Calvin College Engineering Department

Senior Design Project Business Plan

Muscle Glue

Team 20

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Business 357
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1. Executive Summary

Muscle Glue is a startup adhesive manufacturer whose main product is a low-cost, high-strength, mussel-based surgical adhesive produced via recombinant method. The advantage of a mussel-based adhesive over the more commonplace petroleum-based versions are that the mussel-based version can provide strong adhesion even in wet environments, giving it great potential as a surgical glue.

From market research, based on the assumption that the adhesive is used in 5% of target surgery types, the plant will produce 1,640 kg of adhesive per year.

2. Industry Background and Overview

Mussel inspired adhesives have sundry potential applications in today’s market. An adhesive capable of mimicking the adhesive properties of mussel adhesive would be capable of providing strong adhesive strength under wet conditions—a capability that is currently unmatched in the adhesives industry. Applications for such an adhesive would include a wide range of medical applications including wound healing, tissue engineering, dental composites, and orthopedic cements. This will be the target market for this Muscle Glue’s product.

Another potential market for mussel-based adhesive would be the current petroleum-based adhesive market. Mussels are capable of attaching to materials that are known for being impervious to adhesives such as poly(tetrafluoroethylene). A biomimetic adhesive would have higher adhesion strength and would be much more environmentally friendly than current petroleum-based alternatives.
2.1 Brief overview of the strategies that will make the firm a success

The product will be marketed on a basis of differentiation. The primary goal of the product being to minimize or eliminate the use of sutures and other traditional surgical closures. The product will vary from other similar products in that the adhesion strength will be higher and the cost to the consumer will be less than that of current mussel-extracted adhesives on the market. The product will be marketed as an adhesive as opposed to a sealant.

2.2 Technical experience of key people

Paul Freeman

Paul is a double major in biochemistry and chemical engineering. He spent last summer researching MRE combustion emissions for the Environment Protection Agency. Paul is very interested in the medical applications of this adhesive and plans to enter a PhD/ MD program after graduation. Paul takes the role of resident technology guru and comedic relief for our the company. His eye for the aesthetic is also an invaluable asset.

Michael Dornbush

Major in chemical engineering and a focus on business practices. Mike had an internship at Vertellus Specialties, Inc. in Zeeland, MI working with experienced engineers to reduce nitrogen usage, troubleshoot, and increase data-locating efficiency. Mike contributes his knowledge of business and strong intuitive understanding of engineering principles to the company.

Michael VandenBerg

Double major in biochemistry and chemical engineering. Michael is very interested in nanotechnology and plans to do graduate level work in that field after graduation from Calvin.
He spent last summer researching fluorescence of woody material extracts from local trees for Calvin College. His biochemistry major and research experience makes him an asset to the team in his understanding of the chemical mechanism of the adhesive.

Kimberly Braybrook

Kimberly is double majoring in biochemistry and chemical engineering. She spent last summer in the research and development lab at an adhesive and sealant company, Seal Bond. With her organizational skills and her knowledge of the adhesives industry, Kim brings the background knowledge needed for a successful project.

2.3 Brief statement of the financial request and how the money will be used

For this project, an initial investment of $10 million will be required to supplement planned loans and cover the capital and startup costs associated with the building, equipment, payments, and final legal steps until product sales begin to generate revenue.

3. Vision and Mission Statement

3.1 Entrepreneur's vision for the company

Muscle Glue’s vision is to produce a relatively low-cost, high-strength adhesive for surgery and potentially other applications. This adhesive will be produced via recombinant methods in order to decrease cost to the consumer and, therefore, make the product more financially competitive. Producing the adhesive using mussel foot proteins similar to those naturally produced by the Mediterranean mussel (*Mytilus galloprovincialis*) will give the adhesive higher strength than its competitors.
3.2 Values and principles on which the business stands

Mussel Glue strives to produce a surgical adhesive that is congruent with three guiding design norms: caring, delightful harmony, and stewardship. Caring motivates the Muscle Glue to continually improve its methods of production in order to decrease the cost of the product to the consumer. Producing a surgical adhesive that is more financially attainable for a larger number of people allows more people to benefit from such an adhesive. Muscle Glue’s R&D studies the adhesive proteins of Mediterranean mussel (*Mytilus galloprovincialis*) as a basis for the design of the product. Such use of nature as a model for design displays delightful harmony. Since current methods of producing similar adhesive involve harvesting 10,000 mussels to produce 1 g of adhesive, producing an adhesive through methods that better use the available resources fits in with Muscle Glue’s goal of stewardship.

4. Industry Profile and Overview

4.1 Industry background and overview

The market for mussel-based adhesives is new and there is little competition. The blue mussel adhesive on the market is Cell-Tak™ by Corning®. This is priced at $200 / mg and is extracted from the mussels.

