



MESA DAY CONTEST RULES

2024-2025

(DRAFT)

BIO BREAKTHROUGH (Pilot Competition)

LEVEL:	High School (HS)
DIVISION(S):	Grades 9/10 and 11/12
COMPOSITION OF TEAM:	2-3 students per team
NUMBER OF TEAMS:	Preliminary – Determined by your local MESA center Regional - NO regional event
SPONSORS:	University of California San Francisco University of Southern California

OVERVIEW: Did you know that you can find superpowers in DNA? By using CRISPR technologies, scientists are able to edit and create new DNA. CRISPR has been used to study and treat a wide variety of diseases. In this four-part competition, students will research, design, and present innovative ways to explore the potential of using CRISPR technology to solve real-world problems.

Watch: [CRISPR Explained](#)

SCIENCE JOURNAL: A science journal is a required component of this competition. The purpose of the Science Journal is not only to help guide students through some of the information surrounding the competition, but to also align with the process that scientists follow while completing research. MESA projects are not designed to be completed in a single class period or day, but to be the result of thoughtful research, planning, analysis and evaluation. Keeping a science journal throughout the process will help to keep a designer on track, using a logical progression of planning, in order to develop their project efficiently.

For the Science Journal, **electronic submissions will be required.** Teams should use an electronic portal/application such as Google Docs to keep and maintain a science journal. Access and permission to the science journal is then given to MESA Day staff and judges OR science journal is submitted electronically (e.g., PDF file) for review. **Please check with your local MESA center for the deadline and submission platform to submit your team's science journal for local events.**

- Purpose of Science Journal:
 - Record notes / research for quiz bowl
 - Verify monogenic disease
 - Verify guide RNA is correct (sequence)

MATERIALS:

For the Cas9 CRISPR Model:

- All materials are legal with the exception of food, hazardous materials, or unsafe energy. The use of recycled and repurposed materials is highly encouraged.
- No kits allowed.

The Host Center will provide the following:

- Printouts of Quiz Bowl instructions given at proper time intervals
- Tables to set up physical models

GENERAL RULES FOR QUIZ BOWL / SUPERPOWER:

- 1) Students will be in their predetermined teams of 2-3 scientists. Teams will be given table space away from other teams. Each team should be assigned a number (or choose team names).
- 2) The Quiz Bowl and Superpower Competition rules will be announced by the judges. Both activities will occur simultaneously. Teams may choose which activity they want to complete first.
- 3) Teams will write their team number / name of team members, school site, MESA Center, and grade level on the given *Quiz Bowl Questions Handout*, as well as the *Superpower Competition Puzzle Handout*.
- 4) The quiz bowl consists of 10 questions. All questions will be given to each team and/or projected onto a screen. The superpower portion consists of 3 transcription puzzles. Once prompted, **students will have 60 minutes** to work within their team to record their answers. When students are ready, the start of the competition will be announced. Students may talk within their own teams, but not with other teams. After 60 minutes, judges will collect each team's handouts. The competition will consist of one timed round. Students must show each part of the process to be awarded points.
- 5) Each team can earn 4 points for each correct answer (40 total) for the quiz bowl portion. Each team can earn up to 20 points for each level of the superpower portion (60 total). Only correct answers will receive points.
- 6) If a team completes both tasks in fewer than 60 minutes, they must raise their hand quietly and judges will come to collect their handouts. Once handouts have been collected, teams may not revise responses. Additionally, submission times will be recorded and used in the event of a tie-breaker to create an efficiency score.
- 7) Efficiency score = # correct points / submission time
- 8) Digital media (e.g., photos, video recordings, etc.) will not be accepted for judging purposes.
All judging decisions are final.

GENERAL RULES FOR SCIENCE JOURNAL:

- 1) Teams will be required to submit a science journal with the following requirements:
 - a) The students' full name, grade level, school name and MESA center must be clearly labeled/identified in the Science Journal. A 10% penalty in the score will be assessed for failing to properly label.

- b) TRANSCRIPTION AND TRANSLATION: Describe the processes of transcription and translation:
 - i) What is Transcription?
 - ii) What is Translation?
 - iii) What are the steps of transcription?
 - c) Basic CRISPR Knowledge: In two or three sentences, describe the following
 - i) What is a CRISPR Cas9?
 - ii) What is a monogenic disease?
 - iii) How does scissoring work in a Cas9 protein?
 - d) Define the following scientific terms:
 - i) Gene editing
 - ii) Guide RNA (gRNA)
 - iii) Cas9 Protein
 - e) Sketch of Cas9 with labeled parts (sketches can be hand drawn or computer generated):
 - i) Cas9 protein
 - ii) gRNA
 - iii) PAM sequence
 - iv) Target DNA
 - v) Repair template
 - f) Describe in four or five sentences how CRISPR can be used to impact marginalized communities or communities impacted by a specific disease/disorder
- 2) The science journal must be the original work of the students.

