

Group 3: Utilizing Multiple LAMP Assays for Ebola Virus Detection

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I. INTRODUCTION

Since its discovery in 1976, the Ebola virus, which belongs to the Filoviridae family, has posed a continuous danger to international health. Many strains of Ebola are quite severe such as Ebola Zaire which has a 90% death rate and is well-known for creating severe and frequently deadly epidemics of hemorrhagic fever[14]. In addition to their immediate health consequences, these epidemics cause havoc with healthcare systems, and instability in local communities, and make it harder for responders to contain the virus [15]. As a result, improved diagnostic instruments are desperately needed to reduce the socioeconomic burden of Ebola epidemics by accelerating detection and response.

In resource-constrained environments where outbreaks are common, conventional diagnostic techniques like polymerase chain reaction (PCR) and enzyme-linked immunosorbent assay (ELISA) have limitations [15]. These approaches are less appropriate for quick and dispersed deployment because they need intricate laboratory processes, lengthy turnaround times, and reliance on well-equipped facilities.

The development of Loop-Mediated Isothermal Amplification (LAMP) assays has brought about a radical change in diagnostic methods in recent years, offering promise for revolutionizing viral detection [3]. LAMP assays overcome the drawbacks of conventional techniques and provide significant benefits. Since LAMP assays operate isothermally, they do not require complex thermal cycling apparatus, which improves their adaptability to point-of-care settings and resource-constrained environments [3]. Additionally, LAMP assays are fast and robust when it comes to nucleic acid amplification, which is essential for the timely identification of the Ebola virus as it allows for sensitive and specific detection of viral genetic material. The promise of LAMP assays is

highlighted by Bonney et al., lies in their versatile format intended for quick and accurate Ebola virus detection [3]. This innovation enables decentralized testing, which improves the ability to contain Ebola epidemics quickly.

Conventional approaches to Ebola virus detection have a number of difficulties, the most notable of which are high turnaround times and sensitivity-specificity problems [15]. Conventional methods, like enzyme-linked immunosorbent assays (ELISA) and polymerase chain reactions (PCR), sometimes need complex laboratory techniques, which causes delays in obtaining diagnostic data. When one considers the dire repercussions of delayed diagnoses, the urgent necessity for accurate and timely diagnosis becomes clear. Beyond the effects on personal health, delayed discovery puts pressure on public health services and hinders efficient response to outbreaks.

James et al. stress the need for better approaches and the shortcomings of current Ebola virus detection procedures. These obstacles not only make it more difficult for afflicted individuals to receive prompt medical care, but they also reduce the overall efficacy of public health initiatives [15]. Therefore, it is critical to solve these issues to improve the ability to quickly detect and contain Ebola epidemics, thereby protecting public and individual health.

As a breakthrough in molecular biology, loop-mediated isothermal amplification (LAMP) tests provide a groundbreaking method for detecting viruses. Because LAMP tests function isothermally, they do not require the intricate temperature cycling that conventional techniques do [3]. The assay's isothermal nature facilitates quick and reliable nucleic acid amplification in addition to streamlining operating needs. Because of these characteristics, LAMP assays are especially useful at point-of-care settings and places with limited resources, where it might be difficult to maintain exact temperature control.

Isothermal procedures are not as adaptable as LAMP tests. LAMP assays provide a flexible framework for the quick detection of infectious agents and may be adjusted to fit various formats[3]. The adaptability of LAMP assays is crucial for Ebola virus detection because it allows for quick test modification and adjustment to improve

diagnostic specificity and sensitivity. Because of their flexibility, LAMP assays can keep up with the ever-changing viral strains and overcome the shortcomings of inflexible diagnostic methods.

Bonney et al. demonstrated that LAMP tests can identify Ebola and provided a framework that can be adjusted to provide accurate findings quickly [3]. Faster detection without sacrificing accuracy is what makes this test so useful; it can replace more time-consuming and error-prone conventional diagnostic procedures. Furthermore, LAMP tests significantly impact the whole field of infectious disease diagnosis, beyond their technological benefits.