In the market for surgical glues, the main competitor is BioGlue® by CryoLife®. Other products include CoSeal, Tisseel, Crosseal, Duraseal, and TissuGlu. BioGlue and TissuGlu are the only ones sold specifically as adhesives with the potential to work alone without assistance from sutures. BioGlue advises this usage only in cases where use of traditional repair techniques is impossible. TissuGlu only recently (February 2015) passed FDA approval and is being sold
solely for the purpose of abdominoplasty. The other four surgical glues on the market currently are advertised more as sealants to be applied over sutures to eliminate fluid and blood loss. The range of prices for these products is approximately $75 to $150 per mL.

In terms of adhesion strength, when tested attaching periosteum to bone, BioGlue® showed a shear strength of 45.9 kPa. BioGlue® has a Young’s Modulus of 3,122.04 +/- 1639.68 kPa, which is much stiffer than any of the sealant-purposed glues. In testing, a year after BioGlue was introduced to a goat, traces were still detectable, this showed that the adhesive does not break down quickly in vivo. Preliminary biocompatibility research shows that it does not have major negative effects, as should be expected from the premier surgical glue on the market.

One major advantage of BioGlue as listed on the CryoLife website is that it develops green strength in 20 - 30 seconds and is fully cured within 20 minutes.

In order to compete with BioGlue, Muscle Glue’s adhesive has high strength and biocompatibility, and improves on BioGlue’s stiffness. These qualities are expected to offset the longer curing time that the mussel-based adhesive will require.

4.2 Major customer groups

Muscle Glue’s main goal is to produce a high-strength, biodegradable adhesive that can be used in surgical applications. However, other potential future applications include producing a similar mussel-based, high-strength adhesive as an alternative to petroleum-based adhesives.

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Such an adhesive would be much more environmentally friendly than current products which are produced using non-renewable petroleum.

4.2.1 Medical adhesive customers

Healthcare Providers

Healthcare providers are Muscle Glue’s target market. Muscle Glue’s high strength and biodegradability make it a viable alternative to current surgical adhesives. That fact that it is produced via recombinant methods makes Muscle Glue the financially better option in surgical adhesives.

At-home users

Continuous process improvement will eventually lower the market price of Muscle Glue so it can be sold over-the-counter at the local pharmacy. At home, Muscle Glue can be used to save parents a trip to the emergency room as they can simply use Muscle Glue’s adhesive to close their child’s wounds themselves.

4.2.2 High-strength Adhesive Customers

Automotive

The mere size of the automotive industry makes it a good costumer for Muscle Glue. Using Muscle Glue in automotive manufacturing would be especially beneficial for customers such as Tesla that highly value sustainability in manufacturing their product.

Aviation

As the aviation industry has embraced lighter, more fuel-efficient equipment, adhesives have played an increasingly large role in the manufacturing process. Muscle Glue’s high strength adhesive would be a good alternative to the current adhesives used in aviation
manufacturing. Aviation would be very financially lucrative industry to sell to due to the large quantities of adhesive that would be needed for manufacturing.

**Electronics**

The rapid growth of the electronics industry makes it a good industry to which to sell Muscle Glue’s high-strength adhesive. The adhesive could be used to adhere the circuitry of smartphones and tablets.

**Homeowners**

Muscle Glue’s mussel-based adhesive would have myriad uses for home repair work and do-it-yourself projects. The adhesive could be used to install cabinets, repair a leaking pipe, or fix a broken chair. In this application, the adhesive would especially be useful in home repairs that require an adhesive that will cure well in a wet environment. Muscle Glue can easily manage plumbing repairs.

**4.3 Regulatory restrictions**

One of the main regulatory restrictions that Muscle Glue will have to overcome is gaining FDA approval to produce a surgical adhesive. Anything that is intended for use in the human body must pass stringent FDA regulations. Much of this approval must happen before the product goes into production. Well before Muscle Glue plans to put its surgical adhesive on the market it must produce proof that its process meets FDA standards and that the surgical adhesive is not harmful to humans. Proving that the process meets FDA standards will require pilot plant setting up the process in a pilot plant before making the manufacturing process large scale.

An additional implication of the need for FDA approval is that the process cannot be changed without FDA approval. Thus, Muscle Glue will not be able to switch from a batch to
continuous process without FDA approval. Since Muscle Glue plans to quickly scale up production of the process after the initial launch of its surgical adhesive, it will be necessary to initially design the process for large scale production. A continuous process would be best for large scale production, but designing for large scale production at first would force underutilization of the equipment in the beginning stages of the company before the process is scaled up. Therefore, it would be most efficient to scale-up the process as quickly as possible to optimally utilize the equipment available.

4.4 Significant trends

Using adhesives as an alternative to traditional methods of wound closure is a quickly growing trend. Most similar adhesives on the market currently are not strong enough to replace sutures and are merely used to supplement more traditional methods. The industry is quickly moving towards high-strength, biocompatible adhesives.

