What is the Teen Biotech Challenge?

TBC2022 is a poster design contest that challenges middle and high school students to demonstrate their understanding of biotechnology's impact on society and the importance of science and technology in addressing global challenges. Students will be asked to research a biotech topic and share fact-based information in a scientific poster format suitable for general audiences. In addition to learning about biotechnology, students will develop creative writing and graphic design skills.

Winning first place posters in the junior (Grades 6-8), intermediate (Grades 9-10) and senior (Grades 11-12) contest levels will be highlighted on the TBC webpage each year, as well as a list of all contest winners (2nd place, 3rd place and Honorable Mention).

Important Dates for the 2021 – 2022 Contest

Nov 15th — TBC2022 Contest Launch - Instructions and Poster Templates Posted Online

April 1st — Contest Deadline. The following items will be due electronically by 11:59pm PDT:

1. Online TBC Application Form with Parent/Guardian Permission found at: https://biotech.ucdavis.edu/teen-biotech-challenge
2. The final poster entry should be submitted as a .pdf attachment via email to biotechprogram@ucdavis.edu. The email subject line should contain the student's name, grade and school name. The body of the email text should indicate the poster title and TBC category. The final PDF size should be manageable – recommend less than 10MB.

Early May (date TBA) — Announcement of Contest Winners

Overview

Biotechnology plays an important role in the development of new technologies for human health, agriculture and environmental sustainability. Life science technologies typically rely on the use of living cells to facilitate processes or generate products useful to humans. However, the modification of other living organisms to support the survival of humanity is not a new concept. For centuries, humans have used selective breeding of plants and animals to generate food, medicine and other useful products. The biotech innovations that we see today are the result of advances in science and technology over the last century, especially those that allow researchers to quickly analyze and modify genetic information, manipulate cellular processes and build biomaterials. The goal of the Teen Biotech Challenge is to help teachers, students, and parents gain an understanding of the many ways that biotechnology positively impacts society and potential career paths open to college graduates in science, technology, engineering and math (STEM). Participating students will gain skills in topical research and conference poster design, while achieving recognition from peers, educators and members of the biotech community.

Contest Entry Development

The first step for TBC student participants in grades 6-8 and 9-12 will be choosing a biotech topic of interest. Topics have been organized into six categories: 1) Agricultural Biotechnology; 2) Biomanufacturing; 3) Computational Biology & Genomics; 4) Environmental Biotechnology & Planetary Health; 5) Molecular Tools – Nanobiotechnology, Synthetic Biology & Genetic Engineering; and 6) Regenerative Medicine & Biomedical Engineering.

Next, after gathering information on a biotech topic of choice, students will develop an educational poster.

- Contest entrants at the junior (Grades 6-8) level should include the following items on their posters: Title, I. Topic Background, II. Technology Timeline, ~2-3 Images/Graphics, and V. References.

- Contest entrants at the intermediate (Grades 9-10) and senior (Grades 11-12) levels should include the following items on their posters: Title, I. Topic Background, II. Technology Timeline, III. Biotech Innovators & Economic Impact, IV. Ethical, Legal and Social Issues, and V. References.

Two grade-specific poster templates and detailed guidelines have been developed and are described in Part II (pages 8-12) of this document. Note that the template for Grades 6-8 is different from the template for Grades 9-12. **Please follow the appropriate template for the student contestant's grade level.** TBC Posters may be created in Google slides, PowerPoint or similar presentation software, but must adhere to formatting guidelines (e. g. overall poster size and shape, font sizes, section types) described in Part II of these instructions. The final contest entry must be saved as a .pdf and submitted via email to biotechprogram@ucdavis.edu by the contest deadline.

Contest Judging and Awards

In each of the six categories, first, second, third and honorable mention winners will be chosen by a panel of UC Davis Designated Emphasis in Biotechnology (DEB) graduate student researchers who volunteer to serve as judges. The judges will have a rubric to follow in ranking their assigned posters. TBC2022 awards will be announced via email in early May 2022 and, if sponsor funding permits, we will designate student support for each winning category (first, second, third, honorable mention). If secured, sponsorship funding may cover the costs of: TBC 2022 Awards Symposium event space and catering; printing the winning posters for display at the symposium; category award ribbons or plaques; and TBC participant tee-shirts or other commemorative items to share with participants. More details regarding possible student awards and a celebratory event will be announced in spring 2022, once sponsor-funding amounts are tallied.

