— PREMIUM RESOURCE —

BIOLOGY

REAL-WORLD APPLICATION ACTIVITIES

10 Stand-Alone Activities | Grades 9–12

CONNECTING CONCEPTS TO CONTEXT

WHAT'S INSIDE

- **Engaging Reading Passages** — Authentic real-world contexts
- **Analysis Questions** — Critical thinking & application
- **Extension Activities** — Project-based & creative tasks
- **Vocabulary Lists** — Key terminology per activity
- **Complete Answer Keys** — Easy grading & teacher prep

TOPICS COVERED

- Cell Biology & Cancer
- Genetics & Ancestry
- Ecology & Wildfires
- Evolution & Superbugs
- Physiology & Vaccines
- Biotechnology & CRISPR

UM Printables

Premium Teaching Resources

TEACHER GUIDE

How to Use This Resource

- These activities are designed as stand-alone modules. Use them in any order that aligns with your curriculum.
- Each activity takes approximately 45-60 minutes, perfect for a standard class period.
- Assign digitally or print for in-class work, homework, or sub plans.
- Use the Extension activities for early finishers, group projects, or extra credit.

Activity Structure

- Vocabulary List: Pre-teach key terms or have students define them as they read.
- Reading Passage: Contextualizes a core biology concept in a real-world scenario.
- Analysis Questions: Move beyond recall; require application and critical thinking.
- Extension Activity: Open-ended tasks involving research, argumentation, or design.

Tips for Success

- Encourage students to highlight or annotate the reading passages.
- Use the vocabulary lists for mini word-wall displays or quiz preparation.
- Facilitate Socratic seminars based on the extension activity prompts.
- Emphasize that there may be multiple valid perspectives on complex real-world issues.

ACTIVITY 1: CELL BIOLOGY & CANCER RESEARCH

VOCABULARY

Oncogene | Tumor Suppressor Gene | Metastasis | Apoptosis | Angiogenesis

READING PASSAGE

Cancer is not a single disease, but a collection of over 100 diseases driven by uncontrolled cell growth. At its core, cancer is a breakdown of the normal cell cycle. Healthy cells grow, divide, and die (apoptosis) in a highly regulated manner. However, when genetic mutations occur in key regulatory genes, this process goes awry. Two types of genes are most commonly involved: proto-oncogenes and tumor suppressor genes. Proto-oncogenes act like the gas pedal in a car, encouraging cell division. When mutated, they become oncogenes, permanently pressing the gas pedal. Tumor suppressor genes act like the brakes, stopping damaged cells from dividing. When these are mutated, the brakes fail. As the faulty cells accumulate, they form a tumor. To grow beyond a certain size, tumors undergo angiogenesis, forming new blood vessels to supply themselves with nutrients. Even more dangerously, some cells gain the ability to break away from the original tumor and travel through the bloodstream to other parts of the body—a process called metastasis. Modern cancer research focuses on targeting these specific mechanisms. For example, anti-angiogenic drugs starve tumors by cutting off their blood supply, while targeted therapies aim to block the signals from specific oncogenes, sparing the healthy cells that traditional chemotherapy would destroy.

ACTIVITY 1: CELL BIOLOGY & CANCER RESEARCH (CONT.)

ANALYSIS QUESTIONS

1. Explain the difference between a proto-oncogene and a tumor suppressor gene using the car analogy from the passage.

2. Why is apoptosis a critical process for maintaining healthy tissues, and what happens when it fails?

3. Describe the role of angiogenesis in tumor development. Why would a tumor struggle to grow without it?

4. How does metastasis make cancer significantly more difficult to treat than a localized tumor?

5. Why might a targeted therapy that blocks a specific oncogene be preferable to traditional chemotherapy?

EXTENSION ACTIVITY

Research one modern targeted cancer therapy (e.g., a specific drug like Imatinib/Gleevec or a class of drugs like checkpoint inhibitors). Write a short summary explaining exactly which cellular mechanism the drug targets and how it disrupts the cancer cycle.