4.5 Growth rate

According to the Adhesives & Sealants Industry Magazine, “the global surgical adhesives and sealants market is estimated to reach $2.64 billion by 2020, growing at a compound annual growth rate of 9.2%”.<sup>5</sup>

4.6 Barriers to entry and exit

As mentioned previously, gaining FDA approval to begin producing the product is one obvious barrier to entry. The fact that Muscle Glue must also gain credibility in the surgical adhesive industry is another barrier to entry. Later in the life of the company, when Muscle Glue attempts to enter industries that are currently dominated by petroleum-based adhesives, the

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company must convince potential customers that spending slightly more money on an adhesive is worth the environmental sustainability of reducing the use of fossil fuels. Since Muscle Glue deals will live bacteria cultures in its process, barriers to exit the industry would include finding another company to purchase the bacteria culture or determining a method to dispose of biowaste.

4.7 Key success factors in the industry

Ultimately, success in the industry will be gained by producing a product that is biocompatible, high strength, low cost, and able to cure in wet environment.

4.8 Outlook for the future

The new company will focus on producing a high-strength, low-cost surgical adhesive. Continuous process improvement will eventually lower the cost of producing the adhesive to a point where it can be a financial competitor to current petroleum-based adhesives. At this point, Muscle Glue will expand into new industries such as automotive, aviation, electronics, and home repair.

5. Business Strategy

5.1 Desired image and position in market

By determining the number of the surgeries performed annually in the United States which would most likely benefit from surgical glue, and estimating that each surgery would use an average of 4 mL of surgical glue, the company determined its goal was to take 5% of the U.S. market in surgical adhesives in the first year. The company also desires to become well-known as a producer of high-strength, low-cost surgical adhesive.
5.2 Company goals and objectives

5.2.1 Operational

In the first year of operation, the company plans to produce 1172 L of adhesive per year (this constitutes 5% of the total market).\(^6\) In this year, the company will prepare for scale up of the process to take a larger portion of the market. The company will also complete research and development and prepare to launch variations of its adhesive into new markets (i.e. alternatives to petroleum-based adhesives).

5.2.2 Financial

Muscle Glue plans to implement continuous improvement strategies in order to continue to decrease the cost of the product to the consumer. This will make the product available to a wider range of consumers and make the product more competitive in the industry.

5.3 SWOT analysis

5.3.1 Internal Strengths

Muscle Glue’s product is one of the few of its kind currently on the market. The surgical adhesive industry is relatively new, so Muscle Glue has only one real competitor. Being one of the first companies in the industry is a huge advantage because it provides tremendous opportunity for growth and leaves much room for innovation. Muscle Glue’s product has higher strength adhesion properties and is available at a lower cost than its main competitor BioGlue.

5.3.2 Internal Weaknesses

One of Muscle Glue’s internal weaknesses is its lack of experience in a relatively new industry. As a new name in the industry, Muscle Glue must quickly prove the strength of its product in order to establish itself as a trusted company.

5.3.3 External Opportunities

The company benefits from being one of the few companies producing a surgical adhesive that can be used without sutures. As such, the company has a tremendous opportunity for growth and can establish itself as a leader in surgical adhesives. Muscle Glue also has the opportunity to establish its products as an environmentally friendly alternative to petroleum-based adhesives.

5.3.4 External Threats

BioGlue, Muscle Glue’s main competitor, advertises that its product begins to develop green strength within 20 to 30 seconds. Muscle Glue’s product does not cure as quickly so the company must strongly advertise its product’s low cost and high strength to compete with BioGlue.

5.4 Competitive strategy

Muscle Glue mainly competes on the basis of cost leadership and differentiation.

5.4.1 Cost leadership

Muscle Glue’s competitive strategy will mainly rest on the basis of cost leadership. Since Muscle Glue surgical adhesive is offered at three-fourths the cost of its lowest price competitor, it should be the obvious choice in surgical adhesives.
5.4.2 Differentiation

Muscle Glue also competes on the basis of having a higher level of shear strength than its competitors.

6. Company Products and Services

6.1 Description

6.1.1 Product features

Because it mimics mussel adhesive proteins (MAPs), Muscle Glue’s surgical adhesive does not degrade in the hostile, wet, saline environment of the human body. Thus it provides high strength even after prolonged exposure to bodily fluids. It is non-toxic to the human body and can easily adhere to flesh to flesh as well as flesh to metal or other implant materials. It is also capable of curing in the wet environment of the human body. The product has a higher strength than its competitors and is available at a lower cost.

6.1.2 Customer benefits

The customer benefits from a product that provides higher strength adhesion in surgical procedures and is less costly than similar products. Healthcare providers also benefit from increased speed in their surgical procedures gained from using adhesive rather than sutures. Patients gain from not having to undergo some of the pain of having stitches put in and from not having to return to the healthcare provider to have the stitches removed later.

6.1.3 Warranties and guarantees

Muscle Glue guarantees that its surgical adhesive will not tear due normal post-surgical activities (as recommended by the healthcare provider) and that it will not have any unwanted
side effects (other than those typical of post-surgical operations--some swelling and inflammation, etc.).

6.1.4 Future product or service offerings

Muscle Glue will eventually produce a version of its surgical adhesive for at-home use by non-healthcare providers. Such a product could be used in place of bandages to close larger flesh wounds. Muscle Glue also hopes to produce a low-cost, more environmentally friendly alternative to current petroleum based adhesives.