SPARK Research Scholar Awards – Tentative Planning for Summer 2022

Our UC Davis Team, led by PI Prof. Gerhard Bauer at the Institute for Regenerative Cures, is attempting to renew funding for the California Institute for Regenerative Medicine (CIRM) SPARK Research Scholar Awards. We will not know if this opportunity will be available until early 2022. If the UC Davis SPARK program is renewed, only TBC student participants who submit a judging quality poster by the April 1st contest deadline will be **eligible to apply** for this eight-week stem cell biology summer research experience. The last pool of awardees (TBC2020) participated in a distance-learning experience. We hope to host a traditional, in-person research experience for SPARK students in Summer 2022, if funded, but details will not be confirmed until Spring 2022.

Part I: Researching a Biotech Topic

TBC2022 participants should choose a biotech research topic from one of the six categories described below. Students must work individually on TBC poster projects (unlike past years, team projects will not be allowed).

Category 1 - Agricultural Biotechnology

Understanding the interaction between genes and the environment will help us to optimize agricultural production systems and cope with climate change. As world population accelerates toward 8 billion, we need to find sustainable strategies to increase the quantity and quality of our food and feed supplies. Agriculture must also deliver more plant biomass, fibers, and seed oils for renewable products. Agricultural scientists are challenged to increase production yields while preserving natural resources, protecting biodiversity and dealing with the ever-shrinking availability of arable farm land and available water resources. The tools of biotechnology can be used to address challenges in agriculture by speeding up traditional methods of plant and animal breeding, helping to identify the most sustainable farming and ranching practices, and in understanding the biology of important agricultural species and ecosystems.

Possible topics for research include, but are not limited to:

- Aquaponics
- Crop and animal-associated microbes for health and agricultural productivity
- Post-harvest food safety (monitoring microbes that may make people sick)
- Vertical farming (indoors)
- Plant and Animal Breeding Methods
    - Crop breeding by marker assisted selection (MAS), mutation breeding, transgenesis, gene-editing, etc.
        - Agronomic crop traits - Herbicide tolerance (HT), Insect resistance (IR), Disease resistance, Salt tolerance, Submergence/flood tolerance, Water use efficiency (WUE)/drought tolerance, Nitrogen use efficiency (NUE)
        - Nutritionally enhanced crops (BioCassava Plus, Golden Rice, celiac-safe wheat, GLA safflower, high oleic soybeans)
        - Crops that produce biomass or high value products (pharming, plant-made industrial products)
    - Animal breeding by marker assisted selection (MAS), mutation breeding, transgenesis, gene-editing, etc.
        - Disease-resistant pigs, chickens, and other agriculturally important animals
        - Fast growing salmon or other aquatic species (efficiency = more edible protein, fewer inputs!)
        - Technologies for large livestock breeding (gene-editing for polled dairy cattle, cloning valuable racehorses)

Category 2 - Biomanufacturing

Many types of cells, including mammalian cells, plant cells, fungi, yeast and bacteria may be genetically engineered to produce useful proteins, including: cultivated meats and edible alternative proteins; therapeutic drugs and vaccines; industrial enzymes; and, other industrial manufacturing precursors. Research and development in this field generally includes the use of recombinant DNA technologies, screening of candidate organisms or molecules for appropriate activities, designing nutrient medias to support cell growth, and optimizing conditions for the growth of cells in small and large culture systems. Downstream processes require operating large-scale bioreactors, collecting the product of interest (either the cells or proteins/molecules that the cells were making, and methods for isolating, purifying, testing

and packaging these biotech products. An important aspect of biomanufacturing is compliance with current Good Manufacturing Practices (cGMPs) and cooperation with the appropriate state and federal regulatory agencies, such as the US Food and Drug Administration (FDA).