ACTIVITY 2: GENETICS & ANCESTRY TESTING

VOCABULARY

SNP (Single Nucleotide Polymorphism) | Haplogroup | Autosomal DNA | Mitochondrial DNA (mtDNA) | Y-Chromosome DNA

READING PASSAGE

Direct-to-consumer DNA testing has revolutionized how people understand their ancestry. When you send a saliva sample to a company, they extract your DNA and analyze specific markers. Most tests look at Autosomal DNA, which you inherit from both parents and makes up the majority of your genome. It is used to estimate your overall ethnic mix from the last several hundred years. However, autosomal DNA gets diluted each generation, meaning it cannot trace your lineage far back in time. To go deeper, companies use two other types of DNA. Mitochondrial DNA (mtDNA) is passed exclusively from mother to child, tracing a direct maternal line back thousands of years. Similarly, Y-Chromosome DNA is passed from father to son, tracing the direct paternal line. Both mtDNA and Y-DNA are used to assign individuals to a Haplogroup—a genetic population group sharing a common ancestor. These tests rely heavily on SNPs (Single Nucleotide Polymorphisms), which are variations at a single point in the DNA sequence. By comparing your SNPs to reference databases, companies estimate your geographic origins. However, it is important to remember that these databases are heavily skewed toward populations of European descent, meaning results for other ethnicities can be less precise or overly broad. Furthermore, while DNA can tell you about genetic lineage, it cannot measure culture, which is learned and shared through experience.

ACTIVITY 2: GENETICS & ANCESTRY TESTING (CONT.)

ANALYSIS QUESTIONS

1. Explain the difference between Autosomal DNA and mtDNA in terms of inheritance and what they reveal about ancestry.

2. Why are SNPs (Single Nucleotide Polymorphisms) useful for determining a person's geographic ancestry?

3. What is a haplogroup, and which type of DNA (mtDNA or Y-DNA) would a female use to trace her direct paternal line? Explain your answer.

4. Why might ancestry test results be less accurate for individuals with non-European heritage compared to those with European heritage?

5. The passage states that DNA cannot measure culture. Give an example of a cultural trait that would NOT show up in a DNA test.

EXTENSION ACTIVITY

Debate the ethical implications of law enforcement using public genealogy databases (like GEDmatch) to solve cold cases by finding relatives of suspects. Write one paragraph arguing FOR the practice and one paragraph arguing AGAINST it, focusing on privacy and consent.

ACTIVITY 3: ECOLOGY & WILDFIRES

VOCABULARY

Primary Succession | Secondary Succession | Fire-adapted Ecosystem | Canopy | Understory

READING PASSAGE

Wildfires are often portrayed as purely destructive forces, but in many ecosystems, fire is a natural and essential process. In fire-adapted ecosystems, like the coniferous forests of the American West, certain plant species have evolved to not only survive fire but to depend on it. For example, some pine trees have serotinous cones—cones sealed with resin that only melt and release seeds in the intense heat of a wildfire. This ensures that seeds are dropped into a nutrient-rich, sunlit environment cleared of competing understory plants. When a fire sweeps through, it burns the underbrush and lower canopy. Historically, these were low-intensity surface fires. However, decades of fire suppression policies have allowed massive amounts of dead wood and dense underbrush to accumulate. When a fire does ignite in these overgrown forests, it climbs into the upper canopy, becoming a catastrophic crown fire. These intense fires kill mature trees and can destroy the soil's seed bank. After a moderate fire, the ecosystem recovers through secondary succession, where surviving roots and seeds sprout quickly in the nutrient-rich ash. If a catastrophic fire destroys everything, primary succession may begin, taking much longer to recover as soil must be rebuilt from scratch. Modern forest management uses prescribed burns—intentionally set, controlled fires—to clear underbrush and restore the natural, low-intensity fire cycle.

ACTIVITY 3: ECOLOGY & WILDFIRES (CONT.)

ANALYSIS QUESTIONS

1. Explain the relationship between serotinous cones and wildfires. How does this adaptation benefit the pine tree?

2. How does decades of fire suppression actually lead to more catastrophic, uncontrollable wildfires?

3. Compare and contrast primary succession and secondary succession in the context of a forest fire.

4. What is the difference between a surface fire and a crown fire, and why are crown fires more damaging to the ecosystem?

