ABOUT YOUR PROJECT

Please answer each of the following questions. If more space is needed, please attach extra pages. Please avoid using names of specific teachers and/or schools in your responses as all grants are blinded for review.

TITLE: **Bringing Anatomy & Fossils to Life: 3D Printed Skulls & Skeletons for Student Exploration**

PROJECT DESCRIPTION

1. Briefly describe the project, please include the project's goals and how they will be attained and measured.

This project seeks to integrate a classroom 3D printer into high school Academic Biology, Honors Biology, Anatomy & Physiology, and AP Biology instruction to create accurate, durable models of vertebrate bones, skulls, organs, and soft-tissue structures. In addition to skeletal elements, the printer will be used to create detailed representations of hearts, brains, kidneys, and complex invertebrate organisms such as jellyfish bodies and tentacles. These physical models will deepen student understanding of comparative anatomy, evolution, adaptation, and structure–function relationships through tactile, inquiry-driven learning. Additionally, producing these models in the classroom ourselves is far more cost-effective than purchasing them from educational supply companies, resulting in substantial savings on curricular materials. In addition, students can actively participate in the 3D printing process, gaining valuable hands-on experience with design, problem-solving, and real-world applications of STEM technology.

A key requirement of the printer is the ability to print in up to 16 distinct colors within a single model, as demonstrated in the 3D images of skulls below. This capability allows the instructor to highlight homologous bones across multiple species, enabling direct comparison of structures such as jaws, cranial bones, limb elements, and vertebrae. Using multicolor prints—similar to the reference diagrams of the Komodo dragon skull, snake skull, and homologous arm structures shown below, where each bone is uniquely color-coded—students can more easily visualize how the same ancestral bone is modified across fish, amphibians, reptiles, birds, and mammals. The multicolor capacity transforms each print into a detailed anatomical map, improving student comprehension of homology, divergence, and evolutionary patterning. In addition, the printer must support dissolvable PVA support material, which is essential for producing complex, multi-part anatomical models with internal cavities and intricate overhangs. PVA supports dissolve cleanly in water, allowing models to be printed intact without manual removal that could damage fine structures or compromise anatomical accuracy, ensuring high-quality instructional models suitable for repeated classroom use. All materials used in this process, including PLA filament and PVA dissolvable supports, are non-toxic and produce no harmful fumes during printing, making them safe for use in a classroom environment.

High-resolution 3D scan files—publicly available through national and international museum collections—will be downloaded and printed as classroom models. These specimens will supplement existing digital 3D resources as well as locally collected bone samples from native wildlife. Students will benefit from the opportunity to handle accurate replicas of rare and fragile specimens, including dinosaur bones, saber-toothed cats, ancient horses, and modern exotic species such as Bengal tigers or aardvarks. These 3D scan files have already been tested, and prototypes have been printed to demonstrate the capability of 3D printers to accomplish accurate printing using these files and this

technique. With the ability to also multicolor labeling of individual bones, as would be possible with this printer setup, these replicas become even more powerful tools for instruction in comparative anatomy and phylogenetics.

Project Goals Include:
• Improving student mastery of key standards involving skeletal structures, organ systems, evolution, and phylogeny.
• Increasing engagement and comprehension through multisensory learning using both hard and soft anatomical models.
• Enhancing comparative anatomy instruction through multicolor prints that clearly identify homologous structures across species.
• Expanding access to authentic specimens that would otherwise remain digital or inaccessible due to rarity, cost, fragility, or museum restrictions.

Progress will be measured through pre- and post-unit assessments, student reflection surveys, and lab-based performance tasks evaluating anatomical comparison, structural analysis, and classification skills.

REFERENCED RESOURCES – PUBLICLY AVAILABLE 3D SCANS
The 3D files used for printing are free, legal, and publicly accessible, ensuring long-term sustainability of the project. Examples include:

Digital 3D Collections and Databases
• **MorphoSource** – A major repository hosting high-resolution scans of vertebrate specimens from museums worldwide, including dinosaurs, mammals, birds, and soft-tissue reconstructions.
https://www.morphosource.org/
• **Vertebres3D** – A French national museum initiative providing detailed 3D models of vertebrates, including skulls, skeletons, and organ systems.
https://www.vertebres3d.fr/
• **CARCAS (Carleton College)** – Offers educational 3D scans of skulls, skeletons, and soft tissues designed specifically for teaching comparative anatomy.
https://www.carleton.edu/carcas/3d-scans/

Articles Demonstrating National Access to 3D Museum Collections
These articles help reviewers understand the scientific movement making this project possible:
• “3D database allows virtual access to animal specimens” (Phys.org)
https://phys.org/news/2025-06-3d-database-virtual-access-animal.html
• “Museums' vertebrate collections go online in 3D” (UC Berkeley VCR Research News)
https://vcresearch.berkeley.edu/news/museums-vertebrate-collections-go-online-3d

These resources ensure that the biology program will have long-term access to a growing library of museum-quality specimens for printing, including multicolor anatomical prints that illuminate homologous structures for evolutionary comparison.

Innovation and Enhancement of Learning

2. Explain what makes this project innovative. How will assist you in meeting the needs of our students? Please be specific and provide data to support the need if possible.

