriction Analysis:

In this lab the students will actually have a hands-on chance to analyze information relevant to the chemistry of restriction endonucleases, and gel electrophoresis as a technology for analyzing the DNA restriction endonuclease reaction. They will model this by setting up different restriction digests, running the gels independently, and examine the importance of an Ethidium Bromide stain when scrutinizing the results as compared to a provided data set.

Associated Next Generation Science Standard Performance Expectations:

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Related Disciplinary Core Idea:

- **LS1.A: Structure and Function**
  - Systems of specialized cells within organisms help them perform the essential functions of life.
  - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

Related Engineering Practices:

Constructing Explanations and Designing Solutions

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- *I.e. Students will analyze segments of DNA extracted by the action of natural restriction enzymes.*

Cross Cutting Concepts:

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS-LS3-1. Ask and clarify relationships about the role of DNA and Chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Related Disciplinary Core Idea:

- **LS1.A: Structure and Function**
  - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.
- **LS3.A: Inheritance of Traits**
  - Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in

regulatory or structural functions, and some have no as-yet known function

Related Engineering Practices:
Asking Questions and Defining Problems-

- Ask questions that arise from examining models or a theory to clarify relationships.
- *I.e. Students will model this by using expected data to compare to their observed data and determine potential sources for error.*

Cross Cutting Concepts:
Cause and Effect-

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Related Disciplinary Core Idea:

- **LS1.A: Structure and Function**
  - The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

Related Engineering Practices:
Asking Questions and Defining Problems-

- Use mathematical representations of phenomena to support claims.
- *I.e. Students will model this by calculating the range of sensitivity of DNA detection by ethidium bromide and using data to determine how the resulting fragments were separated.*

Cross Cutting Concepts:
Energy and Matter-

- The total amount of energy and matter in closed systems is conserved.

4. Polymerase Chain Reaction (7 weeks)

Description:
When a particular segment of DNA is isolated, it is too small to analyze. Students must utilize Polymerase Chain Reaction (PCR) as a first step in DNA analysis. Students must understand the differences in each step of PCR and how the temperature of the cycling environment facilitates each step of the in vitro DNA replication. This involves the student's background knowledge in biochemical charges and how these interactions can facilitate DNA replication in a non-cell environment. Overall students will have hands on experience with a basic procedure in biomedical research.

Amplification of a Segment of Lambda DNA:
Students will employ the process of PCR to answer how products identified, and measured, on a stained agarose gel. The goal of the assignment is to isolate and amplify a 500 base pair section of Lambda DNA from a genome of 48,502 bases. This lab also uses a control to model the potential room for contamination and error that may happen in the classroom but is also possible in a professional lab setting.

Associated Next Generation Science Standard Performance Expectations:

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Related Disciplinary Core Idea:

- **LS1.A: Structure and Function**
  - Systems of specialized cells within organisms help them perform the essential functions of life.
  - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

Related Engineering Practices:
Constructing Explanations and Designing Solutions

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- *I.e. Students will use PCR to assist in amplification of particular DNA segments and analyze them by use of charged agarose gels.*

Cross Cutting Concepts:
Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Related Disciplinary Core Idea:

- **PS1.B: Chemical Reactions**
  - Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and

the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

Related Engineering Practices:
Constructing Explanations and Designing Solutions-

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- *I.e. Students will see the effects of temperature change in each step of PCR and will connect the procedure with the step by step DNA amplification.*

Cross Cutting Concepts:

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

5. Student Presentations (2 weeks cumulative)

Skills:

21st Century Skills which students will learn in this course:

- Provide an environment which supports academic, social and emotional growth and success and opportunities for student choice.
- Provide a program which prepares students for graduation and provides opportunities for student growth, development and post-secondary options.
- Communicate articulately, effectively, and persuasively when speaking and writing.
- Read and analyze material in a variety of disciplines.
- Use technology as a tool to access information, analyze and solve problems, and communicate ideas.
- Apply mathematical knowledge and skills to analyze and solve problems.
- Demonstrate scientific literacy.
- Demonstrate school-to-work/post-secondary transition skills and knowledge.

Assessment Criteria:

Student Assessment

Next Generation Science Standard Evidence Statements will be utilized throughout the course to assess student progression in learning. A link to evidence statements can be found here : http://www.nextgenscience.org/ngss-high-school-evidence-statements

Course progress will be assessed via portfolio work, check in/formative assessments, summative assessments, and project work. Students' grades will be assigned based on their final evaluations determined by the evidence statements.

Course Assessment

Formal student feedback will be sought and collected each semester. Grade distribution data reflecting semester grades, project grades, and exam grades will be prepared each year as well. Both of these

indicators will be used to determine how well student needs are being met, student perceptions, and student performance in the context of the course goals.

Course Materials (primary and/or supplemental; websites used):

- Campbell, NA and JB Reece. 2008. Biology, eighth edition. Pearson Benjamin Cummings, San Francisco.
- Computer based presentation hardware
- Software: presentation, digital video editing, graphics and visual effects, web-based applications, spreadsheet, word-processing
- CD-ROM and DVD based presentations and tutorials
- Biotechnological equipment (micropipettes, thermal cyclers, centrifuges, flame loops, petri dishes, microscopes, etc.)

Course Author(s):

Skip Lovelady, Redwood HS
Jennifer Brown, Tamalpais HS
Alyssa Sandner, Tamalpais HS

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