GENERAL RULES FOR MODEL:

- 1) Teams will explore how the use of CRISPR technology can help create a solution for a social issue impacting a particular community.
- 2) Teams must create a Cas9 model that demonstrates their knowledge of CRISPR.
 - a) The design concept should address the following: using the principles of CRISPR, create a Cas9 model that will target a monogenic disease that impacts a community of your choice (i.e., disease chosen **MUST** be monogenic).
- 3) Only non-perishable items may be used for the Cas9 model (no food items).
- 4) The Cas9 model must have a **MINIMUM** width/length of 25cm by 25cm and **MAXIMUM** width/length of 35cm by 35cm with a **HEIGHT** minimum of 25 cm and maximum height of 35cm.
 - a) All materials are legal with the exception of food, hazardous materials, or unsafe energy.
- 5) The Cas9 model must have the following parts **CLEARLY** labeled and displayed on the model:
 - a) **Cas9 Protein:** The enzyme that acts as molecular scissors.
 - b) **Guide RNA (gRNA):** The RNA sequence that guides Cas9 to the specific DNA location.
 - c) **Target DNA:** The DNA sequence to be edited.
 - d) **PAM Sequence:** The short DNA sequence required for Cas9 binding.
 - e) **Repair Template:** The DNA strand used for homology-directed repair.
- 6) Teams are not allowed to use pre-made components for the Cas9 model (i.e., no kits allowed).
- 7) The Cas9 model must be the original work of the students

GENERAL RULES FOR PRESENTATION:

- 1) Teams will explore how the use of CRISPR technology can help create a solution for a social issue impacting a particular community.
- 2) Teams must create a pre-recorded video presentation that demonstrates their knowledge of both

CRISPR and the world.

- 3) Teams must submit presentations in advance of the competition day. **Please check with your local MESA center for the deadline and submission platform to submit your team's presentation for local events.**
- 4) Teams' video presentations should not exceed 5 minutes. The video should include information on the community impacted by the disease, the genetic mutation in question, and an explanation of how their Cas9 technology will correct the mutation.
- 5) The video presentation **MUST** incorporate a visual aid in addition to the Cas9 model. The visual aid can be in the form of slides, animations, diagrams, or any other relevant digital media that enhances the explanation.
 - a) Teams are encouraged to incorporate additional research into their video presentations, particularly regarding the potential impacts of medicine on marginalized communities. This may include potential negative consequences of CRISPR/gene editing.
- 6) Teams must clearly describe the genetic mutation and indicate, within their video, where and how the DNA will be "scissored" or cut using Cas9.
- 8) Teams should ensure that their presentation is engaging, clear, and well-organized.

QUIZ BOWL + SUPERPOWER JUDGING:

- 1) Judges will have the roles of proctors, time keepers, and material distributors.
 - a) *Quiz Bowl and Superpower Competitions can be proctored by one person if necessary.*
- 2) Judges will announce start and end transitions, track submission times, and record scores.
- 3) During the quiz bowl and superpower portion, judges will provide each team with all 10 quiz bowl questions and/or project them on a screen, as well as the 1 transcription puzzle simultaneously. Judges will collect completed handouts when teams indicate that they are finished, or when the 20 minute timer runs out.
- 4) Submission times will be recorded and used in the event of a tie.

SCORING:

- 1) Science Journal = Up to 60 points
- 2) Quiz Bowl = up to 40 points (4 point for each correct answer, round is timed)
- 3) Superpower = up to 60 points (round is timed).
- 4) CRISPR Cas9 Model = up to 50 points per category
- 5) Bio Breakthrough Presentation = Up to 48 points.
- 6) The team with the most cumulative points after all rounds are completed wins.
- 7) Efficiency score = # correct points / submission time

AWARDS:

- Awards will be given per division: Grades 9/10 and Grades 11/12.
- Medals will be awarded for 1st, 2nd, and 3rd place.
- This pilot competition concludes at preliminary events and will not move on to regional events.