The novel idea of combining several assays for Ebola virus detection is put out in an effort to enhance the efficacy of individual LAMP testing. Lin et al. Kurosaki et al., and Wanjala et al. are just a few of the viral contexts where this approach has been successfully applied [16] [7] [17]. The probability of viral strain alterations, which might impact the sensitivity of the diagnosis, justifies the use of several LAMP tests.

A portable LAMP system based on microfluidic chips may be utilized to rapidly and concurrently identify many Ebola virus species, according to research by Lin et al. The methodology benefits greatly from this research, which shows that using numerous tests can improve overall sensitivity and reliability in Ebola virus identification [16]. Multiple LAMP tests can provide a thorough and reliable detection technique by focusing on distinct sections of the viral genome. This reduces the possibility of false negative results and accounts for the genetic diversity of Ebola virus strains.

The project's use of many LAMP assays seeks to provide a synergistic impact by fusing the advantages of each test to provide a more robust and flexible diagnostic platform. This strategy is in line with the way molecular diagnostics is developing, where multiplexing techniques improve the performance of diagnostic tests, particularly when it comes to infectious disorders.

This research goes beyond the lab and has significant ramifications for managing infectious diseases and global health. The study supports early intervention, strong containment methods, and the reduction of epidemics

globally by improving Ebola virus identification by numerous Loop-Mediated Isothermal Amplification (LAMP) tests. This novel strategy presents a possible path forward for the management of infectious diseases and is consistent with the larger goal of improving diagnostic skills.

This research has implications that go beyond the immediate context of Ebola epidemics. Rapid and precise diagnosis, made possible by the use of many LAMP tests, can change the course of infectious illnesses, reducing their reach and worldwide effect. Since LAMP assays can adapt to changing virus strains, public health organizations may quickly execute targeted treatments by using them as important instruments for real-time monitoring and assessment.

The study tries to accomplish particular goals and is guided by previous research (Lin et al.; Kurosaki et al.; Wanjala et al. [16] [7] [17]. These include determining whether it would be feasible to use this strategy in actual situations, confirming the tests against known Ebola virus samples, and refining the settings of the LAMP assay. The process of improving assay conditions includes adjusting experimental parameters to achieve increased sensitivity and specificity, taking into account the findings of Kurosaki et al. and Lin et al. [7] [16]. The dependability of the numerous LAMP assays is established by validation against known samples, which is a crucial step in fostering trust in their practical implementation. Last but not least, Wanjala et al. are consulted for evaluating practicality in the actual world, providing guidance for evaluating feasibility and scalability in various contexts [17].

II. DEVICE DESIGN

Current PCR detection methods offer impressive precision but suffer from slow detection speed. In contrast, the innovative LAMP detection method promises swift detection but comes with limited accuracy [6][7]. Our new device design, on the other hand, combines high accuracy with rapid detection by simultaneously targeting multiple genes using the LAMP technique. Specifically, we focus on the nucleoprotein (NP) and glycoprotein (GP) gene regions of the Ebola virus. Utilizing Primer Explorer V5, a specialized primer design software, we successfully identified the desired nucleotide sequences for the required

primers (F3, B3, FIP, BIP, Loop F, Loop B) to effectively target the designated regions within the Ebola virus.

To identify the amplified sequences in LAMP, we will divide the LAMP detection into two separate reactions: one for amplifying the NP region and the other for amplifying the GP region. We will employ a fluorescent intercalating dye, propidium iodide, for both reactions to enable optical detection. Propidium iodide is chosen based on its affordability with a price of \$37 per 10 mg from HelloBio which claims its effectiveness at a dilution of 1 µg/mL. In contrast, other fluorescent dyes like SYBR green are significantly more expensive at \$412 for a 500 µL bottle from Thermo Fisher. Under UVA (315-400 nm) light [1], Propidium iodide appears bright red if it detects the amplified DNA sequence, otherwise it appears a dull red [8].

Fig 1. Primer nucleotide sequences for targeting Nucleoprotein (NP) gene in Ebola which were generated through Primer Explorer V5 [2].