5. Explain the ecological purpose of a prescribed burn. What risks do forest managers take when using them?

EXTENSION ACTIVITY

Imagine you are a forest manager facing a severe drought in a fire-adapted forest near a small town. Write a proposal to the town council outlining whether you would recommend a prescribed burn or continued fire suppression. Defend your choice using ecological concepts from the passage.

ACTIVITY 4: EVOLUTION & ANTIBIOTIC RESISTANCE

VOCABULARY

Natural Selection | Antibiotic Resistance | Selective Pressure | Horizontal Gene Transfer | Broad-spectrum Antibiotic

READING PASSAGE

The discovery of antibiotics revolutionized medicine, but their overuse has triggered an evolutionary arms race. When a patient takes an antibiotic, it kills the susceptible bacteria, but a few bacteria with genetic mutations that make them resistant survive. The antibiotic acts as a selective pressure, favoring the resistant individuals. These survivors reproduce, passing on their resistance genes to their offspring. Because bacteria reproduce rapidly, a resistant population can emerge in a very short time. Furthermore, bacteria can acquire resistance through horizontal gene transfer, where they share DNA (often on plasmids) with other bacteria, even of different species. This is why prescribing broad-spectrum antibiotics for minor infections is dangerous; it wipes out harmless bacteria in the body, leaving behind resistant strains that can share their genes. The result is the rise of "superbugs" like MRSA, which are resistant to multiple antibiotics. To combat this, doctors must prescribe antibiotics only when necessary, and patients must complete their entire prescription to ensure all bacteria are eliminated, leaving no survivors to evolve resistance.

ACTIVITY 4: EVOLUTION & ANTIBIOTIC RESISTA... (CONT.)

ANALYSIS QUESTIONS

1. Explain how the overuse of antibiotics creates a selective pressure in a bacterial population.

2. What is the role of a random genetic mutation in the development of antibiotic resistance?

3. How does horizontal gene transfer make the antibiotic resistance crisis worse compared to vertical gene transfer alone?

4. Why is it critical for a patient to finish their entire prescribed course of antibiotics, even if they feel better after a few days?

5. How does the evolution of antibiotic resistance serve as a real-time, observable example of Darwin's theory of natural selection?

EXTENSION ACTIVITY

Design a public health campaign (either a poster or a social media script) aimed at farmers or doctors to reduce the overuse of antibiotics. Include at least two scientific facts from the passage to support your argument.

ACTIVITY 5: PHYSIOLOGY & VACCINES

VOCABULARY

Antigen | Antibody | Memory Cell | Herd Immunity | Pathogen

READING PASSAGE

Vaccines are one of the greatest public health achievements in human history, working by training the immune system without causing actual disease. When a pathogen enters the body, it has specific molecules on its surface called antigens. The immune system produces antibodies, which are Y-shaped proteins that lock onto these antigens to neutralize the pathogen or tag it for destruction. After the infection is cleared, specialized white blood cells called memory cells remain in the bloodstream. If the same pathogen enters the body again, memory cells recognize it immediately and produce a massive, rapid antibody response, preventing illness. Vaccines introduce weakened or inactivated pathogens (or just their antigens) into the body. This triggers a primary immune response, producing antibodies and memory cells without the person having to suffer the actual disease. Therefore, when the person encounters the live pathogen in the future, their secondary immune response is swift and strong. Furthermore, vaccines protect more than just the individual. When a high percentage of a population is vaccinated, a concept known as herd immunity is achieved. This means the pathogen cannot easily spread from person to person, protecting those who cannot be vaccinated, such as infants or immunocompromised individuals.

ACTIVITY 5: PHYSIOLOGY & VACCINES (CONT.)

ANALYSIS QUESTIONS

1. Describe the difference between the primary and secondary immune responses in terms of speed and antibody production.

2. How does a vaccine trick the immune system into providing long-term immunity without causing the disease?

3. Explain the concept of herd immunity. Why does a drop in vaccination rates threaten individuals who are NOT vaccinated?