7. Marketing Strategy

7.1 Target market

Muscle Glue’s target market is healthcare facilities who would use its product in surgical procedures in all of their surgical units. In surgery, this product would be used in the human body to adhere flesh to flesh or flesh to man-made materials.

7.1.1 Problem to be solved or benefit to be offered

Muscle Glue will provide a high-strength, lower-cost surgical adhesive than similar products that are currently on the market. Currently, there is only one surgical adhesive on the market that is capable of being used in place of sutures. Most similar products are marketed as merely sealants that can only be used to keep bodily fluids inside the body. Other similar surgical adhesives are not strong enough to be used without sutures. Muscle Glue’s surgical adhesives will fulfill all these needs.

7.1.2 Demographic profile

The product will probably be used in surgeries on people of all demographics; however, since this product will probably be more expensive than more traditional methods of closing
wounds (such as sutures) the product will likely be sold to healthcare providers that serve a more affluent population who can afford to use the newest and most convenient methods of wound closure.

7.1.3 Customers' motivation to buy

Customers will be motivated to buy Muscle Glue’s surgical adhesive because it is stronger and less expensive than its competitors. The product is also more convenient to both the healthcare provider and the patient than traditional methods of wound closure.

7.2 Market size and trends

The global surgical adhesives and sealants market is expected to reach $2.64 billion in the next five years. More specifically, natural (biological) adhesives, such as Muscle Glue’s product, take 60% of the current market. The increase in this industry is partially due to the aging population, the growth in surgical adhesive technology, and the increasing acceptance of the use of adhesives in surgery.⁷

7.3 Advertising and promotion

7.3.1 Message

Muscle Glue will be promoted as the latest in high-strength surgical adhesives. It will be marketed as superior to its competitors in cost, strength, and durability.

7.3.2 Budget

The company plans to budget 10% of its gross annual income on marketing.

7.3.3 Plans for generating publicity

The product will specifically be marketed to healthcare providers by publishing articles in healthcare journals regarding the benefits of the product. Muscle Glue’s surgical adhesive will also be showcased at healthcare conferences where the healthcare providers will be able to see statistics that demonstrate the benefits of Muscle Glue’s product versus its competitor’s product.

7.4 Pricing

7.4.1 Desired image in market

Muscle Glue hopes to project an image of its surgical adhesive as the latest in surgical technology available at a fraction of the price of its competitors.

7.4.2 Comparison against competitors’ prices

The range of prices for Muscle Glue’s competitors’ products is approximately $75 to $150 per mL. Muscle Glue’s surgical adhesive will sell for about $40 per mL.

7.4.3 Discount policy

Muscle Glue will offer a 15% discount to healthcare providers who regularly purchase a sizable quantity of the surgical adhesive.

7.4.3 Gross profit margin % anticipated

Muscle Glue anticipates a gross profit margin of 67% in the first year after start up.

7.5 Distribution strategy - Channels of distribution

Muscle Glue’s surgical adhesive will be sold wholesale to healthcare providers.
8. Competitive Analysis

8.1 Existing competitors

8.1.1 Who they are

In the market for surgical glues, the main competitor is BioGlue® by CryoLife®. Other products include CoSeal, Tisseel, Crosseal, Duraseal, and TissuGlu. BioGlue and TissuGlu. These products are the only ones sold specifically as adhesives with the potential to work alone without assistance from sutures. However, BioGlue advises this usage only in cases where use of traditional repair techniques is impossible. TissuGlu only recently (February 2015) passed FDA approval and is being sold solely for the purpose of abdominoplasty. The other four surgical glues are advertised more as sealants to be applied over the sutures to eliminate fluid and blood loss.

8.1.2 Strengths

In terms of adhesion strength, when tested attaching periosteum to bone, BioGlue® showed a shear strength of 45.9 kPa. BioGlue has a Young’s Modulus of is 3,122.04 +/− 1639.68 kPa, which is much stiffer than any of the sealant-purposed glues. Muscle Glue has a shear strength of 100 kPa. The range of prices for the competitors’ products are approximately $75 to $150 per mL. Muscle Glue will sell for about $40 per mL.

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8.1.3 Weaknesses

One major advantage of BioGlue, as listed on the CryoLife website, is that it has initial green strength at 20 - 30 seconds and is fully cured within 20 minutes. Muscle Glue’s surgical adhesive develops green strength at about 1 minute--about twice as long as its main competitor.

8.2 Potential competitors: companies that might enter the market

8.2.1 Who they are

3M and Gore are two companies that currently make adhesives and medical products. Both companies could easily enter the market for medical adhesives.

8.2.2 Impact on the business if they enter

Since both companies have a large amount of experience in the adhesive and healthcare industries as well as a large amount of credibility in both fields, either company would probably draw a large sector of the market if they were to enter.

9. Description of Management Team

9.1 Key managers and employees

Director of Engineering - Michael Dornbush

Michael is responsible for managing a team of engineers in the design of equipment and scale-up of the adhesive production process. He will play a major role in the initial launch of production and in ensuring a smooth scale up of the process early in the life of the company. As the company grows, he will lead continuous improvement endeavors and ensure that production continues to run smoothly.
**Director of Marketing and Technology - Paul Freeman**

Paul is responsible for leading a team of software developers in maintaining the company website and automating the adhesive production process as much as possible. He is also in charge of leading the team in producing literature and promotional videos for use in marketing.