Possible topics for research include, but are not limited to:

- Industrial Biomanufacturing
    - Cellular agriculture – production of edible proteins, fibers and other nutrients within culture systems
        - Plant-based or fungal-based proteins and meat alternatives (e. g. Better Meat Company)
        - Lab-grown egg, meat, fish and dairy (e. g. the companies, Upside Foods, TurtleTree, Eat Just, BlueNalu, Perfect Day, and many others)
    - Industrial enzymes (e. g. the biotech company, Novozymes)
    - Molecules useful for cosmetics, fragrances or flavorings (e. g. the biotech company, International Flavors and Fragrances)
    - Fibers for textiles and other materials (e. g. the biotech companies, GALY and Bolt Threads)
    - Dyes for the textile industry (e. g. the biotech company, Huue)
- Drug Discovery and Pharmaceutical Biomanufacturing
    - "Orphan drug" development for rare genetic diseases (e. g. the company, BioMarin)
    - Development of biologic drugs (vaccines, monoclonal antibodies, hormones) to treat autoimmune disorders, cancer, diabetes and other chronic diseases, and infectious diseases
    - Antibiotics and new technologies to treat infectious disease
    - Vaccines and therapeutics for "Neglected Tropical Diseases" (parasitic worms, leishmaniasis, Chagas Disease, river blindness, African sleeping sickness, leprosy, elephantiasis, snail fever, dengue fever)
    - HIV/AIDS drug discovery

Category 3 - Computational Biology & Genomics

Computational biology or bioinformatics is the use of information technology to store, sort, analyze, share and understand biological data. Through data analysis and machine learning, scientists aim to build accurate computational models that can correctly predict biological phenomena. Similar informatics tools are used, whether one is analyzing events that occur within a single cell (e.g. protein folding of a particular polypeptide) or looking at interactions in multicellular systems (e.g. gut microbiome impacts on human health). Ultimately, the goal of computational biology is to help us understand how complex natural systems work.

Thanks to computational biology tools and genomics research, information about an individual's genome is now readily available to help tailor lifestyle choices and medical treatments for humans and pets. Information about our genomes will likely be incorporated into our medical records and our pets' veterinary records, much as family history and test results are currently compiled. So… what does this mean for the average consumer? For hopeful parents who would like healthy children? For pet owners who want to know more about the health of their animal? For adoptees who do not have access to ancestry information or family medical histories? For drug companies and doctors aiming to treat patients with pharmaceuticals that are highly efficacious, with few side effects? Understanding the relative contributions of genes vs. the environment to human health and well-being is a complex task, but with the emerging tools of personal genomics, we are at the dawn of a new era in human and veterinary medicine.

Possible topics for research include, but are not limited to:

- Personalized medicine – tailoring medical treatments to genotypes
- Direct-to-consumer genome testing for humans and dogs (e. g. 23andMe, AncestryDNA, Embark, Wisdom)
- Human or companion animal genetics and reproduction
    - Cloning and "designer babies" or "designer pets"
    - Understanding genome mutations and inheritance of genetic diseases
    - Epigenetics (environmental influence on gene expression/inheritance of traits)
- Ancestry/DNA profiling of humans and pets
    - Paternity/relationship testing and haplotype (mitochondrial DNA and Y-chromosome) analysis
    - Genetic relationships between ancient populations of people (modern humans, Neanderthals, Denisovans and other ancient lineages) or companion animals
- Genomics and evolution
    - Hologenomics – organisms evolving together
    - Metagenomics and microbiomes (plant-soil microbiome studies, Human Microbiome Project, breast milk influence on infant gut flora)
    - Tree of Life Project
    - Comparative genomics (e. g. How are dogs genetically different from wolves? How are domestic cats genetically different from wild cats? What are the differences between the human genome and other primate genomes?)
- Life science informatics (genome sequencing projects, online tools and resources [e.g. NCBI's GenBank, MapViewer, Entrez Gene, OMIM, PubMed])
- Computer simulations of complex biological processes and systems
    - Nutrient and energy flows
    - Spread of infectious disease in a population
    - Predictive modeling of intracellular biological processes (gene expression, RNA processing, protein production and folding, metabolic pathways)

Category 4 - Environmental Biotechnology & Planetary Health

Environmental biotechnology uses living cells and systems to address natural resource limitations, the need for renewable energy technologies, pollution and climate change. As technological advances in information, transportation, medicine and many other areas of human achievement require ever more electricity and liquid fuel supplies; we need to find clean, "green" sources to keep us moving! Harnessing the metabolic and photosynthetic talents of microalgae, microbes and feedstock plants, scientists are developing new liquid biofuels, such as cellulosic ethanol and biodiesel. Biofuels decrease reliance on petroleum, which is beneficial for the environment and the economy. Scientists are also looking for ways to convert the energy stored in biomass into heat and electricity, including the development of anaerobic digestion systems and microbial fuel cells.