This project is innovative because it harnesses emerging technology to provide students with hands-on access to museum-grade anatomical models. A global effort to digitize vertebrate collections—featured in recent scientific publications—has led to thousands of high-quality 3D scans becoming freely accessible to educators. By integrating these files with a classroom 3D printer, students can hold, rotate, measure, and compare accurate physical replicas that mimic real specimens.

This enhancement is particularly valuable because:

- **Hands-on models support diverse learners**, including tactile, visual, and spatially oriented students.
- **Soft-tissue models** (e.g., hearts, kidneys, jellyfish) allow students to explore structures often too delicate or inaccessible to examine in real life.
- **Research shows** that physical 3D models significantly improve comprehension of spatially complex biological content.
- **Authentic scientific resources** align with inquiry-based learning and NGSS practices such as modeling, structure/function analysis, and using real-world data.

The need for this project is further supported by national trends demonstrating increased digitization of museum collections for educational use—for example, recent reports highlighting online access to vertebrate research archives and 3D model libraries.

AUDIENCE & SUSTAINABILITY

3 (a). Describe the student population targeted by this project. Might this project be repeated with new students in future years? Explain.

The primary audience includes students enrolled in high school Academic Biology, Honors Biology, Anatomy & Physiology, and AP Biology. These courses represent a diverse population with a wide range of academic needs, learning styles, and interests. 3D printed models provide accessible, hands-on experiences that benefit all learners, including students with various learning styles and students with individualized education plans.

The project is highly sustainable. Once printed, the models are durable and reusable year after year. The 3D printer allows ongoing expansion of the classroom model library, supporting future units, new curricula, and additional student projects.

3 (b).How many students will be served?

Approximately **500 students per year**, enrolled in Academic Biology, Honors Biology, Anatomy & Physiology, and AP Biology courses, with continued use benefiting many, many students in future classes annually for decades.

PROJECT EVALUATION

4. How will you evaluate the success of this project? What data, criteria, assessments, surveys, statistics or other measures will you use to assess its impact?

The success of this project will be evaluated using multiple quantitative and qualitative measures:

- Lab performance tasks requiring classification, skeletal comparison, and structural inference using physical models.
- Teacher observational data evaluating student participation, accuracy of anatomical identification, and depth of inquiry.
- Longitudinal analysis of Keystone Biology Exam scores, examining whether increased hands-on anatomical modeling correlates with improved performance on state standards related to body structures, homology, cellular processes, and biological systems.
- Review of AP Biology Exam scores, particularly in units related to evolution, information processing, and organismal biology, to determine whether enhanced spatial and structural understanding translates into higher achievement on national assessments.
- Comparison to prior-year course data to measure improvement in student mastery, engagement, and retention across Biology, Anatomy & Physiology, and AP Biology.

BUDGET

5. Please provide the following information for the items you intend to purchase for this project (please include shipping costs, if applicable). If some of the items you will use to carry out this project are being paid by using funds from sources other than the GEO Grant (i.e., the school district, other grants, etc.) please include these items but enter zero (0) for the amount. This will let the reviewers know that the project is completely sustainable even if the Foundation is not financing the entire budget. Attach additional pages if necessary. Briefly describe any items that may be unfamiliar to the application reviewers.

Please consider your "ideal" request and also what you would be willing to accept if funds are limited. (For example, if 20 items for your classroom is ideal, but you would accept 5 or 10 and have students work in groups please indicate that below.)

	ITEM	UNIT PRICE	TOTAL	TOTAL* (if you will accept less based on funds available)
1	Bambu Lab P2S Combo – 3D printer and AMS https://us.store.bambulab.com/products/p2s?srsltid=AfmBOopt_uyrJhpLI1_fz1wXVura1dk-tDN7_f7UreIAdkmSmAbN2ZBL&id=664977091405410311	$799.00	1	$799.00
2	Bambu Lab AMS 2 Pro – Automatic Material System https://us.store.bambulab.com/products/ams-2-pro?srsltid=AfmBOoopNeXunT9JtdxDbyGK4ECXL4Sw5M_IQapYVngRmHUcNForrzgF&id=580876092018089987	$359.00	3	$718.00
3	Bambu Lab MS 2 Pro – Automatic Material System + Upgrade Kit with Hub https://us.store.bambulab.com/products/ams-2-pro?srsltid=AfmBOoopNeXunT9JtdxDbyGK4ECXL4Sw5M_IQapYVngRmHUcNForrzgF&id=665692645061685252	$454.00	1	$454.00
4	PLA Basic Plastic filament with spool – various colors https://us.store.bambulab.com/products/pla-basic-filament	$22.99	16	$367.84
5	Bambu PVA – filament with spool - support material – easily dissolves in water to remove from printed molds https://us.store.bambulab.com/products/pva	$39.99	4	$159.96
6	Shipping method – 3-10 business days – cart on line indicates it is free	FREE	1	$0.00
		BUDGET TOTAL:		$2,498.80

IMPORTANT NOTE: In order to ensure that projects including technology are priced properly, employees requesting technology or technology related items must submit prices for review to Adam Swinchock, Director of Instructional Technology. **Technology proposals without his signature will not be considered by the committee.** Please also consider allowing for a 2-4% increase in pricing as pre-holiday prices typically increase in the new year when we are purchasing the items.

Required for proposals including technology items:

Signature: _____ Date: _____

Required for proposals including technology items:

Signature: _____ Date: 12/22/25