Primer	Gene Sequence
F3	GTGGCGCAGTCAAGTATT
B3	GTATCAGTCCTTGCTCTGC
FIP	TGGCAGCAAGTGTCTCTTAATGT GAAGCGTGATGGAGTGAAG
BIP	GCCGGAAGAGGAGACAAGTCTT GGAAGGAATAGACTTGC
Loop F	GCAGCAATTCCTCAAGGC
Loop B	AAGCTAATGCCGGTCAGTT

Fig 2. Primer nucleotide sequences for targeting Glycoprotein (GP) gene in Ebola which were generated through Primer Explorer V5 [3].

Primer	Gene Sequence
F3	GACGGGAGTGAGTGTCTACC
B3	AGCTTGGGGCAGTATCAGAA
FIP	GGCACATGGTCCCGTTCCTGATTT TTAGCGCCAGACGGGATTCG
BIP	TGCCTTCCACAAAGAGGGTGCTTT TTGCGAAAGTCGTTCTCGGT

Loop F	GCACATACCGGCACC
Loop B	CTTCCTGTATGATCGACTTGCTTC

Our device design incorporates two separate LAMP reactions to enhance accuracy. In one of these reactions, six designated primers are utilized to target the NP region of the Ebola virus, while in the other reaction, six designated primers target the GP region of the virus. The required primers, buffers, polymerases, and samples are carefully placed into the two test tubes. Upon pressing the "Start" button, a signal is transmitted to the memory board, initiating the reaction. Beneath the test tubes, there is a heat block which, upon pressing the "Start" button, activates and maintains the temperature of the test tubes at 60°C for 30 minutes. This temperature is optimal for DNA amplification [9][10][11]. The chosen duration of 30 minutes is deliberate, as reducing the reaction time too much may not allow for sufficient DNA amplification, potentially leading to false negative results [9][10]. Once the 30-minute interval has elapsed, a signal is sent to the Arduino, causing the heating block to shut off. Subsequently, the Arduino sends a signal to illuminate the "done" signal, which appears as a bright green indicator when the reaction is complete. This serves as a notification to the user to add propidium iodide to each of the test tubes. Upon pressing the "Analyze" button, the Arduino activates the UV light source as well as the photodiodes. Photodiodes are semiconductor devices capable of converting light into an electrical current and are used to measure the brightness of the emitted light. Depending on the intensity of the light emitted, each photodiode will either transmit a positive signal (in the presence of intense, bright red light) or a negative signal (in the presence of dull, dim red light) for each LAMP reaction. If the Arduino receives positive signals from both photodiodes, it will output an overall positive signal, causing the positive signal indicator on the machine to illuminate brightly green. Conversely, if the Arduino receives negative signals from either photodiode, it will output an overall negative signal, causing the negative signal indicator on the machine to illuminate brightly green.

Fig 3. CAD diagram of inner workings of device.

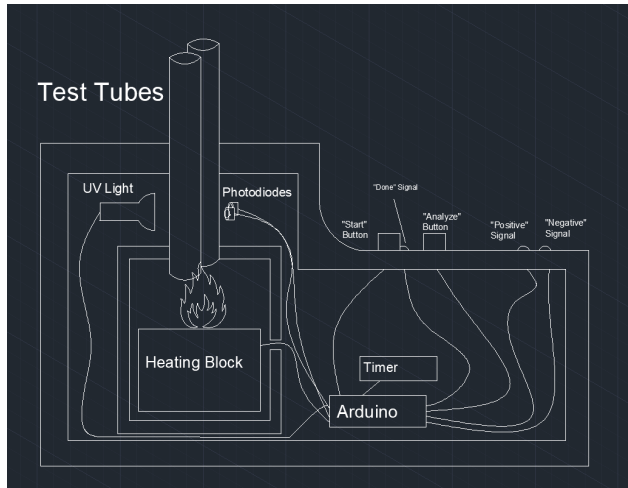
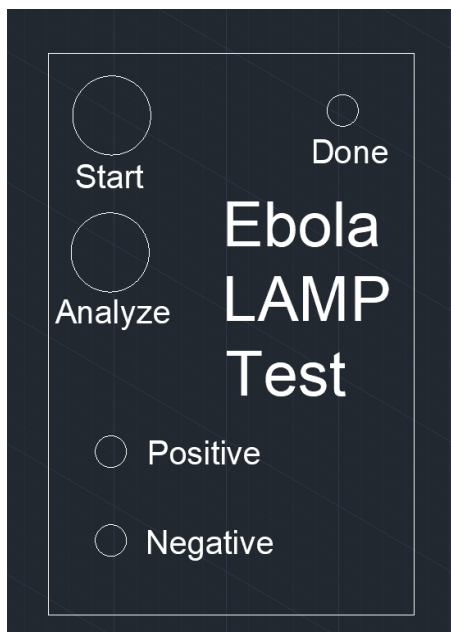