**Director of Research and Development - Michael VandenBerg**

Michael is the head of the research and development team at Muscle Glue. He is responsible for leading the team responsible for the chemistry of the adhesive. As the company experiences growth, Michael will formulate new adhesives and test the variations for higher strength, durability, faster cure time, and better compatibility with the human body.

**Director of Human Resources - Kimberly Braybrook**

Kimberly is in charge of the team that is responsible for organizing conferences with healthcare providers and press releases on the new product. She is also responsible for maintaining good relationships with main contacts at healthcare facilities and establishing contacts in future target markets.

**9.2 Future additions to management team**

As the company branches into different sector and expands internationally, the management team will expand to include a head of each of the markets entered (automotive, aviation, etc.) and a head of international affairs. The company will also need a head of sales and director of finances.
9.3 Board of directors

The board of directors includes the four key employees, the directors of finance and marketing, as well as an expert in the target market who will assist in the industry in developing new products.

10. Operations

10.1 Legal form of ownership chosen and rationale

Initially, the company will be privately held by the four key employees. The four key employees have chosen to start the company as a privately owned company in order to maintain control of the company for ease of early decision making. As the company grows, the board of directors may choose to bring Muscle Glue into the public sector.

10.2 Company structure

![Organizational Structure of Muscle Glue](image)

Figure 1: Organizational Structure of Muscle Glue
10.3 Decision making authority

All decisions regarding major changes in the company will be made through majority vote of the board of directors.

10.4 Significant compensation and benefits packages

Employees will receive health insurance, life insurance, a 401K retirement plan, tuition reimbursement, and two weeks paid vacation.

10.5 Description of production or process

A complete process flow diagram of the process needed to produce this surgical adhesive is shown in the Appendix.

A brief overview of the production process is as follows: plasmid construction/insertion of the fp-151RGD hybrid protein into “Rosetta” *E. coli*, which are then grown to suitable optical density in a bioreactor. At this point, isopropyl-β-D-thiogalactopyranoside (IPTG) is injected into the broth, which initiates the expression of the desired adhesive protein. The reactor slurry is then collected and put through several stages of centrifugation at 18,000g and extraction with 5% acetic acid. The mixture is then run through a metal affinity column and +His tags on the protein cause them to stick to the column, separating them from the other components. The proteins then exit the column with an elution buffer and dialysis is performed, followed by tyrosination of Tyrosine residues to DOPA.

10.6 Raw materials

The following raw materials are needed for production:

- acetic acid
- 10 mM Tris-Cl
• Tyrosinase
• IPTG
• Tryptone
• Yeast Extract
• Glucose
• NaCl
• 100 mM NaPO4
• *E. coli* bacteria culture

### 10.7 Costs

Costs will include the costs of raw materials, equipment, land, research and development, salaries and benefits for employees.

### 10.8 Key supply chain components

Once Muscle Glue obtains a base culture of *E.coli*, modified *E.coli* will be created by insertion of a DNA vector into a DNA plasmid that will be assimilated into the host organism genome. This DNA vector will have to be ordered from a supplier through an interface such as addgene.org. Muscle Glue’s in-house lab will maintain a small culture of this modified *E.coli* for the duration of the industrial process as a backup. Also, *E. coli* will be continuously supplied to a new reaction scheme by taking a portion of pre-IPTG broth and starting another incubation period in a secondary bioreactor. Therefore, once the initial modified host cells have been created, there shouldn’t be a need for re-contacting the supplier of base *E. Coli* culture and recombinant protein DNA vector. However, for each run, this process will require a fresh Luria Bertani cell culture medium. Each run will require ampicillin and chloramphenicol supplements
so that only the resistant cells will grow. Each batch will also require a dosage of IPTG, ample 5% acetic acid solution for extractions, tyrosinase and elution buffers. Suppliers of these products will be key supply chain components.

11. Facilities

11.1 Location

Considering its target market, Muscle Glue will build its plants near large clusters of medical facilities. This will lower the cost of transportation of the finished product to the target customer. This will also allow Muscle Glue to easily do market testing and research and development in collaboration with the health care providers that will be using the product.

11.2 Layout

Muscle Glue plans to start production of a surgical adhesive as a continuous process. Since Muscle Glue plans to scale up production relatively soon after start-up in order to expand into other markets, the original layout of the plant will include more separation equipment than needed in order to allow for ease of scale-up. A process flow diagram of the equipment needed for the process is included in the Appendix.

11.2.1 Possible setup constraints

To maintain a continuous process, Muscle Glue will need to maintain two bioreactors (one incubating cell culture and one reacting). Some of the separation equipment will be run in batch while the rest of the process is run continuously. In order to do this, several instances of the same separation equipment will be required. Setting up this equipment in the most logical
manner will require implementation of lean thinking. FDA requirements will also put some
constraints on how the process can be set up.