ATTACHMENTS/APPENDIX:

- Next Generation Science Standard
- Cas9 Labeling Example
- Score Sheet for Bio Breakthrough

Next Generation Science Standard

The specific Next Generation Science Standard link this competition covers is below:

- [HS-LS1-1 From Molecules to Organisms: Structures and Processes](#)

- 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. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]

Science Concept Resource (Key topics to cover:)

- DNA bases, and which pair together
- RNA bases, and which pair together
- DNA to RNA: “transcription”, and base complementarity
- Start codons
- Stop codons
- RNA to proteins: “translation”
- Amino acids (building blocks of proteins) - names and abbreviations
- Nucleases, specifically the Cas9 nuclease involved in CRISPR
- Cas9 PAM sequence
- Chemical & functional differences between DNA RNA
- Uracil vs. Thymine - Usage differences: single strand (ss) vs. double strand (ds)

Additional related information:

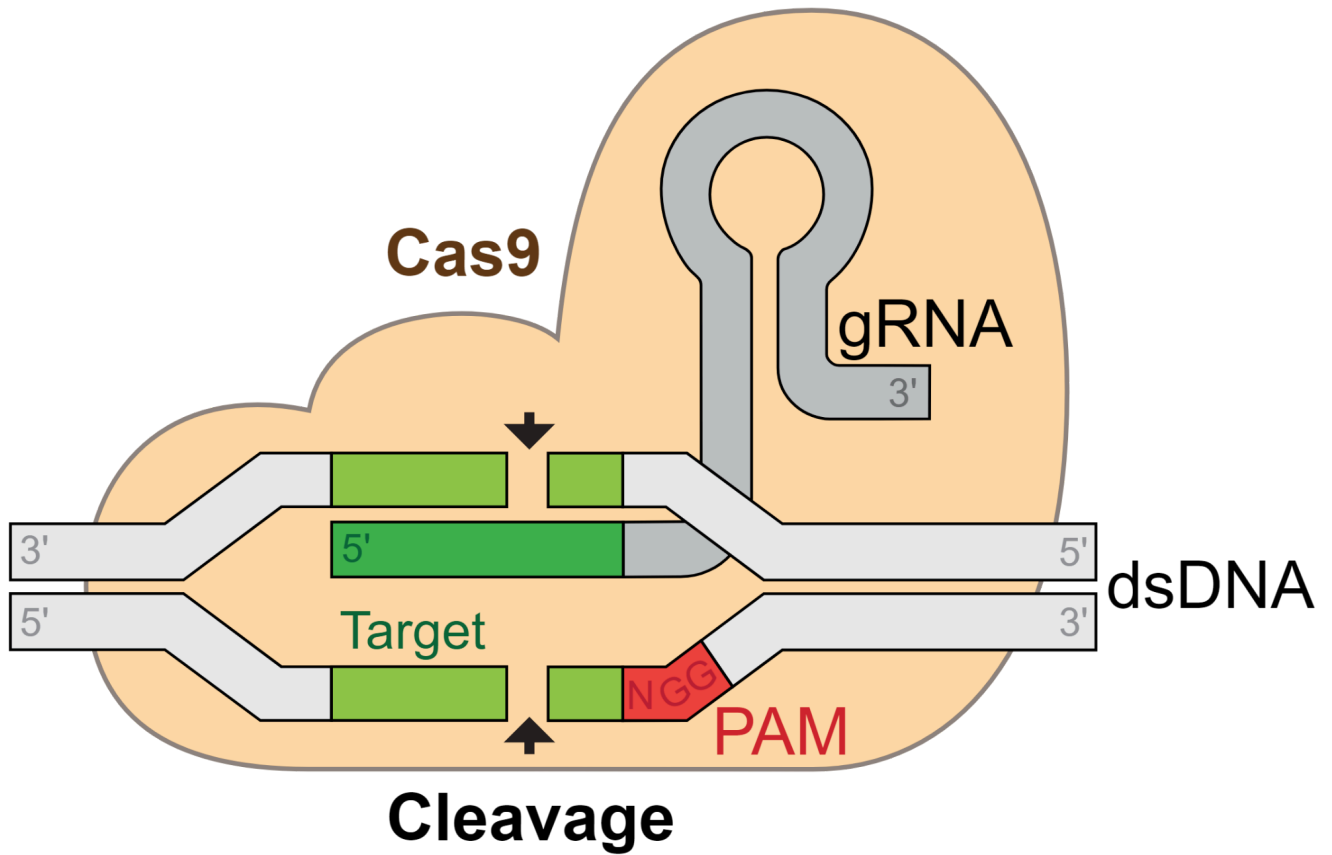
- RNA polymerase
- 5’ to 3’ replication
- Types of DNA mutations: point, frame-shift, missense, silent, etc
- Recombinant DNA
- Plasmids
- Cloning vectors
- Restriction enzymes

Vocabulary

- Genetic code
- Nucleotide
- Nucleoside
- Adenine
- Guanine
- Cytosine
- Thymine
- Uracil

Cas9 Labeling Example: Image of a CRISPR Cas9

This picture functions as a reference for labeling Cas9 models.