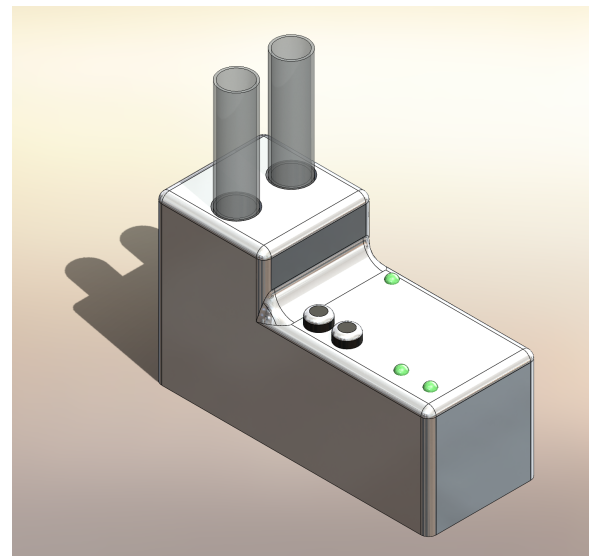
Fig 4. CAD diagram of control panel of device.



The device is constructed using cost-effective aluminum alloy 3003, which offers a balance of moderate strength and excellent durability. A 48" x 48" x 0.032" sheet of aluminum alloy 3003, priced at \$72.96 (available from Metals Depot), provides sufficient material for building the device. With a melting point of 643°C, it exhibits high temperature resistance, ensuring it remains unaffected by heat [4]. As a result, the device can be used repeatedly. Furthermore, aluminum alloy 3003 boasts a relatively low density of 0.0986 lb/in³, making the device lightweight and easily transportable [4]. This feature is particularly crucial for applications in remote or rural areas. The device's user-friendly design and clear instructions make it suitable for universal use, allowing anyone to operate it effectively.

The estimated cost of constructing the device, excluding primers or buffers, is approximately \$205. After the device's construction, the cost of running each test, including reagents (primers, buffers, polymerases), and energy consumption, amounts to approximately \$15. It's worth noting that bulk purchases may result in even lower costs, especially for larger-scale production. The current market average of a one-time cost of an Ebola test is approximately \$100, although this price may vary depending on the region and accessibility factors [5].

Fig 5. 3D CAD model of device design in Solidworks.



While our device may have a higher initial cost, its affordability over time due to repeatability makes it significantly more cost-effective than many existing products on the market. Moreover, our device offers a unique advantage by combining high accuracy with rapid detection, a feature that sets it apart from other testing kits currently available.

III. KEY CHALLENGES

One significant challenge of the device is the rigorous tests to get the device regulatory approval. To understand how lengthy the approval process is, one must account for the efficiency of the device and the harm it can cause. Although our device does not cause harm to the body, possible false positives can lead to unnecessary costly, and risky treatment. Meanwhile, false negatives can lead to lethal health risks. Additionally, Ebola is a very serious and dangerous virus causing the process to be extremely lengthy. This will necessitate a multitude of tests to prove

the efficiency of our product. These tests will also require the collection of patient data, which brings up many ethical issues such as privacy concerns. However, if the tests find that the accuracy of our device is comparable to other FDA-approved devices that diagnose the same disease, the approval process can be sped up. The accuracy that our device needs in order for the FDA to approve us is that our sensitivity must be or greater than 95% and the specificity must be 99% or greater[12].