11.3 Capacity issues and constraints

Only one gram of purified protein is produced from one liter of bioreactor culture. The capacity is limited by how much bioreactor culture is needed to produce a small amount of purified protein.

12. Loan or Investment Proposal

12.1 Amount requested – Equity and/or Debt

Twenty million dollars total in capital is required, ten million of this will be an investment or equity in the company, while the remaining ten million will be borrowed and paid back over time with a 10% annual interest rate.

12.2 Purpose and uses of funds

Six million dollars of the funds will be used to purchase equipment and outfit the plant to the point that production can be started. Another eight million will go towards installation and set-up costs. Two million will go towards finalizing clinical trials and FDA approval, one million towards equipment and setup of a pilot plant to model the process, and two million towards employment of necessary supervisors and employees to prepare to initialize production of the adhesive. The remaining million will be used as a temporary source of funding until revenue from sales begins to flow in.

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12.3 Repayment or "cash out" schedule (exit strategy)

Three million dollars will be paid back per year until all debt is paid off beginning at the end of the second year. At this rate all debt will be repaid at the end of the sixth year.

12.4 Timetable for implementing plan and launching the business

Upon receiving the resources from the investments and loans, construction of the chemical plant, final clinical trials and FDA approval, applications will start immediately. The plant will be ready to begin production at the beginning of the second year.
Appendix

Financial statements

A.1 Statement of Income

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<th>Year 2</th>
<th>Year 3</th>
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<td>Muscle Glue</td>
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<td>Pro-Forma Statement of Income</td>
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<td>Sales revenue</td>
<td>-</td>
<td>37,504,000</td>
<td>46,880,000</td>
</tr>
<tr>
<td>Variable Cost of Goods Sold</td>
<td>-</td>
<td>11,251,200</td>
<td>14,064,000</td>
</tr>
<tr>
<td>Fixed Cost of Goods Sold</td>
<td>-</td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td>Depreciation</td>
<td>1,000,300</td>
<td>1,714,300</td>
<td>1,224,300</td>
</tr>
<tr>
<td>Gross Margin</td>
<td>(1,000,300)</td>
<td>24,238,500</td>
<td>31,291,700</td>
</tr>
<tr>
<td>Variable Operating Costs</td>
<td>10,000,000</td>
<td>7,500,800</td>
<td>9,376,000</td>
</tr>
<tr>
<td>Fixed Operating Costs</td>
<td>2,000,000</td>
<td>8,000,000</td>
<td>8,000,000</td>
</tr>
<tr>
<td>Operating Income</td>
<td>(13,000,300)</td>
<td>8,737,700</td>
<td>13,915,700</td>
</tr>
<tr>
<td>Interest Expense</td>
<td>500,000</td>
<td>850,000</td>
<td>550,000</td>
</tr>
<tr>
<td>Income Before Tax</td>
<td>(13,500,300)</td>
<td>7,887,700</td>
<td>13,365,700</td>
</tr>
<tr>
<td>Income tax (40%)</td>
<td>3,155,080</td>
<td>5,346,280</td>
<td></td>
</tr>
<tr>
<td>Net Income After Tax</td>
<td>(13,500,300)</td>
<td>4,732,620</td>
<td>8,019,420</td>
</tr>
</tbody>
</table>

A.2 Statement of Cash Flows

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle Glue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pro-Forma Statement of Cash Flows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beginning Cash Balance</td>
<td>-</td>
<td>500,000</td>
<td>3,946,920</td>
</tr>
<tr>
<td>Net Income After Tax</td>
<td>(13,500,300)</td>
<td>4,732,620</td>
<td>8,019,420</td>
</tr>
<tr>
<td>Depreciation expense</td>
<td>1,000,300</td>
<td>1,714,300</td>
<td>1,224,300</td>
</tr>
<tr>
<td>Invested Capital (Equity)</td>
<td>10,000,000</td>
<td>1,714,300</td>
<td>-</td>
</tr>
<tr>
<td>Increase (decrease) in borrowed funds</td>
<td>10,000,000</td>
<td>(3,000,000)</td>
<td>(3,000,000)</td>
</tr>
<tr>
<td>Equipment Purchases</td>
<td>(7,000,000)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ending Cash Balance</td>
<td>500,000</td>
<td>3,946,920</td>
<td>10,190,640</td>
</tr>
</tbody>
</table>
### A.3 Break-even analysis