"Green chemistry" is a field of research that aims to eliminate the use or production of hazardous substances during industrial processes. One option that green chemists pursue is the use of genetically engineered cells (algal, microbial, fungal, insect, plant, etc…) to produce bioplastics, industrial precursors and useful chemicals. Cells and organisms have

been genetically engineered (or characterized for naturally occurring abilities) and used in bioremediation (clean-up of hazardous substances in soils and waterways).

Possible topics for research include, but are not limited to:

- Biofuels and Biomass conversion
    - Algal biofuels
        - Macroalgae (seaweed!) for biomass
        - Microalgae for oils and transportation fuels
    - Anaerobic digestion of biomass or "biogassification" (municipal trash, human and animal waste, agricultural waste)
    - Biodiesel
    - Cellulosic ethanol, other liquid alcohols
    - Feedstock development (specific crops for maximum biomass)
    - Microbe or enzyme engineering (to breakdown and ferment biomass)
- Bioremediation
    - Metal-accumulating bacteria and plants (arsenic, lead, palladium)
    - Microbial biodegradation of petroleum products, chlorinated organic solvents, and other contaminants
    - Phytoremediation (plants remove or degrade contaminants)
- Green Chemistry
    - Bioplastics
- Microbial fuel cells
    - Water desalinization
    - Electricity generation from biomass

Category 5 - Molecular Tools: Nanobiotechnology, Synthetic Biology & Genetic Engineering

The Molecular Tools category captures all technologies for manipulating, changing or synthesizing cellular structures or useful molecules in biotechnology. Nanobiotechnology is the use of nanoscale (10^{-9}) molecular systems to develop medical diagnostic devices, biomaterials, therapeutics and industrial processes. Research in nanobiotechnology often leads to the development of new tools that may be important "platform technologies" that are useful across many different fields of biotechnology. Synthetic biology uses information gained through computational biology and informatics (which allows understanding/modeling of biological systems) to design and/or reverse engineer biological devices and systems for useful purposes. Genetic engineering via "molecular tools", such as the CRISPR-Cas9 system, allows scientists to redesign cellular systems by specifically changing the genetic code.

Possible topics for research include, but are not limited to:

- Genome editing (CRISPR-Cas9, TALENS, ZFNs)
- DNA computing
- Synthetic biology
    - Designing biological devices and systems (molecular circuits, diagnostic tools, biosensors)
    - Designing whole viruses, microbes and other organisms
- Nanobiopharmaceutics

  - Drug delivery via nanocarriers (liposomes, nanoparticles)
  - Nanoparticles acting as drugs and therapeutics (biodegradable nanoparticle for immunotherapeutic MS treatment, nanoparticles as antimicrobial agents)
- Biomimetics or "biologically inspired design"
- Current and developing DNA sequencing technologies
  - Nanopore DNA sequencing (single molecule)
  - "next generation" DNA sequencing (short reads – 454 pyrosequencing, SOLiD, Ion Torrent, DNA nanoball, Illumina)
- "Lab-on-a-chip" systems and sensors
- Molecular and medical imaging systems

Category 6 - Regenerative Medicine & Biomedical Engineering

Biomedical engineers, immunologists, physicians and medical researchers from many fields are looking to stem cells and advanced biomaterials for new ways to repair damaged and diseased human tissues and organs. Work in regenerative medicine began many years ago, with the first bone marrow transplants, organ transplants and skin grafts. However, patients receiving donated body tissues have had to deal with immune responses to donated tissues, taking immunosuppressive anti-rejection medications that negatively impact length and quality of life. A revolution in regenerative medicine is now occurring, with new discoveries in stem cell technologies and biomaterials derived from engineered materials and patients own stem cells, preventing immune rejection and repairing the body. For aging populations in developed countries, such as U.S. Baby Boomers, regenerative medicine will play an especially important role in maintaining quality of life and allowing these people to contribute to our society well into their 70's and 80's. Regenerative medicine is also a vital field for treating and rehabilitating military veterans that have sustained severe injuries in the line of duty.