Another problem that can occur is accessibility. Because the device is reusable, the only necessity for subsequent uses is a new set of primers for the two proteins. This however could be a troubling task because these primers need to be delivered with the utmost caution, or else the test's accuracy will be affected. This will cause the delivery of these primers to be pretty expensive, particularly in remote areas, making it hard for everyone to have access to them. Especially for the targeted audience who are in places like the Democratic Republic of the Congo where Ebola is prominent making it harder for the people there to have access to the full potential of the device. One solution would be to use the healthcare facilities in Africa to make delivery not needed, but this will only help a few. According to a Stanford Business Review, less than 50% of Africans have access to modern healthcare facilities and many African countries only spend 10% of their GDP on healthcare[13]. So we decided that collaborating with distributors experienced in transporting biological materials to remote areas is the way to go. Having a partnership will allow us to negotiate to keep a cost-effective price for the primers and a cost-effective way to transport them. Additionally, we can have a test kit in each village/city/town so delivery would only need to be directed to that place, optimizing the cost for individuals.

IV. ETHICAL ISSUES

As with any medical device, there are a myriad of ethical implications to consider regarding the reality of implementing such a device. The first of these concerns is data privacy and security. Because this ebola virus detection technique involves collecting genetic information, it is imperative that researchers and clinicians work to protect that information. A breach of data security could, for example, result in individuals being discriminated against based on their diagnosis, or their data could be used with other malicious implications. Clearly, this would present a detriment to affected patients, but a further reaching implication would be the probable distrust

towards the scientific community. Such distrust could pose challenges in patient cooperation or implementation of the device in the medical field. There are steps that can be taken to minimize these risks: in the case of research, anonymizing patient data as well as encrypting data storage could help protect patient information. It is also crucial to obtain informed consent from the patients beforehand so they understand the potential risks; in emergent cases such as an ebola virus outbreak, this could get lost in the shuffle—however it should remain a priority to clearly explain to patients the process of the test and the potential risks in terms that they can understand. Data security is an important ethical issue because it hinges on individuals' right to autonomy and privacy, as well as the importance of maintaining trust within the scientific community.

Another ethical concern with this device is equity and prioritizing providing access to underserved populations. Fortunately, this device design is already aimed to address such concerns: since LAMP does not require thermocyclers, it is generally easier to transport in addition to being cheaper than tests relying on other DNA amplification methods such as PCR. Therefore the use of LAMP in ebola virus detection makes it much easier to set up mobile testing units to provide point-of-care testing, making it easier for example for patients in rural or remote areas to receive testing since they do not have to travel long distances in order to access care. Further improvements such as making the device more compact and finding other ways to reduce associated costs down the line could additionally increase accessibility by lessening the cost barrier.

V. GENERATIVE AI

We asked AI to create a novel device to increase the accuracy of LAMP detection for Ebola. The AI designed a device called "EbolaGuard Precision Probe." This device introduces advanced biosensor technology that significantly improves the sensitivity and specificity of LAMP detection. The device is made to be portable with a user-friendly interface and primer cartridge system allowing it to be easily deployed. However, for data collection, the device must be connected to the Internet and inserted in an AI for accurate results.

When comparing our device to the AI-designed "EbolaGuard Precision Probe," there are both similarities and differences. Both devices are reusable and use a fluorescent intercalating dye for optical detection. But, our

device uses propidium iodide, chosen for its cost-effectiveness, while the EbolaGuard Precision Probe uses an advanced biosensor technology for enhanced sensitivity and specificity. Another difference is that our device uses two reactions: one for the NP protein and another for the GP protein. Meanwhile the AI device uses multiplexing to target multiple genes in one reaction. Nonetheless, multiplexing adds considerable complexity, necessitating the use of significantly more resources to identify optimal primers that do not interfere with one another. Furthermore, an intercalating dye would make little sense for multiplexing with LAMP. As intercalating dyes are non-specific, it would be hard to differentiate between results where one gene and another where multiple genes are detected [14]. Instead, it would be better if the AI-design device implemented fluorescence probe-based primers such as FAM; however, this creates a whole new myriad of problems, including cost and difficulty [15][16].

As a result, our device design is a better choice than the AI device. Not only is our device cheaper and more easily distributable, but it also does not lack a fundamental issue in identifying results. However, the AI device introduces a new way in increasing accuracy and specificity. The novelty of the AI device is superb; however, its usage of a flawed fluorescent dye with its multiplexing method means it will get an 18/20 for the device design.