#### Muscle Glue

**Break - Even Analysis**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sales revenue</strong></td>
<td></td>
<td>37,504,000</td>
<td>46,880,000</td>
</tr>
<tr>
<td><strong>Less: Variable Costs:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable Cost of Goods Sold</td>
<td></td>
<td>11,251,200</td>
<td>14,064,000</td>
</tr>
<tr>
<td>Variable Operating Costs</td>
<td>10,000,000</td>
<td>7,500,800</td>
<td>9,376,000</td>
</tr>
<tr>
<td><strong>Total Variable Costs</strong></td>
<td>10,000,000</td>
<td>18,752,000</td>
<td>23,440,000</td>
</tr>
<tr>
<td><strong>Contribution Margin</strong></td>
<td>(10,000,000)</td>
<td>18,752,000</td>
<td>23,440,000</td>
</tr>
<tr>
<td><strong>Less: Fixed Costs:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Cost of Goods Sold</td>
<td></td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td>Fixed Operating Costs</td>
<td>2,000,000</td>
<td>8,000,000</td>
<td>8,000,000</td>
</tr>
<tr>
<td>Depreciation</td>
<td>1,000,300</td>
<td>1,714,300</td>
<td>1,224,300</td>
</tr>
<tr>
<td>Interest Expense</td>
<td>500,000</td>
<td>850,000</td>
<td>550,000</td>
</tr>
<tr>
<td><strong>Total Fixed Costs</strong></td>
<td>3,500,300</td>
<td>10,864,300</td>
<td>10,074,300</td>
</tr>
<tr>
<td><strong>Income Before Tax</strong></td>
<td>(13,500,000)</td>
<td>7,887,700</td>
<td>13,365,700</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fixed Costs</td>
<td>3,500,300</td>
<td>10,864,300</td>
<td>10,074,300</td>
</tr>
<tr>
<td>Contribution Margin %</td>
<td>56%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Break Even Sales Volume</strong></td>
<td>21,728,600</td>
<td>20,148,600</td>
<td></td>
</tr>
</tbody>
</table>

#### Equipment Purchases and Depreciation

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Purchases Year 1</td>
<td>7,000,000</td>
<td>1,000,300</td>
<td>1,224,300</td>
</tr>
<tr>
<td>Equipment Purchases Year 2</td>
<td></td>
<td>1,714,300</td>
<td></td>
</tr>
<tr>
<td>Equipment Purchases Year 3</td>
<td></td>
<td></td>
<td>1,224,300</td>
</tr>
<tr>
<td><strong>Total Equipment Purchases</strong></td>
<td>7,000,000</td>
<td>1,000,300</td>
<td>1,224,300</td>
</tr>
</tbody>
</table>

#### MACRS Rates (7-year recovery period)

- 14.29%
- 24.49%
- 17.49%

#### Interest Expense:

- **Annual interest rate on debt**: 10%

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average debt balance</td>
<td>5,000,000</td>
<td>8,500,000</td>
<td>5,500,000</td>
</tr>
<tr>
<td>Interest expense</td>
<td>500,000</td>
<td>850,000</td>
<td>550,000</td>
</tr>
</tbody>
</table>
### A.4 Ratio analysis

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Margin of Revenue</td>
<td>--</td>
<td>0.65</td>
<td>0.57</td>
</tr>
<tr>
<td>Profit Margin</td>
<td>--</td>
<td>0.13</td>
<td>0.17</td>
</tr>
<tr>
<td>Net Asset Turnover</td>
<td>--</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Debt and Equity Ratio</td>
<td>0.5</td>
<td>0.85</td>
<td>0.55</td>
</tr>
</tbody>
</table>
A.6 Resumes of Key Employees

Paul Freeman

School Address: 1946 Morningside Dr SE
Grand Rapids, MI 49506

Cell Phone: 301-456-4042
Cell Phone: 301-456-4042

Home Address: 5709 Butter Churn Way
Fuquay-Varina, NC 27526

Objective
Senior Chemical Engineering, Biochemistry and Pre-Medical student seeking full or part time research experience.

Education
Calvin College - Grand Rapids, MI
Bachelor's of Science in Engineering, Biochemistry, Pre-Medical Track
GPA - 3.1

Relevant Courses
- Intro to Engineering Design
- Graphical Communication Lab
- General Chemistry
- Physical Chemistry
- Calculus I, II, III
- Differential Equations
- Engineering Statistics
- Applied Computing
- Business Aspects for Engineers
- Intro to Circuit Analysis

- Physics: Mechanics and Gravity
- Physics: Electricity and Magnetism
- Materials Science and Chemistry
- Organic Chemistry I, II
- Biochemistry I
- Kinetics and Thermodynamics
- Intro to Chem Engr & Thermo I, II
- Fluid Flow & Heat Transfer
- Separation Process Principles
- Kinetics / Reactor Design

Computer Experience
- AutoCAD
- AutoDesk Inventor
- PTC Mathcad
- Microsoft Office
- Python 3
- UNISIM

Work Experience
Environmental Protection Agency
Research Triangle Park, North Carolina - Summer 2015
Research Assistant
- Advised on experimental design, collected data, and observed chemical analysis for MRE burn emission testing for Natick research project.
- Performed analysis of various samples on GC-MS.

Engineering Senior Design Project
Calvin College, Grand Rapids, Michigan - 2015 - 2016
- Designed process for synthesis of blue mussel adhesive, a biocompatible durable adhesive primarily intended for medical applications.