SCORE SHEET FOR BIO BREAKTHROUGH

High School - Grade 9/10 and Grades 11/12

Copies of this score sheet will be provided by the MESA Day Host Center.

Student Names: _____ Grade: **9/10** or **11/12** (circle one)

SCHOOL: _____ HS CENTER: _____

SCIENCE JOURNAL						TOTAL
Transcription Definition ____/5	Translation Definition ____/5	Transcription steps defined ____/5	CRISPR Defined ____/5	Monogenetic Defined ____/5	Scissoring Defined ____/5	
Gene Editing Defined ____/5	Guide RNA Defined ____/5	Cas9 Protein Defined ____/5	Cas9 sketch w/ correct labels: ____/5	CRISPR impact in communities: ____/10		

QUIZ BOWL QUESTION SET RUBRIC		
Question 1:	/ 4 pt4	
Question 2:	/ 4 pts	
Question 3:	/ 4 pts	
Question 4:	/ 4 pts	
Question 5:	/ 4 pts	
Question 6:	/ 4 pts	
Question 7:	/ 4 pts	
Question 8:	/ 4 pts	
Question 9:	/ 4 pts	
Question 10:	/ 4 pts	
SUPERPOWER TRANSCRIPTION SET RUBRIC		
Transcription (20 points per level):	/ 60 pts	
Recorded Time For Quiz Bowl + Transcription (/ 60 min)		
TOTAL Question Set + Superpower Transcription (max of 100 pts)		

BIO BREAKTHROUGH PRESENTATION CRITERIA	Excellent (4 points)	Good (3 points)	Fair (2 points)	Needs Improvement (1 point)
Scientific Accuracy:				
Explanation of how CRISPR-Cas9 targets and edits genes is clear and correct	4	3	2	1
Correct identification and understanding of the chosen disease's genetic basis (<u>including disease being monogenetic</u>)	4	3	2	1
Demonstrates an understanding of the potential off-target effects and challenges of CRISPR-Cas9 technology	4	3	2	1
Creativity and Innovation:				
Design is original and creative in design and construction of the model	4	3	2	1
Model Construction:				
Quality of craftsmanship of the visual aid (Cas9 Model)	4	3	2	1
Model is durable and can be easily understood by viewers	4	3	2	1
Presentation:				
Engagement and Impact	4	3	2	1
Collaboration and Teamwork	4	3	2	1
Group Explained the model and its functions clearly	4	3	2	1
Ethical Considerations and potential risks of gene editing solutions are acknowledged and addressed	4	3	2	1
Relevance to Community:				
Clear explanation of the chosen disease's impact on the specified community	4	3	2	1
Potential impact of the proposed gene editing solution on the community	4	3	2	1
COLUMN TOTALS:				
BIO BREAKTHROUGH SCORE:	____ /48			
TIME DEDUCTION: <i>(-10% FOR EVERY MINUTE OVER 5MINS)</i>	- ____%			
TOTAL SCORE: <i>(BIO BREAKTHROUGH MINUS TIME DEDUCTION)</i>	_____			

Cas9 MODEL RUBRIC						TOTAL
MODEL LABELING	Cas9 Protein ____/10	Guide RNA ____/10	Target DNA ____/10	PAM Sequence ____/10	Repair Template ____/10	____/50

OVERALL SCORE
SCIENCE JOURNAL TOTAL(X/60): ____/60
SCIENCE JOURNAL LABELING DEDUCTION(-10%): YES/NO:
Science Journal SUBTOTAL: _____.
PRESENTATION TOTAL: ____/48
Cas9 MODEL SCORE (X/50): ____/50
MODEL LABELING DEDUCTION(-10%): YES/NO:
Model SUBTOTAL: _____.
QUIZ BOWL QUESTION SET TOTAL(X/100 POINTS): ____/100
OVERALL SCORE = science journal + model + question set + presentation (X/220 POINTS): ____/258