VI. CONCLUSION

To conclude, the threat of the Ebola virus has underscored society's need for effective diagnostic tools that improve speed and accuracy of detection—especially vital in impoverished environments where outbreaks are likely to occur. Conventional diagnostic techniques like PCR and ELISA are limited in their complexity and speed, and they may depend on resource availability. In contrast, Loop-Mediated Isothermal Amplification (LAMP) assays provide a viable alternative by addressing PCR's and ELISA's shortcomings: it operates isothermally and is highly adaptable to point-of-care settings and resource-constrained environments.

The approach of employing multiple LAMP assays for Ebola virus detection targets different gene regions to enhance sensitivity and reliability. The device design aims to combine accuracy, speed, and portability, and cost-effective materials like aluminum alloys ensure higher accessibility in remote areas. While the initial cost of constructing the device may be high, it can be used multiple times: a great alternative to existing testing kits. However, the proposed device design does come with its

own set of challenges like a complicated regulatory approval process and precise primer delivery to ensure accuracy. Additionally, ethical concerns like data privacy and informed consent must be addressed in the tool's implementation.

Contrastingly, the generative AI-designed device, “EbolaGuard Precision Probe,” utilizes advanced biosensor technology for high sensitivity and specificity. Its reliance on complex multiplexing and potentially flawed fluorescent dyes, however, may cause problems in its implementation: it may not be effective in real life.

To conclude, the research and device design presented have high potential to contribute to current efforts to improve Ebola virus detection. Provided that the key challenges and ethical issues are addressed, the device presented in the paper can impact the field of infectious disease management as a whole. It is highly important that the scientific community pursues similar effective and innovative solutions to disease-related problems to further global health.

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APPENDIX I.

October 25, 2023, 5pm:

- Participants: Swathi, Emma, Christine, Ethan, Tayson
- Agenda: choose project topic and assess what areas of the project each member would like to contribute to
- Chose prenatal genetic testing as our topic, focus on time and cost
- TBD: Each person picks a paper about prenatal genetic testing & performs an evaluation of the device
 - Cost-benefit analysis: what are its shortcomings, benefits, etc.?
 - Brainstorm what possible improvements we can make to the device (Come up with a list of 2-3)
 - Link papers in the drive with your name (everyone needs different ones)
- General split into:
 - Swathi: Device Design
 - Emma: Key Challenges/ Ethical Issues
 - Christine: Intro/ Conclusion /Key Challenges
 - Tayson: Intro/ Conclusion
 - Ethan: Device Design
- Final Project Due: Nov 15
 - Sunday: Finish paper analysis & put pdf of your analysis into Drive
 - Wednesday: Decide the device we want to do & have an improvement
 - Firmly split up all the tasks
 - In discussion Wednesday, create an outline of the project and debate on improvements
- Filled out contract
- Potential device improvements:
 - Cost: current cost is ~ \$1600, not provided/covered by insurance
 - Time: 7-10 days for turnaround, Importance for time: for abortions before term limit
 - Currently uses qf-PCR

November 1, 2023, 5pm:

- Participants: Swathi, Emma, Christine, Ethan, Tayson
- Agenda: Decide what improvement to make within prenatal genetic testing
- Discussed potential device improvements for Chromosomal Microarray Analysis for prenatal testing

November 2, 2023, 12pm:

- Participants: Swathi, Emma, Christine, Ethan, Tayson
- Agenda: Assess feasibility of prior ideas, and pivot the project direction as necessary. Establish individual responsibilities for next week.
- Decided to change focus of project to ebola virus detection
- Device proposal: using multiple LAMP assays for rapid/accurate ebola virus detection
- Split up presentation slides:
 - Christine: Intro
 - Ethan: Device Design
 - Tayson: Key Challenges
 - Emma: Ethical Issues
 - Swathi: Conclusion

Weeks of November 5 and 12:

- Communicated electronically
- Action items: Complete independent portions of the presentation.

Week of November 12, 2023:

- Communicated electronically
- Action items: Final presentation and contribute to feedback for other groups' presentations.