Other
Sports:
Calvin College Swim & Dive team (4 years)

International Experience:
1 week service trips: Lipotsky, Slovakia (2007); Turnov, Czech Republic (2008)
Lived in Rota, Spain 2005 - 2010, and in Okinawa Japan 1998 - 2002

References
Wayne Wentzheimer, Calvin College Engineering Department, (616)-526-6318
Daniel Gelderloos, Calvin College Swim Team Head Coach, (616)-526-6703
Michael Dornbush
mjd63@students.calvin.edu  •  616.510.6149
455 Alice Ave., Zeeland MI, 49464

Objective:
As a detail-oriented chemical engineering senior with an intuitive edge, I seek a full-time position where I can contribute to a company and work with experienced engineers.

Education
Calvin College – Grand Rapids, MI
 Bachelor of Science in Engineering with a concentration in Chemistry
 GPA: 3.552
 Technical University of Berlin – Berlin, Germany
 Coursework in Engineering and German Language/Culture
 Expected Graduation in May 2016
 Summer, 2013

Work Experience
Engineering Internship at Vertellus Specialties Inc. (Zeeland, MI)
Reduced nitrogen usage for an annual cost savings of $50,000
Prepared place to refresh a glycol refrigeration cycle
May, 2015 – Present

Engineering Internship at Rapid-Line (Grand Rapids, MI)
Worked as an unsupervised 2nd shift engineer
Prepared customer designs for fabrication
Worked closely with operators to resolve problems
June, 2014 – June 2015

Building Security Officer for Campus Safety at Calvin College
Patrolled and secured buildings after hours
Feb., 2014 – May 2014

Temporary Jobs Through Manpower (Zeeland, MI)
General maintenance at GVSU apartments
May 2013 – June, 2013

Extracurricular Activities
Leadership for Chemical Engineering and Chemistry Club
Jan. 2015 - Present

Leadership for Engineering Unlimited

Oratorio at Calvin (Handel’s Messiah)

Calvin College Gospel Choir
Sept. 2012 – May. 2013

Computer Skills
Unisim, OSI-PJ, AutoCAD, MathCAD, Excel, Python

Course Work
Engineering: Kinetics and Reactor Design; Mass Transfer and Staging Operations; Fluid Flow and Heat Transfer; Chemical Engineering Principles and Thermodynamics; Intro to Conservation Laws and Thermodynamics; Chemistry and Materials Science; Statics and Dynamics; Circuits Analysis and Electronics

Science: Organic Chemistry 1 and 2; Intro to Biochemistry; Physical Chemistry; Mechanics and Gravity; Electricity and Magnetism

Business: Introduction to Managerial Accounting; Introduction to Microeconomics; Introduction to Business

Other: Two German Language and Culture classes, Four years of high school Spanish

Expected by Graduation: Process Control Systems; Engineering Senior Design Project

Awards and Honors
Dean’s List for three semesters
Scholarships: Calvin Academic Achievement Award, Lakeshore Alumni Chapter – Community Service Scholarship; Faculty Honors Scholarship; Jack and Eleanor Eltenbaas Family Scholarship; Wilma Zondervan Tegelaar Family Scholarship; Ida Baas Scholarship

References
Randy Eltenbaas  Dan DeGroot  Prof. Jeremy VanAntwerp
Engineer at Vertellus  Engineer at Rapid-Line  Chen. Eng. Prof. at Calvin College
(616).886.2668  (616).330.0061 ext. 1310  jva@calvin.edu
Kimberly Braybrook

Address
1859 Woodlawn Ave. SE
Grand Rapids, MI 49506

Contact Information
ksb57@students.calvin.edu
(810) 946-0158

Objective
Senior chemical engineering and biochemistry double major seeking a full-time job to contribute strong interpersonal skills, good time management, and a big picture perspective to an engineering firm

Education
Calvin College—Grand Rapids, MI
Bachelor of Science in Biochemistry and Engineering, Chemical Concentration
Expected Graduation Date: May 2016
GPA: 3.577/4.000

Courses
Math: Calculus I, II, and III, Differential Equations and Linear Algebra, Statistics
Sciences: Cell Biology, Human Physiology, General, Organic, and Physical Chemistry, Biochemistry, Physics: Mechanics and Gravity, Electricity and Magnetism, Introduction to Python Programming

Experience
Seal Bond Internship, Summer 2015
Seal Bond—Spring Lake, MI
- Performed research and development on adhesives and sealants
- Assisted in process engineering focused on batch time reduction

Resident Assistant, August 2014 – May 2015
Calvin College—Grand Rapids, MI
- Responsible for building community and providing mentoring relationships for underclassmen

Summer Camp Staff, Summers 2012 and 2013
Camp Geneva—Holland, MI
- Provided spiritual guidance to girls ages 7 to 13 through strong teamwork and leadership skills

Costume Shop Assistant, 2012-2013
Calvin College—Grand Rapids, MI
- Created well-made costumes for the college’s theatrical productions

Banquet Server, 2012-2013
The B.O.B.—Grand Rapids, MI
- Used interpersonal skills with a wide variety of people

References
Professor Aubrey Sykes, Calvin College, Engineering, asykes@calvin.edu
Austin Brown, Calvin College, Resident Director, acb39@calvin.edu
Jim Klein, Seal Bond, Director of Engineering and Technology, jklein@seal-bond.com