Possible topics for research include, but are not limited to:

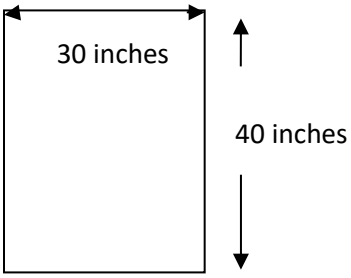
- Artificial limbs and biocompatible prostheses
- Stem cell types & potential uses
  - Cord blood stem cells
  - induced pluripotent stem cells
  - embryonic stem cells vs adult stem cells
- Synthetic organs
- Non-immunogenic tissue scaffolds & biomaterials

Note: Sponsor teachers and student participants, please email dsjamison@ucdavis.edu to ask for clarification if you are unsure of the most appropriate category for a particular poster topic. TBC contest administrators reserve the right to re-categorize submitted contest posters for final judging.

Part II: Poster Design

General Guidelines for Submissions

Make a poster describing a biotech topic that you find interesting. Imagine that your audience includes students your age and members of the community that may not know about this topic. Use creativity in designing the poster and select interesting images, photos, and/or original artwork to illustrate the topic. Most importantly, follow the directions below in writing about your biotech topic. Have fun!



Poster Basics

a. **File Size and Shape –** PDF less than 10MB, portrait (30" x 40")

b. **Content Layout** (see the last pages of these instructions for sample poster layouts)
- Poster Title & Student Information – *all entry levels*
- I. Topic Background – *all entry levels*
- II. Technology Timeline – *all entry levels*
- III. Biotech Innovators: Research & Economic Impacts – *only intermediate and senior entry levels*
- IV. Ethical, Legal & Social Issues (ELSI) – *only intermediate and senior entry levels*
- V. Reference List – *all entry levels*

c. **Readability**
- There are no restrictions on background colors, text colors, etc., but keep in mind that judges will be scoring the posters on their readability and usefulness in conveying the biotech topic information. If your poster is difficult to read or understand, it is not likely to score well. We recommend that students use background-text combinations that are easy on the eyes (e. g. black text on light colored backgrounds, white text on dark colored backgrounds, avoiding very bright or fluorescent text).
- Use proper grammar and spelling on the written portions of the poster content.

Poster Title & Headings

d. **Student Information**
- Centered directly under your title (60pt font), include your name, grade and school (48pt font).

e. **Section Headings & Text Boxes**
- Junior entrants will incorporate poster sections I, II, and V below. Intermediate and senior entrants will use all five section headings (48pt font):
  - I. Topic Background
  - II. Technology Timeline
  - III. Biotech Innovators: Research & Economic Impacts
  - IV. Ethical, Legal & Social Issues
  - V. Reference List
- Use ~24pt font to write the text for each section, I-IV. Section V may use ~16-18pt font to list references if space is limited.
- Use ~18-24pt captions for images and graphics, where needed.

Keep in mind that poster clarity and legibility will play a significant role in judging decisions, so keep it neat!

Example Poster Title (60pt font) and Student Information (48pt font):

Biofuels: Remarkable, Renewable Energy for All
Ana Rodriguez, Grade 7 – Hillsdale Middle School

Finding & Citing References
Scientists communicate discoveries to each another, and to the rest of the world, through research articles published in scientific journals. Research articles are "peer-reviewed", meaning that scientific experts in a field of study read and critique articles before publication. Articles that do not meet high standards of excellence are not published. Given this tradition of "quality control", scientific journals are generally the most reputable and reliable sources of scientific information. Most schools and individuals do not have free access to scientific journals. Luckily, the "Open Science" movement has made the results of cutting-edge scientific research publicly available through open access journals. One of the first open access journals and a great resource for TBC2022 is the Public Library of Science https://www.plos.org/. Also, search the free PubMed Central (PMC) article database https://www.ncbi.nlm.nih.gov/pubmed.