November 29, 2023, 5pm:

- Participants: Swathi, Emma, Christine, Ethan, Tayson
- Agenda: Check in about final paper responsibilities and timeline
- Action items: Finish writing our own part by next Tue (Dec 5) / If necessary, have a zoom meeting on Wed (Dec 6) / Finish editing by (Dec 9).

Outside of organized meeting times, the group communicated digitally in order to adhere to deadlines, discuss project content, and touch base regarding individual and group responsibilities.

APPENDIX II.

Personal goals statements:

Swathi Badrinarayanan

In my time at Berkeley, I wish to develop an engineering mindset when I problem-solve. To elaborate, I hope not to give up when I encounter an issue that I find difficult to fix- something I currently struggle with. Additionally, I wish to delve into different kinds of engineering like mechanical engineering and energy engineering. I believe

that interdisciplinary engineering is a way for me to become a life-long learner.

During the final project, I wish to work on my abilities to close-read papers and to design devices. Close-reading papers is a useful skill, which will be useful in developing both my knowledge in bioengineering and generally. Designing devices or making improvements to devices by learning CAD design and designing schematics will also help me in my future engineering endeavors.

In the project, I played the role of the coordinator as well as bringing new information to the table. In this way, I was proactive while improving my organizational skills. For our slides, I worked on further improvements and on overall coordination. For this paper, I wrote the conclusion and edited the rest as best I could.

Additionally, I would be able to explore new topics and suggest improvements, which is part of engineering (we must keep growing). I also like getting input from other people and often ask the group for their opinions.

Finally, these goals are important to me for my growth as an engineer and as a person. By constantly learning, I will improve my skills and ultimately, the product that I produce. Additionally, I can become more empathetic as a person by designing specific devices to target specific groups, a value that I think is of great importance.

Emma Horne

During my time at Berkeley, I want to develop a myriad of problem-solving skills I can take with me into industry to tackle issues I am passionate about. Problem solving is, after all, the heart of engineering, through scientific and mathematical avenues. This can include developing a specific mindset or approach to problem solving, hard skills such as learning coding languages, and further developing soft skills such as effective communication, collaboration, and leadership. During this final project, I look forward to learning how to write and format a scientific paper following IEEE format. This will help me be more comfortable reading research papers in the future, as well as provide a valuable introduction should I engage in publishable research later in my career. My group agreed during week 1 not to box ourselves into any specific roles—important I think because it can be easy for social dynamics such as gender roles to impact a selection of roles so early in the process—but rather to approach tasks together and assume equal responsibilities throughout the progression of the project. Also, many of the roles outlined in week 1 should be held by all group members during a productive, joint discussion; for example, I see myself holding the role of opinion-seeker and giver,

elaborator, and coordinator. These goals are important to my growth as an engineer and as a person because problem solving, team work, and conducting productive dialogue are abilities which will serve me well in any area of life. In the final project, I took on the task of writing about ethical concerns raised by our device. While learning about the technical aspects of our design and other aspects of introducing technology to the medical field (such as certain FDA pathways to be followed), I appreciated the opportunity to consider the ethical implications such a device might raise because, after all, our scientific discoveries affect real people with complex issues; centering humanity at the forefront of innovation is of the utmost importance in any engineering application.

Christine Yuna Jang

As a person dedicated to personal development and an aspirant engineer, I have a set of goals that are very important to me. These goals go beyond simple scholastic exercises; they serve as the cornerstones that inspire my love of bioengineering and mold my future goals. First and foremost, my development as an engineer depends on my pursuit of engineering competence through the assignments I have been completing. It helps me to apply concepts from theory to practical situations, which broadens my perspective on bioengineering. Furthermore, it builds problem-solving abilities, which are valuable to me in both my personal and professional efforts and are required for conquering challenges.

Additionally, I believe that critical thinking is a crucial skill. My assignments for the course force me to assess current designs, point out their advantages and disadvantages, and develop my capacity for solution analysis. I am able to make wise judgments in my daily life because of these transferable critical thinking abilities. Projects in bioengineering are multidisciplinary, which promotes cooperation with specialists in other domains. My interpersonal and communication skills are improved via this partnership, which is beneficial for my profession as well as my personal connections. I also find that ethical issues in bioengineering are important, and solving ethical conundrums makes me more conscious of my moral principles.