4. What is the specific role of a memory B cell in adaptive immunity?

5. Why might a new influenza vaccine be required every year, whereas the measles vaccine provides lifelong immunity?

EXTENSION ACTIVITY

Research antigenic drift and antigenic shift in influenza viruses. Write a short explanation of how these processes change the antigens on the virus surface, and explain how this impacts the need for annual flu vaccines.

ACTIVITY 6: BIOTECHNOLOGY & CRISPR

VOCABULARY

CRISPR-Cas9 | Guide RNA (gRNA) | Gene Editing | Off-target Effects | Germline Editing

READING PASSAGE

CRISPR-Cas9 has revolutionized the field of biotechnology, acting as a highly precise molecular scissors for editing DNA. Originally discovered as a bacterial immune defense, scientists adapted it to edit the genomes of other organisms. The system has two key components: a Guide RNA (gRNA) and the Cas9 protein. The gRNA is designed to match a specific target sequence of DNA in a cell. Once injected, the gRNA guides the Cas9 protein to that exact location. Cas9 then cuts both strands of the DNA. Once the DNA is cut, the cell's natural repair mechanisms kick in. Scientists can exploit these repairs to disable a gene or insert a new sequence of DNA. This technology holds incredible promise for curing genetic diseases like sickle cell anemia by correcting the mutation in the patient's cells (somatic editing). However, it raises serious ethical questions when applied to germline editing—altering the DNA of embryos, which means changes are passed down to all future generations. Additionally, "off-target effects" occur when the gRNA directs Cas9 to cut at unintended locations in the genome with similar sequences, potentially causing harmful mutations like cancer. As we navigate this powerful technology, the scientific community is actively debating where to draw the line between healing and "enhancing" the human genome.

ACTIVITY 6: BIOTECHNOLOGY & CRISPR (CONT.)

ANALYSIS QUESTIONS

1. Explain the specific roles of the Guide RNA (gRNA) and the Cas9 protein in the CRISPR system.

2. How did bacteria originally use the CRISPR system before scientists adapted it for biotechnology?

3. What is the fundamental difference between somatic gene editing and germline gene editing?

4. Why are "off-target effects" a significant safety concern for scientists using CRISPR in human patients?

5. Based on the passage, explain one ethical concern associated with germline editing in humans.

EXTENSION ACTIVITY

Sickle cell anemia is caused by a single nucleotide mutation in the hemoglobin gene, and it can be cured using CRISPR somatic editing. However, if a couple wants to use CRISPR germline editing on an embryo to ensure their child never develops the disease, the changes are passed to future generations. Write an argument either FOR or AGAINST allowing germline editing for sickle cell anemia, weighing the benefits against the ethical risks.

ACTIVITY 7: ENVIRONMENTAL SCIENCE & OCEAN ACIDIFICATION

VOCABULARY

Ocean Acidification | pH Scale | Calcification | Carbonate Ion | Keeling Curve

READING PASSAGE

While much attention is given to global warming, the "evil twin" of climate change—ocean acidification—poses an equally severe threat to marine ecosystems. The ocean acts as a massive carbon sink, absorbing about 30% of the carbon dioxide (CO_2) released into the atmosphere. When CO_2 dissolves in seawater, it reacts with water to form carbonic acid (H_2CO_3). This acid releases hydrogen ions (H^+), lowering the pH of the ocean and making it more acidic. This chemical shift has a devastating biological consequence: it reduces the concentration of carbonate ions in the water. Marine organisms like corals, oysters, and some plankton rely on carbonate ions to build their calcium carbonate shells and skeletons through a process called calcification. With fewer carbonate ions available, calcification slows down, and existing shells can actually begin to dissolve. Because these organisms form the base of the marine food web, their decline threatens fish populations and the entire ocean ecosystem. Additionally, the Keeling Curve shows a steady, relentless rise in atmospheric CO_2 since the 1950s, meaning the ocean will continue to absorb more CO_2. Polar oceans are particularly vulnerable because cold water absorbs CO_2 more easily than warm water, putting cold-water corals and pteropods at immediate risk.