Use a balanced approach when discussing "pros", "cons" and other opinions about a particular technology. All statements should be supported by citation of reputable references. **Be careful not to present false, "pseudoscientific" information as valid "con" arguments against biotechnology – this will detract from your poster score during final judging.** Many anti-science groups publish incorrect information online. If you are unsure about the reliability of an information source, please ask your sponsor teacher or librarian.

All sources of information used in building the poster should be appropriately cited in section V of the poster content. In accordance with U.S. copyright laws, please reference all materials obtained from the Internet with the original source. Students should take care to phrase gathered information in their own words, as all final entries will be checked for plagiarism. **Posters with plagiarized content, as determined by the judges, will be disqualified from the contest. If needed, use quotation marks around text taken from other sources and provide an accurate reference citation.**

Appropriate Content
Please do not include explicit/offensive language, images or visual elements in the poster content. For safety, we suggest that students do not include personal contact information (home address, phone, social media, email) on the poster – please review any images and/or contact information with parent(s)/guardian(s) for approval. **Posters with inappropriate content, as determined by the judges, will be disqualified from the contest.**

Poster Content

Use the following section headings to organize the content of your poster:

I. Topic Background (Junior, Intermediate and Senior Entrants)
Provide a general overview of your chosen topic and the corresponding biotech category. Questions to consider: When, where, how and why was this application of biotechnology developed? Have traditional technologies been modified or improved through the use of biotechnology? What are the major challenges to research and scientific

advancement in this area of biotechnology? Is this application of biotechnology still under development--if so, what are the main technical challenges and what do scientists hope to accomplish in the coming years?

II. Technology Timeline (Junior, Intermediate and Senior Entrants)

Create a timeline that illustrates the development of your chosen biotechnology. For each point along the timeline, include a date (may be written as a year or general timeframe), a brief description of major technical milestones and the names of key scientists and engineers that pioneered the work in this biotech field.

III. Biotech Innovators & Economic Impact (Only Intermediate and Senior Entrants)

Identify at least three currently available biotech products and/or services that have resulted from research and development efforts in your topic area. Discuss the roles that specific members of the biotech community (i.e. research universities, biotech companies, government regulatory agencies, etc...) have played in developing each of these products and/or services. Questions to consider: What types of consumers need or use these biotech products? Is there a large market? A small market? Who funded the research and development required to make the biotech product? What are the benefits of using biotech products, relative to conventional products used for the same purpose. What role (if any) does the average consumer/member of the public play in driving technological innovation?