Furthermore, it's critical to promote creativity and innovation. My creative thinking is put to the test when working on bioengineering projects, and this inventive thinking helps me both personally and professionally in my engineering pursuits. In the end, it makes me happy to know that my work in bioengineering is making the world a better place. My sense of purpose in life is strengthened

by knowing that my efforts have a positive impact on people's health and happiness.

Ethan Schein

At Berkeley, my primary goal is to acquire the technical skills required for my major, bioengineering, while also recognizing the importance of diversifying my skill set. I am eager to develop proficiency in various areas, such as CAM programming, ladder programming, and wet lab techniques like spectrophotometry, gel electrophoresis, and assays. My objective is to become confident and proficient in laboratory work, ensuring that I can efficiently execute tasks within this setting.

Regarding our final project, I am taking on the role of overseeing the design aspects of the device. I aim to enhance my CAD programming skills, specifically focusing on improving my understanding of Solidworks's contour and hole wizard tools. Additionally, I'm eager to gain deeper insights into contemporary DNA amplification techniques. During the final project, I designed the device: from how it works, to designing the primers, what genes it would target, and how the design actually functions. Furthermore, I created the various CAD drawings of the design through Solidworks and AutoCAD. Finally, I revised various other parts of the project, especially the Generative AI. During the project, I tried not to be overly controlling in the group project, as I value fostering an environment where each member can explore, learn, and make meaningful contributions to our shared objectives. Ultimately, during my time at Berkeley, I aspire to connect with new individuals, engage in productive academic collaborations, expand my knowledge base, and acquire the essential skills necessary for success in my chosen field.

Tayson Tran

During my time at Berkeley, I want to develop as an engineer by working on my social skills, work ethic, and learning as much as possible. I want to come out of Berkeley as a reliable person who does good. During the project, I want to learn more about teamwork. I am a very shy person so I always have found team projects a bit hard to do so this is a great opportunity to force me out of my comfort zone. Some skills I want to improve on during this project are my public speaking skills and probably my technical writing. Both that I believe I need a lot of work on. The roles I want to play with my team are the Information giver and seeker, and Opinion seeker and giver. These roles I think are the most comfortable roles for me in a group project setting. However, I want to get out of my comfort zone and also try to focus on the role of

the Energizer, but I feel like it does not match who I am personality-wise so it will be very hard.

These goals are important to me because they connect to my values of wanting to have a successful career, knowledge, and family. Working on all these skills listed will allow me to develop as a person and help me find a high-paying job, allowing me to give back to my family.

For our final project, I contributed to the key challenges and generative AI. The role that I believed that I played the most was Opinion and Information seeker. When I was confused about certain aspects of the device I would ask questions in the group chat.

APPENDIX III.

Contract for BioE 10 Final Project

We, the undersigned, have agreed to work together on a final research project. Each of us understands that we are jointly responsible for the final product as a whole, and though we may split the work up amongst ourselves, all of us will be expected to comprehend and be able to explain any part of the final product.

Each of us understands that we will personally be responsible to put in approximately 4-6 hours of work per week into the final project. If any of us are unable to do so due to **unforeseen** and **extraordinary** circumstances, we know that it is *our* responsibility to inform the instructor *as soon as possible* so that alternate arrangements can be made. We understand that the instructor reserves the right to assign different grades to various members of the group if the workload is not distributed and carried out evenly.

Each of us promise to adhere to the Berkeley Code of Student Conduct (<http://students.berkeley.edu/uga/conduct.asp>) and understand that plagiarism of any kind will not be tolerated.

Brief description of project:

Utilizing multiple LAMP assays for rapid and accurate Ebola virus detection.

Name (printed): Emma Horne Signature: Emma Horne

Name (printed): Sinath Bodinayagamuwa Signature: Sinath

Name (printed): Christine Yuna Jung Signature: Christine Yuna Jung

Name (printed): Tayson Tran Signature: Tayson

Name (printed): Ethan Schein Signature: Ethan