IV. Ethical, Legal and Social Issues (Only Intermediate and Senior Entrants)

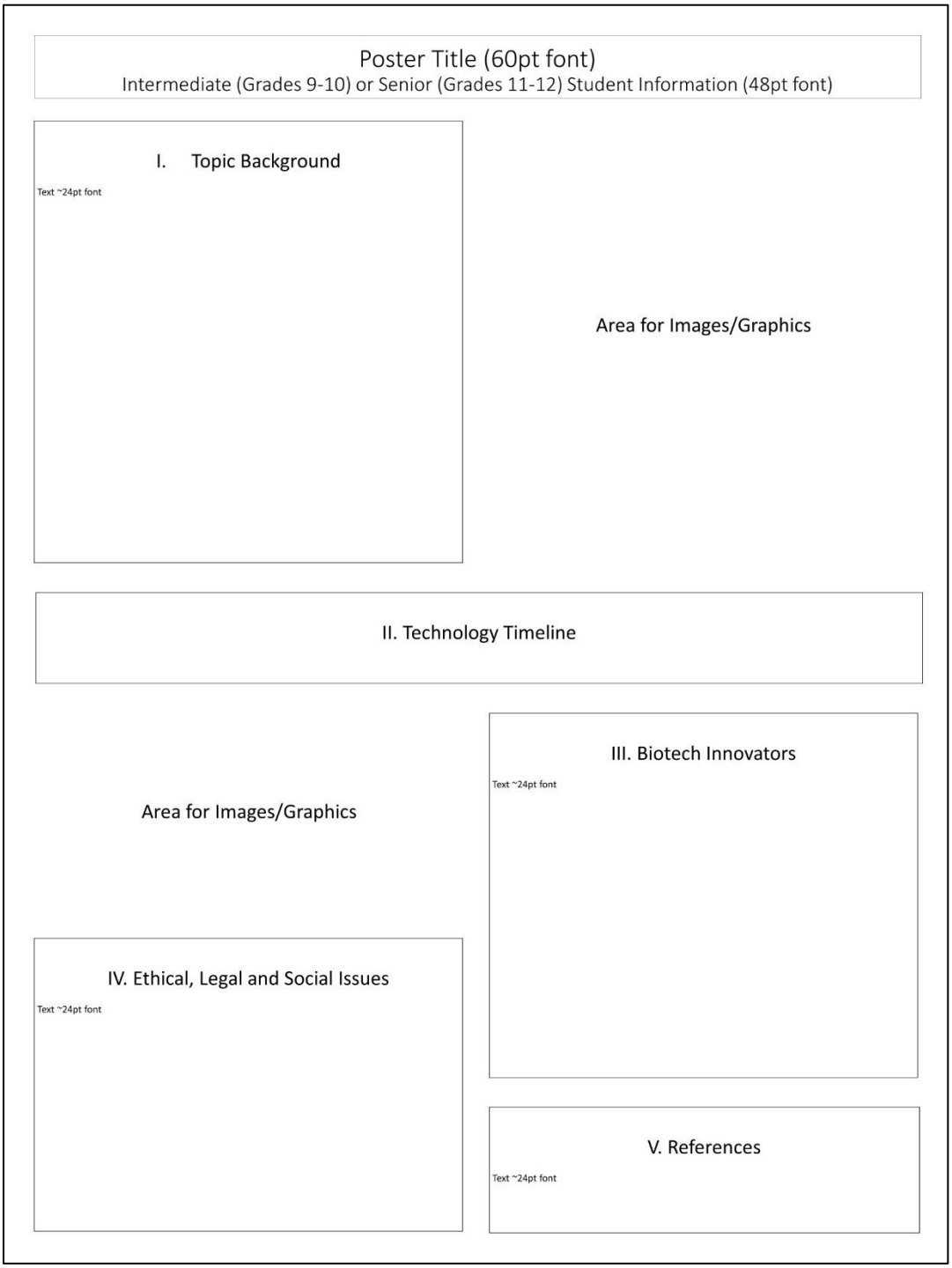
Throughout history, new technologies have often had major impacts on human health and nutrition, daily habits, migration patterns, competition for resources, etc... In some cases, new products and processes are received with suspicion and, in other cases, new ways of "doing" are accepted right away. New technologies are evaluated by society for positive impact, quality and safety, and if they stand up to scrutiny, are usually widely adopted. In biotechnology, we aim to address questions of environmental impact, human safety and intellectual property (ownership of DNA, cells and living materials) before products are released. Biotech research and product development is subject to strict federal regulatory oversight (USDA, EPA, FDA, etc.).

In this section, discuss the impact your biotech topic has had on our society & the world, including related regulatory, ethical or legal issues, and public understanding/perception of biotech. Questions to consider: How does technological innovation in your biotech topic area impact the daily lives of people in the US and in other countries? How do we weigh potential risks against known benefits for new biotech products? Are risks and benefits fairly shared across all members of society? When dealing with biological materials, how do we decide issues of intellectual property and ownership? Which US agencies are involved in regulating this area of biotechnology? Are current ethical norms, regulatory and legal practices sufficient to address societal concerns in your biotech topic area? Why or why not?

V. Related Links & Project References (Junior, Intermediate and Senior Entrants)

Use only factual information from scholarly sources to develop your poster, and clearly indicate which statements are supported by specific references. Use APA, MLA or similar reference format to construct a reference list of sources used in your preliminary research. Cite sources within the body of the poster text. EasyBib is an online citation generator that can help with formatting http://www.easybib.com/style.

Example poster layouts are provided below. Contestants may follow the template or change the shape and orientation of content sections, with the exception of the Poster Title/Student Info (*must stay at the top*) and the Reference List (*must stay at the bottom*). Background colors, text colors and styles, the location of images, photos and artwork may vary between posters. Final .pdf file size should be less than 10MB. Express your inner artist!



Junior (Grades 6-8) entries will have more space for images and graphics and may want to use a larger font (24pt +) within the text areas.